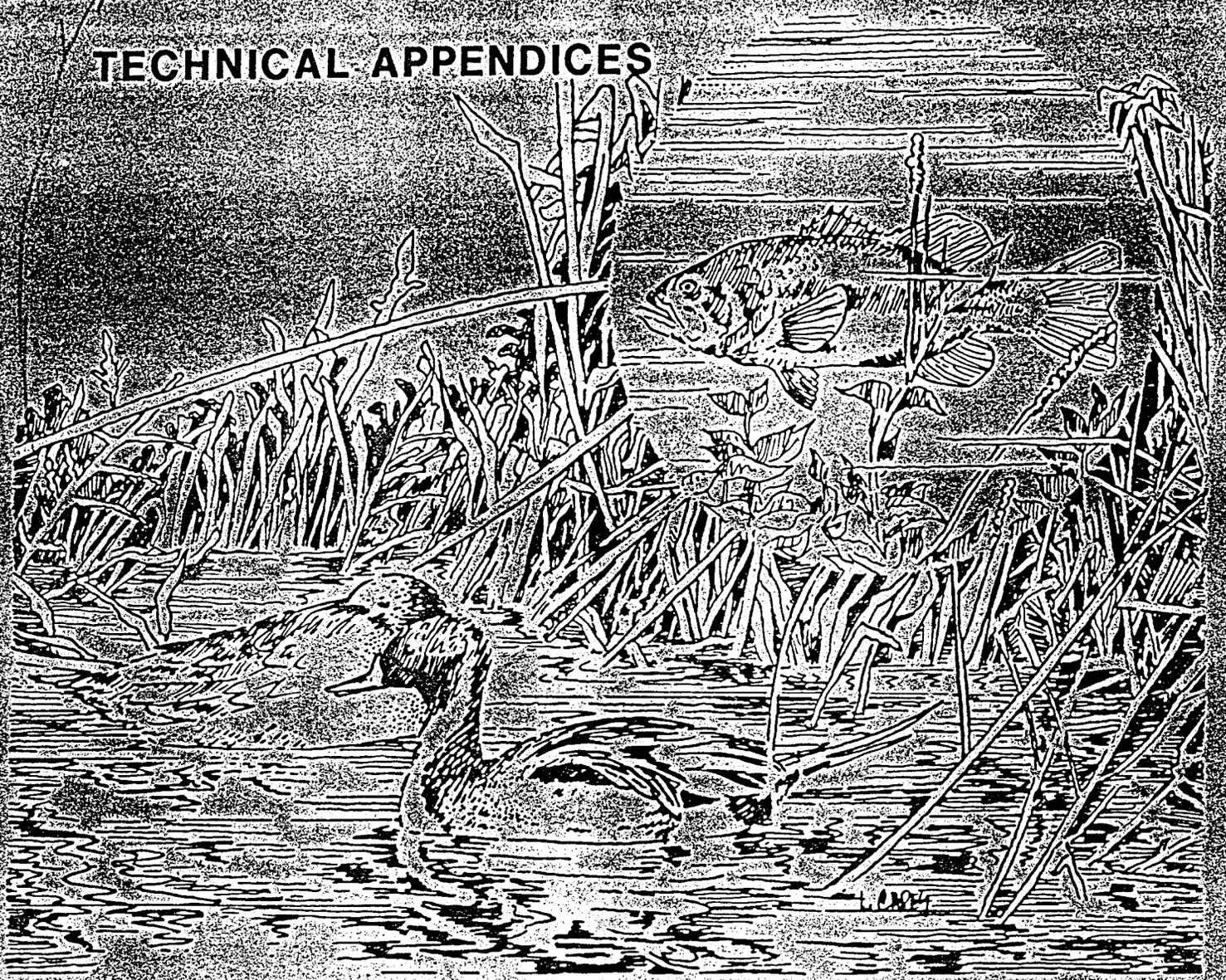


ED LN

**UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)  
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT**

**ANDALUSIA REFUGE  
REHABILITATION AND ENHANCEMENT**

**TECHNICAL APPENDICES**



US Army Corps  
of Engineers  
Rock Island District

NOVEMBER 1988

Pool 16  
UPPER MISSISSIPPI RIVER  
ROCK ISLAND COUNTY, ILLINOIS

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT

ANDALUSIA REFUGE  
REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

TECHNICAL APPENDICES

- A - HYDROLOGY AND HYDRAULICS
- B - WATER QUALITY
- C - GEOTECHNICAL CONSIDERATIONS
- D - STRUCTURAL DESIGN
- E - HYDRAULIC DREDGING - WATER COLUMN DATA
- F - MECHANICAL AND ELECTRICAL CONSIDERATIONS
- G - SEDIMENTATION STUDY
- H - ILLINOIS DEPARTMENT OF CONSERVATION FISHERIES  
INVESTIGATION OF DEAD SLOUGH
- I - WATERFOWL OBSERVATION DATA FOR ANDALUSIA REFUGE

**HYDROLOGY AND HYDRAULICS**

A

P

P

E

N

D

I

X

A

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE  
REHABILITATION AND ENHANCEMENT

POOL 16, RIVER MILES 462 THROUGH 463  
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX A  
HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS

| <u>Subject</u>                           | <u>Page</u> |
|--|-------------|
| General                                  | A-1         |
| Climate                                  | A-1         |
| Hydrology                                | A-2         |
| Sediment Condition                       | A-3         |
| Hydraulics of Proposed Project Condition | A-3         |
| Water Control Structure                  | A-4         |
| Riprap Design                            | A-4         |
| Pump Size                                | A-6         |
| Diversion Ditch Design                   | A-7         |

### List of Tables

| <u>No.</u> | <u>Title</u>   | <u>Page</u> |
|------------|--|-------------|
| A-1        | Average Monthly Precipitation                                    | A-2         |
| A-2        | Number of Times the 2-Year<br>Elevation Was Exceeded (1965-1987) | A-4         |

### List of Plates

| <u>No.</u> | <u>Title</u>             |
|------------|--------------------------|
| A-1        | Area-Capacity Curve      |
| A-2        | Standard Flood Profiles  |
| A-3        | Elevation-Duration Curve |
| A-4        | Elevation-Duration Curve |
| A-5        | Elevation-Duration Curve |
| A-6        | Elevation-Duration Curve |
| A-7        | Channel Cross Section    |

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE  
REHABILITATION AND ENHANCEMENT

POOL 16, RIVER MILES 462 THROUGH 463  
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX A  
HYDROLOGY AND HYDRAULICS

GENERAL

The Andalusia Refuge area, shown on plate 1 of the main report, is located within the Upper Mississippi Wildlife and Fish Refuge between river miles 462 and 463 in Pool 16. This area, located 1 mile north of Illinois City, is currently managed as a waterfowl refuge by the Illinois Department of Conservation.

The purpose of this appendix is to present the development and evaluation of proposed improvements which will provide a water control structure system. This system will provide a moist soil management unit with controlled water levels, reduce sedimentation into the refuge area, and divert upland sedimentation from the refuge area. Approximately 1.55 square miles of overland area will drain into the moist soil management unit. The elevation area and capacity curves for the project are shown on plate A-1.

CLIMATE

The climate in east-central Iowa is characterized by extreme temperatures and moderate precipitation. The National Weather Service operates a weather station in Moline, Illinois, located about 25 miles north of Andalusia, which has over 50 years of

record. Temperatures range from a maximum of 107 degrees Fahrenheit in the summer to a minimum of -26 degrees Fahrenheit in the winter. The normal temperature is 49.5 degrees Fahrenheit.

Most of the precipitation occurs in summer and fall months, with May, June, and July normally the wettest months, having a monthly average of over 4 inches. Winters are normally the driest parts of the year. The average annual precipitation is 37.2 inches and the average annual snowfall is 28 inches. Table A-1, shown below, lists the appropriate monthly precipitation amounts at the Moline gage for the 36 years of record during the periods 1951 to 1987.

TABLE A-1

| <u>Average Monthly Precipitation</u> |               |              |               |
|--------------------------------------|---------------|--------------|---------------|
| <u>Month</u>                         | <u>Inches</u> | <u>Month</u> | <u>Inches</u> |
| January                              | 1.64          | July         | 4.88          |
| February                             | 1.30          | August       | 3.76          |
| March                                | 2.77          | September    | 3.74          |
| April                                | 3.97          | October      | 2.70          |
| May                                  | 4.21          | November     | 2.16          |
| June                                 | 4.32          | December     | 1.92          |

#### HYDROLOGY

Mississippi River discharge frequency relationships and corresponding water surface profiles were promulgated by the Upper Mississippi River Basin Commission (UMRBC) in a November 1979 study entitled Upper Mississippi River Water Surface Profiles, River Mile 0.0 to River Mile 847.5. Plate A-2 presents pertinent data from this study. Actual water elevations are recorded daily at Fairport, Iowa (RM 462.0). Plates 5 and 6 of the main report show daily stage hydrographs for the period of record 1967 through 1986 (gage zero equals 535.16 feet above mean sea level (MSL)). These data were used to compute monthly and year-round elevation duration relationships for the project site as presented on plates A-3 through A-6. The 50 percent duration elevation can be interpreted as the average elevation. The months of July, August, and September have the lowest normal elevations, referenced to feet above MSL, of 545.4, 545.3, and 545.3, respectively. The year round normal elevation is about 545.5 feet. Typical floods appear to last for at least 25 days and raise the water surface about 5 feet.

## SEDIMENT CONDITIONS

Historical records of past sedimentation rates are essentially nonexistent. A paper by J. Roger McHenry dated March 1981 entitled "Recent Sedimentation Rates in Two Backwater Channel Lakes, Pool 14, Mississippi River" indicates widely varying deposition rates, with an average of about 0.1 foot per year. Diversion of the upland drainage from the refuge area and the proposed levee with 2-year flood protection will decrease the sedimentation rate. A detailed discussion of sedimentation is presented in Section 2 of the main report.

## HYDRAULICS OF PROPOSED PROJECT CONDITION

The proposed project includes a levee constructed to provide protection from the 2-year flood event. The levee height will be 552.8 feet MSL at the most upstream end and slope to 550.8 feet MSL at the most downstream end. The levee will be tied into the natural ground elevation of 551.8 feet MSL at both ends as shown on plates 8 and 12 of the main report.

Located at the downstream end of the levee is a 600-foot armored section designed for overflow purposes. The overflow section was designed to be the area where overtopping will first occur during flood events greater than the 2-year frequency. Once overtopping of the overflow section occurs, the interior of the levee will fill before overtopping of the main levee section occurs. This will equalize the hydrostatic pressure and reduce damage during flood events greater than the 2-year frequency. The riprap for this armored section is discussed in a following section.

The area of conveyance for the 100-year flood event was computed for existing conditions and compared to that of the proposed conditions. There was approximately a 7 percent reduction in the cross-sectional area at the project site. The reduction occurs in the over bank area which does not normally convey much of the flood flow. The estimated difference in flood elevations for all floods is substantially less than 0.1 foot. A channel cross section for existing and proposed conditions is shown on plate A-7. Table A-2 lists the number of times per month the 2-year flood elevation was exceeded during the years 1965 through 1987 at the Fairport gage.

TABLE A-2

Number Of Times The 2-Year Elevation  
Was Exceeded (1965-1987)

| <u>Month</u> | <u>Number</u> | <u>Month</u> | <u>Number</u> |
|--------------|---------------|--------------|---------------|
| January      | 0             | July         | 0             |
| February     | 0             | August       | 0             |
| March        | 3             | September    | 0             |
| April        | 9             | October      | 1             |
| May          | 7             | November     | 0             |
| June         | 1             | December     | 0             |

WATER CONTROL STRUCTURE

A significant aspect of the project is the upstream gated water control structure between Dead Slough and the Refuge as shown on plate 10 of the main report. The purpose of this structure is to allow river water entry into the moist soil unit during non-managed periods of the year. The unit consists of one gate well with a slide gate as shown on plate 21 of the main report. The structure was designed to fill or drain the interior with 200 acre-feet of volume in a 14-day period. It was concluded that an average head of about .5 foot will be available and an area of 1.8 square feet will be required. This will be provided with a 36-inch pipe as shown on plate 21 of the main report, resulting in an average discharge velocity of approximately 4.0 feet per second.

RIPRAP DESIGN

An 18-inch layer of riprap was designed to armor the overflow portion of the levee. The overflow levee will be used in flood events to back water into the refuge area. During the initial stages of overtopping, the overflow section will have water overtopping in free flow, which is considered the most critical time for stability. For floods greater than the 2-year event, the project levee will be in a submerged state and less likely to be damaged.

Routing a typical Mississippi River flood through the overflow portion of the levee resulted in a maximum head of approximately 0.55 foot above the levee crest prior to submergence. Technical

Report NO. 2-650 "Stability of Riprap and Discharge Characteristics, Overflow Embankments, Arkansas River, Arkansas" was referenced in order to determine the stability of the overflow section. The data in this report did not cover small head elevations above the crest. However, interpolation of the data would result in the overflow section being borderline unstable if unprotected.

The overflow portion of the levee is located in a north-south direction and will be exposed to expected wind velocities as high as 70 miles per hour. In accordance with CETN-I-6 "Revised Methods for Wave Forecasting in Shallow Water," it was determined that 2.5-foot waves could be caused as a result of wind velocities, fetch, and depth of water at the project area. Due to the possible unstable condition of the overflow levee and the possible wave attack, a minimum 15-inch layer of riprap was determined to be required to armor the levee. This was based on a density 165 pcf which results in a D50 of .58 feet. However, as discussed in Appendix C - Geotechnical Considerations, based on experience 18-inch thick riprap will be provided for adequate protection during all overflow scenarios. The minimum required riprap design gradation was determined in accordance with procedures in EM 1110-1601 and ETL 1110-2-120. The following is the required minimum and the recommended gradations for the riprap:

| <u>Percent Lighter by Weight</u> | <u>Limits of Stone wt., lbs.</u> |                    |
|----------------------------------|----------------------------------|--------------------|
|                                  | <u>Minimum</u>                   | <u>Recommended</u> |
| 100                              | 170-70                           | 150-400            |
| 50                               | 50-35                            | 60-170             |
| 15                               | 25-10                            | 15-50              |

The riprap blanket should extend beyond the toe of the bank. A bedding layer 6 inches thick should be provided under the riprap.

Riprap protection is also recommended at the upstream gated water control structure. A horizontal blanket of riprap will be provided to prevent scour during the worst case scenario for which the velocities could be as high as 12 feet per second. This is based on assumed conditions including incorrect operation of the gate, involving opening it with low pond conditions during a 2-year flood event on the river. The required riprap blanket was determined in accordance with procedures in Research report H-70-2, "Erosion and Riprap Requirements at Culvert and Storm-Drain Outlets." The riprap blanket, as shown on plate 21 of the main report, will be 18 inches thick with a D50 of .58 foot. The minimum and recommended riprap gradation are the same as shown above for the overflow portion of the levee.

## PUMP SIZE

Another significant aspect of the project is the pump station located at the downstream end of the levee as shown on plate 12 of the main report. The station will be a two pump system with the capability to pump into the river from the moist soil unit during desirable periods and will also have the capability to pump from the river into the moist soil unit during low river events to ensure adequate water depth during critical periods. The effects of normal rainfall, seepage, evaporation, and upland drainage were all considered in the pump design.

One pump was designed with the capability to pump from the refuge area in order to drawdown the refuge from flat pool elevation 545 (MSL) to approximately 543.5 (MSL) within 14 days. This will be accomplished by a 5,000 gallons per minute (gpm) pump. Alternative pump sizes studied were 10,000 and 2,000 gpm. The 10,000 gpm pump would enable the refuge operator to draw down the refuge within 14 days during periods of extended high flow without utilizing gravity flow. The 2,000 and 5,000 gpm pump would utilize gravity flow to draw the refuge area down to elevation 545 feet (MSL) and then complete the drawdown to elevation 543.5 feet (MSL) within 14 days. The time increment for gravity flow from overflow elevation of 550.8 (MSL) to flat pool elevation of 545 (MSL) would depend upon river flood recession. A typical Mississippi River flood will recede approximately .5 foot per day. The Refuge area will drop at about the same rate as the river. Therefore pumping should not be initiated until the flood event passes and normal levels of approximately 545 to 546 (MSL) occur. Operating in this manner is economically consistent with a low operating budget, and meets Refuge objectives. The 5,000 gpm pump was the selected alternative based on being most economical within the desired 14-day drawdown period. The 2,000 gpm pump would require longer running time and would limit the flexibility of the Refuge operator.

The second pump was designed with the capability to raise and maintain the water elevation within the levee from elevation 545 feet (MSL) to 547.0 feet (MSL) within 10 days. This will be provided by a 3,500 gpm pump. A smaller pump would require a longer time to fill the interior and larger size would be unnecessary for typical operating procedures. Table A-3 lists the number of pumping days required to raise the water level within the MSMU to selected elevations from flat pool elevation of 545 feet (MSL). The pumping days shown are conservative estimates because average rainfall was not considered. Studies indicate that evaporation during typical pumping periods is negligible.

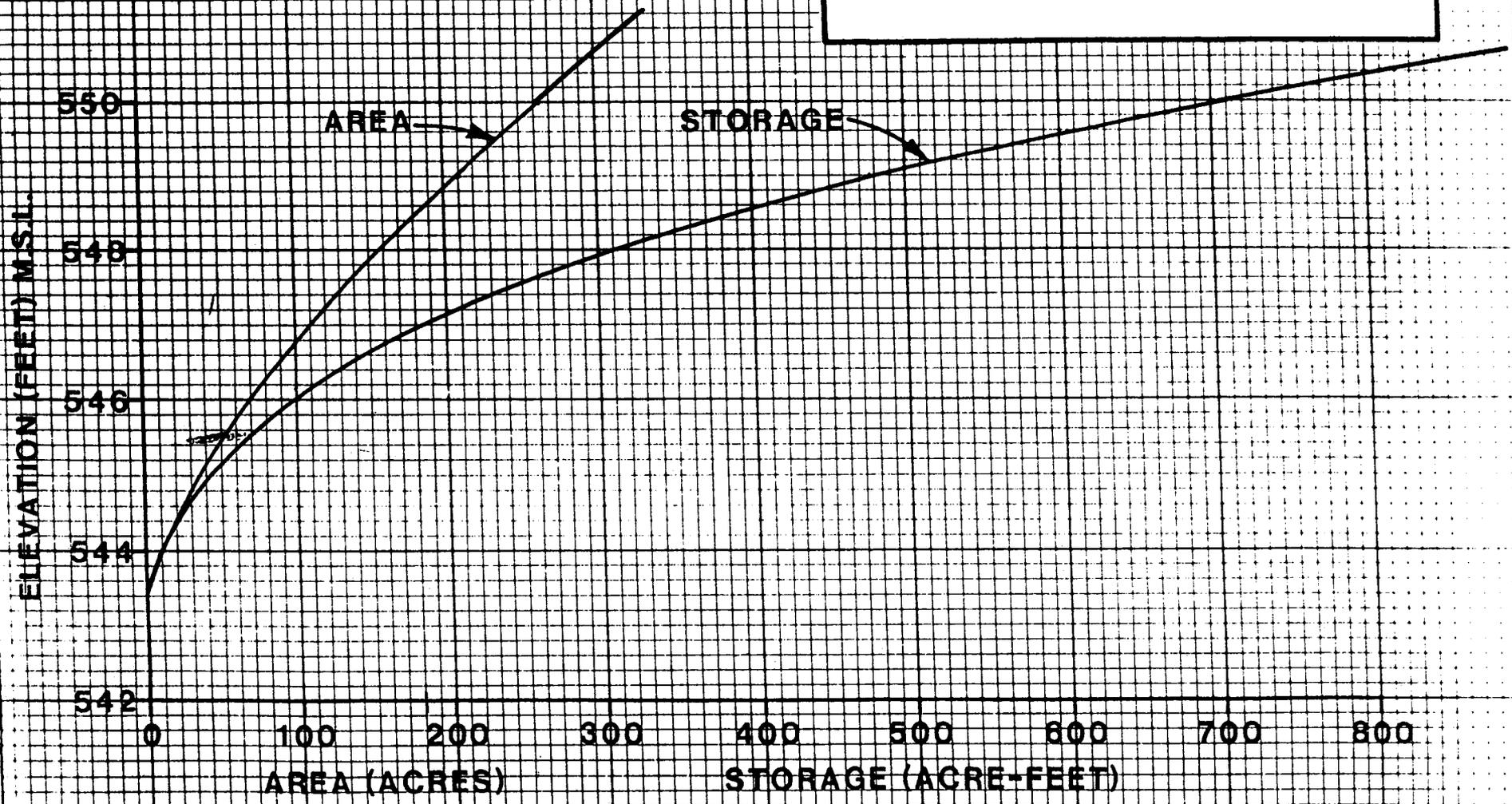
TABLE A-3  
PUMPING DAYS REQUIRED  
FOR 3500 GPM PUMP

| <u>ELEVATION</u><br><u>ft. (MSL)</u> | <u>PUMPING DAYS</u> |
|--------------------------------------|---------------------|
| 546                                  | 3.5                 |
| 547                                  | 9.5                 |
| 548                                  | 17                  |
| 549                                  | 28                  |
| 550                                  | 43                  |
| 550.8                                | 55                  |

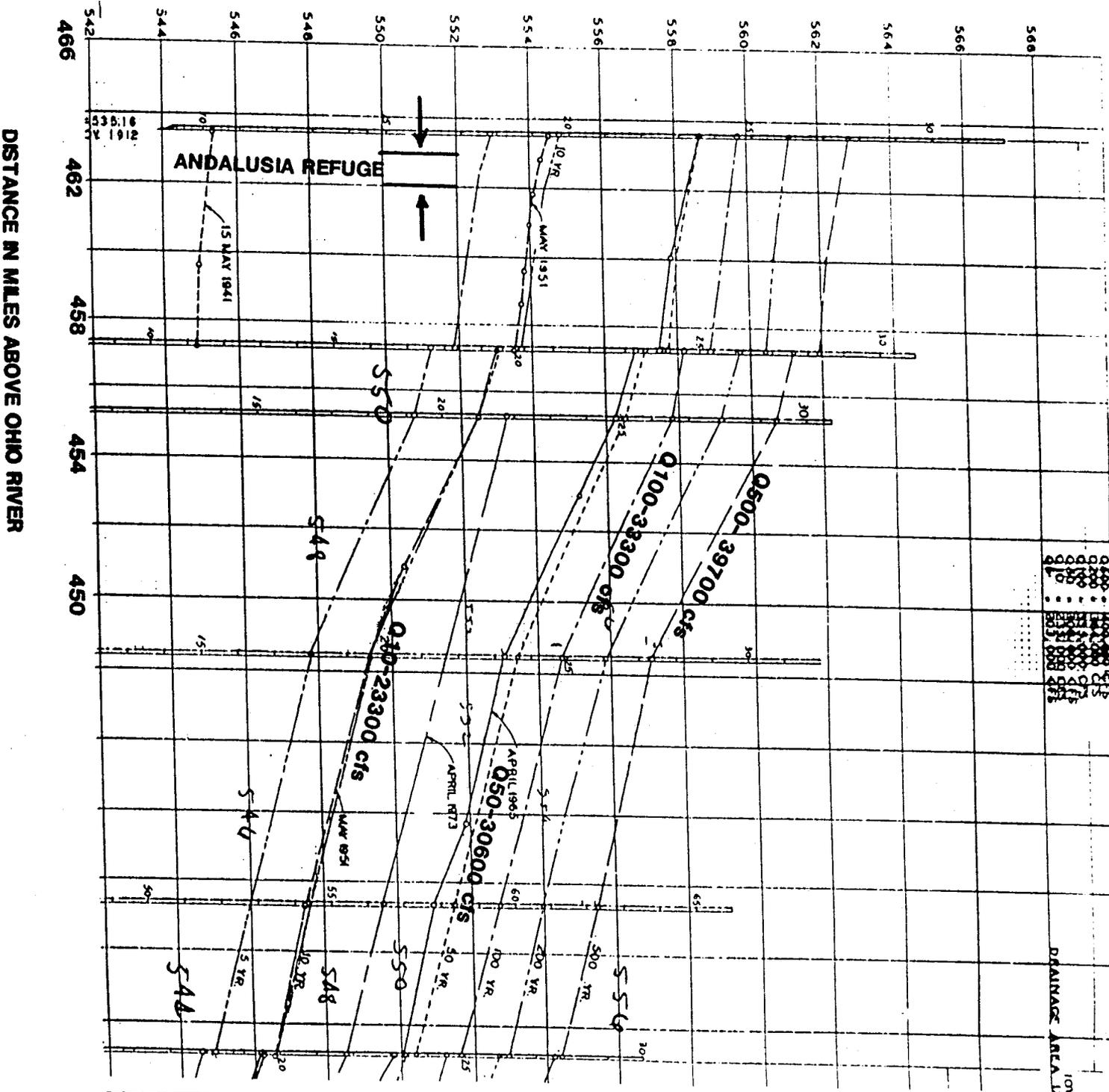
DIVERSION DITCH DESIGN

The drainage ditch shown on plate 8 of the main report was diverted because of the objective of reducing upland erosion sedimentation from entering the project site. The ditch has a 1.8-square-mile drainage area and was designed for a discharge of 340 cubic feet per second, which is approximately the 2-year frequency flood and is consistent with the existing ditch capacity. The ditch cross section should have a 30-foot bottom width and 3:1 side slopes. A profile slope of .0025 ft./ft. was designed to match existing profile conditions as close as possible, as shown on plate 16 of the main report. A design flood will result in an average velocity of approximately 3 feet per second.

ANDALUSIA REFUGE  
ROCK ISLAND COUNTY, ILLINOIS  
AREA CAPACITY



ELEVATION IN FEET (M.S.L.)



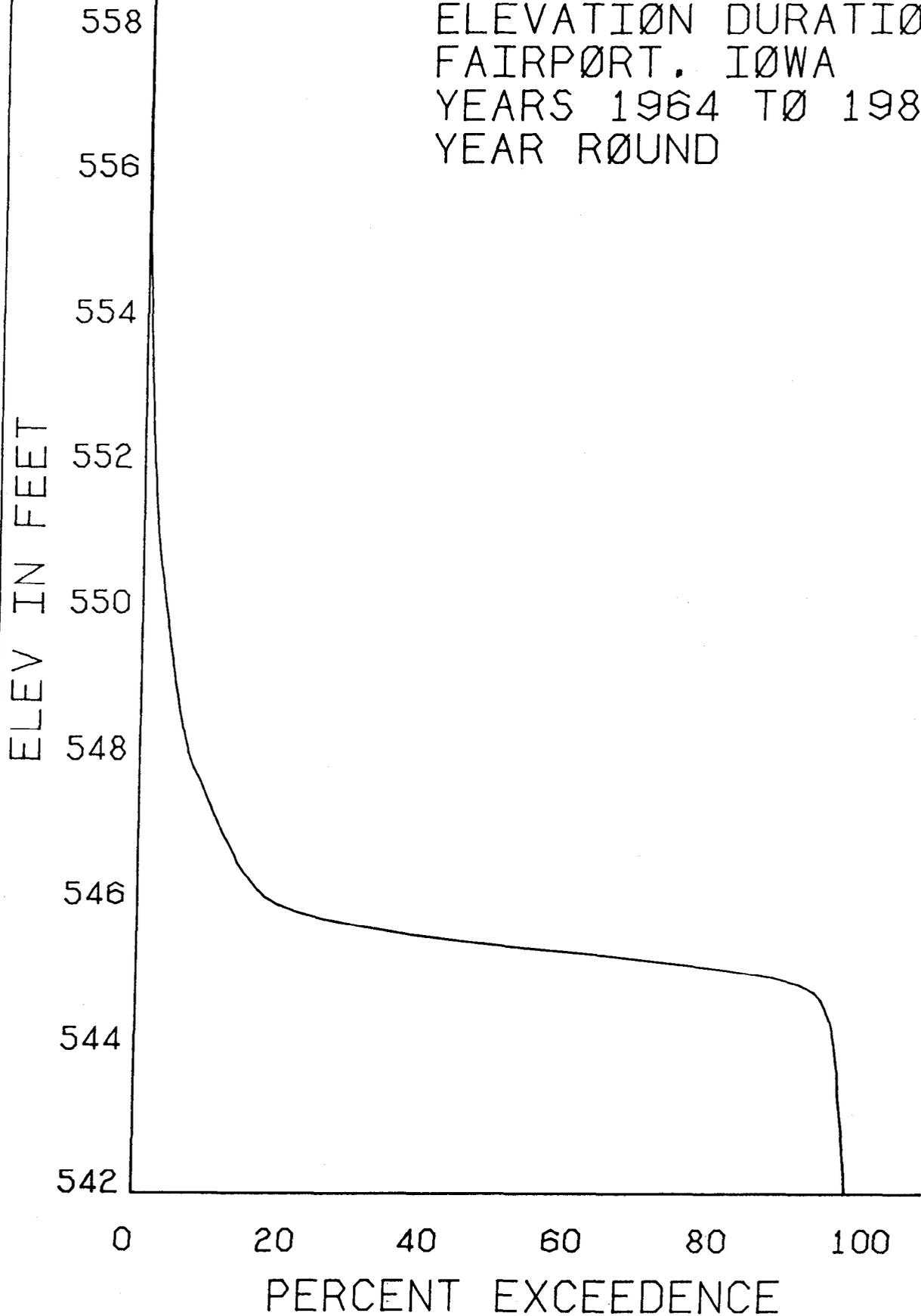
DISTANCE IN MILES ABOVE OHIO RIVER

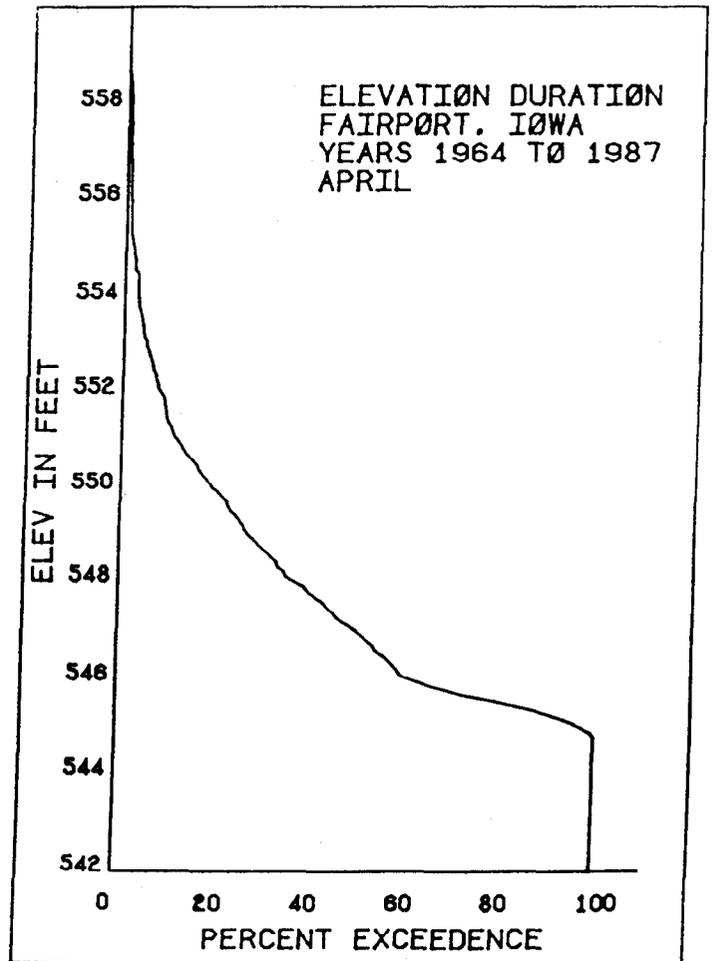
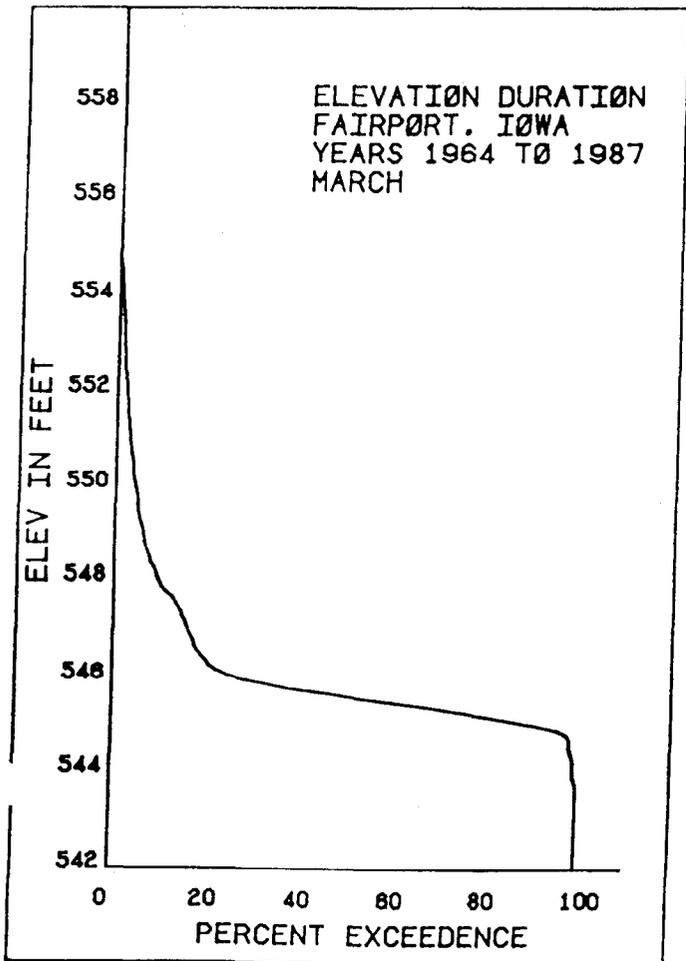
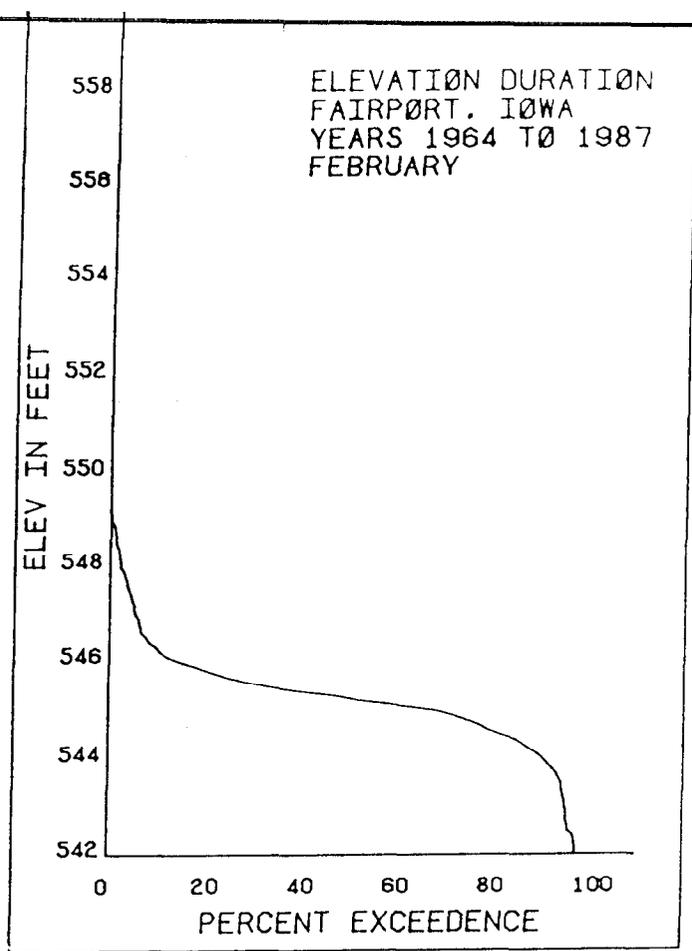
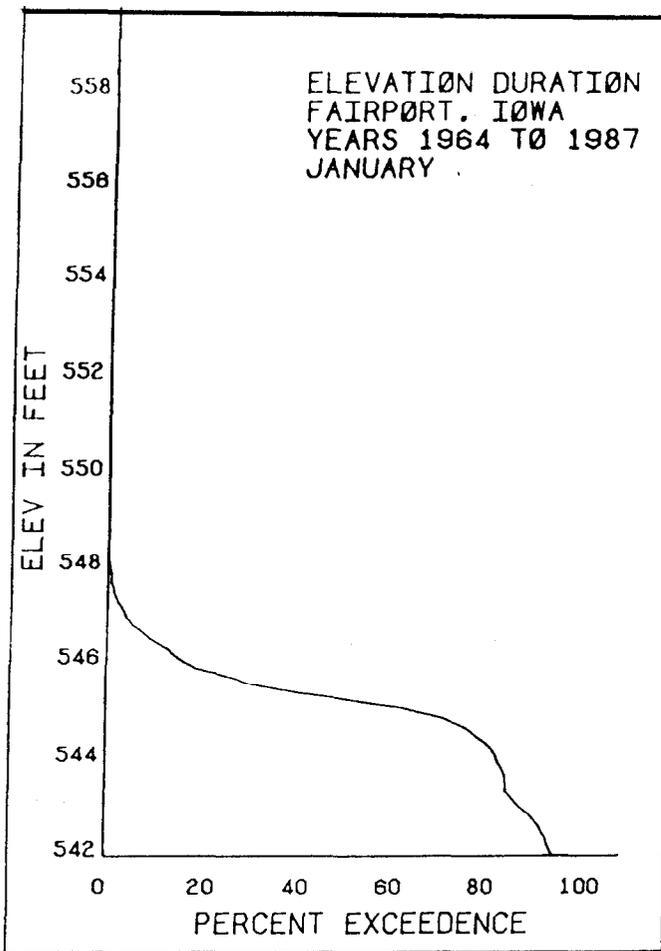
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000 4100 4200 4300 4400 4500 4600 4700 4800 4900 5000 5100 5200 5300 5400 5500 5600 5700 5800 5900 6000 6100 6200 6300 6400 6500 6600 6700 6800 6900 7000 7100 7200 7300 7400 7500 7600 7700 7800 7900 8000 8100 8200 8300 8400 8500 8600 8700 8800 8900 9000 9100 9200 9300 9400 9500 9600 9700 9800 9900 10000

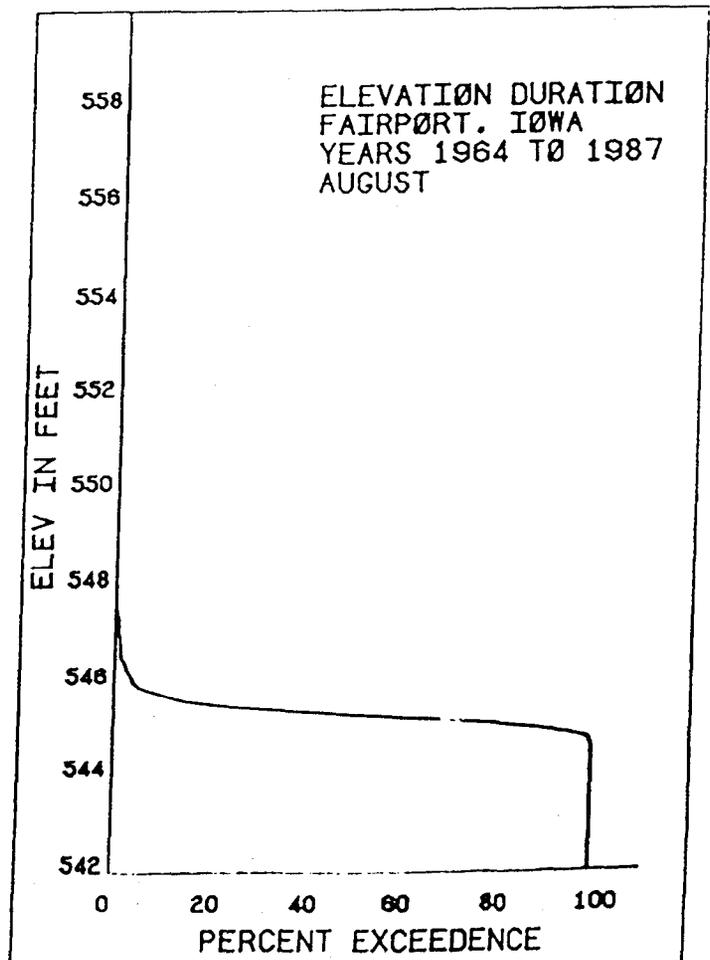
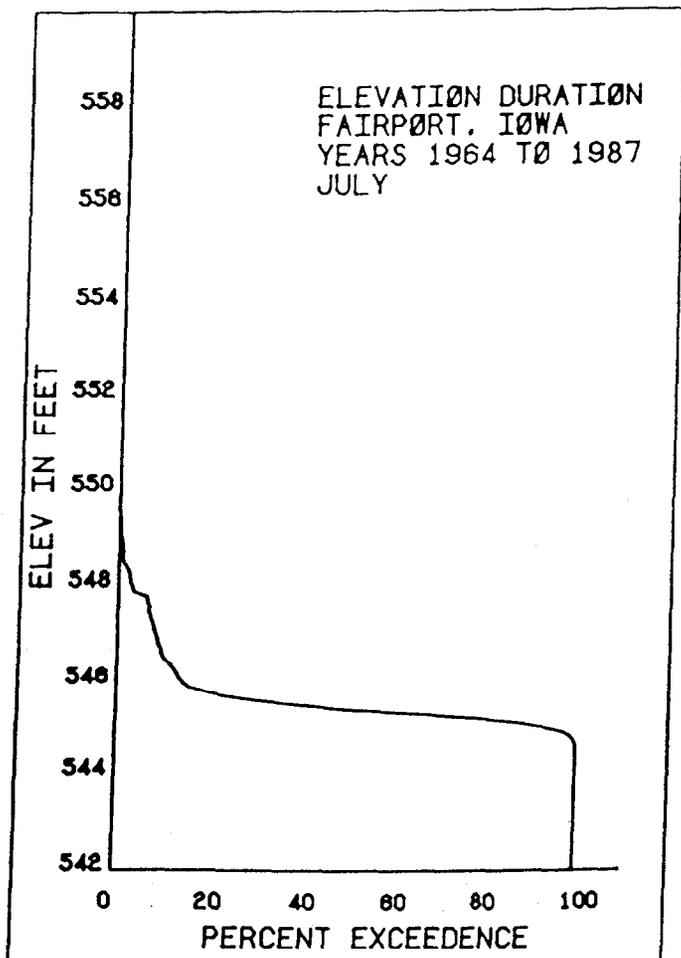
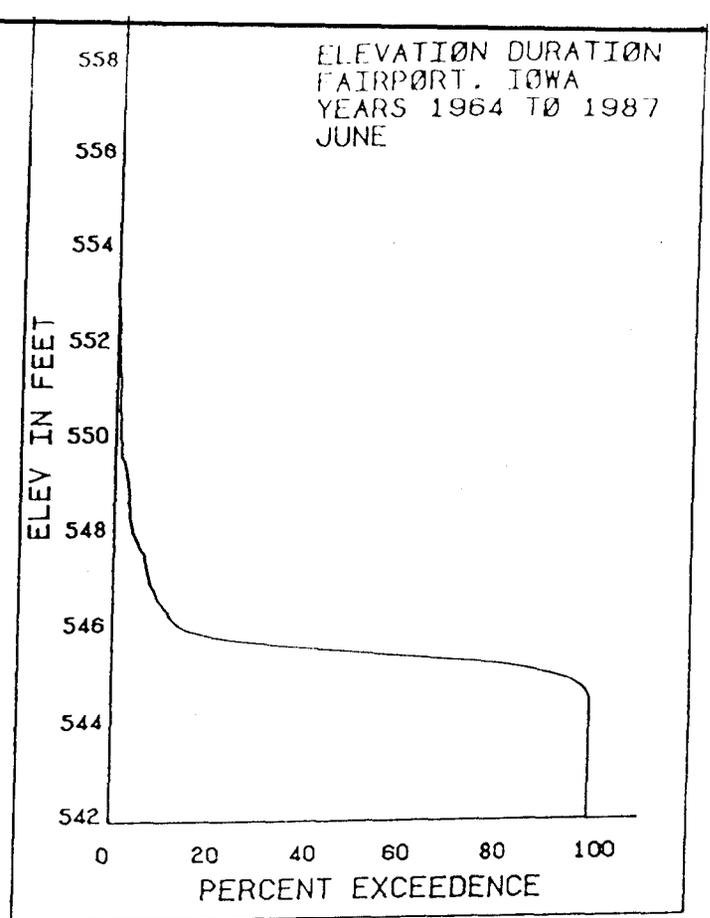
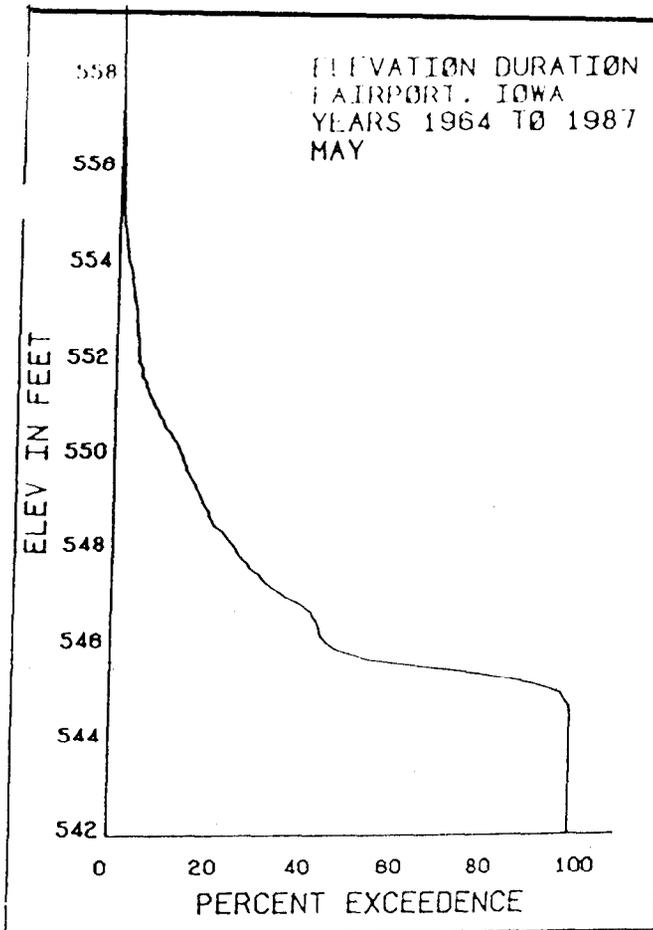
DRAINAGE AREA 10'

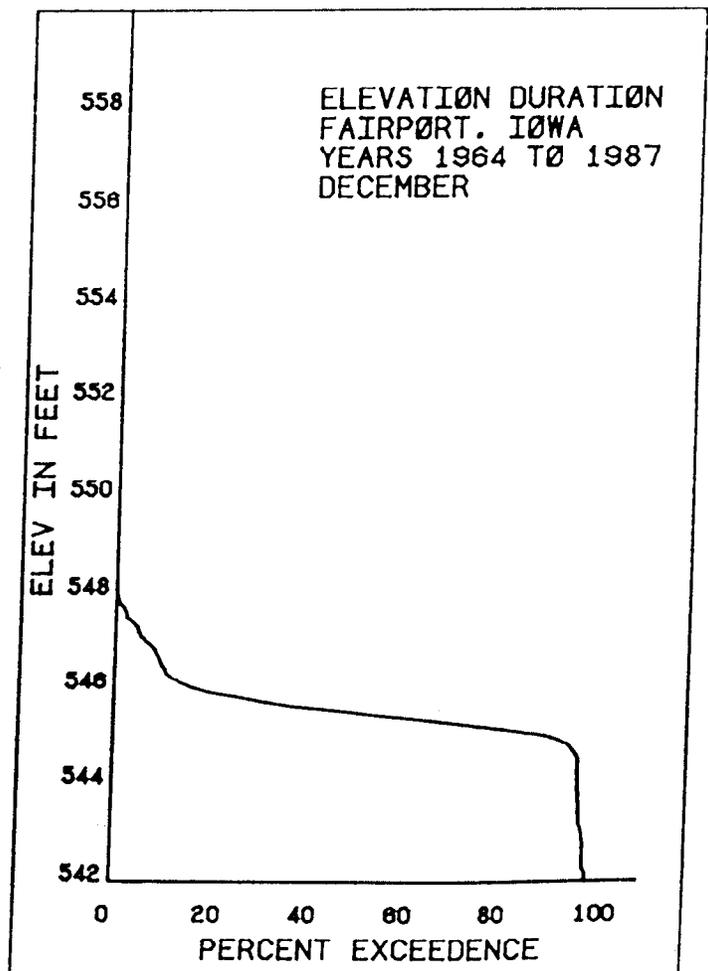
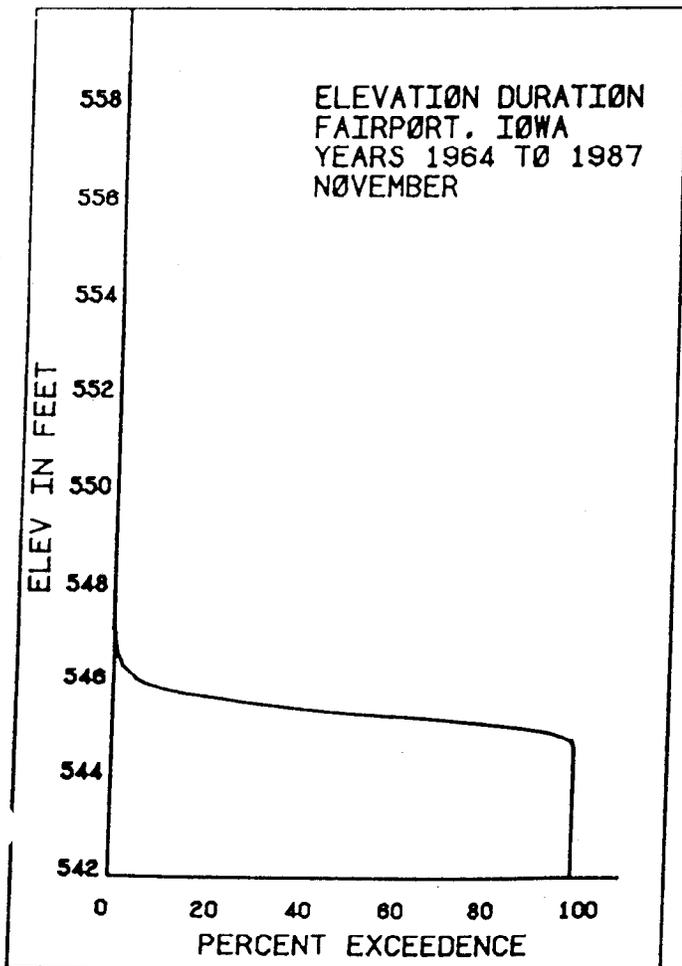
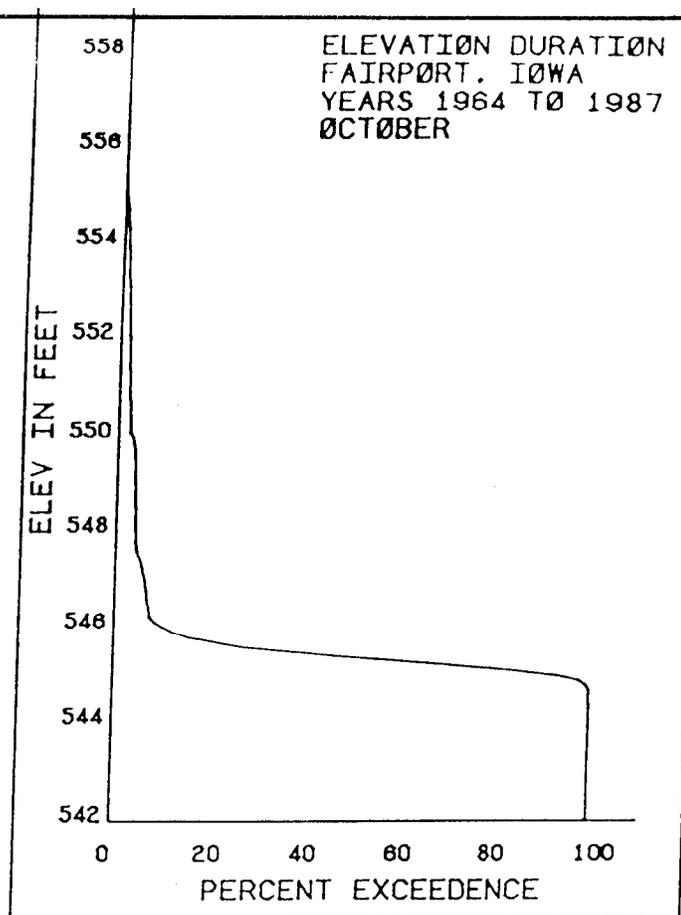
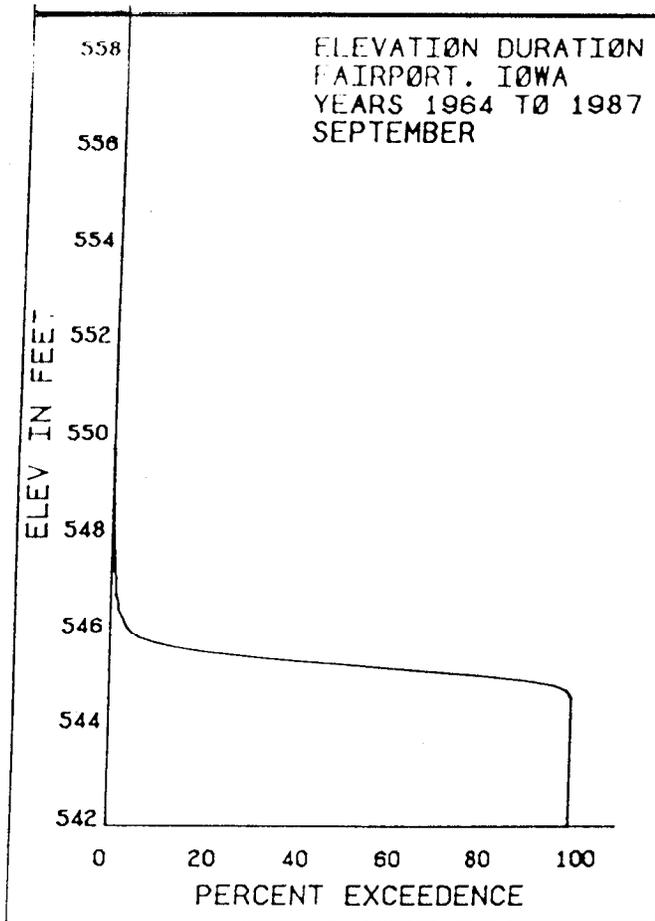
|  |      |  |    |
|--|------|--|----|
| DESIGNER   | DATE | OCCUPATION   | BY |
| CORPS OF ENGINEERS, U. S. ARMY<br>OFFICE OF THE DISTRICT ENGINEER<br>ROCK ISLAND, ILLINOIS |      |  |    |
| DRAWN BY: <i>CEH</i><br>CHECKED BY: <i>JMS</i><br>SUBMITTED:                               |      | UPPER MISSISSIPPI RIVER<br>STANDARD FLOOD PROFILES<br>ROCK ISLAND DISTRICT |    |
| CHIEF HYDRAULICS BRANCH<br>APPROVED:   |      | 5, 10, 50, 100, 200, & 500 YEAR FLOOD<br>RIVER MILES 516.52 TO 463.5       |    |
| CHIEF ENGINEERING DIVISION   |      | PLATE A-2  |    |
| DATE:  |      |  |    |

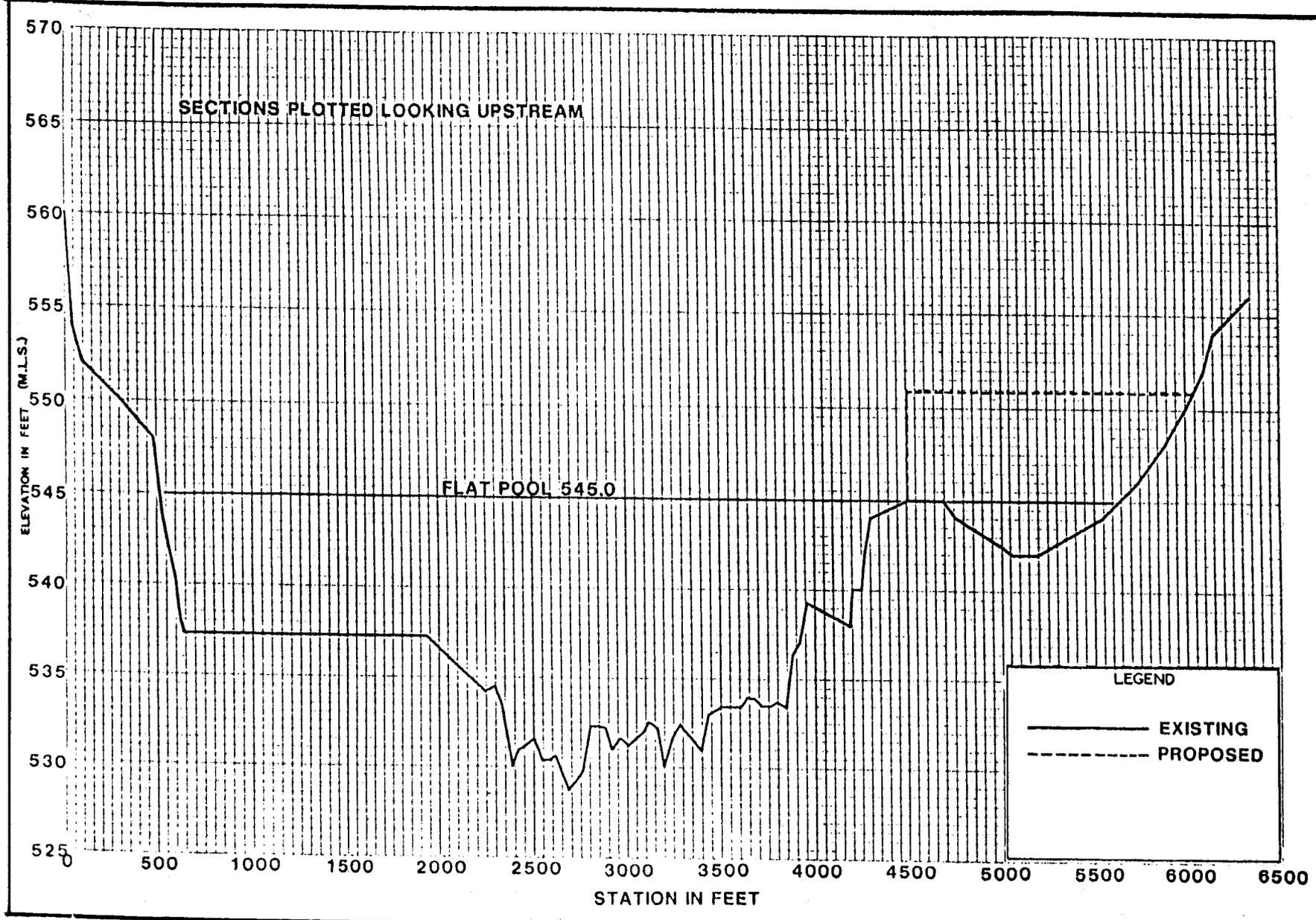
ELEVATION DURATION  
FAIRPORT, IOWA  
YEARS 1964 TO 1987  
YEAR ROUND











CHANNEL SECTION AT RIVER MILE 462.0

MISSISSIPPI RIVER

ANDALUSIA REFUGE

WATER QUALITY

A

P

P

E

N

D

I

X

B

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463  
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX B  
WATER QUALITY

OVERVIEW

Several water quality related factors bear on the suitability of the backwater complex to support valuable aquatic and semi-aquatic species. These include the chemical composition of the water, the chemical and physical composition of the sediment, and the depth and availability of water throughout the year. Representatives of the Iowa Department of Natural Resources (DNR) indicated that water quality within Andalusia Slough is currently adequate to support the native fisheries during the summer months. However, under ice cover, conditions develop which result in periods where dissolved oxygen (D.O.) becomes depleted to the point where fish kills can occur. In fact, fish kills have been observed on several occasions during the early spring immediately after ice out. Although it is not known with certainty that the cause of these fish kills is low D.O., it is reasonable to assume that it is at least a contributing factor. As the entire backwater area is heavily laden with aquatic vascular plants during the summer months, it is easy to envision the decomposition of this organic material during the winter leading to low D.O. levels.

In order to assess the existing water quality situation and predict the impacts of any enhancement efforts, a monitoring program was initiated in 1987. Water samples were taken every 2 weeks during the summer and less frequently during the remainder of the year. In addition, sediment and elutriate samples were collected. These data provide the basis for the assessment of water quality within the study area.

METHODS

Ambient water samples were collected on eight occasions between January and September 1987. An attempt to collect samples was made on two other occasions, however, insufficient water depth existed to permit taking representative samples. On January 28, 1987, samples were taken from the ice at locations R2 and R3

shown on plate 23 of the main report. On seven occasions, samples were taken from boat at the single location A1 shown on plate 23. Due to the shallow water and abundant aquatic plant growth, it was not possible to collect samples during the summer from the immediate project area. The location selected was as close to the project site as water conditions would allow. Due to the lack of significant flow through the backwater area and the relative proximity of the winter and summer sampling locations, it is quite likely that little, if any, difference in water quality exists between the sampling sites. In all cases, grab samples were taken from immediately below the surface using a Kemmerer sampler. Field analyses (temperature, pH, D.O., specific conductance and secchi disk depth) were performed immediately, while the samples requiring laboratory analysis were appropriately preserved, placed on ice, and shipped the same day they were collected.

Sediment and elutriate samples were taken at six locations on August 12, 1988. The locations are shown on plate 23 and coincide quite closely with the locations of the surface samples collected on January 28, 1987. Locations R1 - R3 were taken using a 48-inch coring device. The resulting cores were between 24 and 36 inches in length. At locations L1 - L3, no water was present and the soil was quite dry and compacted. Samples at these locations were taken using a shovel and were from the upper 1 to 2 feet of the soil. All water samples taken for the purpose of preparing the elutriate samples were collected and handled in the manner described above. All sediment samples were placed on ice and shipped to the laboratory the same day they were collected.

Grain size analyses were performed in accordance with U.S. Army Corps of Engineers, Engineer Manual 1110-2-1906, Appendix V, November 1970. Chemical analyses were performed according to "Standard Methods for the Examination of Water and Wastewater," 16th Edition, American Public Health Association, Washington, D.C., 1985. Elutriate samples were prepared by mixing 1 part sediment with 4 parts ambient water, shaking for 30 minutes, and allowing 4 hours to settle.

## RESULTS

Results of all field and laboratory analyses are presented in tables B-1 through B-4. Table B-1 lists the results of grain size analyses of samples collected on June 21, 1988. It is apparent from the results that the sediment is very fine throughout the backwater area. For a complete hydrometer analysis, see appendix C. Table B-2 lists the results of all laboratory and field tests performed on ambient water samples. From the results it can be seen that D.O. concentrations are low during several weeks of the observation period. While levels do not fall below 4.0 mg/l, they approach this level and probably do

fall below this level during the night. The chlorophyll concentrations indicate that phytoplankton are quite abundant at certain times and probably contribute to fluctuations in D.O. concentrations.

Even though samples were taken some distance from the actual project location due to access problems, water depth was still quite shallow and was barely adequate to permit reaching this point by boat. This was true despite the fact that the river was at or above flat pool each day that samples were collected.

Table B-3 lists the results of bulk sediment analyses performed on samples collected on August 12, 1988. As can be seen from the data, all inorganic contaminants except total volatile solids fell in the range considered to be nonpolluted based on EPA's draft criteria for Great Lakes sediment. Total volatile solids undoubtedly exceeded the criteria due to the large amount of detritus present in the sediments. There is no evidence of large concentrations of soluble organic contaminants as seen from the fact that all pesticide concentrations were below the detection limits.

Table B-4 lists the results of elutriate analyses performed on samples collected on August 12, 1988. As can be seen from the data, concentrations of most parameters were quite low. The only exception to this is ammonia nitrogen. Concentrations were observed which exceeded the general water quality standards at two locations. All pesticide concentrations were below the detection limits.

### CONCLUSIONS

Based on field observations and analytical results, water quality within the project area appears adequate to support aquatic life during the majority of the time. During the summer there may be periods when D.O. approaches levels considered to be detrimental to certain fish species. This was observed during the study period, although no fish kills were observed. During the winter there may be ice and snow conditions, which, in combination with decayed organic matter, could develop into a "winter kill." Although this was not observed during the study period, it has been reported by DNR personnel. Results from the analyses of sediment and elutriate samples show no excessive concentrations of contaminants as compared with interim EPA criteria for Great Lakes Sediment and the State water quality standards, with the exception of ammonia nitrogen. Concentrations of this parameter should be viewed in light of the proposed mixing zone, and, if necessary, toxic effects can be minimized by coordinating construction with those periods when water temperature and pH are low.

TABLE B-1

Grain Size Analyses

| <u>Location</u> | <u>Percentage Passing a #230 Sieve (&lt;0.062um)</u> |
|-----------------|--|
| 1L              | 98.2   |
| 1R              | 99.7   |
| 2L              | 93.6   |
| 2R              | 98.2   |
| 3R              | 83.6   |
| 3L              | 82.5   |

TABLE B-2

Ambient Water Quality Results, 1987

| <u>Parameter</u>     | <u>Date</u>     |      |      |      |      |      |      |      |      |      |
|----------------------|-----------------|------|------|------|------|------|------|------|------|------|
|                      | 1/28            | 1/28 | 6/8  | 6/22 | 7/6  | 7/20 | 8/10 | 8/24 | 9/8  | 9/21 |
|                      | <u>Location</u> |      |      |      | A1   | A1   | A1   | A1   | A1   | A1   |
|                      | R3              | R2   | A1   |
| Time                 | 1030            | 1045 | 1030 | 1020 | 1025 | 0925 | 1055 | 1055 | 1025 | 1205 |
| Ice Thickness (cm)   | 12.5            | 12.5 | -    | -    | -    | -    | -    | -    | -    | -    |
| Water Temp. (C)      | -               | -    | 25.0 | 26.7 | 26.7 | 27.8 | 24.4 | 20.0 | 21.7 | 15.6 |
| Depth (M)            | .3              | .5   | .9   | .8   | .7   | .6   | .6   | .7   | .8   | .7   |
| D.O. (mg/l)          | 15.4            | 23.2 | 6.9  | 4.3  | 5.7  | 6.6  | 4.4  | 4.7  | 4.5  | 4.9  |
| pH (units)           | -               | -    | 7.6  | 7.2  | 7.2  | 7.6  | 7.3  | 7.4  | 7.0  | 7.2  |
| Sp. Cond. (umhos/cm) | -               | -    | 436  | 472  | 408  | 381  | 410  | 381  | 475  | 369  |
| Secchi Depth (M)     | -               | -    | 1.5  | 2.0  | 2.0  | 2.0  | 2.0  | 2.0  | 2.5  | 2.0  |
| Sus. Solids (mg/l)   | -               | -    | 24   | 15   | 10   | 9    | 4    | 3    | 4    | 3    |
| Chl. a (mg/cu m)     | -               | -    | 46   | 12   | 14   | 6    | 7    | 10   | 8    | 5    |
| Chl. b (mg/cu m)     | -               | -    | 2    | 2    | 2    | 2    | 2    | 2    | 1    | 1    |
| Chl. c (mg/cu m)     | -               | -    | 4    | 2    | 2    | 2    | 2    | 2    | 1    | 1    |
| Pheo. a (mg/cu m)    | -               | -    | 18   | 13   | 6    | 8    | 4    | 4    | 4    | 2    |

TABLE B-3

Bulk Sediment Analyses, August 12, 1988 (mg/kg)

| <u>Parameter</u>      | <u>Location</u> |        |        |        |        |        |
|-----------------------|-----------------|--------|--------|--------|--------|--------|
|                       | R1              | R2     | R3     | L1     | L2     | L3     |
| Arsenic (Total)       | 2.0             | 2.7    | 1.8    | 2.7    | 4.0    | 2.9    |
| Barium (Total)        | 74              | 67     | 62     | 98     | 88     | 94     |
| Cadmium (Total)       | <0.87           | <0.69  | <0.82  | <0.79  | <0.79  | <0.68  |
| Chromium (Total)      | 12              | 13     | 12     | 17     | 19     | 13     |
| Copper (Total)        | 11              | 11     | 11     | 16     | 17     | 15     |
| Lead (Total)          | 6.3             | 6.3    | 5.2    | 17     | 17     | 15     |
| Mercury (Total)       | <0.019          | <0.027 | <0.025 | <0.031 | <0.026 | <0.026 |
| Nickel (Total)        | 15              | 12     | 11     | 20     | 25     | 18     |
| Selenium (Total)      | <0.87           | <0.69  | <0.83  | <0.79  | <0.79  | <0.68  |
| Zinc (Total)          | 67              | 64     | 63     | 91     | 94     | 78     |
| Ammonia-N             | 120             | 82     | 89     | 41     | 41     | 37     |
| Total Organic Carbon  | 7.5%            | 6.9%   | 7.7%   | 8.2%   | 8.3%   | 7.9%   |
| Oil and Grease        | 50              | 190    | 190    | 110    | 250    | 360    |
| Total Volatile Solids | 9300            | 19500  | 13200  | 12600  | 4200   | 13300  |
| Aldrin                | <8.0 *          | <8.0 * | <8.0 * | <8.0 * | <8.0 * | <8.0 * |
| Chlordane             | <80 *           | <80 *  | <80 *  | <80 *  | <80 *  | <80 *  |
| DDD                   | <16 *           | <16 *  | <16 *  | <16 *  | <16 *  | <16 *  |
| DDE                   | <16 *           | <16 *  | <16 *  | <16 *  | <16 *  | <16 *  |
| DDT                   | <16 *           | <16 *  | <16 *  | <16 *  | <16 *  | <16 *  |
| Dieldrin              | <16 *           | <16 *  | <16 *  | <16 *  | <16 *  | <16 *  |
| Endrin                | <16 *           | <16 *  | <16 *  | <16 *  | <16 *  | <16 *  |
| Heptachlor            | <8.0 *          | <8.0 * | <8.0 * | <8.0 * | <8.0 * | <8.0 * |
| Hepachlor Epoxide     | <8.0 *          | <8.0 * | <8.0 * | <8.0 * | <8.0 * | <8.0 * |
| Lindane               | <8.0 *          | <8.0 * | <8.0 * | <8.0 * | <8.0 * | <8.0 * |
| Methoxychlor          | <80 *           | <80 *  | <80 *  | <80 *  | <80 *  | <80 *  |
| Toxaphene             | <160 *          | <160 * | <160 * | <160 * | <160 * | <160 * |
| 2,4-D                 | - *             | - *    | - *    | - *    | - *    | - *    |
| 2,4,5-TP              | - *             | - *    | - *    | - *    | - *    | - *    |
| Total PCB's           | <160 *          | <160 * | <160 * | <160 * | <160 * | <160 * |

\* ug/kg

TABLE B-4

Elutriate Results from August 2, 1988, Sampling (mg/l)

| <u>Parameter</u>    | <u>Location</u> |         |         |         |         |         | <u>Ambient</u> |
|---------------------|-----------------|---------|---------|---------|---------|---------|----------------|
|                     | L1              | L2      | L3      | R1      | R2      | R3      | <u>Water</u>   |
| Arsenic             | <0.003          | <0.003  | <0.003  | <0.003  | <0.003  | <0.003  | 0.012          |
| Barium              | 0.07            | 0.08    | 0.08    | 0.01    | 0.09    | 0.10    | 0.07           |
| Cadmium             | <0.005          | <0.005  | <0.005  | <0.005  | <0.005  | <0.005  | <0.005         |
| Chromium            | <0.009          | <0.009  | <0.009  | 0.01    | <0.009  | <0.009  | 0.03           |
| Copper              | <0.009          | <0.009  | <0.009  | <0.009  | <0.009  | <0.009  | <0.009         |
| Lead                | <0.001          | <0.001  | <0.001  | <0.001  | <0.001  | <0.001  | <0.001         |
| Mercury             | <0.0001         | <0.0001 | <0.0001 | <0.0001 | <0.0002 | <0.0001 | <0.0001        |
| Nickel              | <0.025          | <0.025  | 0.03    | 0.12    | 0.06    | 0.03    | 0.03           |
| Selenium            | <0.005          | <0.005  | <0.005  | <0.005  | <0.005  | <0.005  | <0.005         |
| Zinc                | 0.03            | 0.09    | 0.11    | 0.11    | 0.09    | 0.11    | 0.04           |
| Ammonia-N           | 4.2             | 2.4     | 2.9     | 15      | 18      | 0.13    | 0.13           |
| Total Vol Solids    | 530             | 450     | 420     | 580     | 640     | 420     | 300            |
| Oil and Grease      | 4.0             | 16      | 6.0     | <2.0    | 32      | <2.0    | -              |
| TOC                 | 48              | 47      | 16      | 1100    | 50      | 42      | 13             |
| Aldrin*             | <0.10           | <0.10   | <0.15   | <0.10   | <0.10   | <0.05   | <0.05          |
| Chlordane*          | <1.0            | <1.0    | <1.5    | <1.0    | <1.0    | <0.50   | <0.50          |
| DDD*                | <0.20           | <0.20   | <0.30   | <0.20   | <0.20   | <0.10   | <0.10          |
| DDE*                | <0.20           | <0.20   | <0.30   | <0.20   | <0.20   | <0.10   | <0.10          |
| DDT*                | <0.20           | <0.20   | <0.30   | <0.20   | <0.20   | <0.10   | <0.10          |
| Dieldrin*           | <0.20           | <0.20   | <0.30   | <0.20   | <0.20   | <0.10   | <0.10          |
| Endrin*             | <0.20           | <0.20   | <0.30   | <0.20   | <0.20   | <0.10   | <0.10          |
| Heptachlor*         | <0.10           | <0.10   | <0.15   | <0.10   | <0.10   | <0.05   | <0.05          |
| Heptachlor Epoxide* | <0.10           | <0.10   | <0.15   | <0.10   | <0.10   | <0.05   | <0.05          |
| Lindane*            | <0.10           | <0.10   | <0.15   | <0.10   | <0.10   | <0.05   | <0.05          |
| Methoxychlor*       | <1.0            | <1.0    | <1.5    | <1.0    | <1.0    | <0.50   | <0.50          |
| Toxaphene*          | <2.0            | <2.0    | <3.0    | <2.0    | <2.0    | <1.0    | <1.0           |
| 2,4-D*              | =               | =       | =       | =       | =       | =       | =              |
| 2,4,5-TP*           | =               | =       | =       | =       | =       | =       | =              |
| Total PCB's*        | <2.0            | <2.0    | <3.0    | <2.0    | <2.0    | <1.0    | <1.0           |

\* Concentrations of all organics are expressed as ug/l.

**GEOTECHNICAL CONSIDERATIONS**

A

P

P

E

N

D

I

X

C

UPPER MISSISSIPPI RIVER  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT

ANDALUSIA REFUGE  
REHABILITATION AND ENHANCEMENT  
POOL 16 MISSISSIPPI RIVER MILES 462 THROUGH 463  
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX C  
GEOTECHNICAL CONSIDERATIONS

TABLE OF CONTENTS

| <u>Subject</u>                            | <u>Page</u> |
|---|-------------|
| Location                                  | C-1         |
| Physiography                              | C-1         |
| Bedrock                                   | C-1         |
| Pleistocene and Recent Deposits           | C-2         |
| Subsurface Explorations                   | C-2         |
| Perimeter Levee Embankment                | C-3         |
| Foundation for Embankments                | C-4         |
| Foundation for Other Structures           | C-4         |
| Groundwater                               | C-5         |
| Subsurface Conditions at Excavation Sites | C-5         |
| Slope Stability                           | C-6         |
| Underseepage                              | C-6         |
| Settlement                                | C-7         |
| Borrow Material                           | C-7         |

List of Plates

| <u>No.</u> | <u>Title</u>             |
|------------|--------------------------|
| C-1        | Slope Stability Analysis |
| C-2 - C-3  | Settlement Analysis      |
| C-4 - C-7  | Hydrometer Analysis      |

## LOCATION

The Andalusia EMP Project is situated within the Upper Mississippi Wildlife and Fish Refuge, between river mile 462 and 463. The site is bordered by Dead Slough directly to the north, forested loess-covered bluffs to the south, which are part of 393 acres managed by the State of Illinois, Department of Conservation. The major part of Andalusia Slough continues to the east; and Drury Slough to the west. The project area lies within the Galesberg Plain section of the Central Lowlands Province.

## PHYSIOGRAPHY

The topography within the project site consists of a series of sloughs and shallow backwater lakes. Site elevation varies from 546-548 feet MSL (Mean Sea Level). Land surface configuration was originally controlled by the shape of the underlying bedrock surface. The Mississippi River valley is constricted from Andalusia to Muscatine with little or no flood plain. At the point of the project site, the valley is only about 1-1/4 miles wide. The area is known as the lower part of the "upper narrows" (Savage 1921). This narrowing is caused by the unusual thickness of Pennsylvanian age sandstone which the river runs across. On the valley walls, the erosional slopes are concealed by a mantle of unconsolidated material derived from slumping and landslides over underlying Pennsylvanian age shales.

The presence of more resistant bedrock is indicated by the steep lower slopes of the valley bedrock. Maximum relief of valley sides adjacent to the project site is 100-150 feet (Horberg 1956b).

## BEDROCK

The bedrock of the project area consists of Pennsylvanian age sandstones, shales, and coals, setting unconformably on top of Devonian age shale and limestones (Fitzgerald 1985). Middle Devonian age limestones outcrop 10 miles upstream in Buffalo, Iowa and in the near by town of Andalusia, Illinois. These rocks are almost horizontal and in general slope toward the southwest at an average rate of 10 feet per mile. Overall the Devonian age rocks are about 140 feet thick. There is a Middle Devonian age shale lying directly beneath a thick section of Pennsylvanian age rocks at Wyoming Hill, and outcrop about a mile downstream from the project site on the Iowa side of the river. Overall the Pennsylvanian age rocks are up to 150 feet thick; but at Wyoming

Hill, along highway 22, NE 1/4, Sec. 34, T77N, RIW, (Horberg 1956b), the outcrop is about 100 feet thick, and consists of sandstones shales, and coals.

#### PLEISTOCENE AND RECENT DEPOSITS

Above, and to some extent within the Mississippi River, and tributary valleys are deposits of Pleistocene drift or till, loess, terrace deposits, recent alluvium, and dune deposits. Maximum thickness of these deposits do not exceed 100 feet around project area (Savage 1921) (Horberg 1956b). Pleistocene deposits resulted from the numerous advances and retreats of glaciers which blanketed this entire area. A road cut 4 miles upstream from the project site at Loud Thunder Forest Preserve, SW 1/4, SE 1/4, Sec. 27, TT7N, R4W, exposes 43 feet of Pleistocene sediments. The outcrop includes 23 feet of Pre-Illinoian age tills, 8 feet of Illinoian age tills, and 12 feet of Wisconsinan age, Peorian loess (Horberg 1956b).

In the Mississippi River valley at the mouth of the adjacent watersheds, the sediments consists of alluvial deposits. These alluvial deposits are unconsolidated glacial outwash sands and gravels on bedrock, with deposits of alluvial silts and clays on top. The outwash sands and gravels are of the Henry formation of Wisconsinan age, overlain by Cahokia alluvial silts and clays, Wisconsinan or Holocene in age (Willman 1970). Thicknesses of alluvial deposits along the Mississippi River from Le Claire, Iowa to Muscatine, Iowa usually varies from 15 to 45 feet (Savage 1921). At the project site, borings were drilled no futher than 30.5 feet and bedrock was not encountered.

#### SUBSURFACE EXPLORATIONS

Access to the project site was limited by surface water. During February 1987, eight primary borings A-87-1 through A-87-8 were taken. Borings A-87-1, 2, 5, 6, and 7 were obtained by hand with a 4-inch Iwan Auger. Borings A-87-3, 4, and 8 were obtained with a CME-45 drill rig using a 5-inch hallow stem auger.

During January and February 1988, fourteen additional exploratory borings were taken. These numbered A-88-1 through A-88-14. Holes A-88-6 and A-88-8 were obtained by using 4-inch Iwan hand auger. The other holes were obtained using CME-45 drill rig. Locations of the borings and boring logs are show on plate 2 of the main report. The deepest boring taken with the drilling rig extended to a depth of 30.5 feet, approximate elevation 517.8 feet MSL.

PERIMETER LEVEE EMBANKMENT

The proposed perimeter levee as shown on plate 2 of the main report, is approximately 6 feet high, and approximately 8,600 feet long. The purpose of the levee is to create a moist soil management unit with controlled water levels for wildlife habitat on the landside of the levee. The crown of the levee will be at least 12 feet wide for ease of construction and normal maintenance and operation. The side slopes of the levee will be 1 vertical (V) on 4 horizontal (H). From station 12+00 to 8+00 CE, the proposed levee will be wider (60-foot wide) compared to other reaches of the levee. This portion of the levee will be built with clay borrowed from the Dead Slough excavation. The majority of the excavated material from Dead Slough will be placed in the adjacent levee as a thicker, instead of transporting it to a disposal site. The typical cross sections of the proposed levee are shown on plate 18 of the main report.

From station 12+21 C to station 25+18+CE, the side slopes of the levee will be grass seeded since a heavy timber growth is evident on both sides of the proposed levee. Therefore, it is anticipated that grass protection will be adequate against wave wash. From stations 25+18+CE to 29+18+CE, the profile of the levee will be placed on a steeper gradient than the natural river flood profile to ensure overtopping occurs from the downstream end. Therefore, both side slopes of the levee will be protected against the wave wash and current action by an 18-inch thickness of riprap with the following gradation:

| <u>Percent Lighter by Weight</u> | <u>Weight of Stone in Pounds</u> |
|----------------------------------|----------------------------------|
| 100                              | 150-400                          |
| 50                               | 60-170                           |
| 15                               | 15- 50                           |

A similar gradation used on various similar installations has served satisfactorily for several years. A bedding layer of 6-inch thickness will be of the following gradation:

| <u>U.S. Standard Sieve Size</u> | <u>Percentage Passing (By Weight)</u> |
|---------------------------------|---------------------------------------|
| 1 - 1/2                         | 85 - 100                              |
| 3/4                             | 40 - 85                               |
| 3/8                             | 15 - 45                               |
| No. 4                           | 0 - 20                                |
| No. 8                           | 0 - 5                                 |

The entire levee will be built with uncompacted impervious material lie, (ie, fill place by casting).

## FOUNDATION FOR EMBANKMENTS

The entire foundation beneath the proposed levee embankment will be stripped of vegetation and other deleterious materials to a depth of 6 inches. All top roots, lateral roots, and trees within the embankment foundation areas will be removed to a depth of 3 feet below natural ground surface.

An extensive field investigation was made to ascertain the proposed levee foundation conditions. According to borings which were pertinent to approximately 6 feet high perimeter levee foundation analyses, the foundation material consists of alluvial deposits. Boring logs are shown on plate 7 of the main report. The top stratum varies in thickness from 16 to 20 feet, and consists of normally consolidated impervious alluvial deposits (SC, CL, CL-CH, and CH). The moisture content ranges from 24 to 37 percent for CL soils, 27 to 35 for CL-CH soils, and 29 to 48 for CH soils. Borings A-88-8, A-88-9, and A-88-14 show that the top 1-foot consists of slightly organic clay with moisture content of 85 percent.

The Atterberg limits testing was performed on the selected soil samples after thoroughly evaluating each soil sample. Atterberg limits testing reveals a range from 44/16 (liquid limit/plastic limit) to 44/18 for CL soils, 55/21 to 58/22 for CL-CH soils, and 71/28 to 82/29 for CH soils. The standard penetration test "N" values recorded during the drilling operations for top stratum ranged from 2 to 9 blow counts, with average "N" values of 6. The shear strength of the top stratum based on standard penetration tests varies from 250 psf to 1,125 psf with an average of 750 psf. The pocket penetrometer tests were also run on the selected clay samples. The pocket penetrometer tests indicate a range in cohesion from 250 to 1250 psf.

The soils below the impervious substratum are found to be medium to fine sand (SP). The "N" values obtained for the sand ranged from 4 to 23, with average "N" values of 11. Detailed descriptions of the encountered materials are shown on boring logs, on plate 7 of the main report. None of these borings were extended to bedrock.

## FOUNDATION FOR OTHER STRUCTURES

A water control structure near station 21+00 will be built as a part of the proposed project. The location of the proposed structure is shown on plate 2 of the main report. Boring A-88-3, 32 feet deep was taken to evaluate physical characteristic of subsurface conditions. Detailed descriptions of soils encountered are shown on boring logs, see plate 7 of the main report. The boring does not show undesirable or soft material.

The unsuitable material which might not have been encountered by this boring will be replaced with appropriate fill. The replacement material will be placed and compacted to obtain a density equal to the adjacent undisturbed foundation. A dewatering system will be required to maintain the excavation area in dry condition. Foundation design details of the proposed structures are given in Appendix D.

Borings have not been completed due to site change location of pump plant. Therefore, two additional borings will be taken prior to final design to determine engineering properties of the soils underlying the pump station foundation.

#### GROUNDWATER

Water level observations were monitored during the boring operations and are noted on the boring log as shown on plate 7 of the main report. Based on these observations the ground water levels encountered in the vicinity of the proposed embankment area approximately from station 4+00 to 21+50 were found to be fairly consistent from hole to hole. The depth at which water was located ranged from 2 to 3 feet; from elevations 544.5 to 545.5 feet MSL. From approximately stations 21+50CE to 31+00CE (end of the levee) the ground water was found to be .2 to 1 foot above the ground surface; from elevations 545 to 546 feet MSL. The water levels should be expected to fluctuate with changes in climatic conditions and river levels.

#### SUBSURFACE CONDITIONS AT EXCAVATION SITES

REFUGE DREDGING/DITCHING. Refuge excavation/ditching is proposed as shown on plate 18 of the main report. The site indicates removal of 2 to 4 feet of soils, which will have a width of 50 feet. Borings A-87-4, A-88-2, and A-88-13 were taken to identify the subsurface conditions and the engineering characteristics of the encountered material at the proposed site.

Borings revealed the presence of about 4 feet of very soft clay (CH-OH, CL, CH). The moisture content varied from 43% to 71%. This is underlain by medium clay (CL-CH). The moisture content varied from 32% to 37%. A detailed description of the encountered material is shown in the logs of soil borings on plate 7 of the main report.

DEAD SLOUGH EXCAVATION. Dead slough site will be located approximately 40 feet from riverside toe of the proposed levee as shown on plate 18 of the main report. The site indicates the need for removal of 6 to 9 feet of soils, which will have a width of 60 feet. Borings A-88-10 and A-88-11 were considered pertinent taken to determine the various soil profile components and the engineering characteristics of the material for dredging the dead slough. A typical soil profile of this site consists of very soft clay. The average water content was 98 percent, with a range of 98 to 107 percent. A detailed description of the encountered materials is shown on the logs of soil borings on plate 7 of the main report.

### SLOPE STABILITY

The proposed levee near station 28+50 CE is found to be most critical for slope stability analysis for end of construction condition. The stability of slopes was analyzed by the Modified Swedish Method for a circular Arc Slope Stability Analysis in accordance with EM 1110-2-1902, "Engineering Design Stability of Earth and Rockfill Dams," dated 1 April 1970.

A sudden drawdown and steady seepage conditions were not evaluated since high water levels will be of such short duration that saturation of uncompacted impervious embankment cannot occur and the Mississippi River low water level will not impose any seepage pressure on the levee.

A range of extremely conservative shear strengths (Q) was assumed for the most severe configuration of embankment and foundation, to estimate the stability of the embankment. These values are shown on plate C-1 and are based on tests and samples from other projects with generally similar soils and construction. Successive trials of various sliding surfaces were analyzed and determination of the critical failure arc having the lowest safety factor was made. The summary of the slope stability analysis and the solution of the most critical arc appears on plate C-1. The computed minimum, safety factor of 2.3 for end of construction condition exceed the 1.3 required by EM 1110-2-1913, "Design and Construction of Levees," dated March 31, 1978. Therefore, no slope stability problems are expected.

### UNDERSEEPAGE

The underseepage analyses for the proposed is based on a thorough study of thickness and permeability, engineering characteristics of the impervious stratum and the pervious substratum, in addition to the extent of the riverward and landward top strata.

Case 2 (EM 1110-2-1913)-Impervious Top Stratum Both Riverside and Landside was considered appropriate since 15- to 20-foot thick top stratum appears to exist on the both sides of the approximately 6 feet high levee, and continuing infinitely on the landward side. For such a condition seepage will not occur through the landside top stratum; therefore, underseepage and berm analyses were not made.

#### SETTLEMENT

The proposed levee, from approximately station 23+00CE to 30+18CE is found to be most critical with respect to settlement. A study at station 28+50 was selected for analysis, where the levee is approximately 7 feet high.

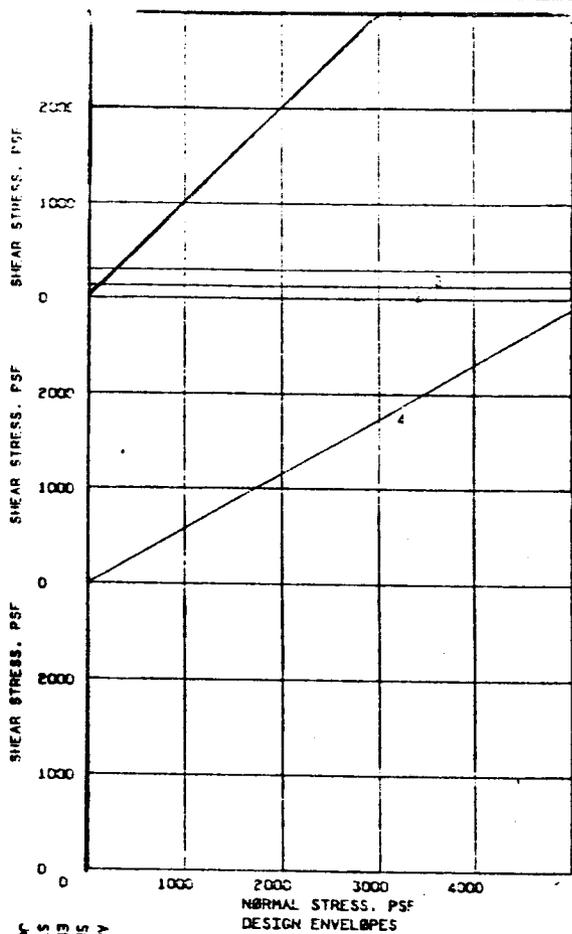
The foundation, in this reach of the levee consists of a 1-to 2-foot thick layer of very soft organic clay. The soil below the soft clay consists of clay of a higher shear strength and a low compressibility. It is anticipated that the very soft clay will be displaced during the construction of the levee by stronger fill material. Therefore, a 9-foot high levee is considered appropriate for the settlement analysis. The 9-foot high levee will impose a maximum load of 810 pounds per square foot on the 15-foot-thick alluvial clay top stratum foundation. A settlement analysis conforming to Joseph E. Bowles "Foundation Analysis and Design," 3rd edition, 1982, indicates total settlement to be on the order of 14 inches, as shown on plate C-3. In order to anticipate the unexpected settlement, a shrinkage allowance of 24 percent of the levee height will be provided in the specifications to allow for any consolidation of the embankment and settlement in the foundation.

#### BORROW MATERIAL

The borrow material will be removed from areas as shown on plate 18 of the main report. The source of the borrow site location was determined to be as close as adjacent to the levee toe. A 40-foot width berm will be left in place between the toe of the levee and near the edge of borrow site to ensure levee stability and to facilitate construction. According to borings which are pertinent to borrow areas, the borrow material consist of very wet soft clay, exceeding the liquid limit. The moisture content varies from 43 to 107 percent. Atterberg limits testing reveals a range from 71/28 (liquid limit/plastic limit) to 82/29. These borrow areas are economically feasible source of material to construct the uncompacted levee. Because it involves a short

or no haul distance and is conducive to dragline operation. Due to the soft nature of the borrow soils, care will be required in excavation and placement to insure the soils will stay in place on the slopes.

A dragline will be used to excavate and place the material. Excessive displacement of the excavated material should be expected due to very soft material of low strength and standing water. The material placement will require gentle laying of the excavated material from bottom to top to minimize the disturbance. The excavated material will be left in place for a period until it regains strength. The excavated material will not be stockpiled higher than the height of the proposed embankment or the embankment will be constructed in multiple stages.

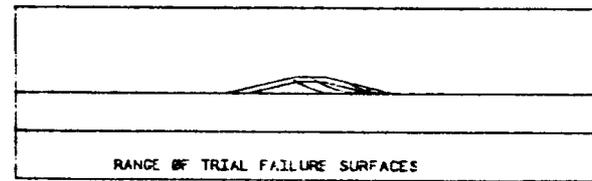


ANDALUSIA EMP  
 SLICE STABILITY ANALYSIS  
 END OF CONSTRUCTION  
 STA. 28+30  
 JULY 1988 (5422)

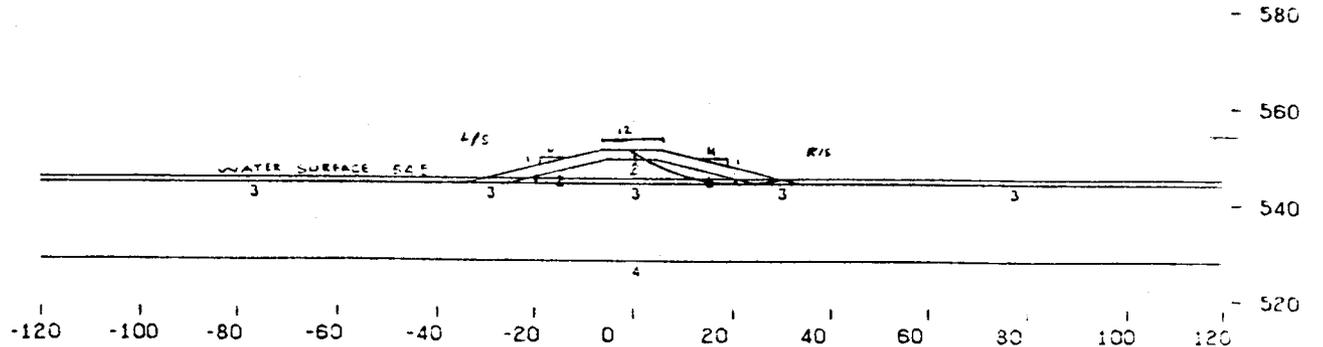
| MATERIAL                              | 1522 LBS/CUFT |        | SHEAR STRENGTH |              |             |              |             |              |             |              |
|---------------------------------------|---------------|--------|----------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|
|                                       | MOIST         | SET    | PHI DEGREES    | COHESION PSF | PHI DEGREES | COHESION PSF | PHI DEGREES | COHESION PSF | PHI DEGREES | COHESION PSF |
| RIPRAP AND BEDDING<br>ELEV 544 TO 551 | 1             | 170.00 | 100.00         | 45.00        | 0.00        | 0.00         | 0.00        | 0.00         | 0.00        | 0.00         |
| CLAY EMBANKMENT<br>ELEV 544 TO 546    | 2             | 80.00  | 80.00          | 0.00         | 130.00      | 0.00         | 0.00        | 0.00         | 0.00        | 0.00         |
| CLAY FOUNDATION<br>ELEV 528 TO 544    | 3             | 115.00 | 115.00         | 0.00         | 300.00      | 0.00         | 0.00        | 0.00         | 0.00        | 0.00         |
| SAND FOUNDATION<br>ELEV TO 528        | 4             | 120.00 | 120.00         | 30.00        | 0.00        | 0.00         | 0.00        | 0.00         | 0.00        | 0.00         |

CIRCLE FAILURE SURFACE  
 RESULTS BY HARRIS-300  
 COMPUTER PROGRAM 741-HS-F424A  
 TANGENT TO ELEV 544.00

| RADIUS OF CIRCLE | CENTER OF CIRCLE |        | F.S. |
|------------------|------------------|--------|------|
|                  | DISTANCE FROM Q  | ELEV   |      |
| 38.00            | 22.00            | 583.00 | 2.30 |
| 34.00            | 12.00            | 578.00 | 2.87 |
| 34.00            | 32.00            | 578.00 | 3.84 |
| 24.00            | 22.00            | 568.00 | 2.44 |
| 44.00            | 22.00            | 588.00 | 2.31 |
| 28.00            | 22.00            | 573.00 | 2.34 |



- NOTES
- ANALYSES WERE RUN ACCORDING TO EM 1110-2-1002 DATED APRIL 1970
  - THE SIDE EARTH FORCE DIRECTION WAS TAKEN AS THE AVERAGE OF THE EMBANKMENT SLOPES IMMEDIATELY ADJACENT TO THE SLICE INTERFACE
  - PSI-SEISMIC COEFFICIENT USED IN ANALYSES



|             |                                   |            |         |
|-------------|-----------------------------------|------------|---------|
| Subject     | ANDALUSIA EMP ANDALUSIA, ILLINOIS | Date       | JUNE 88 |
| Computed by | ZS                                | Checked by | GC      |
|             |                                   | Sheet      | 1 of 2  |

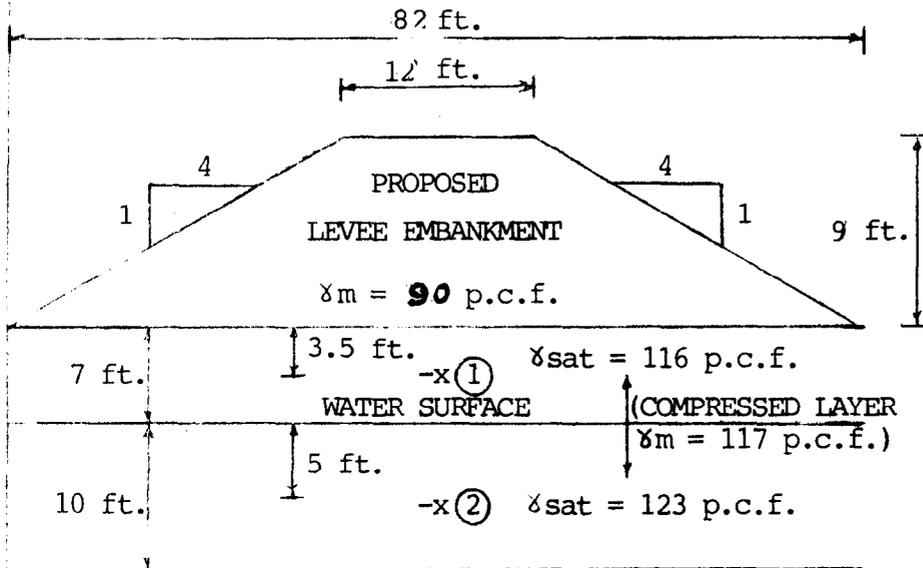
ANDALUSIA EMP  
ANDALUSIA, ILLINOIS  
SETTLEMENT ANALYSIS

Layer 1

Moisture Content = 36%  
Ave. LL/(WL) = 71%  
Specific Gravity (Gs) = 2.7  
 $e_o = WGs = .36(2.7) = .972$

Layer 2

Ave. Moisture Content (Wn)  
= 28%  
Ave. LL/(WL) = 44%  
Specific Gravity (Gs) = 2.7  
 $e_o = WGs = (.28)(2.7) = 0.76$



$P$  = Stress exerted by the 7 ft. high embankment

$P_o$  = Initial stress at the center of the compressible layer

$\Delta P_o$  = Change in stress in compressible layer due to applied loading

$C_c$  = Compression Index

$e_o$  = Initial void Ratio

$H$  = Thickness of compressible layer over which settlement is being calculated

$C_c = .30 (e_o - .27)$ : Ref. Physical & Geotechnical Properties of Soils by Joseph E. Bowles.

$C_c = .210$  (layer 1),  $C_c = .147$  (layer 2)

$C_c = .009$  (LL-10): Ref. Soil Mechanics in Engineering Practice by Terzaghi & Peck

$C_c = .549$  (layer 1),  $C_c = .306$  (layer 2)

Use  $C_c = .37(e_o + .003WL + .0004Wn - .34)$ ,  $C_c = .318$  (layer 1),  $C_c = .208$  (layer 2)

Ref. fnd. Analysis & design by Joseph E. Bowles. It is recommended by Joseph E.

Bowles which has a reported 86% reliability.

|  |                  |                 |
|--|------------------|-----------------|
| Subject<br>ANDALUSIA EMP - ANDALUSIA, ILLINOIS |                  | Date<br>JUNE 88 |
| Computed by<br>SZ                              | Checked by<br>GC | Sheet 2 of 2    |

$P_o$ :

@ mid depth of layer No. 1 =  $3.5(116-62.4) = 188$  p.s.f.

@ mid depth of layer No. 2 =  $7(116-62.4) + 5(123 - 62.4) = 678$  p.s.f.

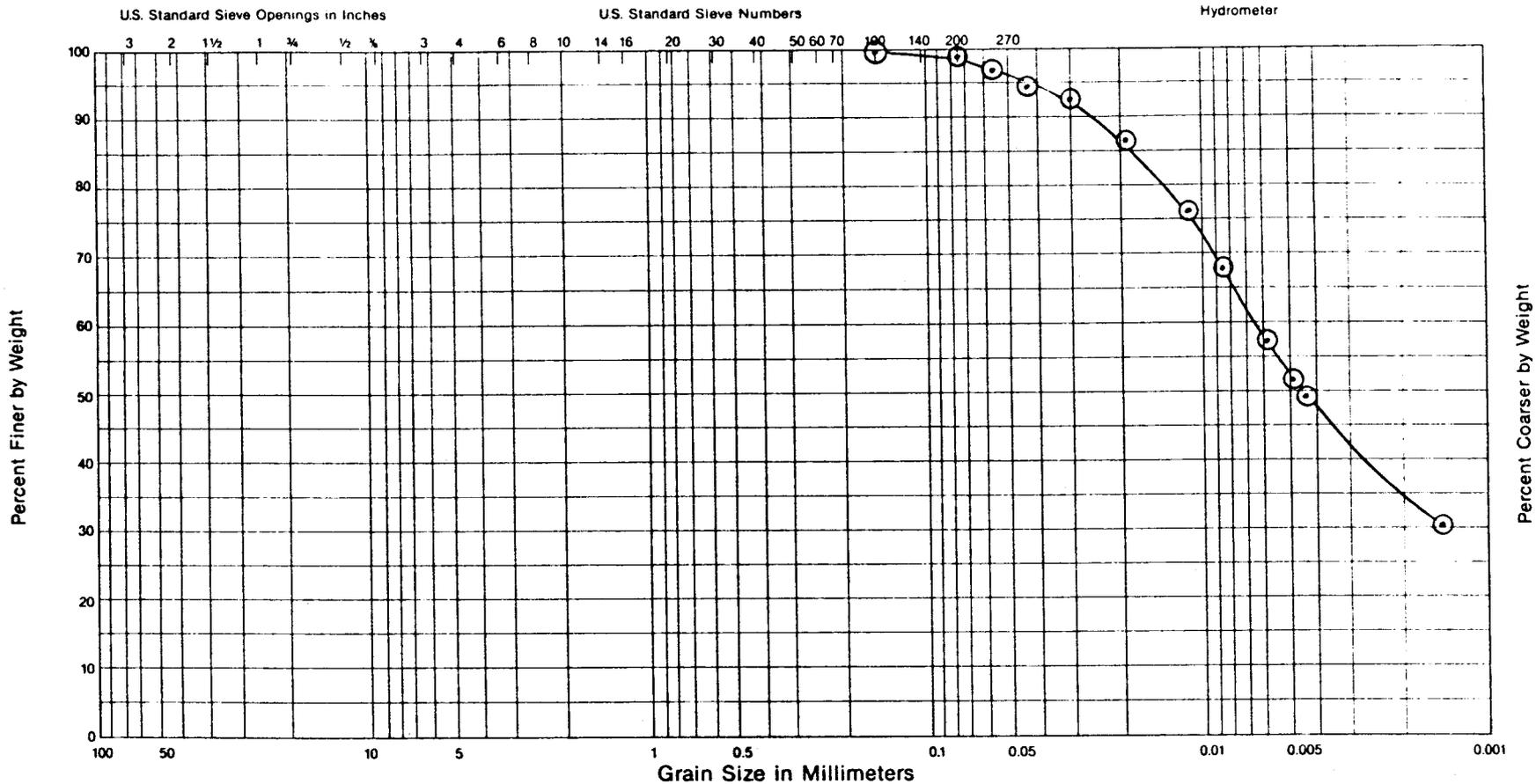
$\Delta P_o$  @ layer 1 Boussinesq coefficient \* h \* m.  
(.982)\*(9)\*(90) = 795 p.s.f.

@ layer 2 Boussinesq coefficient \* h \* m.  
(.861)\*(9)\*(90) = 697 p.s.f.

$$S = \frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + P_o}{P_o}$$

| Depth (ft.) | $C_c$       | $P_o$ (p.s.f.) | $\Delta P_o$ (p.s.f.) | H (ft.) | S (ft.) |
|-------------|-------------|----------------|-----------------------|---------|---------|
| 0           |             |                |                       |         |         |
| 7           | 3.5<br>.318 | 188            | 795                   | 7       | .81     |
| 17          | 10<br>.208  | 678            | 697                   | 10      | .36     |

TOTAL SETTLEMENT = 1.2 ft. 14 inches



|        |      |        |        |      |              |
|--------|------|--------|--------|------|--------------|
| GRAVEL |      | SAND   |        |      | SILT or CLAY |
| Coarse | Fine | Coarse | Medium | Fine |              |

**GRAIN SIZE DISTRIBUTION CURVE**

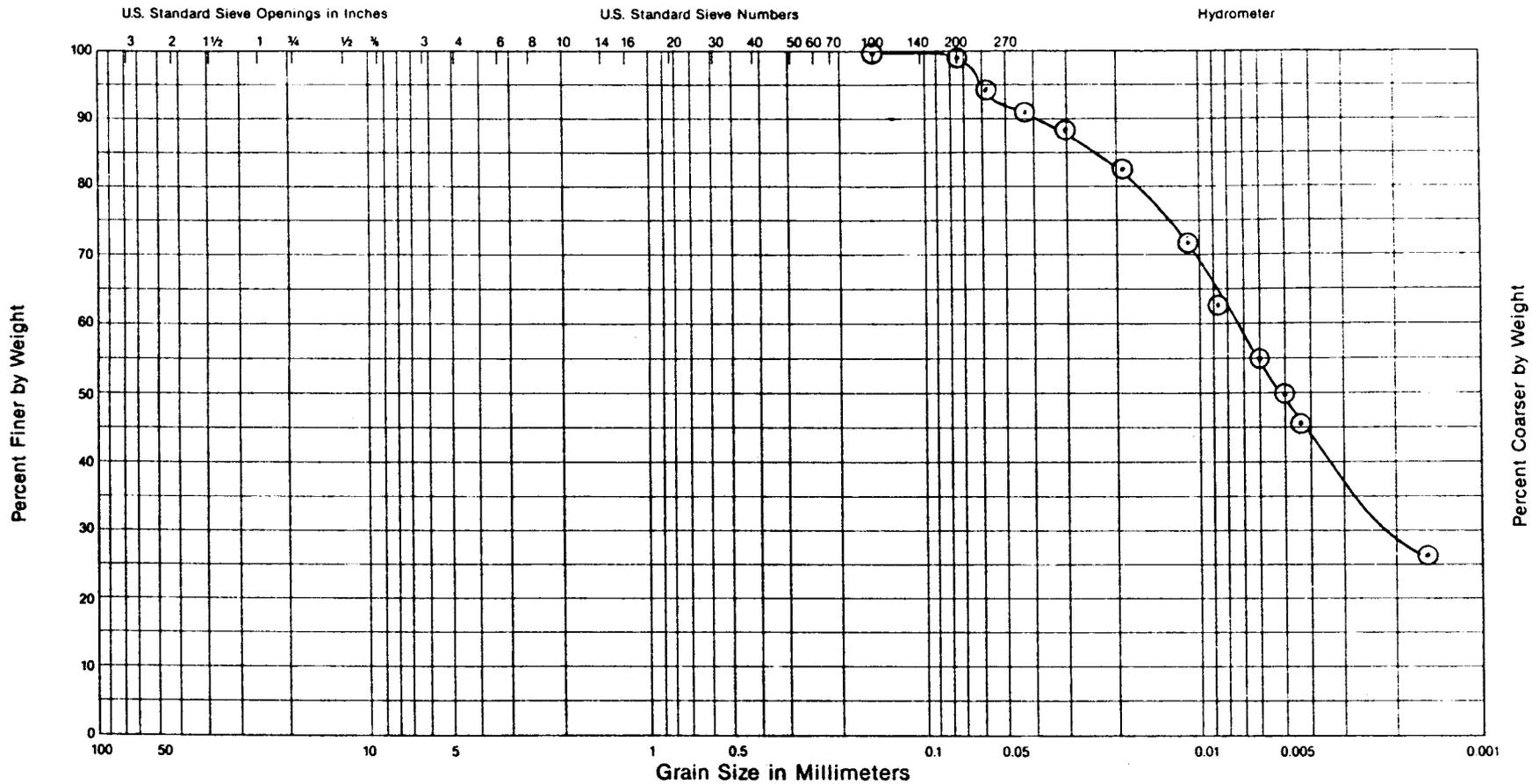
| Boring No. | Sample No. | Depth or Elev. | Description | Unified Symbol | Natural WC | LL | PL | PI |
|------------|------------|----------------|-------------|----------------|------------|----|----|----|
| A-4        | 1          | 2.5' to 3.5'   |             |                |            |    |    |    |

Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87



PLATE C-4



|        |      |        |        |      |              |
|--------|------|--------|--------|------|--------------|
| GRAVEL |      | SAND   |        |      | SILT or CLAY |
| Coarse | Fine | Coarse | Medium | Fine |              |

**GRAIN SIZE DISTRIBUTION CURVE**

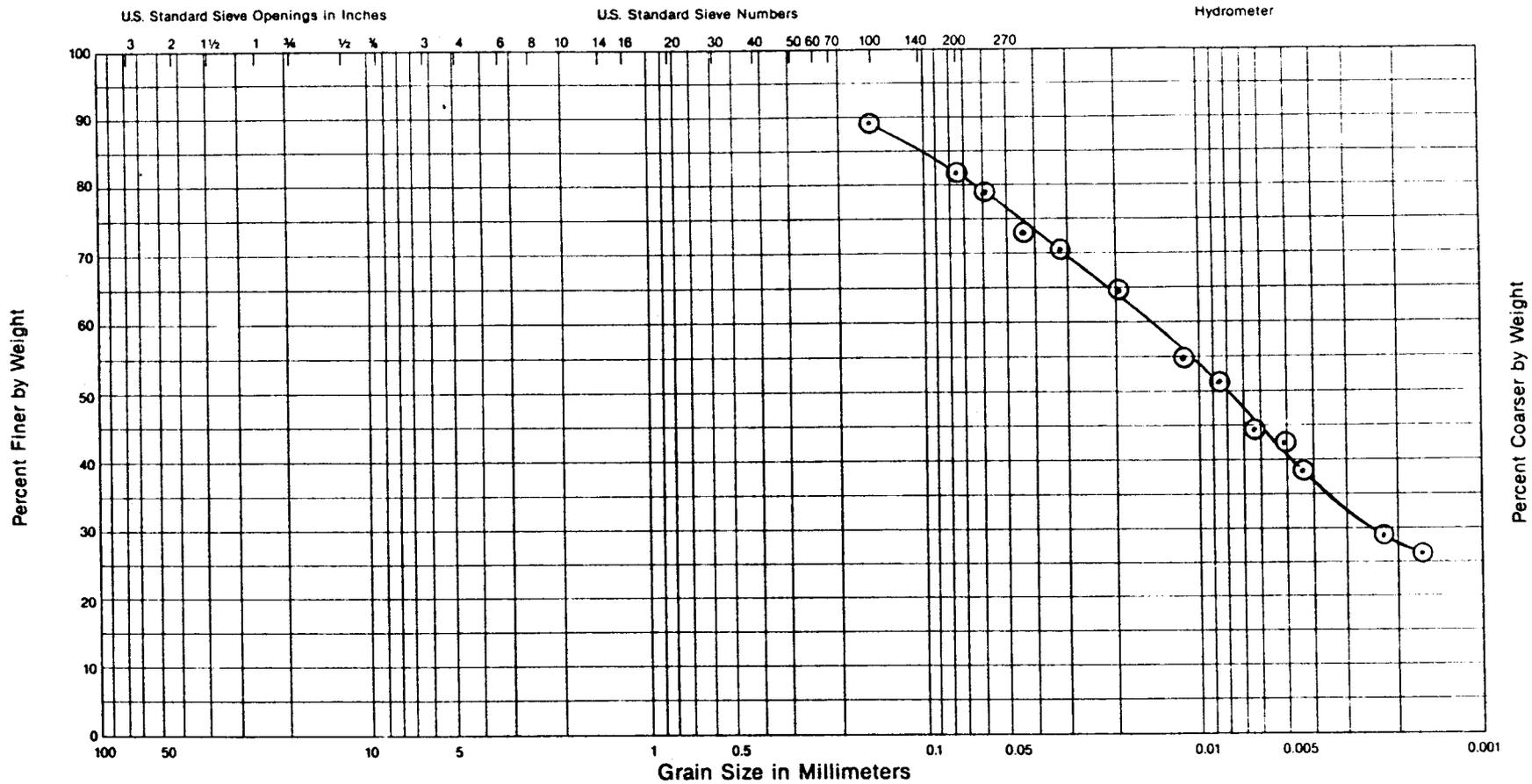
| Boring No. | Sample No. | Depth or Elev. | Description | Unified Symbol | Natural WC | LL | PL | PI |
|------------|------------|----------------|-------------|----------------|------------|----|----|----|
| A-5        | 1          | 3'             |             | CH             |            | 61 | 27 | 34 |

Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87



PLATE C-5



|        |      |        |        |      |              |
|--------|------|--------|--------|------|--------------|
| GRAVEL |      | SAND   |        |      | SILT or CLAY |
| Coarse | Fine | Coarse | Medium | Fine |              |

**GRAIN SIZE DISTRIBUTION CURVE**

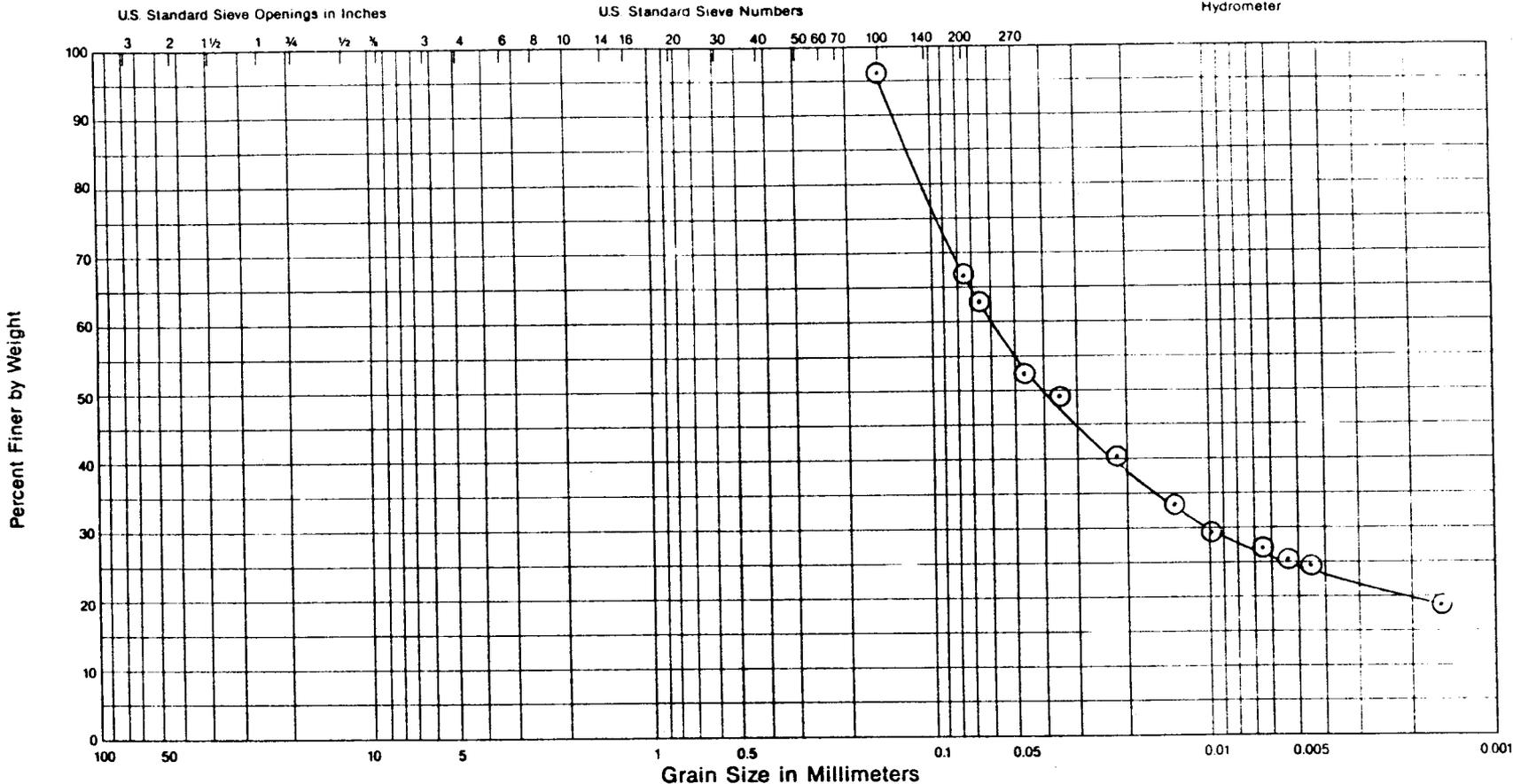
| Boring No. | Sample No. | Depth or Elev. | Description              | Unified Symbol | Natural WC | LL | PL | PI |
|------------|------------|----------------|--------------------------|----------------|------------|----|----|----|
| A-5        | 3          | 7'             | Specific Gravity = 2.654 | CL             |            | 46 | 16 | 30 |

Project Andalusia Refuge Emp

Call # 7002 (18Mar87) Job No. 07861088D Date 4-13-87

**Terracon**

PLATE C-6



|        |      |        |        |      |              |
|--------|------|--------|--------|------|--------------|
| GRAVEL |      | SAND   |        |      | SILT or CLAY |
| Coarse | Fine | Coarse | Medium | Fine |              |

**GRAIN SIZE DISTRIBUTION CURVE**

| Boring No. | Sample No. | Depth or Elev. | Description | Unified Symbol | Natural WC | LL | PL | PI |
|------------|------------|----------------|-------------|----------------|------------|----|----|----|
| A-2        | 2          | 4'             |             | CL             |            | 34 | 17 | 17 |

Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87

**Terracon**

PLATE C-7

**STRUCTURAL DESIGN**

A

P

P

E

N

D

I

X

D



FORCES ON PUMP STATION

REFERENCES

- ① TM 5-809-1 / AFM 88-3, CHAP-1, "LOAD ASSUMPTIONS FOR BUILDINGS", 2 E.M.A.E.
- ② "STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES" AASHTO, 1983
- ③ EM 1110-2-2607, "NAVIGATION DAM MASONRY" 1 JULY 58

WIND FORCES REF. ①, CHAPTER 5

$V = 80 \text{ mph}$  ASSUME EXPOSURE C

$q_z = 0.00256 K_z (IV)^2$  WHERE  $K_z =$  VELOCITY PRESSURE COEF. (Table 5.2)

HEIGHT OF PUMP STATION IS  
 $\approx 20 \text{ FT}$  ABOVE THE LEVEL  
 $\approx 9 \text{ FT}$  ABOVE 100 YR FLOOD.  
 $I =$  IMPORTANCE FACTOR (Table 5.4) = 1.00

| $z$  | $K_z$ | $q_z$     |
|------|-------|-----------|
| 0-15 | 0.80  | 13.11 psf |
| 20   | 0.87  | 14.25 psf |

$P = q G_h C_p$  WHERE  $G_h =$  GUST HEIGHT FACTOR (Table 5.5)

FORCES ON PUMP STATION

|          |                      |
|----------|----------------------|
| <u>Z</u> | <u>G<sub>n</sub></u> |
| 0-15     | 1.32                 |
| 20       | 1.20                 |

C<sub>p</sub> = EXTERNAL FLEASURE COEFF. (FIGURE 5-2)

|          |
|----------|
| <u>Z</u> |
| 0-15     |
| 20       |

WINDWARD WALL

C<sub>p</sub> = 0.8

P<sub>WALL</sub> = 13.85 psf  
P<sub>WALL</sub> = 14.71 psf

LEEWARD WALL

C<sub>p</sub> = -0.8

P<sub>WALL</sub> = -8.02 psf  
P<sub>WALL</sub> = -12.57 psf

|          |              |
|----------|--------------|
| <u>Z</u> | <u>TOTAL</u> |
| 0-15     | 22.51 psf    |
| 20       | 20.90 psf    |

P<sub>ROOF</sub> = 14.25 (1.20 (-0.7)) = 12.87 psf

RIVER FLOW FORCES REF. (2), SEC. 3.18.1

P = K V<sup>2</sup>  
= 1.375 (7.0)<sup>2</sup>  
= 68 psf

V = FLOW OF RIVER  
= 7 ft/SEC. (FOLET ED-HW)

K = CONSTANT = 1.375  
FOR FLEET SURFACE

WEIGHT OF PUMP TUBE

ASSUME 1/4" PLATE FOR TUBES, WT. = 10.2 #/FT<sup>2</sup>

TUBE I.D. = 32" ; PERIMETER =  $\pi(D) = \pi \left( \frac{32.00}{12} \right)$   
 $= 8.443$  FT

VERT. TUBE LENGTH

INTAKE PUMP = 562.0 - 539.5 - 1.33 = 21.17 FT  
 OUTLET PUMP = 562.0 - 539.5 = 22.50 FT

VERT. TUBE WEIGHT

INTAKE PUMP = 10.2 (8.443) (21.17) = 1,823 #  
 OUTLET PUMP = 10.2 (8.443) (22.50) = 1,938 #

HORIZ. TUBE LENGTH

INTAKE PUMP = 10.2 (8.443) (11.25) = 969 #  
 OUTLET PUMP = " " " = 969 #

WEIGHT OF PUMPS = 2,870 # EHD 14 (MANUF. DATA.)

WEIGHT OF H<sub>2</sub>O IN VERT. TUBES

INTAKE PUMP =  $\pi \frac{(16)^2}{144} (21.17 - 1.04) (62.4) = 7,016$  #  
 OUTLET PUMP =  $\pi \frac{(16)^2}{144} (22.50 - 1.04) (62.4) = 7,479$  #

Subject ANDALUSIA SLOUGH - PUMP STATION Date 27 MAY 88

Computed by KEW

Checked by chJ

Sheet 254 of

WEIGHT OF H<sub>2</sub>O IN HORIZ. TUBES

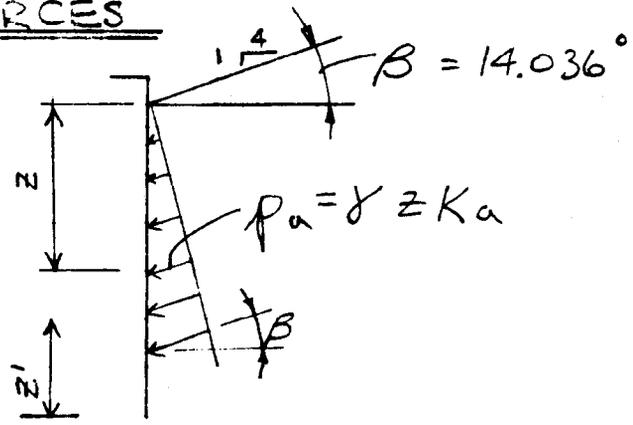
$$\text{INTAKE PUMP} = \pi \frac{(16)^2}{144} (11.25)(62.4) = 3,921 \#$$

$$\text{OUTLET PUMP} = 3,921 \#$$

FORCES ON PUMP STATION

BACKFILL MAT'L

EARTH FORCES



$\gamma_{DAMP} = 115 \text{ pcf}$   
 $C = 0$   
 $\phi = 32^\circ$

$$K_a = \cos \beta \frac{\cos \beta - \sqrt{\cos^2 \beta - \cos^2 \phi}}{\cos \beta + \sqrt{\cos^2 \beta - \cos^2 \phi}}$$

$$K_a = 0.97014 \frac{0.97014 - \sqrt{(0.97014)^2 - (0.84805)^2}}{0.97014 + \sqrt{(0.97014)^2 - (0.84805)^2}}$$

$$= 0.97014 \frac{(0.97014 - 0.47115)}{(0.97014 + 0.47115)} = 0.33587$$

$$K_{a,H} = 0.97014 (0.33587) = 0.32587$$

$$K_p = \tan^2 \left( 45 + \frac{\phi}{2} \right)$$

$$= \tan^2 \left( 45 + \frac{32}{2} \right) = 3.25450$$

Subject ANDALLUSIA SLOUGH - PUMP STATION

Date 21 JUNE 88

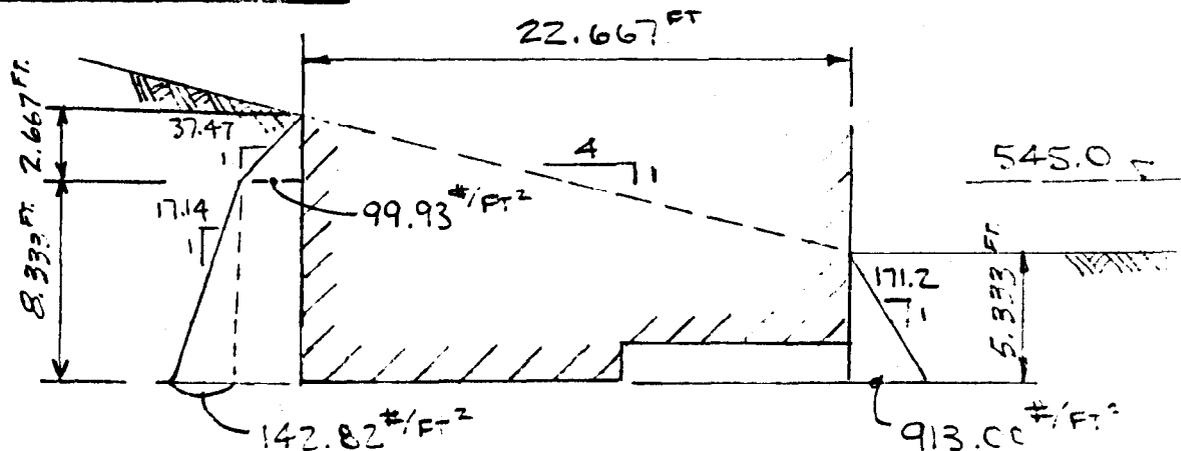
Computed by LEW

Checked by chd

Sheet 1 of 6  
PS 6

FORCES ON PUMP STATION

EARTH FORCES



ICE FORCES

BECAUSE THE REFUGE IS ABOVE THE PUMP STATION AND FLAT FLOOD AND HIGH WATER WITHIN THE REFUGE IS BELOW THE TOP OF THE LEVEE, ICE FORCES WILL NOT ACT ON THE PUMP STATION.

FLOATING OBJECTS

THE PUMP STATION IS IN A PROTECTED AREA, OUT OF THE MAIN FLOW OF THE RIVER. IT WILL NOT BE SUBJECT TO LARGE FLOATING OBJECTS.

REVISED 15 OCT. 88

STABILITY (Y)

| UNIT                                    | FORCE     | ARM    | MOMENT      |
|---|-----------|--------|-------------|
| ROOF 0.33 (150) (10.00) (13.67)         | 6,835     | 6.833  | 46,704      |
| WALLS 0.75 (150) (8.00) (13.67) (2)     | 24,606    | 6.833  | 168,133     |
| - 0.75 (150) (7.17) (3.33)              | - 2,686   | 6.833  | - 18,353    |
| 0.75 (150) (8.00) (8.50)                | 7,650     | 0.375  | 2,869       |
| 0.75 (150) (8.00) (8.50)                | 7,650     | 13.292 | 101,684     |
| FLOOR 0.50 (150) (13.67) (11.67)        | 11,965    | 6.833  | 81,755      |
| - 0.50 (150) (2.50) (2.50)              | - 469     | 5.917  | - 2,775     |
| - 0.50 (150) $\pi$ (1.333) <sup>2</sup> | - 419     | 3.667  | - 1,536     |
| - 0.50 (150) $\pi$ (1.333) <sup>2</sup> | - 419     | 10.000 | - 4,190     |
| - 0.50 (150) (2.5) (4.17)               | - 782     | 10.583 | - 8,276     |
| BMS 0.50 (150) (8.00) (0.83)            | 498       | 7.833  | 3,901       |
| (BELOW SLAB) 1.33 (150) (11.67) (1.25)  | 2,910     | 6.833  | 19,884      |
| WALLS 1.00 (150) (20.50) (15.67)        | 48,185    | 13.167 | 634,451     |
| - 1.00 (150) (7.00) (5.00)              | - 5,250   | 13.167 | - 69,127    |
| 1.00 (150) (20.50) (15.67)              | 48,185    | 0.500  | 24,093      |
| - 1.00 (150) $\pi$ (2.00) <sup>2</sup>  | - 1,885   | 0.500  | - 942       |
| 1.00 (150) (20.50) (11.67) (2)          | 71,770    | 6.833  | 490,404     |
| 1.00 (150) (11.50) (13.67)              | 23,581    | 6.833  | 161,129     |
| - 1.00 (150) (3.00) (3.00)              | - 1,350   | 6.833  | - 9,225     |
| BASE 2.83 (150) (17.67) (15.67)         | 117,539   | 6.833  | 803,144     |
| - 1.33 (150) (13.67) (5.33)             | - 14,536  | 3.667  | - 53,304    |
|   | 343,578 # |        | 2,370,423 # |

$\bar{Y} = 6.899 \text{ FT.}$

Subject **ANDALUSIA SLOUGH - PUMP STATION** Date **19 MAY 88**

Computed by **KEW**

Checked by **chj**

Sheet **PS 8** of **8**

REVISED 19 OCT. 88

STABILITY (Y)

| UNIT  | FORCE   | ARM    | MOMENT   |
|---|---------|--------|----------|
| WIND 24(10.00)(8.33)  | 2,000   | 27.495 | 54,990   |
| 24(15.67)(9.20)   | 3,460   | 18.733 | 64,816   |
| RIVER FLOW 68(15.67)(9.20)  | 9,803   | 18.733 | 183,640  |
| EARTH LOADS (NORMAL)(SHT. PS 6)   |         |        |          |
| ACTIVE  |         |        |          |
| 37.47(2.667)(2.667)(15.67)<br>2   | 2,088   | 9.222  | 19,256   |
| 37.47(2.667)(8.333)(15.67)  | 13,049  | 4.167  | 54,375   |
| 17.14(8.333)(8.333)(15.67)<br>2   | 9,325   | 2.777  | 25,896   |
| PASSIVE   |         |        |          |
| 171.2(5.333)(5.333)(15.67)<br>2   | -38,172 | -      | -        |
| * PASSIVE FORCE IS GREATER THAN ACTIVE FORCES INCLUDING WIND AND EARTH, ∴ USE Σ ACTIVE            |         |        |          |
|   | -29,922 | 1.777  | - 53,171 |
| EARTH LOADS (100YR.)  |         |        |          |
| ACTIVE  |         |        |          |
| 17.14(11.00)(11.00)(15.67)<br>2   | 16,249  | 3.667  | 59,585   |
| PASSIVE (SEE ABOVE)   |         |        |          |
|   | -38,172 | **     |          |
| ** PASSIVE FORCE IS GREATER THAN ACTIVE FORCES INCLUDING WIND, RIVER FLOW & EARTH, ∴ USE Σ ACTIVE |         |        |          |
|   | -28,052 | 1.777  | - 49,848 |

Subject **ANDALUSIA SLOUGH - PUMP STATION** Date **19 MAY 88**

Computed by **KEN**

Checked by **chj**

Sheet **PS9** of

REVISED 18 OCT. 88

STABILITY ( $\bar{Y}$ )

| UNIT  | FORCE                     | ARM           | MOMENT                        |
|---|---------------------------|---------------|-------------------------------|
| <b>PUMPS &amp; PIPING</b>                     |                           |               |                               |
| 2,870 + 1938 (1.10)                           | 5,002                     | 3.667         | 18,342                        |
| 2,870 + 1,823 (1.10)                          | 4,875                     | 10.000        | 48,750                        |
| 969 (1.10)                                    | 1,066                     | 5.500         | 5,863                         |
| 969 (1.10)                                    | 1,066                     | 8.167         | 8,706                         |
| <b>LIVE LOAD 100 (8.5)(12.167)</b>            | <b>10,342</b>             | <b>6.833</b>  | <b>70,667</b>                 |
| <b>SNOW LOAD 20 (15.667)(13.667)</b>          | <b>4,282</b>              | <b>6.833</b>  | <b>29,259</b>                 |
| <hr/>   |                           |               |                               |
| <b>INLET 0.50 (150)(6.00)(6.00)</b>           | <b>2,700</b>              | <b>16.667</b> | <b>45,000</b>                 |
| <b>1.00 (150)(7.50)(9.00) 2</b>               | <b>20,250</b>             | <b>18.167</b> | <b>367,882</b>                |
| <b>1.00 (150)(6.00)(3.50)</b>                 | <b>3,150</b>              | <b>22.167</b> | <b>69,826</b>                 |
| <b>1.50 (150)(8.00)(8.00)</b>                 | <b>14,400</b>             | <b>18.667</b> | <b>268,805</b>                |
| <hr/>   |                           |               |                               |
|   | <b>40,500*</b>            | <b>18.556</b> | <b>751,514<sup>FT-F</sup></b> |
| <hr/>   |                           |               |                               |
| <b>WATER (NORMAL)</b>                         |                           |               |                               |
| <b>(542.00 - 538.17)(62.4)(5.33)(13.67)</b>   | <b>17,413</b>             | <b>3.667</b>  | <b>63,853</b>                 |
| <b>(545.00 - 539.50)(62.4)(5.33)(13.67)</b>   | <b>25,006</b>             | <b>10.000</b> | <b>250,060</b>                |
| <b>(545.00 - 539.50)(62.4)(6.00)(9.00)</b>    | <b>18,533</b>             | <b>17.167</b> | <b>318,156</b>                |
| <b>(545.00 - 543.00)(62.4)(6.00)(1.00)</b>    | <b>749</b>                | <b>22.167</b> | <b>16,603</b>                 |
| <b>(545.00 - 539.50)(62.4)(15.67)(1.00) 2</b> | <b>10,756</b>             | <b>6.833</b>  | <b>73,496</b>                 |
| <b>(545.00 - 539.50)(62.4)(7.67)(1.00)</b>    | <b>2,632</b>              | <b>14.167</b> | <b>37,288</b>                 |
| <b>(545.00 - 539.5)(62.4)(15.67)(1.00)</b>    | <b>5,378</b>              | <b>-0.500</b> | <b>-2,689</b>                 |
| <b>- π (2.333)<sup>2</sup> (62.4)(1.00)</b>   | <b>-1,067</b>             | <b>-0.500</b> | <b>534</b>                    |
| <hr/>   |                           |               |                               |
|   | <b>79,400<sup>#</sup></b> |               | <b>757,321</b>                |

Subject **ANDALUSIA SLOUGH - PUMP STATION** Date **19 MAY 81**

Computed by **KEW**

Checked by **chj**

Sheet **PSIC** of

REVISED EC-8'

STABILITY (Y)

| UNIT  | FORCE                        | ARM          | MOMENT                         |
|---|------------------------------|--------------|--------------------------------|
| <b>EARTH ON BASE PROJ. (NORMAL)</b>             |                              |              |                                |
| $(115 - 62.4)(5.5)(15.67)(1.00)Z$               | 9,067                        | 6.833        | 61,955                         |
| $- (115 - 62.4)(1.0)(\frac{4.000}{2})(1.00)Z$   | - 210                        | 13.333       | - 2,800                        |
| $115 (547.917 - 545.0)(\frac{11.67}{2})(1.00)Z$ | 3,915                        | 2.889        | 11,312                         |
| $(115 - 62.4)(4.625)(7.157)(1.00)$              | 1,866                        | 14.157       | 26,436                         |
| $(115 - 62.4)(5.5)(15.67)(1.00)$                | 4,533                        | -0.500       | - 2,267                        |
| $115 (2.792)(15.67)(1.00)$                      | 5,031                        | -0.500       | - 2,516                        |
| $- (115 - 62.4)\pi (2.333)^2 (1.00)$            | - 899                        | -0.500       | 450                            |
|   | <b>23,305<sup>#</sup></b>    | <b>3.972</b> | <b>92,568<sup>F</sup></b>      |
| <b>UPLIFT (NORMAL)</b>                          |                              |              |                                |
| $- (545.0 - 536.67)(62.4)(17.67)(15.67)$        | -143,925                     | 6.833        | - 983,440                      |
| $- (545.0 - 538.00)(62.4)(8.00)(8.00)$          | - 27,955                     | 18.667       | - 521,840                      |
|   | <b>- 171,880<sup>#</sup></b> | <b>8.758</b> | <b>- 1,505,280<sup>F</sup></b> |
| <b>WATER (100 YR.)</b>                          |                              |              |                                |
| $(559.30 - 538.17)(62.4)(5.33)(13.67)$          | 96,068                       | 3.667        | 352,280                        |
| $(559.30 - 539.50)(62.4)(5.33)(13.67)$          | 90,021                       | 10.000       | 900,210                        |
| $(559.30 - 551.00)(62.4)(1.00)(13.67)$          | 7,080                        | 6.833        | 48,378                         |
| $(559.80 - 539.50)(62.4)(6.00)(8.00)$           | 60,803                       | 17.667       | 1,074,207                      |
| $(546.50 - 539.50)(62.4)(1.00)(5.0)$            | 2,184                        | 13.167       | 28,757                         |
| $- 0.50(62.4)(6.00)(6.00)$                      | - 1,123                      | 16.667       | - 18,717                       |
| $(559.80 - 543.00)(62.4)(1.00)(6.00)$           | 6,290                        | 22.167       | 139,430                        |
| $(559.80 - 547.00)(62.4)(1.00)(9.0)Z$           | 14,377                       | 18.167       | 261,187                        |
| $(559.80 - 539.50)(62.4)(15.67)(1.00)Z$         | 39,699                       | 6.833        | 271,263                        |

STABILITY (Y)

| UNIT                                    | FORCE                       | ARM    | MOMENT                        |
|---|-----------------------------|--------|-------------------------------|
| <b>WATER (100 YR) (CONT.)</b>           |                             |        |                               |
| $(559.80 - 539.5)(62.4)(7.67)(1.00)$    | 9,716                       | 14.167 | 137,647                       |
| $(559.80 - 539.5)(62.4)(15.67)(1.00)$   | 19,850                      | -0.500 | - 9,925                       |
| $- \pi (2.333)^2 (62.4)(1.00)$          | - 1,067                     | -0.500 | 534                           |
|   | <b>343,898<sup>#</sup></b>  |        | <b>3,185,252<sup>#</sup></b>  |
| <b>EARTH ON BASE PROJ. (100 YR)</b>     |                             |        |                               |
| $52.6 (5.5)(15.67)(1.00) 2$             | 9,067                       | 6.833  | 61,955                        |
| $- 52.6 (1.0)(4.00)(1.00) 2$            | - 210                       | 13.333 | - 2,800                       |
| $52.6 (2.97)(11.67)(1.00) 2$            | 1,791                       | 2.889  | 5,174                         |
| $52.6 (4.625)(7.67)(1.00)$              | 1,863                       | 14.167 | 26,436                        |
| $52.6 (8.292)(15.67)(1.00)$             | 6,835                       | -0.500 | - 3,417                       |
| $- 52.6 \pi (2.333)^2 (1.00)$           | - 899                       | -0.500 | 450                           |
|   | <b>18,450<sup>#</sup></b>   |        | <b>87,798<sup>#</sup></b>     |
| <b>UP LIFT (100 YR.)</b>                |                             |        |                               |
| $-(559.8 - 536.67)(62.4)(17.15)(15.67)$ | -399,637                    | 6.833  | -2,730,720                    |
| $-(559.8 - 538.00)(62.4)(8.00)(8.00)$   | - 87,060                    | 18.667 | - 1,625,158                   |
|   | <b>-486,697<sup>#</sup></b> |        | <b>-4,355,878<sup>#</sup></b> |

Subject **ANDALUSIA SLOUGH - PUMP STATION**

Date **18 MAY 88**

Computed by **KEW**

Checked by **ckj**

Sheet **PS11** of

REVISED 18 Oct. 88

STABILITY ( $\bar{x}$ )

| UNIT  | FORCE                      | ARM    | MOMENT                       |
|---|----------------------------|--------|------------------------------|
| ROOF 0.33 (150)(10.00)(13.67)               | 6,835                      | 5.000  | 34,175                       |
| WALLS 0.75 (150)(8.00)(13.67)               | 12,303                     | 0.375  | 4,614                        |
| 0.75 (150)(8.00)(13.67)                     | 12,303                     | 9.625  | 118,416                      |
| -0.75 (150)(7.17)(3.33)                     | -2,686                     | 9.625  | -25,853                      |
| 0.75 (150)(8.00)(8.50)(2)                   | 15,300                     | 5.000  | 76,500                       |
| FLOOR 0.50 (150)(13.67)(11.67)              | 11,965                     | 7.833  | 93,722                       |
| - 0.50 (150)(2.50)(2.50)                    | - 469                      | 2.250  | - 1,055                      |
| - 0.50 (150) $\pi$ (1.333) <sup>2</sup> (2) | - 838                      | 12.667 | - 10,615                     |
| - 0.50 (150)(2.5)(4.17)                     | - 782                      | 2.250  | - 1,760                      |
| BMS. 0.50 (150)(8.00)(0.83)                 | 498                        | 5.000  | 2,490                        |
| (BELOW SLAB) 1.33 (150)(11.67)(1.25)        | 2,910                      | 9.625  | 28,009                       |
| WALLS 1.00 (150)(20.50)(15.67)(2)           | 96,370                     | 7.833  | 754,866                      |
| - 1.00 (150)(7.00)(5.00)                    | - 5,250                    | 4.500  | - 23,625                     |
| - 1.00 (150) $\pi$ (2.00) <sup>2</sup>      | - 1,885                    | 4.500  | - 8,483                      |
| 1.00 (150)(20.50)(11.67)                    | 35,885                     | 0.500  | 17,943                       |
| 1.00 (150)(20.50)(11.67)                    | 35,885                     | 15.167 | 544,268                      |
| 1.00 (150)(11.50)(13.67)                    | 23,581                     | 7.833  | 184,710                      |
| - 1.00 (150)(3.00)(3.00)                    | - 1,350                    | 4.500  | - 6,075                      |
| BASE 2.83 (150)(17.67)(15.67)               | 117,539                    | 7.833  | 920,683                      |
| - 1.33 (150)(13.67)(5.33)                   | - 14,536                   | 7.833  | - 113,860                    |
|   | <b>343,578<sup>#</sup></b> |        | <b>2,589,070<sup>+</sup></b> |

$\bar{x} = 7.536$  FT.

|  |                       |                                |
|--|-----------------------|--------------------------------|
| Subject <b>ANDALUSIA SLOUGH - PUMP STATION</b> |                       | Date <b>19 MAY 88</b>          |
| Computed by <b>KEW</b>                         | Checked by <b>chj</b> | Sheet <b>PS12</b> of <b>12</b> |

REVISED 18 OCT. 88

STABILITY (x)

| UNIT                          | FORCE                     | ARM          | MOMENT                        |
|-------------------------------|---------------------------|--------------|-------------------------------|
| WIND 24 (13.67)(20.66)        | 6,778                     | 21.337       | 144,622                       |
| 24 (13.67)(3.417) ÷ 2         | 561                       | 9.867        | 5,535                         |
| 24 (9.00)(2.75)               | 594                       | 8.958        | 5,321                         |
| 24 (9.00)(2.25) ÷ 2           | 243                       | 6.833        | 1,660                         |
|                               | <b>8,176<sup>#</sup></b>  |              | <b>157,138<sup>FT-#</sup></b> |
| RIVER FLOW - NONE             | —                         | —            | —                             |
| EARTH - EQUAL ON OPP. SIDES   | —                         | —            | —                             |
| PUMPS & PIPING                |                           |              |                               |
| 2,870 + 1938 (1.10)           | 5,002                     | 12.667       | 63,360                        |
| 2,870 + 1823 (1.10)           | 4,875                     | 12.667       | 61,752                        |
| 969 (1.0)(2)                  | 2,132                     | 8.667        | 18,478                        |
| LINE LOAD 100(8.5)(12.167)    | 10,342                    | 5.000        | 51,710                        |
| SNOW LOAD 20 (15.667)(13.667) | 4,282                     | 7.833        | 33,541                        |
| INLET 0.50(150)(6.0)(6.0)     | 2,700                     | 4.000        | 10,800                        |
| 1.00 (150)(7.5)(9.00)         | 10,125                    | 0.500        | 5,063                         |
| 1.00 (150)(7.5)(9.00)         | 10,125                    | 7.500        | 75,937                        |
| 1.00 (150)(6.00)(3.50)        | 3,150                     | 4.000        | 12,600                        |
| 1.50 (150)(8.00)(8.00)        | 14,400                    | 4.000        | 57,600                        |
|                               | <b>40,500<sup>#</sup></b> | <b>4.000</b> | <b>162,000<sup>FT-#</sup></b> |

REVISED 12 OCT 88

STERILITY (x)

| UNIT   | FORCE                 | ARM    | MOMENT                  |
|--|-----------------------|--------|-------------------------|
| <b>WATER (NORMAL)</b>                            |                       |        |                         |
| $(542.00 - 538.17)(62.4)(5.33)(13.67)$           | 17,413                | 7.833  | 136,396                 |
| $(545.00 - 539.50)(62.4)(5.33)(13.67)$           | 25,006                | 7.833  | 195,872                 |
| $(545.00 - 539.50)(62.4)(6.00)(9.00)$            | 18,533                | 4.000  | 74,132                  |
| $(545.00 - 543.00)(62.4)(6.00)(1.00)$            | 749                   | 4.000  | 2,996                   |
| $(545.00 - 539.50)(62.4)(15.67)(1.00)$           | 5,378                 | -0.500 | - 2,689                 |
| $(545.00 - 539.50)(62.4)(15.67)(1.00)$           | 5,378                 | 16.167 | 86,946                  |
| $(545.00 - 539.50)(62.4)(7.67)(1.00)$            | 2,632                 | 11.833 | 31,144                  |
| $(545.00 - 539.50)(62.4)(15.67)(1.00)$           | 5,378                 | 7.833  | 42,126                  |
| $-\pi (2.333)^2(62.4)(1.00)$                     | - 1,067               | 4.500  | - 4,802                 |
|  | 79,400 <sup>#</sup>   |        | 562,121 <sup>#</sup>    |
| <b>EARTH ON BASE PROJ. (NORMAL)</b>              |                       |        |                         |
| $(115 - 62.4)(5.5)(15.67)(1.00) \frac{2}{2}$     | 9,067                 | 7.833  | 71,022                  |
| $-(115 - 62.4)(1.0)(4.00)(1.00) \frac{2}{2}$     | - 210                 | 7.833  | - 1,645                 |
| $115 (547.917 - 545.0)(11.67)(1.00) \frac{2}{2}$ | 3,915                 | 7.833  | 30,666                  |
| $(115 - 62.4)(4.625)(7.67)(1.00)$                | 1,866                 | 11.833 | 22,080                  |
| $(115 - 62.4)(5.5)(15.67)(1.00)$                 | 4,533                 | 7.833  | 35,507                  |
| $115 (2.792)(15.67)(1.00)$                       | 5,031                 | 7.833  | 39,408                  |
| $-(115 - 62.4) \pi (2.333)^2 (1.00)$             | - 899                 | 4.500  | - 4,046                 |
|  | 23,303 <sup>#</sup>   |        | 192,992 <sup>#</sup>    |
| <b>LIFT (NORMAL)</b>                             |                       |        |                         |
| $-(545.0 - 536.67)(62.4)(17.67)(15.67)$          | - 143,925             | 7.833  | - 1,127,365             |
| $-(545.0 - 538.00)(62.4)(8.00)(9.00)$            | - 27,955              | 4.000  | - 111,820               |
|  | -171,880 <sup>#</sup> |        | -1,239,185 <sup>#</sup> |

STABILITY (X)

| UNIT                                    | FORCE                        | ARM    | MOMENT                         |
|---|------------------------------|--------|--------------------------------|
| <b>WATER (100 YR.)</b>                  |                              |        |                                |
| $(559.30 - 538.17)(62.4)(5.33)(13.67)$  | 96,068                       | 7.833  | 752,501                        |
| $(559.30 - 539.50)(62.4)(5.33)(13.67)$  | 90,021                       | 7.833  | 705,134                        |
| $(559.30 - 551.00)(62.4)(1.00)(13.67)$  | 7,080                        | 7.833  | 55,458                         |
| $(559.80 - 539.50)(62.4)(6.00)(8.00)$   | 60,803                       | 4.000  | 243,212                        |
| $(546.50 - 539.50)(62.4)(1.00)(5.00)$   | 2,184                        | 4.500  | 9,828                          |
| $- 0.50(62.4)(6.00)(6.00)$              | - 1,123                      | 4.000  | - 4,492                        |
| $(559.80 - 543.00)(62.4)(1.00)(6.00)$   | 6,290                        | 4.000  | 25,160                         |
| $(559.80 - 547.00)(62.4)(1.00)(9.00)2$  | 14,377                       | 4.000  | 57,508                         |
| $(559.80 - 539.50)(62.4)(15.67)(1.00)2$ | 39,699                       | 7.833  | 310,962                        |
| $(559.80 - 539.50)(62.4)(7.67)(1.00)$   | 9,716                        | 11.833 | 114,967                        |
| $(559.80 - 539.50)(62.4)(15.67)(1.00)$  | 19,850                       | 7.833  | 155,485                        |
| $- \pi (2.333)^2 (62.4)(1.00)$          | - 1,067                      | 4.500  | - 4,802                        |
|   | <b>343,898<sup>#</sup></b>   |        | <b>2,420,923<sup>#</sup></b>   |
| <b>EARTH ON BASE PROJ. (100 YR.)</b>    |                              |        |                                |
| $52.6(5.5)(15.67)(1.00)2$               | 9,067                        | 7.833  | 71,022                         |
| $- 52.6(1.0)(4.00)(1.00)2$              | - 210                        | 7.833  | - 1,645                        |
| $52.6(2.917)(11.67)(1.00)2$             | 1,791                        | 7.833  | 14,029                         |
| $52.6(4.625)(7.67)(1.00)$               | 1,866                        | 11.833 | 22,080                         |
| $52.6(8.292)(15.67)(1.00)$              | 6,835                        | 7.833  | 53,539                         |
| $- 52.6\pi(2.333)^2(1.00)$              | - 899                        | 4.500  | - 4,046                        |
|   | <b>18,450<sup>#</sup></b>    |        | <b>154,977<sup>#</sup></b>     |
| <b>LIFT (100 YR.)</b>                   |                              |        |                                |
| $-(559.8 - 536.67)(62.4)(17.67)(15.67)$ | - 399,637                    | 7.833  | - 3,130,357                    |
| $-(559.8 - 538.0)(62.4)(8.00)(8.00)$    | - 87,060                     | 4.000  | - 348,240                      |
|   | <b>- 486,697<sup>#</sup></b> |        | <b>- 3,478,597<sup>#</sup></b> |

Subject ANDALUSIA SLOUGH - PUMP STATION Date 20 JUNE 88

Computed by KEW Checked by CHJ Sheet PS14 of 1

REVISED 18 OCT. 88

STABILITY (Y)

LOAD CASE I NORMAL CONDITIONS

| UNIT                     | FORCE     | ARM    | MOMENT      |
|--------------------------|-----------|--------|-------------|
| DEAD LOAD OF STRUCTURE ↓ | 343,578 # | 6.899  | 2,370,423   |
| WIND →                   | 2,000     | 27.495 | 54,990      |
|                          | 3,460     | 18.733 | 64,816      |
| EARTH - ACTIVE →         | 2,088     | 9.222  | 19,286      |
|                          | 13,049    | 4.167  | 54,375      |
|                          | 9,325     | 2.777  | 25,904      |
| - PASSIVE ←              | - 29,922  | 1.777  | - 53,171    |
| PUMPS & PIPING ↓         | 12,009    | 6.800  | 81,667      |
| LIVE LOAD ↓              | 10,342    | 6.833  | 70,667      |
| SNOW LOAD ↓              | 4,282     | 6.833  | 29,259      |
| INLET ↓                  | 40,500    | 18.556 | 751,514     |
| WATER ↓                  | 79,400    | 9.538  | 757,301     |
| EARTH ON BASE PROJ. ↓    | 23,303    | 3.972  | 92,568      |
| UPLIFT ↑                 | - 171,880 | 8.758  | - 1,505,280 |
|                          | 341,534 # | 8.240  | 2,814,275   |

$$e_y = 8.240 - \frac{13.667}{2} = 1.407 \text{ FT} < \frac{13.667}{2} = 2.278 \text{ FT}$$

Subject ANDALUSIA SLOV.GW - PUMP STATION Date 20 JUNE 88

Computed by KEW

Checked by chl

Sheet PS15<sup>01</sup>

REVISED 19 OCT. 88

STERILITY (X)

LOAD CASE I      NORMAL CONDITIONS

| UNIT                          |   | FORCE        | ARM    | MOMENT                         |
|-------------------------------|---|--------------|--------|--------------------------------|
| DEAD LOAD OF STRUCTURE        | ↓ | #<br>343,578 | 7.536  | FT-F <sup>t</sup><br>2,589,070 |
| WIND (NOT IN CONJ. w/ Y WIND) | → | —            | —      | —                              |
| PUMPS & PIPING                | ↓ | 12,009       | 11.957 | 143,590                        |
| LIVE LOAD                     | ↓ | 10,342       | 5.000  | 51,710                         |
| SNOW LOAD                     | ↓ | 4,282        | 7.833  | 33,541                         |
| INLET                         | ↓ | 40,500       | 4.000  | 162,000                        |
| WATER                         | ↓ | 79,400       | 7.080  | 562,121                        |
| EARTH ON BASE PROJ.           | ↓ | 23,303       | 8.282  | 192,992                        |
| UPLIFT                        | ↑ | -171,880     | 7.210  | -1,239,185                     |
|                               |   | #<br>341,534 | 7.308  | FT-F <sup>t</sup><br>2,495,839 |

$$e_x = 7.308 - \frac{15.667}{2} = -0.526 \text{ FT} < \frac{15.667}{6} = 2.611 \text{ FT}$$

REVISED 19 OCT. 88

STABILITY

LOAD CASE I NORMAL CONDITIONS

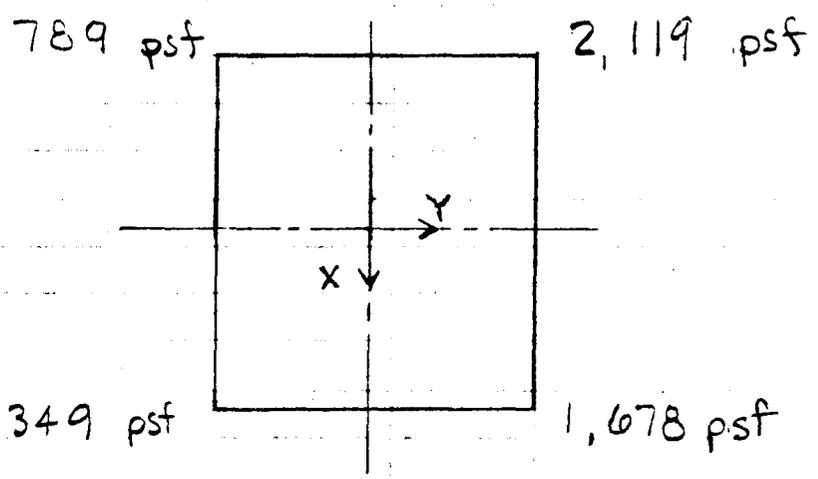
BEARING PRESSURES

$$\frac{P}{A} \pm \frac{Pe_y}{S_y} \pm \frac{Pe_x}{S_y}$$

NOTE: INLET FOOTPRINT WAS NOT USED IN COMPUTING BRG. PRESSURES.

$$\frac{341,534}{15.667(17.667)} \pm \frac{341,534(1.407)6}{17.667(15.667)^2} \pm \frac{341,534(0.526)(6)}{15.667(17.667)^2}$$

$$= 1,233.92 \text{ psf} \pm 664.83 \text{ psf} \pm 220.42 \text{ psf}$$



ALSO SEE SHT. PS 20

REVISED 19 OCT. 88

STABILITY (Y)

LOAD CASE II 100YR. FLOOD CONDITIONS

| UNIT                     | FORCE                       | ARM          | MOMENT                           |
|--------------------------|-----------------------------|--------------|----------------------------------|
| DEAD LOAD OF STRUCTURE ↓ | 343,578                     | 6.899        | 2,370,423                        |
| WIND →                   | 2,000                       | 27.495       | 54,990                           |
| RIVER FLOW →             | 9,803                       | 18.733       | 183,640                          |
| EARTH - ACTIVE →         | 16,249                      | 3.667        | 59,585                           |
| - PASSIVE ←              | - 28,052                    | 1.777        | - 49,848                         |
| PUMPS & PIPING ↓         | 12,009                      | 6.800        | 81,661                           |
| LIVE LOAD ↓              | 10,342                      | 6.833        | 70,667                           |
| INLET ↓                  | 40,500                      | 18.556       | 751,514                          |
| WATER ↓                  | 343,898                     |              | 3,185,252                        |
| EARTH ON BASE PROJ ↓     | 18,450                      |              | 87,798                           |
| UPLIFT ↑                 | - 486,697                   |              | - 4,355,878                      |
|                          | <b>282,080</b> <sup>#</sup> | <b>8.649</b> | <b>2,439,804</b> <sup>FT-#</sup> |

$$e_y = 8.649 - \frac{13.667}{2} = 1.816 \text{ FT} < \frac{13.667}{6} = 2.278 \text{ FT}$$

|             |                                 |            |            |
|-------------|---------------------------------|------------|------------|
| Subject     | ANDALUSIA SLOUGH - PUMP STATION | Date       | 20 JUN 88  |
| Computed by | KEW                             | Checked by | ctj        |
|             |                                 | Sheet      | of<br>PS18 |

REVISED 19 OCT. 88

STABILITY (X)

LOAD CASE II 100 YR. FLOOD CONDITIONS

| UNIT                          |   | FORCE     | ARM    | MOMENT         |
|-------------------------------|---|-----------|--------|----------------|
| DEAD LOAD OF STRUCTURE        | ↓ | 343,578 # | 7.536  | 2,589,070 FT-# |
| WIND (NOT IN CONJ. w/ Y WIND) | → | —         | —      | —              |
| PUMPS & PIPING                | ↓ | 12,009    | 11.957 | 143,590        |
| LIVE LOAD                     | ↓ | 10,342    |        | 51,710         |
| INLET                         | ↓ | 40,500    |        | 162,000        |
| WATER                         | ↓ | 343,898   |        | 2,420,923      |
| EARTH ON BASE PROJ.           | ↓ | 18,450    |        | 154,974        |
| UPLIFT                        | ↑ | -486,697  |        | -3,478,597     |
|                               |   | 282,080 # | 7.245  | 2,043,670 FT-# |

$$e_x = 7.245 - \frac{15.667}{2} = -0.589 \text{ FT} < \frac{15.667}{6} = 2.611 \text{ FT}$$

REVISED 19 OCT. 88

STABILITY

LOAD CASE II 100 YR. FLOOD CONDITIONS

BEARING PRESSURES

$$\frac{P}{A} + \frac{P_{ey}}{S_y} + \frac{P_{ex}}{S_x}$$

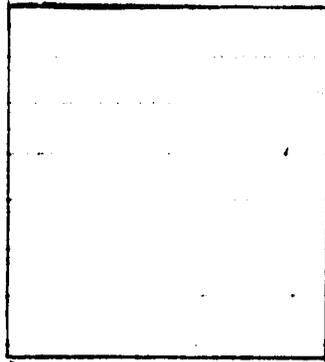
NOTE: INLET FOOTPRINT WAS NOT USED IN COMPUTING BRG. PRESSURES.

$$= \frac{282,080}{(15.667)(17.667)} + \frac{282,080(1.816)(6)}{17.667(15.667)^2} + \frac{282,080(-0.589)(6)}{15.667(17.667)^2}$$

$$= 1,019.12 \text{ psf} \pm 708.77 \text{ psf} \mp 203.86 \text{ psf}$$

514 psf

1,931.75 psf



106 psf

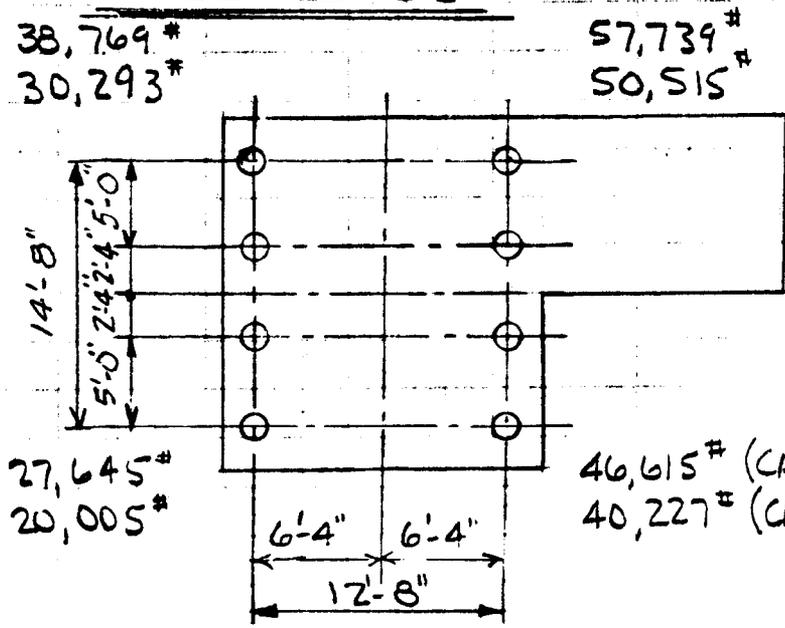
1,524 psf

ALSO SEE SHT. PS 20

REVISED 19 OCT. 80

STABILITY

PILE LOADS



$$A = 8$$

$$I_y = 8(6.333)^2 = 320.85$$

$$I_x = 4(7.333)^2 + 4(2.333)^2 = 236.86$$

LOAD CASE I NORMAL CONDITIONS

$$\frac{P}{A} \pm \frac{P e_y C_y}{I_y} \pm \frac{P e_x C_x}{I_x}$$

$$= \frac{341,534}{8} \pm \frac{341,534(1.407)(6.333)}{320.85} \pm \frac{341,534(-0.526)(7.333)}{236.86}$$

$$= 42,692 \pm 9,485 \mp 5,562 = 46,615^\# ; 57,739^\# ; 27,645^\# ; 38,769^\#$$

LOAD CASE II 100 YR. FLOOD CONDITIONS

$$= \frac{282,080}{8} \pm \frac{282,080(1.816)(6.333)}{320.85} \pm \frac{282,080(-0.589)(7.333)}{236.86}$$

$$= 35,260 \pm 10,111 \mp 5,144 = 40,227^\# ; 50,515^\# ; 20,005^\# ; 30,293^\#$$

STABILITY

CHECK SLIDING

CASE I (NORMAL)

|                |          |
|----------------|----------|
| WIND           | 5,460 #  |
| EARTH - ACTIVE | 24,462   |
|                | 29,922 # |

|                 |          |
|-----------------|----------|
| EARTH - PASSIVE | 38,172 # |
| PILES 8 (1500)  | 12,000   |
|                 | 50,172 # |

$$F.S. = \frac{50,172}{29,922} = 1.68$$

CASE II - (100 YR.)

|                |          |
|----------------|----------|
| WIND           | 2,000 #  |
| RIVER FLOW     | 9,803    |
| EARTH - ACTIVE | 16,249   |
|                | 28,052 # |

|                 |          |
|-----------------|----------|
| EARTH - PASSIVE | 38,172 # |
| PILES 8 (1500)  | 12,000   |
|                 | 50,172 # |

$$F.S. = \frac{50,172}{28,052} = 1.79$$

BATTER RIVERWARD PILES

Subject

W.M. USIA SLOUGH - PUMP STATION

Date

22 SEP. 80

Computed by

KEV

Checked by

ch

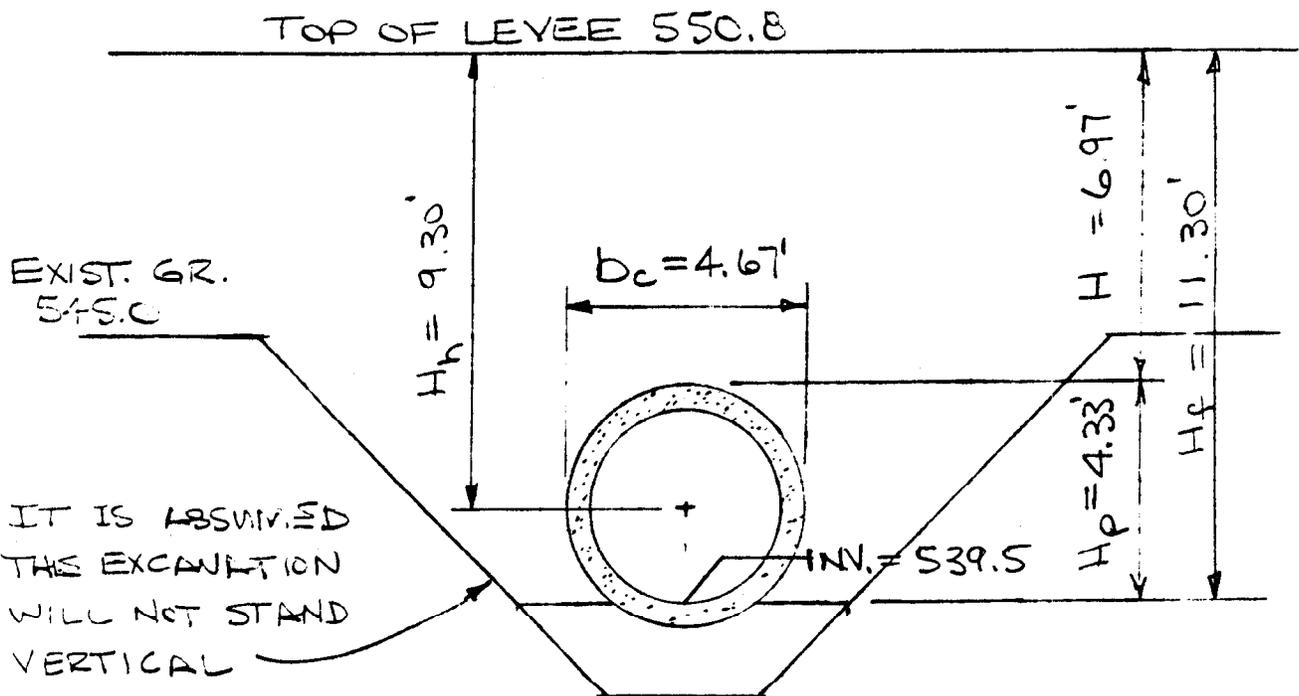
Sheet

PS 21 of

PIPE DESIGN AND SUPPORT

REF. (A) CONDUITS, CULVERTS AND PIPES,  
EM 1110-2-2902, 3 MAR. 1969

(B) CRETEX CONCRETE PRODUCT CAT. 1972



SECTION THRU PIPE AT PUMP STATION.

LOAD CONDITION III

- REF. (A)

CASE I.

$W_e = 1.5 \gamma b_c H_n$

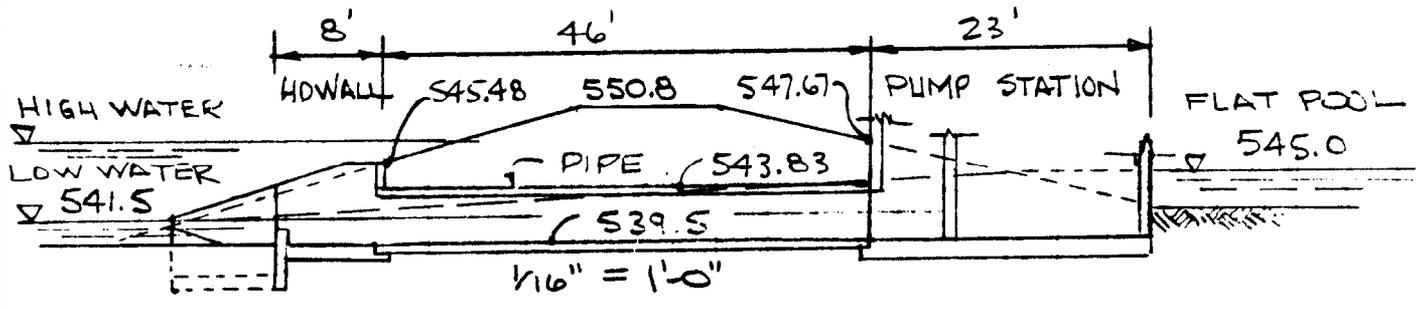
$p_e = 0.5 \gamma H$

CASE II.

$W_e = \gamma L_c H_n$

$p_e = \gamma H$

PIPE DESIGN AND SUPPORT



EARTH LOAD

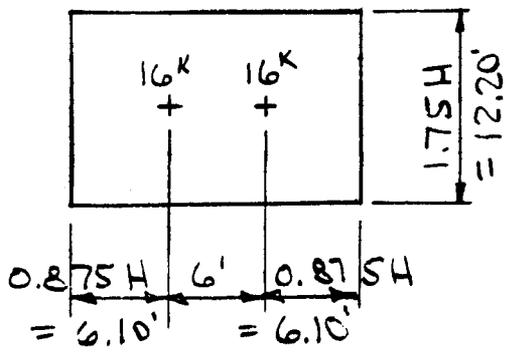
$$W_{e_{MAX.}} = 1.5 (0.115) (4.67) (9.30) = 7.492 \text{ KLF}$$

OR

$$W_{e_{MIN.}} = 0.115 (4.67) (3.98) = 2.137 \text{ KLF}$$

LIVE LOAD

H2O TRUCK = 16.0<sup>k</sup> POINT LOAD AT 6' x 14' SPC'G.



$$W_{LL} = \frac{2(16.0)}{12.20 (18.20)} = 0.144 \text{ KSF}$$

$$W_{LL} = W_{LL}(bc) = 0.144 (4.67) = 0.672 \text{ KLF}$$

PIPE DESIGN AND SUPPORT

WATER LOAD

LOW WATER CONDITION (MAX. LOAD)

- A. PIPE HALF FULL OF WATER.
- B. WATER OUTSIDE OF PIPE IS APPROX. LT. TOP OF PIPE AT PUMP STATION AND 1'-0" BELOW TOP OF PIPE AT HEAD WALL

$$W_{H_2O} = \pi \frac{(2.0)^2}{2} (0.0624) = 0.392 \text{ KLF}$$

$$W_{BOUY} = 0.0624 b_c H_w = 0.0624 (4.67) (4.67 - 0.50)$$

$$= 1.215 \text{ KLF}$$

DEWATERED CONDITION (MIN. LOAD)

- A. PIPE EMPTY
- B. WATER OUTSIDE OF PIPE AT 545.0 FOR LENGTH OF PIPE

$$W_{BOUY} = 0.0624 b_c (545.0 - 539.17) = 0.0624 (4.67) (5.83)$$

$$= 1.699 \text{ KLF}$$

PIPE DESIGN AND SUPPORT

TOTAL LOADS

| <u>LOAD</u>                  | <u>MAXIMUM</u> | <u>MINIMUM</u> |
|------------------------------|----------------|----------------|
| EARTH                        | 7.492 KLF      | 2.137 KLF      |
| LIVE                         | <u>0.672</u>   | —              |
| PIPE WT.                     | 8.164 KLF      | —              |
| 0.145 FT $[2.33^2 - 2.00^2]$ | 0.651          | 0.651          |
| WATER                        | <u>0.392</u>   | —              |
|                              | 9.207 KLF      | 2.788 KLF      |
| BOUYANCY                     | <u>-1.215</u>  | <u>-1.699</u>  |
|                              | 7.992 KLF      | 1.089 KLF      |

CHECK F.S. AGAINST UPLIFT

F.S. =  $\frac{2.788}{1.699} = 1.64 > 1.50$  OKAY FULL TENSION

SELECT CLASS OF ASTM PIPE (REF. (B))

$$D_{.01} = \left( \frac{W_E}{L_{fE}} + \frac{W_L}{L_{fL}} \right) \frac{S_{f0.1}}{D}$$

GIVEN:

PIPE SIZE = 48" ( $b_c = 4.67'$ )

BEDDING CLASS = A OR C

PROJECTION RATIO = 0.90 CLASS A  
 = 0.90 or 0.70 CLASS C

SETTLEMENT RATIO = 1.00 CLASS A  
 0.30 CLASS C

PIPE DESIGN AND SUPPORT

GIVEN: (CONT.)

SAFETY FACTOR = 1.00 (0.01" CRACK)

FIND LOAD FACTOR FROM PAGE Q-25

$$\frac{H}{b_c} = \frac{6.97}{4.67} = 1.493 \quad \text{SAY } 1.50$$

|           |                       |          |          |                    |
|-----------|-----------------------|----------|----------|--------------------|
| CLASS "A" | L <sub>f</sub> = 4.49 | P = 0.9  | P = 0.70 | <u>USE</u><br>4.00 |
| CLASS "C" | L <sub>f</sub> = 2.16 | P = 1.99 |          | 2.00               |

FIND PIPE CLASS FOR "A" OR "C" BEDDING

CLASS "A" BEDDING

$$D_{.01} = \frac{8.164}{4.00} \frac{(1.0)}{(4.0)} = 0.510^k = 510^{\#}$$

CLASS 1 PIPE D-LOAD = 800<sup>#</sup>

CLASS "C" BEDDING

$$D_{.01} = \frac{8.164}{2.00} \frac{(1.0)}{(4.0)} = 1.020^k = 1,020^{\#}$$

CLASS 3 PIPE D-LOAD = 1350<sup>#</sup>

|   |                |                           |
|---|----------------|---------------------------|
| Subject ANCA_USIA SLOUGH - PUMP STATION |                | Date 26 SEPT 83           |
| Computed by KEW                         | Checked by chJ | Sheet PS 26 <sup>01</sup> |

## PIPE DESIGN AND SUPPORT

NOTE: CLASS "A" BEDDING WAS USED FOR PIPE SUPPORTED ON PILES.

THE SOILS ARE SUCH THAT THE PUMP STATION SHOULD BE SUPPORTED ON PILES. IN ORDER TO CONTROL DIFFERENTIAL SETTLEMENT BETWEEN THE PIPE AND PUMP STATION THE PIPE IS ALSO SUPPORTED ON PILES. SEE SHEET PF-5.

Subject **ANDALUSIA SLOUGH - PUMP STA. HEADWALL**

Date **24 JUNE 88**

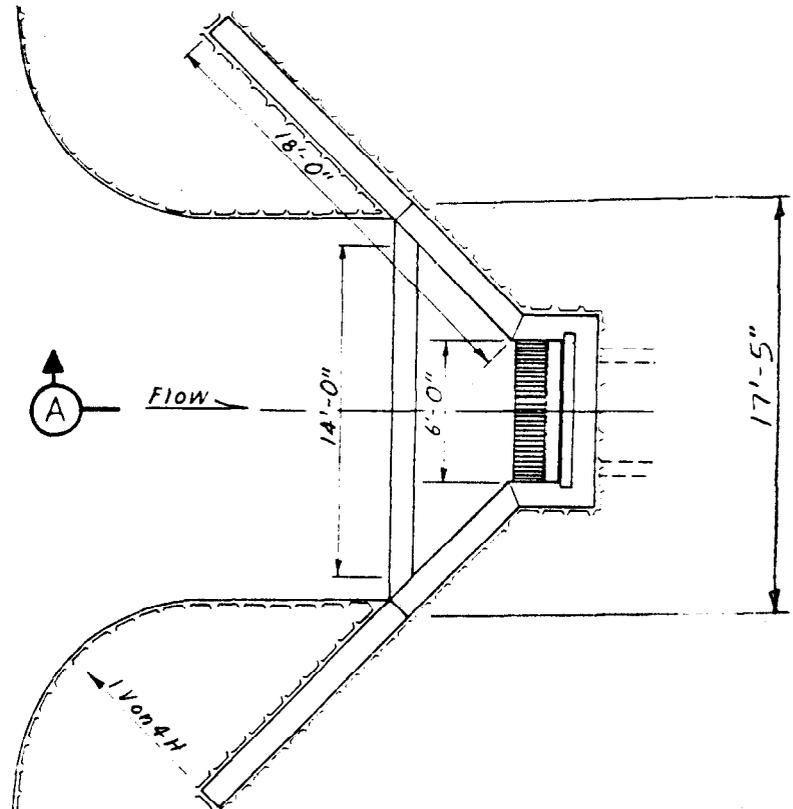
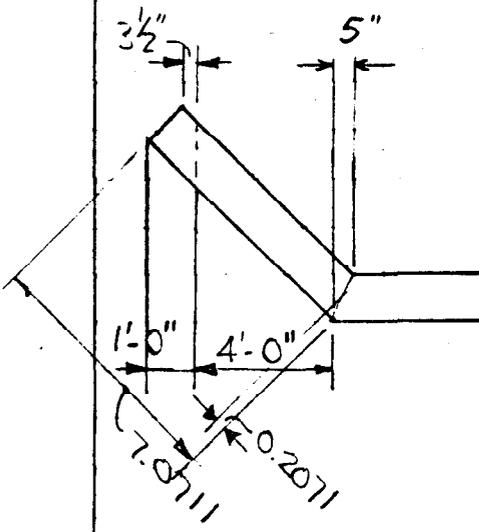
Computed by **KEW**

Checked by **CHU**

Sheet **HV. 1** of

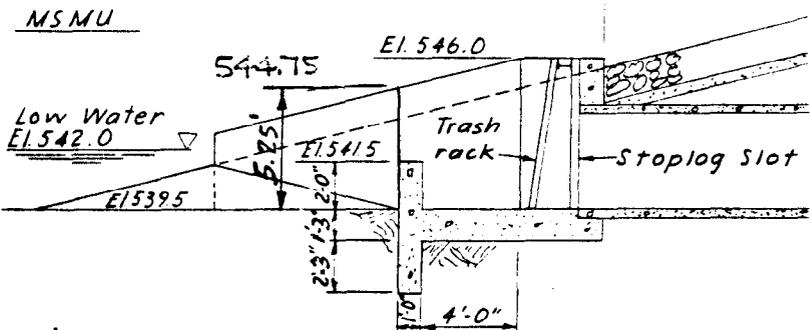
STABILITY

HEADWALL CNTR

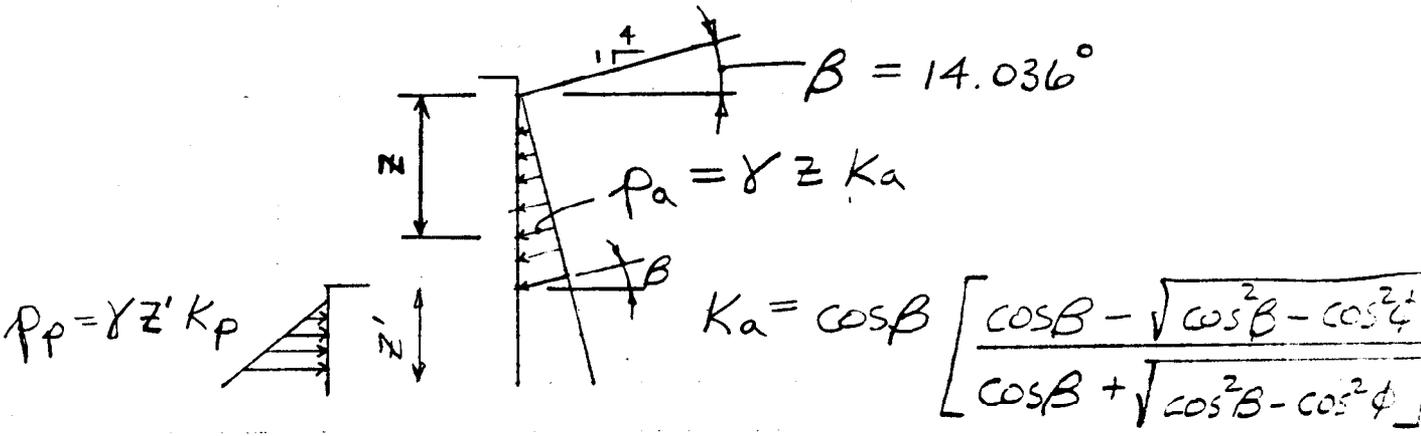


BACKFILL MAT'L.

$\gamma_{DAMP} = 115 \text{ pcf}$   
 $c = 0$   
 $\phi = 32^\circ$



STABILITY HEADWALL CTR.



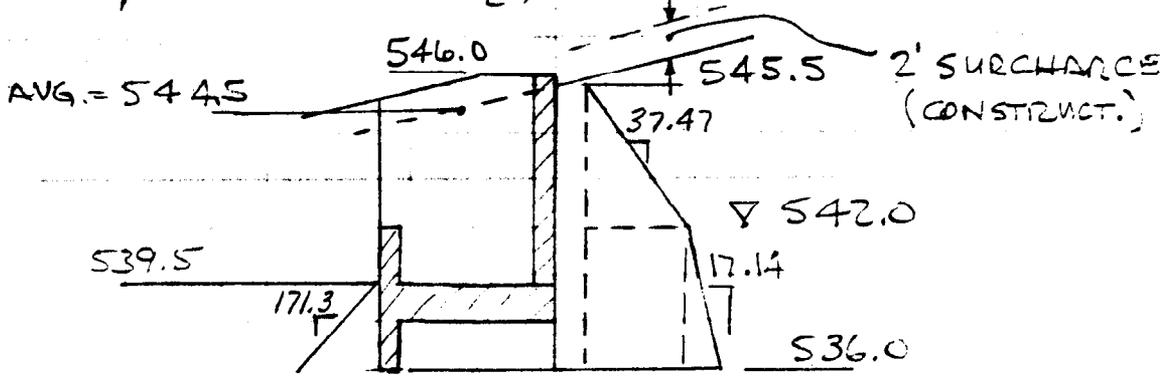
$$K_a = 0.97014 \left[ \frac{0.97014 - \sqrt{(0.97014)^2 - (0.84805)^2}}{0.97014 + \sqrt{(0.97014)^2 - (0.84805)^2}} \right]$$

$$= 0.97014 \frac{(0.97014 - 0.47115)}{(0.97014 + 0.47115)} = 0.97014 \frac{0.49899}{1.44129}$$

$$= 0.33587$$

$$K_{aH} = 0.97014 (0.33587) = 0.32584$$

$$K_p = \tan^2 \left( 45 + \frac{\phi}{2} \right) = \tan^2 (61) = 3.255$$



Subject **ANDALUSIA SLOUGH - PUMP STA. HEADWALL** Date **24 JUNE 80**

Computed by **KEY**

Checked by **CH**

Sheet **11.3** of **11.3**

STABILITY HEADWALL CRT.

| UNIT                                      | FORCE    | ARM    | MOMENT      |
|---|----------|--------|-------------|
| WALLS $1.00 (150) (8.0) (6.5)$            | 7,800    | 0.50   | 3,900       |
| $-1.00 (150) (\pi) (4.0)^2 \div 4$        | - 1,884  | 0.50   | - 942       |
| $1.00 (150) (2.29) (6.5) 2$               | 4,466    | 2.145  | 9,580       |
| $1.00 (150) (15.00) (5.5)$                | 12,375   | 8.00   | 99,000      |
| $1.00 (150) (6.86) (5.25) 2$              | 10,805   | 6.00   | 64,830      |
| $1.00 (150) (6.86) (1.25) 2$              | 1,286    | 5.167  | 6,645       |
| BASE $1.25 (150) (8.0) (7.5)$             | 11,250   | 3.75   | 42,188      |
| $1.25 (150) (4.4167) (4.4167) 2$          | 3,658    | 6.028  | 22,043      |
| WATER $2.50 (62.4) (6.00) (7.5)$          | 7,020    | 3.750  | 26,325      |
| $2.50 (62.4) (4.00) (4.00) 2$             | 2,496    | 6.1667 | 15,392      |
| $0.50 (62.4) (1.00) (15.0)$               | 468      | 8.00   | 3,744       |
| UPLIFT $-3.75 (62.4) (8.00) (7.5)$        | - 14,040 | 3.750  | - 52,650    |
| $-3.75 (62.4) (4.4167) (4.4167) 2$        | - 4,565  | 6.028  | - 27,518    |
| $-6.00 (62.4) (1.00) (16.5)$              | - 6,178  | 8.00   | - 49,424    |
|   | # 34,957 | 4.6653 | FT# 163,118 |
| EARTH LOADS (NORMAL) (SHT. HWZ)<br>ACTIVE |          |        |             |
| $37.47 (2.0) (9.50) (8.00)$               | 5,695    | 4.75   | 27,051      |
| $37.47 (2.0) (8.50) (17.4142 - 8.0)$      | 5,097    | 4.25   | 25,487      |
| $37.47 (3.5) (3.5) (8.00) 2$              | 1,836    | 7.167  | 13,159      |
| $37.47 (2.5) (2.5) (17.4142 - 8.0) 2$     | 1,102    | 6.833  | 7,530       |
| $37.47 (3.5) (6.0) (8.00)$                | 6,295    | 3.00   | 18,885      |

Subject **ANDALUSIA SLOUGH - PUMP STA. HEADWALL** Date **24 JUNE 88**

Computed by **KEW**

Checked by **chJ**

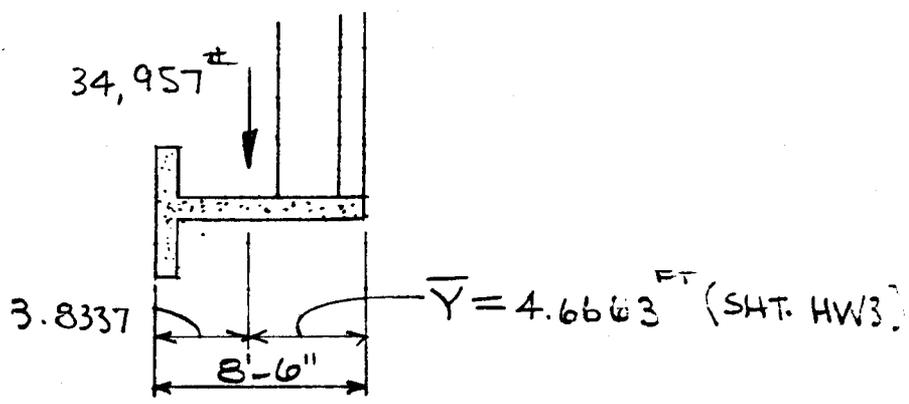
Sheet **HW 4** of

STABILITY HEADWALL CNTR.

| UNIT                                      | FORCE                     | ARM    | MOMENT                       |
|---|---------------------------|--------|------------------------------|
| ACTIVE (CONT.)                            |                           |        |                              |
| 37.47 (2.50)(6.00)(17.4142-8.0)           | 5,291                     | 3.00   | 15,873                       |
| 17.14 (6.00)( $\frac{6.00}{2}$ )(17.4142) | 5,373                     | 2.00   | 10,746                       |
| - 37.47 (5.50)( $\pi$ )(2.5) <sup>2</sup> | -4,046                    | 6.00   | - 24,276                     |
|   | <b>27,543<sup>#</sup></b> |        | <b>94,455<sup>FT-#</sup></b> |
| PASSIVE                                   |                           |        |                              |
| 171.3 (3.50)( $\frac{3.50}{2}$ )(17.4142) | -18,271                   | 1.1667 | - 21,317 <sup>FT-#</sup>     |

CHECK OVERTURNING F.S.

30 JUNE 88



$$M_R = 34,957 (3.8337) + M_{PASSIVE}$$

$$= 134,016 + 21,317 = 155,333 \text{ FT-#}$$

$$M_o = M_{ACTIVE} = 94,455 \text{ FT-#}$$

$$F.S. = \frac{M_R}{M_o} = \frac{155,333}{94,455} = 1.64 > 1.50 \text{ OKAY}$$

|             |                                       |            |            |
|-------------|---------------------------------------|------------|------------|
| Subject     | ANDALUSIA SLOUGH - PUMP STA. HEADWALL | Date       | 30 JUNE 88 |
| Computed by | KEN                                   | Checked by | CHV        |
|             |                                       | Sheet      | HW.5 of    |

STABILITY - HEADWALL CNTR.

CHECK SLIDING

$$P_{ACTIVE} = 27,543 \#$$

$$P_{PASSIVE} + \mu P_{VERT} = 18,271 + 0.30(34,957)$$

$$= 28,758 \#$$

$$F.S. = \frac{28,758}{27,543} = 1.05 < 1.5 \quad \text{NO GOOD}$$

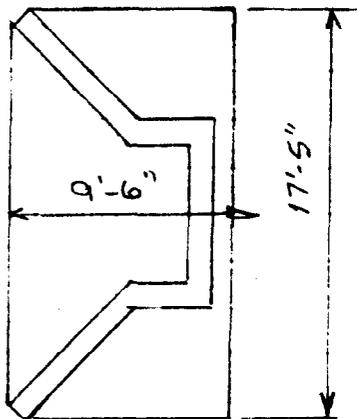
WITHOUT CONSTRUCTION SURCHARGE

$$P_{ACTIVE} = 27,543 - (5,695 + 5,997)$$

$$= 15,851 \#$$

$$F.S. = \frac{28,758}{15,851} = 1.82 < 2.0 \quad \text{NO GOOD}$$

INCREASE BASE TO INCREASE VERT LOAD



Subject **ANDALUSIA SLOUGH - PUMP STA. HEADWALL** Date **30 JUNE 88**

Computed by

Checked by *chl*

Sheet **HW 6** of

STABILITY HEADWALL CNTR.

RECOMPUTED LOADS

| UNIT                                      | FORCE        | ARM    | MOMENT        |
|---|--------------|--------|---------------|
| ADDED $1.25(150)(1.0)(17.4142)$           | 3,265        | -0.50  | - 1,633       |
| BASE $1.25(150)(2.4167)(17.4142-8.0)$     | 4,266        | 1.2084 | 5,155         |
| $1.25(150)(4.7071)(\frac{4.7071}{2})$     | 4,154        | 3.9857 | 16,557        |
| ADDED $6.0(115)(1.0)(17.4142)$            | 12,016       | -0.50  | - 6,008       |
| EARTH $-115(\pi)(2.5)^2(1.0)$             | - 2,258      | -0.50  | 1,129         |
| $5.6(115)(2.4167)(17.4142-8.0)$           | 14,652       | 1.2084 | 17,705        |
| $4.8(115)(4.7071)(\frac{4.7071}{2})$      | 12,231       | 3.9857 | 48,749        |
| ADDED $-37.5(62.4)(1.0)(17.4142)$         | - 4,075      | -0.50  | 2,038         |
| UPLIFT $-37.5(62.4)(2.4167)(17.4142-8.0)$ | - 5,324      | 1.2084 | - 6,434       |
| $-37.5(62.4)(4.7071)(\frac{4.7071}{2})$   | - 5,185      | 3.9857 | - 20,666      |
| PREVIOUS VERT. LOADS                      | 34,957       | 4.6663 | 163,118       |
|   | $\pm$ 68,699 | 3.1982 | $\pm$ 219,710 |
| EARTH LOADS                               |              |        |               |
| ACTIVE                                    |              |        |               |
| $37.47(2.0)(9.75)(17.4142)$               | 12,724       | 4.875  | 62,030        |
| $37.47(3.75)(\frac{3.75}{2})(17.4142)$    | 4,588        | 7.250  | 33,263        |
| $37.47(3.75)(6.00)(17.4142)$              | 14,681       | 3.00   | 44,043        |
| $17.14(6.00)(\frac{6.00}{2})(17.4142)$    | 5,373        | 2.00   | 10,746        |
| $-37.47(5.75)(\pi)(2.5)^2$                | - 4,230      | 6.00   | - 25,380      |
|   | $\pm$ 33,136 |        | $\pm$ 124,702 |
| PASSIVE (SEE SHT. HW 4)                   | - 18,271     | 1.1667 | - 21,317      |

STABILITY - HELENVILLE CNTR

RE-CHECK SLIDING

$$P_{ACTIVE} = 33,136 \#$$

$$P_{PASSIVE} + u P_{VERT} = 18,271 + 0.30(68,699) = 38,881 \#$$

$$F.S. = \frac{38,881}{33,136} = 1.17 < 1.50 \quad \text{NO GOOD}$$

WITHOUT CONSTRUCTION SURCHARGE

$$P_{ACTIVE} = 33,136 - 12,724 = 20,412 \#$$

$$F.S. = \frac{38,881}{20,412} = 1.90 < 2.00 \quad \text{ALMOST GOOD ENOUGH}$$

CHECK BEARING PRESSURES

$$P_v = 68,699 \# \quad \Sigma M = 323,095 \text{ FT-}\#$$

$$\bar{Y} = 4.703 \text{ FT}$$

$$e = 4.703 + 1.00 - \frac{9.50}{2} = 0.953 \text{ FT} < \frac{9.5}{2}$$

STABILITY - HEADWALL CNTR.

$$\frac{P}{A} + \frac{M_{ey}}{S_y} = \frac{68,699}{9.5(17.4142)} + \frac{68,699(0.953' / 6)}{(9.5)^2(17.4142)}$$

$$= 415.3 \pm 249.9 = 665.2 \text{ psf}$$

OR  
165.4 psf

NOTE: ALTHOUGH BEARING APPEARS TO BE NO PROBLEM, SLIDING IS. PROVIDING TIE RODS BETWEEN THE PUMP STATION AND THE HEADWALL CNTR. WILL PREVENT SLIDING.

$$F = \frac{33,136}{2} = 16,568 \text{ \# / ROD}$$

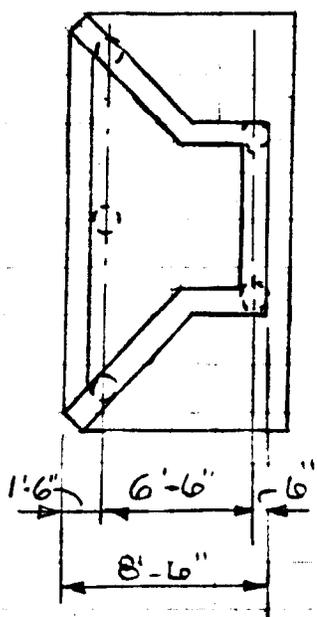
PROVIDE 2 - 1"  $\phi$  A572, GR.50 RODS W/ TURNBUCKLES

USED  
BATTERED  
PILES

CONSIDER PILE FOUNDATION WITH BATTERED (4:1) FRONT PILES

STABILITY - HEADWALL CONTR.

PILE LOADS - 5 PILES



$$A = 5$$

$$C = \frac{2(0) + 3(6.5)}{5}$$

$$= 3.90 \text{ FT}$$

$$I = 2(3.90)^2 + 3(2.6)^2$$

$$= 30.42 + 20.28$$

$$= 50.70 \text{ FT}^2$$

$$e = \bar{Y} - C = 4.703 - 3.90$$

$$= 0.803 \text{ FT}$$

$$\frac{P}{A} + \frac{P_e C}{I} = \frac{68,699}{5} + \frac{68,699 (0.803)(2.6 \text{ OR } 3.9)}{50.70}$$

$$= 13,740 + 2,829 = 16,569 \#$$

$$- 4,244 \quad \text{OR} \quad 9,496 \#$$

PILE LOADS - 3 PILES

$$A = 3 \quad C = \frac{1(0) + 2(6.5)}{3} = 4.333 \text{ FT}$$

Subject ANDALUSIA SLOUGH-PUMF STR. HEADWALL

Date 30 JUNE 88

Computed by KEH

Checked by d.j.

Sheet HW/C

STABILITY - HEADWALL CNTR.

$$I = 1(4.333)^2 + 2(2.167)^2$$

$$= 18.77 + 9.39 = 28.16 \text{ Ft}^2$$

$$e = \bar{Y} - c = 4.703 - 4.333 = 0.370 \text{ Ft}$$

$$\frac{P}{A} + \frac{Pec}{I} = \frac{68,699}{3} + \frac{68,699(0.370)(2.167 \text{ or } 4.333)}{28.16}$$

$$= 22,900 + 1,956 = 24,856 \text{ \#}$$

$$- 3,911$$

$$18,945 \text{ \#}$$

PILE FOUNDATION DESIGN

REF: ① FOUNDATION DESIGN, WAYNE C. TENG, 1962

② FOUNDATIONS & EARTH STRUCTURES, NAVFAC DM-72, MAY 1982

PUMP STATION (SEE SHT. PS-20)

PILE LOAD = 57,739# = 28.87 TON (RIVER SIDE R/L)

FOR BATTERED PILE (4:1),  $P = 1.031 (28.87)$   
 $= 29.76 \text{ TON}$

FROM BORING A-88-2

a.) PILES DRIVEN INTO MEDIUM TO FINE SAND WITH BLOW COUNT OF 8 BLOWS/FT

b.) DEPTH OF BORING IS ONLY 16<sup>FT</sup> BELOW BOTTOM OF PUMP STATION

$\phi = 35^\circ$  ;  $\gamma = 115 \text{ pcf}$  REF. ①, page 12

$N_q = 40$  ;  $N_\gamma = 45$  REF. ①, page 58

$$Q_{ULT} = \pi R_T^2 (\gamma D N_q + 0.6 \gamma R_T N_\gamma)$$

$$+ 2\pi R_A L (\gamma Z + q_u) K \tan \phi \quad \text{REF. ① } E_q (8-1) + E_q (8-2)$$

pg. 212 & 213

PILE FOUNDATION DESIGN

- WHERE :
- $R_T$  = RADIUS OF PILE TIP
  - $R_A$  = AVG. RADIUS OF PILE
  - $\gamma$  = UNIT WEIGHT OF SOIL (BOUYANT WT.)
  - $D$  = TOTAL PENETRATION OF PILE
  - $L$  = LENGTH OF PENETRATION INTO GRANULAR SOIL.
  - $Z$  = DEPTH OF CENTER OF GRAVITY OF EMBEDDED PORTION OF PILE.
  - $Q$  = PERMANENT SURCHARGE LOAD.
  - $K$  = COEFFICIENT OF LATERAL EARTH PRESSURE (ASSUME 1.25) REF. ②,

pg 7.2-194

- ASSUME
- 40<sup>FT</sup> PENETRATION INTO GRANULAR SOIL
  - 47.5<sup>FT</sup> TOTAL PENETRATION (50<sup>FT</sup> PILE)
  - 44" BUTT CIRCUM. 7.00 RADIUS
  - 22" TIP CIRCUM. 3.50 RADIUS
  - 33" AVG. CIRCUM. 5.25 RADIUS

$$\begin{aligned}
 Q_{ULT_s} &= \pi \left( \frac{3.50}{144} \right)^2 \left[ \left( 115 - 62.5 \right) (40) + 0.6 \left( 115 - 62.5 \right) \left( \frac{3.50}{12} \right) (45) \right] \\
 &\quad + 2\pi \left( \frac{5.25}{12} \right) (40) \left[ \left( 115 - 62.5 \right) \left( \frac{40}{2} + 7.5 \right) \right] (1.25) (\tan 35) \\
 &= 672 + 138,945 = 139,617\#
 \end{aligned}$$

CALCULATE REDUCTION DUE TO GROUP ACTION

NOTE: SEE PS-20, PILES ARE FAR ENOUGH APART IN ONE DIRECTION (7 DIAM) TO BE CONSIDERED

A SINGLE ROW GROUP. REF. ② pg 7.2-204

PILE FOUNDATION DESIGN

REF. (3) DESIGN OF PILE FOUNDATIONS AND STRUCTURES, EM 1110-2-2906

$$F = 1 - \left( 2 - \frac{1}{n} - \frac{1}{m} \right) \frac{\theta}{90} \quad \text{REF. (3), pg. 11}$$

WHERE F = EFFICIENCY FACTOR OF A PILE IN A GROUP

n = NUMBER OF PILE IN A ROW

m = NUMBER OF ROWS

$$\theta = \tan^{-1} \frac{d}{s}$$

d = PILE DIAM.

s = PILE SPACING

$$F = 1 - \left( 2 - \frac{1}{4} - \frac{1}{1} \right) \frac{\tan^{-1} \left( \frac{10.50}{12} / 4.667 \right)}{90}$$

$$= 0.9115$$

$$\therefore Q_{ULTG} = 139,617 (0.9115) = 127,262 = 63.63 \text{ \# TON}$$

ASSUME  $\epsilon_{TON}$  NEG FRICTION DUE TO DRIVING OF ADJACENT PILES

ALSO ASSUME F.S. = 2.0

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULT_s}}{F.S.} - S.W. = \frac{63.63}{2.0} - 5.00$$

$$= 26.82^{TON} < 29.76^{TON} \text{ REQ'D}$$

11.0% UNDER DESIGNED

CONSIDERED OKAY BECAUSE THE PILE BEING CONSIDERED IS THE LAST ONE IN THE ROW AND THE ONE WITH THE MAX. MOM. ALSO OVERTURNING IN THE TRANSVERSE DIRECTION WILL BE RESISTED BY EARTH.

PILE LOAD =  $38,769^{\#} = 19.38^{TON}$  (LANDSIDE RCH.)

ASSUME 35<sup>FT</sup> PENETRATION INTO GRANULAR SOIL (45<sup>FT</sup> PILE / 44" BUTT & 24" T.F.)

$$Q_{ULT_s} = \pi \left( \frac{3.82}{12} \right)^2 \left[ (115 - 62.5)(40) + 0.6(115 - 52.5) \left( \frac{3.82}{12} \right)(40) \right]$$

$$+ 2\pi \left( \frac{5.41}{12} \right) (35) \left[ (115 - 62.5) \left( \frac{35 + 7.5}{2} \right) \right] (1.25)(\text{Eq. 35})$$

$$= 812 + 113,894 = 114,706^{\#}$$

$$Q_{ULT_g} = 114,706 (0.9115) = 104,554^{\#} = 52.28^{TON}$$

|             |                                 |            |             |
|-------------|---------------------------------|------------|-------------|
| Subject     | ANCALUSIA SLOUGH - PUMP STATION | Date       | 20 SEPT. 88 |
| Computed by | KEW                             | Checked by | clv         |
|             |                                 | Sheet      | PF-5 of     |

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULTG}}{F.S.} - 5.00 = \frac{52.28}{2.0} - 5.00$$

$$= 21.14 \text{ TON} > 19.38 \text{ TON}$$

PIPE SUPPORT (SEE SH. PS 24)

PILE LOAD = 7,992 (3.5) = 27,972 OR 13.99 TON

NOTE: 30 FT PENETRATION (40 PILE) SHOULD PROVIDE ENOUGH SUPPORT

HEADWALL (SEE SH. HW10)

PILE LOAD = 24,856# = 12.43 TON

FOR BATTERED PILE (4:1), P = 1.031 (12.43)

$$= 12.82 \text{ TON}$$

ASSUME 25 FT PENETRATION INTO GRANULAR SOIL (30 FT PILE / 44" BUTT @ 27" TH)

$$Q_{ULTS} \approx 963 + 2\pi \left( \frac{5.65}{12} \times 25 \right) \left[ \frac{(115 - 62.5)(25 + 7.5)}{2} \right] (125) (1.33)$$

$$= 963 + 67,969 = 68,932# \text{ OR } 34.46 \text{ TON}$$

|   |                |                  |
|---|----------------|------------------|
| Subject ANDALUSIA SLOUGH - PUMP STATION |                | Date 20 SEPT. 89 |
| Computed by KEV.                        | Checked by c/h | Sheet PF-6 of    |

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULT}}{F.S.} - 5.00 = \frac{34.46}{2} - 5.00$$

$$= 12.23 \text{ TON} \approx 12.82 \text{ TON}$$

4.8% UNDER DESIGN

Subject ANDALUSIA SLOUGH - PUMP STATION Date 4 MAY 80

Computed by KEW

Checked by chj

Sheet MISC. 1 of

TRASH RACK DESIGN

EM 1110-2-3104

DESIGN FOR DIFFERENTIAL HEAD OF 5 FT.  
DUE TO TRASH BUILD-UP.

EM 1110-2-3102

BAR SPACING 1 3/4" INCHES CLEAR (3" MAX. IF JUSTIFIED)

FLOW THRU GROSS RACK AREA  
≤ 2.5 FT/SEC.

PUMPING RATE = 10,000 GPM

$$= \frac{10,000}{7.48} = 1,337 \text{ CU. FT. / MIN.}$$

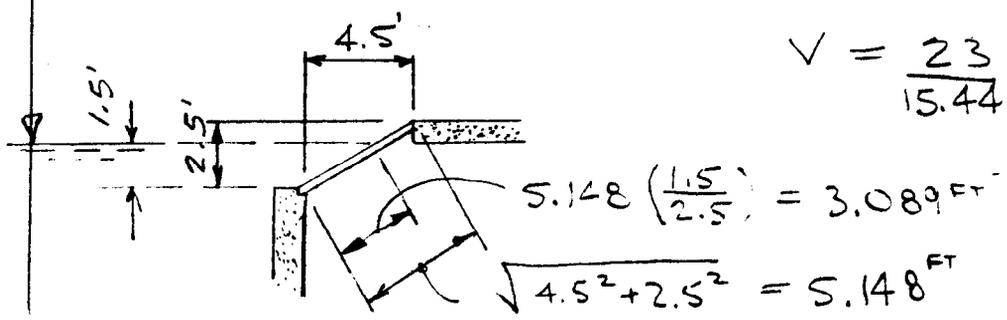
$$= \frac{1,337}{60} = 22.28 \text{ CU. FT. / SEC.}$$

RIVER SIDE TRASH RACK

WIDTH

$$A = 5.00 (3.083) = 15.42 \text{ FT}^2$$

$$V = \frac{22.28}{15.42} = 1.44 \text{ FT/SEC}$$



TRASH RACK DESIGN

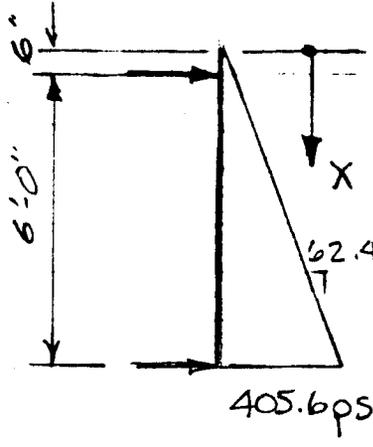
LANDSIDE TRASH RACK

$A = \overset{\text{WIDTH}}{6.00} (\overset{\text{H}_2\text{O DEPTH}}{2.00}) = 12.00 \text{ FT}^2$

$V = \frac{23}{12} = 1.92 \text{ FT/SEC.}$

6'-6" HEAD

$R_{\text{TOP}} = 405.6 \frac{(6.5)(6.5)(1)}{2 \cdot 3 \cdot 6.0} = 476.0 \text{ \#}$



$R_{\text{BOT.}} = 405.6 \frac{(6.5)}{2} \left[ \frac{2(6.5) - 0.5}{3} \right] \frac{(1)}{6.0} = 842.2 \text{ \#}$

$V = 0 = 476.0 - 62.4 \frac{(X)(X)}{2}$

$X = 3.906 \text{ FT.}$

$M = 476.0 (3.906 - 0.50) - 62.4 \frac{(3.906)^3}{6}$   
 $= 1,621.2 - 619.8 = 1,001.5 \text{ FT-# / FT}$   
 $= 12,017.8 \text{ IN-# / FT}$

ASSUME 2" BAR SPACING 3/8" BAR + 1 5/8" CLR.

$M = 2,003.0 \text{ IN-# / BAR}$

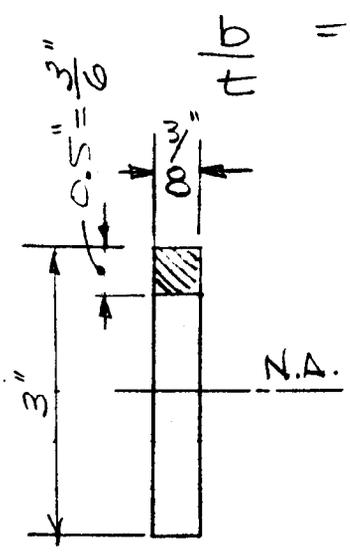
TRUSS RIB DESIGN

TRY 3" x 3/8" BAR

$$S = \frac{3}{8} \left( \frac{3.0}{6} \right)^2 = 0.5625 \text{ IN}^3$$

$$f_b = \frac{2,003.0}{0.5625} = 3,561 \text{ psi}$$

ASSUME BAR NETS AS STEM OF TEE



$$\frac{b}{t} = \frac{2.5}{0.375} = 6.67 < \frac{127}{\sqrt{F_y}} = 21$$

$$r_T = \sqrt{\frac{I}{A}} = \sqrt{\frac{0.5 \left( \frac{0.375}{12} \right)^3}{0.5 (0.375)}} = 0.10825 \text{ IN}$$

$$\frac{\lambda}{r_T} = \frac{8.5 (12)}{0.10825} = 942.2$$

AISC 1.5.1.4.5

$$\sqrt{\frac{510 \times 10^3}{F_y}} = 119.0 < \frac{\lambda}{r_T}; \therefore F_b = \text{LARGER OF BELOW!}$$

$$F_b = \frac{170 \times 10^3}{\left( \frac{\lambda}{r_T} \right)^2} = \frac{170 \times 10^3}{(942.2)^2} = 0.192 \text{ ksi}$$

|             |                                 |            |            |
|-------------|---------------------------------|------------|------------|
| Subject     | ANDALUSIA SLOUGH - PUMP STATION | Date       | 4 MAY 88   |
| Computed by | KEW                             | Checked by | chv        |
|             |                                 | Sheet      | MISC. 4 of |

TRASH RACK DESIGN

$$F_b = \frac{12,000}{\frac{Ld}{Af}} = \frac{12,000 (0.5)(0.375)}{8.5(12)(3.0)}$$

$$= 7.353 \text{ KSI} > f_b = 3.561 \text{ KSI}$$

BEARING BEAM

ASSUME 1,000 #/FT LOAD (NO GUIDE)

$$M = 1,000 \left( \frac{6.00}{8} \right)^2 = 4,500 \text{ FT/#}$$

$$S = \frac{4,500(12)}{24,000} = 2.25 \text{ IN}^2 \quad \text{USE W4 x 13}$$

$$S = 5.46 \text{ IN}^2$$

SIZE CONCRETE PIPE

1. ASSUME PIPE RUNS HALF-FULL
2. SIZE SO THAT VELOCITY IN THE PIPE IS LESS THEN 5.0 FT/SEC.

PUMPING RATE = 10,000 GPM

$$= \frac{10,000}{448.8} = 22.28 \text{ CU. FT./SEC.}$$

PIPE DIAM      VELOCITY

36"  $\frac{22.28}{\frac{\pi}{2} (1.5)^2} = 6.30 \text{ FT/SEC.}$

42"  $\frac{22.28}{\frac{\pi}{2} (1.75)^2} = 4.63 \text{ FT/SEC. OKAY}$

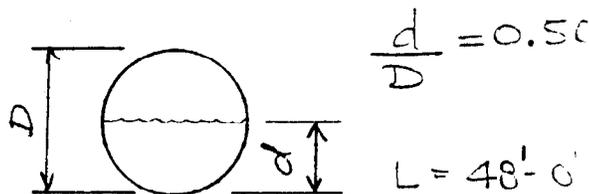
48"  $\frac{22.28}{\frac{\pi}{2} (2.0)^2} = 3.55 \text{ FT/SEC. ← USE}$

SLOPE OF PIPE

$$S = \left[ \frac{Qn}{0.232 D^{5/3}} \right]^2$$

$$= \left[ \frac{22.28(0.015)}{0.232 (4.0)^{2.667}} \right]^2 = (0.0357)^2 = 0.00128 \text{ FT/F}$$

= 0.737 IN TOTAL



NIL - DO NOT SLOPE PIPE

ROOF SLAB (SPAN = 8'-6")

|              |                     |                       |                 |
|--------------|---------------------|-----------------------|-----------------|
| <u>LOADS</u> |                     | CLR                   | $\frac{BAR}{2}$ |
| SLAB         | 50 psf              | $d = 4 - 0.75 - 0.25$ |                 |
| MISC         | $\frac{10}{60}$ psf |                       |                 |
|              |                     | = 3 IN                |                 |

SNOW 30 psf

ACI 318-83

$$W_u = 1.7(30) + 1.4(60) = 135 \text{ psf}$$

$$V_{ud} = 135 \left( \frac{8.5}{2} - \frac{3}{12} \right) = 540 \text{ \#}$$

$$M_u = 135 \left( \frac{8.5}{8} \right)^2 = 1,220 \text{ FT-\#}$$

BALANCED RATIO OF REINFORCEMENT

LET  $f_y = 48,000 \text{ psi}$  ;  $\beta_1 = 0.85$

ACI  
10.2.7.3

$f'_c = 3,000 \text{ psi}$

$$\frac{x_b}{d} = \frac{87,000}{87,000 + f_y} = \frac{87,000}{135,000} = 0.6444$$

$$\rho_b = 0.85 \frac{f'_c}{f_y} \beta_1 \frac{x_b}{d} = 0.85 \left( \frac{3.0}{48.0} \right) (0.85) (0.6444)$$

$$= 0.0291$$

$$0.75 \rho_b = 0.75 (0.0291) = 0.02183$$

ROOF SLAB

DETERMINE DEPTH OF SECTION

$$M_u = \phi \rho f_y b d_b^2 \left(1 - 0.59 \rho \frac{f_y}{f'_c}\right)$$

$$1.220(12) = 0.90 (0.02183)(48)(12)(d_b)^2 \left[1 - 0.59 (0.02183) \left(\frac{48}{3}\right)\right]$$

$$1.220(12) = 8.984 d_b^2$$

$$\therefore d_b = \sqrt{\frac{1.220(12)}{8.984}} = 1.28 \text{ IN} \quad \text{SAY } d = 3 \text{ IN}$$

CHECK SHEAR

$$V_c = 2 \sqrt{f'_c} b d$$

$$= 2 \sqrt{3,000} (12)(3) = 3,943 \#$$

$$\phi V_c = 0.85(3,943) = 3,352 \# > V_{ud} = 540 \#$$

COMPUTE REINFORCING

REF: TECH. REPORT SL-80-4 "STRENGTH DESIGN OF REINFORCED CONCRETE HYDRAULIC STRUCTURES" - REPORT #2

$$\frac{b}{a} = \frac{4}{3} = 1.33 \leftarrow$$

$$f'_c = 3,00 \text{ KSI AND } f_y = 48.00 \text{ KSI}$$

|             |                                 |            |           |
|-------------|---------------------------------|------------|-----------|
| Subject     | ANDALUSIA SLOUGH - PUMP STATION | Date       | 20 MAY 80 |
| Computed by | KEW                             | Checked by | CHU       |
|             |                                 | Sheet      | RF3 of    |

ROOF SLAB

$$\frac{M_N}{bd^2} = \frac{1.220 (12)}{0.90 (12)(3.0)^2} = 0.151$$

FIG. 10  $\rho = 0.0033$

$$\rho_{min} = \frac{200}{48,000} = 0.00417 > \rho = 0.0033$$

$$> \frac{4}{3} \rho = 0.0044$$

$$\therefore A_s = 0.0044 (12)(3)$$

$$= 0.158 \text{ IN}^2/\text{FT} \quad \# 3 \text{ @ } 8 = 0.165 \text{ IN}^2/\text{FT}$$

$$A_{STEMP} = 0.0025 (12)(4)$$

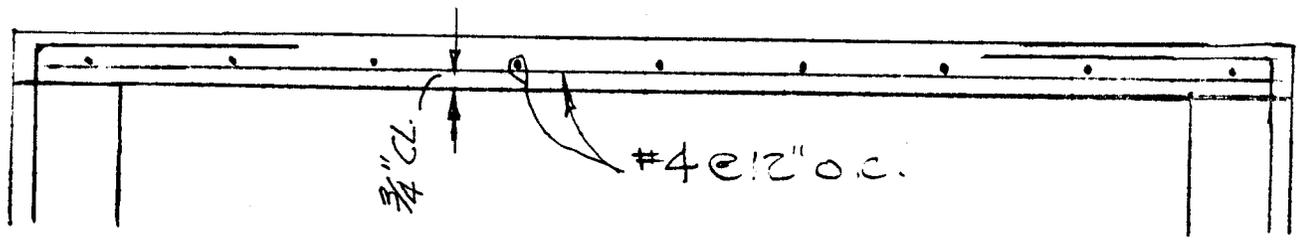
$$= 0.120 \text{ IN}^2/\text{FT} < A_s$$

$$A_{STEMP \text{ EDGE}} = 0.004 (12)(4)$$

$$= 0.192 \text{ IN}^2/\text{FT} > A_s$$

USE #4 @ 12" O.C. EA. WAY

NOTE: BECAUSE THE SLAB IS ONLY 4" THICK USE ONE LAYER OF REINF.



HYDRAULIC DREDGING - WATER COLUMN DATA

A  
P  
P  
E  
N  
D  
I  
X  
E

# The University of Iowa

Iowa City, Iowa 52242



Civil/Environmental Engineering  
Environmental Engineering Laboratories  
105 Water Plant

(319) ~~335-5177~~

December 24, 1987

Corps of Engineers  
Rock Island District  
ATTN: CENCR-ED-DG (Holmes)  
Clock Tower Building  
P.O. Box 2004  
Rock Island, Illinois 61204-2004

Dear Mr. Holmes:

Enclosed are the results of the third set of settling column analyses completed in December. Table E-1 is the data obtained using the bulk sample from location 1. This sample was loaded at a concentration of \*\*\*\*\* , which is equivalent to 145 grams/liter dry weight. Table F-1 was obtained from the bulk sample from location 2, with a loading concentration of \*\*\*\*\* , which is equivalent to 145 grams/liter dry weight.

If you have any questions please let me know.

Sincerely,

J. Kent Johnson, Ph. D.  
Laboratory Director

RECEIVED  
DEC 24 1987  
CENCR-ED-DG

Table E-1

SEDIMENT STUDY  
DECEMBER, 1987

*Reference*  
*Boring A-87-2*  
*Top Off soil*  
*Wt 83% in-situ*

SAMPLE 1

| TIME<br>(HRS) | SAMPLE PORTS |       |       |       |       |       |        | G<br>Number<br>Concent<br>Wt, % |
|---------------|--------------|-------|-------|-------|-------|-------|--------|---------------------------------|
|               | A            | B     | C     | D     | E     | F     | G      |                                 |
| 0             | 128.3        | 129.1 | 123.2 | 126.0 | 123.0 | 121.4 | 119.9  | 796                             |
| .5            | 123.0        | 118.2 | 119.6 | 123.2 | 114.0 | 127.7 | 156.4  | -                               |
| 1             | 124.5        | 123.4 | 118.2 | 128.6 | 119.8 | 132.3 | 181.7  | -                               |
| 2             | 6.3          | 116.3 | 115.0 | 117.6 | 120.6 | 174.0 | 216.0  | -                               |
| 4             | 1.2          | 7.4   | 96.2  | 114.6 | 126.6 | 233.6 | 232.5  | -                               |
| 6             | 1.8          | 2.9   | 3.2   | 145.9 | 248.0 | 287.0 | 252.7  | -                               |
| 12            | 0.4          | 0.4   | 0.5   | 0.4   | 273.0 | 295.0 | 263.6  | -                               |
| 24            | 0.4          | 0.6   | 0.5   | 0.6   | 283.0 | 321.0 | 300.0  | 296                             |
| DAY           |              |       |       |       |       |       |        |                                 |
| 2             | 0.2          | 0.2   | 0.2   | 0.2   | 0.3   | 334.1 | 318.7  | -                               |
| 3             | 0.1          | 0.1   | 0.1   | 0.1   | 0.2   | 364.0 | 374.1  | -                               |
| 4             | 0.1          | 0.0   | 0.1   | 0.1   | 0.1   | 355.5 | 422.0  | -                               |
| 5             | 0.0          | 0.1   | 0.1   | 0.0   | 0.1   | 225.6 | ** 477 | 172                             |
| 10            | 0.0          | 0.0   | 0.0   | 0.0   | 0.0   | 0.3   | ** 484 | 169                             |
| 15            | 0.0          | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | ** -   | -                               |

\*\* SAMPLES WERE TOO CONCENTRATED TO RUN SUSPENDED SOLIDS.  
THE PERCENT DRY WEIGHTS ARE AS FOLLOWS:

| TIME<br>(DAY) | PORT | PERCENT DRY WEIGHT |
|---------------|------|--------------------|
| 5             | G    | 36.8               |
| 10            | G    | 37.2               |
| 15            | G    | 32.5               |

TABLE E-1

Table E-2  
 SEDIMENT STUDY  
 DECEMBER, 1987

SAMPLE 2

*Reference*  
 Boring A-87-2  
 Typ CL soil  
 Wc = 31-3090 in-situ

| TIME<br>(HRS) | SAMPLE PORTS |       |       |       |       |       |                    | G   | G<br>Moisture<br>Content, % |
|---------------|--------------|-------|-------|-------|-------|-------|--------------------|-----|-----------------------------|
|               | A            | B     | C     | D     | E     | F     | G                  |     |                             |
| 0             | 136.4        | 132.0 | 135.2 | 129.4 | 133.9 | 138.4 | 132.5              | 717 |                             |
| .5            | 133.8        | 132.9 | 127.1 | 124.6 | 126.0 | 139.8 | 141.8              | -   |                             |
| 1             | 116.5        | 128.0 | 124.0 | 136.4 | 130.5 | 130.1 | 140.8              | -   |                             |
| 2             | 122.1        | 124.7 | 121.9 | 129.6 | 126.9 | 133.6 | 135.1              | -   |                             |
| 4             | 104.3        | 112.8 | 117.0 | 126.1 | 126.8 | 129.9 | 201.8              | -   |                             |
| 6             | 0.8          | 117.4 | 122.8 | 124.5 | 127.1 | 131.6 | 247.1              | -   |                             |
| 12            | 0.3          | 0.4   | 116.7 | 117.7 | 120.7 | 203.1 | 264.9              | -   |                             |
| 24            | 0.2          | 0.3   | 5.0   | 15.9  | 216.5 | 241.2 | 297.0              | 299 |                             |
| DAY           |              |       |       |       |       |       |                    |     |                             |
| 2             | 0.1          | 0.2   | 0.2   | 0.2   | 241.4 | 229.2 | 292.3              | -   |                             |
| 3             | 0.1          | 0.1   | 0.1   | 0.1   | 233.8 | 255.2 | 300.8              | -   |                             |
| 4             | 0.1          | 0.1   | 0.1   | 0.1   | 218.8 | 226.8 | 291.1              | -   |                             |
| 5             | 0.1          | 0.1   | 0.1   | 0.1   | 221.5 | 221.8 | 316.7              | 278 |                             |
| 10            | 0.0          | 0.0   | 0.0   | 0.0   | 0.4   | 260.9 | 333.2              | 262 |                             |
| 15            | *0.0         | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | <del>568</del> 568 | 138 |                             |

\* THIS SAMPLE WAS TAKEN FROM THE SURFACE OF THE WATER COLUMN.

\*\* THE SAMPLE WAS TOO CONCENTRATED TO RUN SUSPENDED SOLIDS.  
 THE PERCENT DRY WEIGHT OF THE SAMPLE IS 42.0.

**MECHANICAL AND ELECTRICAL CONSIDERATIONS**

A  
P  
P  
E  
N  
D  
I  
X  
F

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16  
MISSISSIPPI RIVER MILE 462 to 463  
Rock Island County, Illinois

APPENDIX F  
MECHANICAL AND ELECTRICAL CONSIDERATIONS

Table of Contents

| <u>Subject</u>    | <u>Page</u> |
|-------------------|-------------|
| Purpose and Scope | F-1         |
| General           | F-1         |
| Station Features  | F-2         |
| Control Sequence  | F-2         |
| Electrical        | F-2         |

List of Plates

| <u>No</u>   |  |
|-------------|--|
| F-1 - F-11  | Pump Station System Head Calculations  |
| F-12 - F-17 | Short Circuit Calculations             |
| F-18        | Annual Operating and Maintenance Costs |

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16  
MISSISSIPPI RIVER MILE 462 to 463  
Rock Island County, Illinois

APPENDIX F  
MECHANICAL AND ELECTRICAL CONSIDERATIONS

Purpose and Scope. The purpose of this appendix is to present preliminary design for the pumping station development at the Andalusia Refuge. Pump manufacturers' engineering information for standard catalog units were used to develop the design presented in this appendix. Pump sizing and layout are based on the efficient operation of the station and ease of normal maintenance.

General. One pumping station containing two submersible propeller type pumps is proposed for the Andalusia Refuge. The pumping station will serve a dual function; discharging interior drainage from the protected area to maintain constant water surface elevation during the drawdown cycle; to discharge river water into the protected refuge during the waterfowl migration seasons for the purpose of creating as large a surface area as possible.

The pumping station will be located on the downstream end of the moist soil unit protected from the main channel of the river and associated debris. The pumping station will be constructed integral with the levee river toe section. The levee fill will be placed, allowed to naturally consolidate for approximately three months and then excavated for the pumping station.

Pump units are sized to complete the drawdown period within a two week period. Pump operation will utilize automatic controls for setting and maintaining water elevation within the moist soil unit. The power and control panels will be housed within the pumping station super-structure and will be protected from condensation damage with unit heaters.

Pump and motor removal can be accomplished through secured sealed manhole accesses exterior of the pump station super-structure. Hand-cleaned trash racks are provided at both intake and discharge ends for maximum protection of the pump impellers against debris. The superstructure will have gravity ventilators and louvers for air circulation. Design of the station is based on the Hydraulic Institute Standards, 13th Edition, 1975, and on applicable sections of EM 1110-2-3102, 03, and 05.

Station Features. This station is fed by a new 48-inch reinforced concrete pipe from the moist soil unit passing through the levee section and by a pump forebay section from the Mississippi River. A sump divider wall separates the two pumps up to elevation 551.0. A slide gate in the divider wall permits gravity flow between the moist soil unit and the Mississippi River. Stoplog slots will be provided at each end to facilitate sump dewatering for maintenance purposes. Gate closure of the gravity outlet occurs for water management operation, at which time the required pump is energized manually, with further control being automatic through the float system. One 24-inch, 5,000 gpm submersible pump of axial or mixed flow type will be utilized for pumping from the moist soil unit and one 24 inch 3500 gpm submersible pump of axial or mixed flow type will be utilized for pumping from the Mississippi River. Discharge of both pumps will be piped over the sump divider wall into a stilling basin that directs flow by gravity out to the river or moist soil unit respectively. Access to the sump area will be by ladder through removable floor hatches at the operating floor level. System head computations and curves and example pump selections are shown on plates F-1 through F-11. The estimated operating energy cost of \$1200 per year is computed on Plate F-18.

Control Sequence. The sluice gate of the pump station should be operated in an open position except during periods of moist soil unit management by Illinois Department of Conservation personnel. During desired drawdown periods, the sluice gate should be closed and the pump station activated for drawdown purposes. The pump station must be manually activated but will automatically turn off at low water level of 542.0. The float control system will automatically turn the pump on at elevation 542.5 to maintain the 542.0 drawdown elevation.

When it is desired to pump from the river into the moist soil unit, the station must be manually activated and will continue pumping automatically until elevation 547 (which can be adjustable to elevation 550.8, the elevation of the levee overflow). Pumping will be at a slower rate of approximately 3500 gpm to permit a slow filling of the moist soil unit.

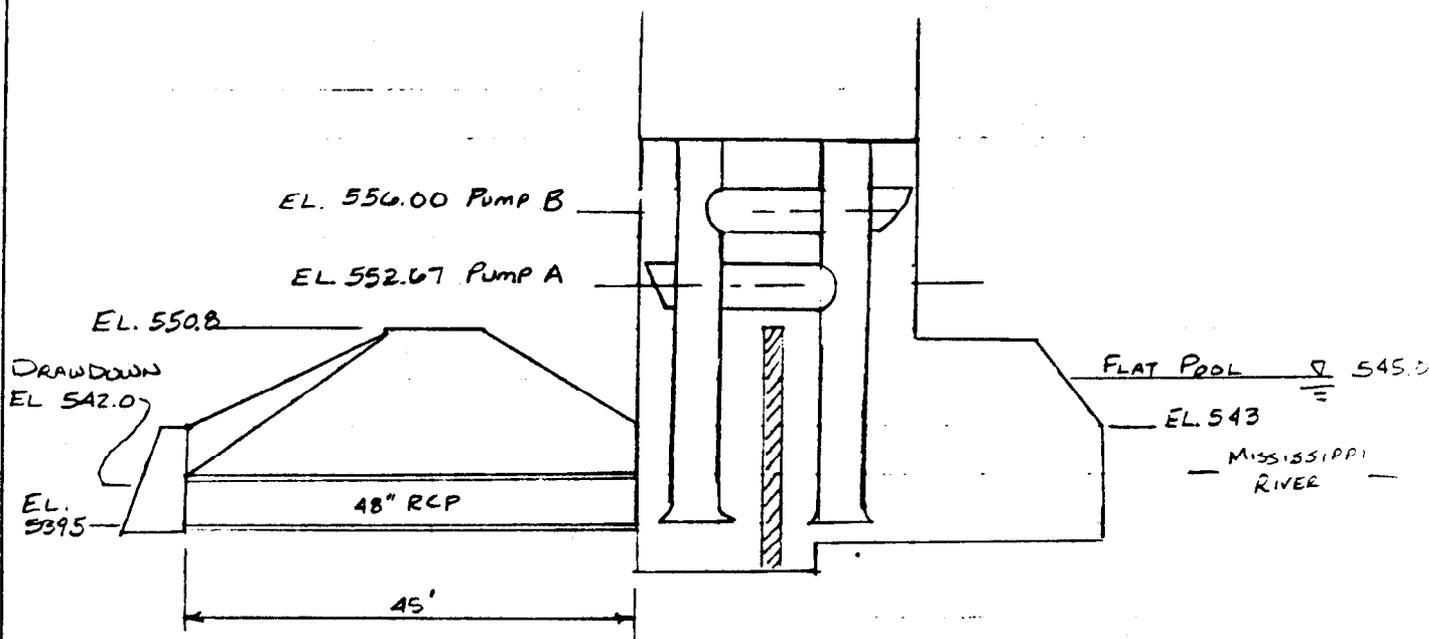
Electrical. The two submersible pumps at the station will be operated with electric motors. Power will be provided by the Iowa-Illinois Gas and Electric Company of Davenport, Iowa. Iowa-Illinois Gas and Electric Company has fossil and nuclear generating plants, is interconnected with many other utilities, and is considered to be a very reliable source of power. Two high voltage power systems are available within the area, 13 KV, 3 phase and 7.6 KV single phase. The nearest 13.2 KV, 3 phase connection point is at the switchgear in Illinois City, Illinois, thereby requiring construction of 3-4 miles of new power line. The 7.6 KV, single phase line can be tapped within one-half mile of the site bringing to conclusion that power to the pump station be tapped from the 7.6 KV line, transformed down with a 37.5 KVA

transformer to 480 volt and converted to 3-phase, 480 volts using a power phase converter located at the pump station location. The high voltage line will span the ± 150 feet of levee from high ground to the east wall of the pump station. The transformer and power phase converter will be mounted on the pumping station roof. Local ownership of the power service will be on the low voltage side of the transformer near the pump station. The Government, through its contractor, will pay for connection charges including powerline, transformers and power converters, and the Iowa-Illinois Gas and Electric Company will own and maintain the high voltage service.

The pumping station will have pump motor loads of approximately 8 KW and 18 KW and motors of 10 hp and 25 hp, one motor of about 3 hp to operate the sluice gate, and a circuit for one motor of about 3/4 hp for the sump pump. A power control panel will be located within the pump superstructure, will house a 480/240/120 volt transformer for lighting, receptacle and the control circuitry.

Short circuit analysis for the station is shown on plates F-12 through F-17. Electrical schematics are shown on plate 22.

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 88 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>1 of   |



GENERAL CONDITIONS

1. PUMP STATION IS INTEGRAL PART OF RIVERSIDE LEVEE TOE
2. PUMP A PUMPS FROM RIVER TO REFUGE WITH FREE PIPE END DISCHARGE
3. PUMP B PUMPS FROM REFUGE TO RIVER WITH FREE PIPE END DISCHARGE
4. REQUIRED PUMPING RATES  
 PUMP A = 3500 gpm max  
 PUMP B = 5000 gpm min.
5. FLAT POOL EL. 545.0  
 REFUGE MAX POND EL = 550.8  
 REFUGE MIN POND EL. = 542.0  
 SUMP FLOOR EL. = 539.5

Subject ANDALUSIA REFUGE PUMP STATION

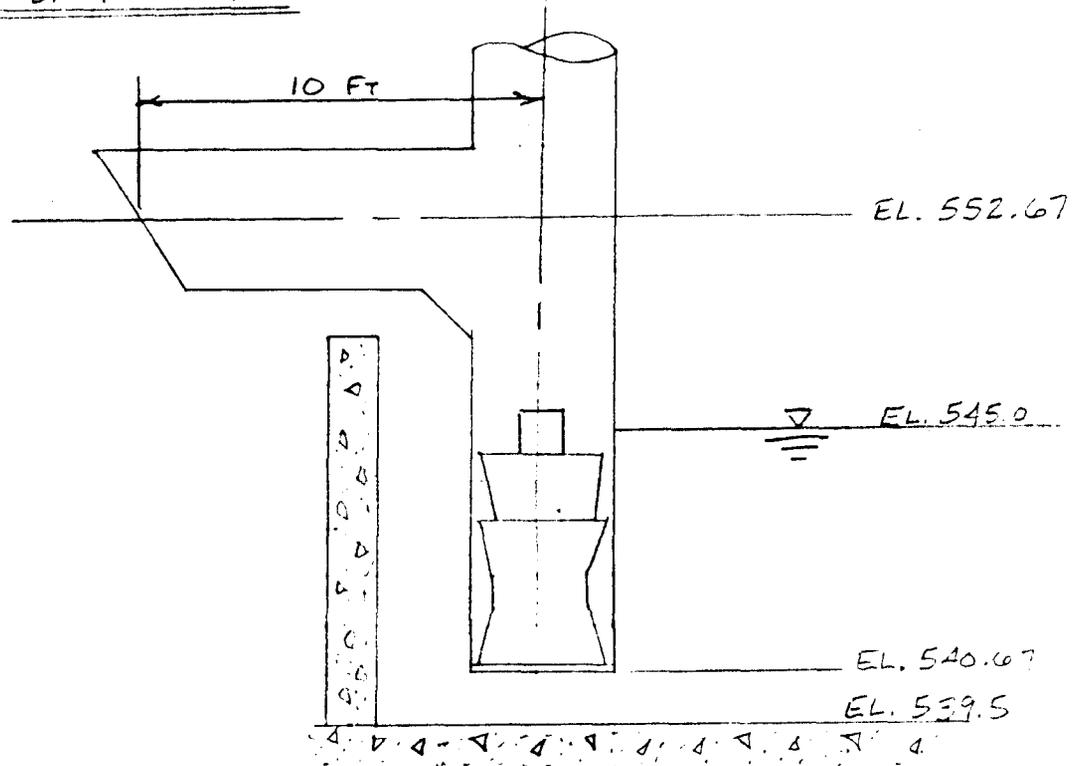
Date JULY 83

Computed by WGH

Checked by DJH

Sheet 2 of 2

DESIGN FOR PUMP A



PARAMETERS:

$$Q_{\max} = 3500 \text{ gpm}$$

$$H_{\text{STATIC}} = 552.67 - 545.0 = 7.67 \text{ FT}$$

SUBMERSIBLE PUMP WITH 26"  $\Phi$  STEEL PIPING

COMPUTE SYSTEM HEAD LOSSES:

PIPE HEAD LOSSES ARE INCLUDED INTO PUMP CURVES UP TO 20 INCHES ABOVE UNIT. ASSUME UNIT HEIGHT EQUAL 50 INCHES.

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 85 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>3 of   |

$$\text{PIPE FLOW VELOCITY} = \left( 3500 \frac{\text{GAL}}{\text{MIN}} \right) \left( \frac{\text{FT}^3}{7.48 \text{ GAL}} \right) \left( \frac{4}{\pi (2.167 \text{ FT})^2} \right) \left( \frac{\text{MIN}}{60 \text{ SEC}} \right)$$

$$= 2.115 \text{ FT/SEC}$$

$$\text{HEAD}_{\text{VEL.}} = \frac{V^2}{2g} = \frac{(2.115 \text{ FT/SEC})^2}{2(32.2 \text{ FT/SEC}^2)} = 0.069 \text{ FT.}$$

SYSTEM COMPONENTS:

PIPE LOSS  $\sim 0.3 \text{ HV}/100 \text{ FT}$

PIPE LENGTH =  $(552.67 - 540.67) - \frac{70 \text{ W}}{12 \text{ IN/FT}} + 10 \text{ FT} = 16.17 \text{ FT}$

ONE ELBOW  $\sim 0.33 \text{ HV}$

EXIT LOSS  $\sim 1.0 \text{ HV}$

TRASHRACK LOSS  $\sim 0.1 \text{ HV}$

INLET SUMP LOSS  $\sim 0.1 \text{ HV}$

$$\text{TOTAL LOSS} = 0.069 \left( 0.3 \left( \frac{16.17}{100} \right) + 0.33 + 1.0 + 0.1 + 0.1 \right)$$

$$= 0.109 \text{ FT.}$$

$$\text{TOTAL DYNAMIC HEAD} = 7.67 \text{ FT} + 0.109 \text{ FT} = 7.78 \text{ FT.}$$

PUMP SELECTION:

FLYGT - 7050, 20 KW, 700 RPM, 4 BLADE,  
5° BLADE ANGLE, CURVE 63-700B4

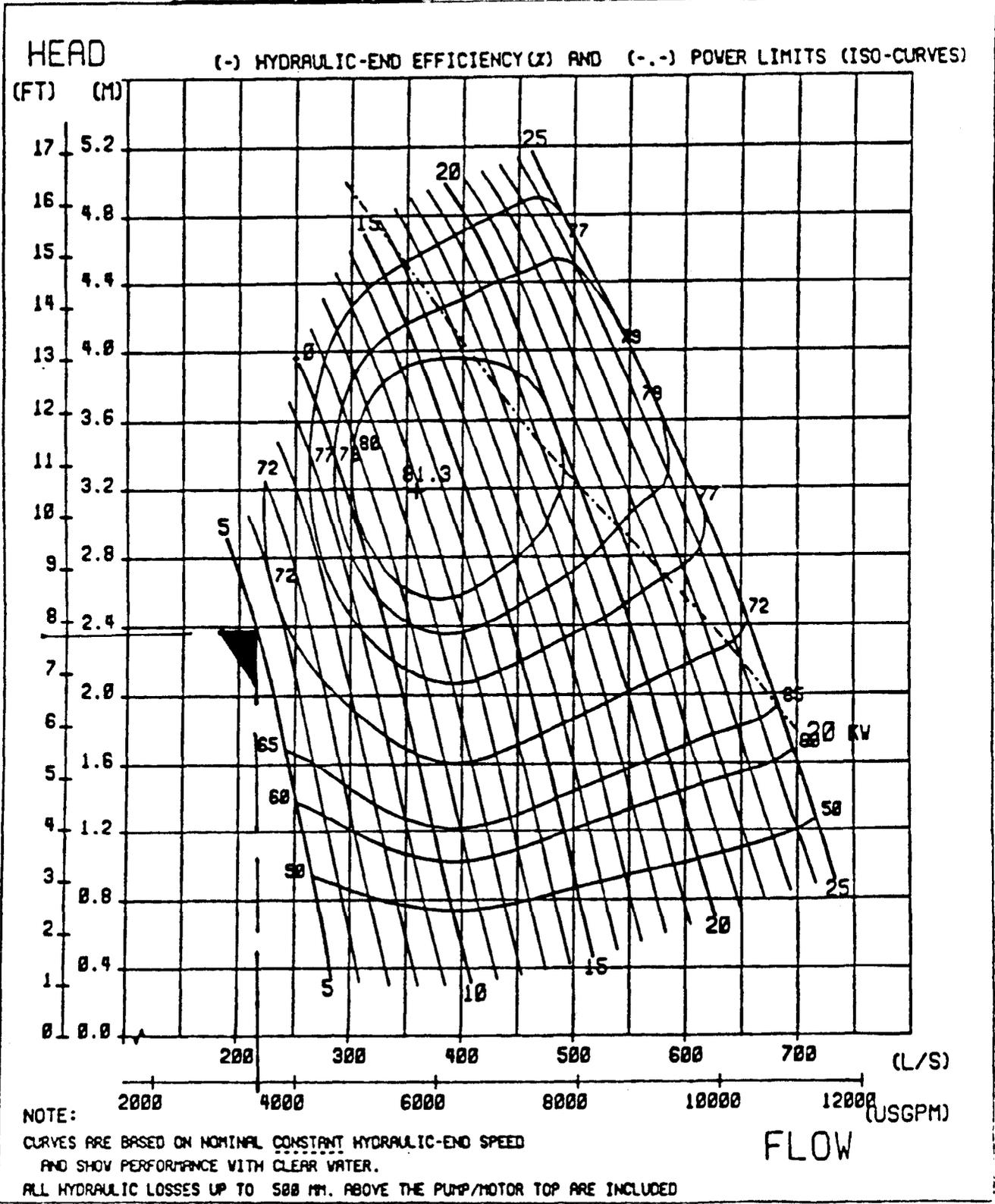
$$Q = 3500 \text{ GPM @ } 7.8 \text{ FT WITH } e^{\text{eff}} = 70\%$$

CHECK MAXIMUM RECOMMENDED PUMP SPEED IN ACCORDANCE WITH  
HYDRAULIC INSTITUTE STANDARDS & FIG 60

$$N = \frac{N_s H^{0.75}}{\sqrt{Q}} = \frac{20,000 (8)^{0.75}}{\sqrt{3500}}$$

$$N = 1608 \text{ RPM} > 700 \text{ RPM O.K.}$$

|                   |       |                             |         |
|-------------------|-------|-----------------------------|---------|
| PERFORMANCE CURVE |       | PROD.                       | 7050    |
|                   |       | CURVE NO                    |         |
| FREQ              | 60 HZ | NOMINAL HYDRAULIC-END SPEED | 700 RPM |



Subject

ANDALUSIA REFUGE PUMP STATION

Date

JULY 89

Computed by

WGH

Checked by

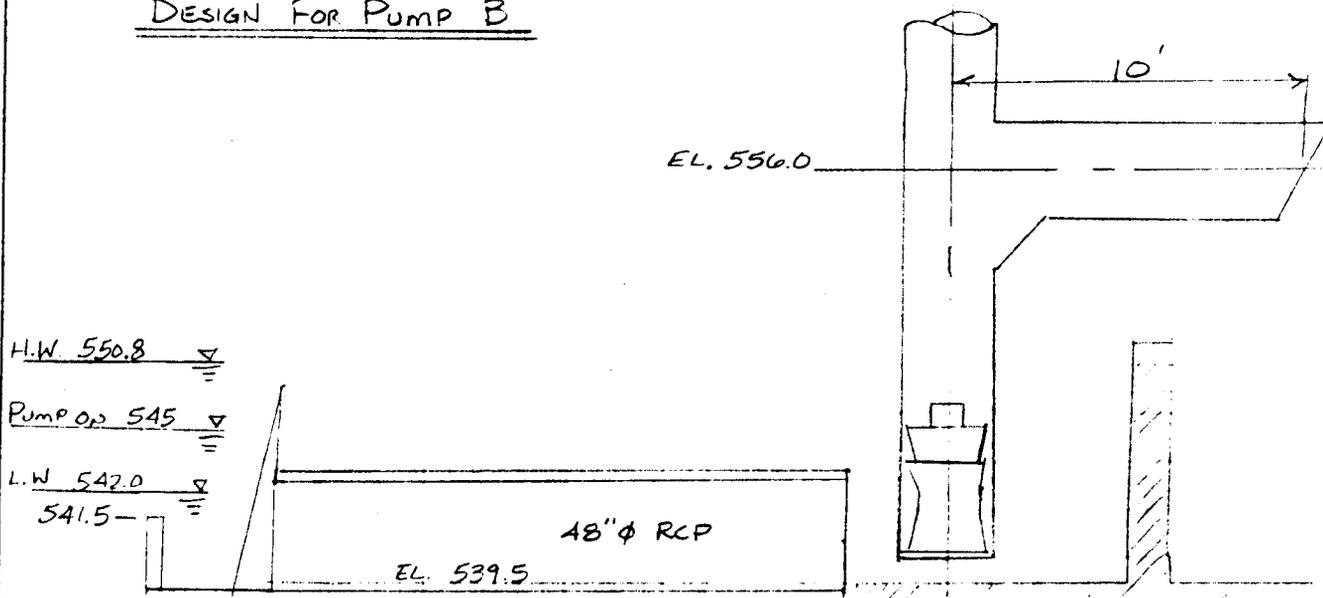
DH

Sheet

of

5

DESIGN FOR PUMP B



PARAMETERS:

$Q_{min} = 5,000 \text{ GPM} = 11.14 \text{ cfs}$

$H_{static \text{ min}} = 556.0 - 545.0 = 11.0 \text{ FT.}$

$H_{static \text{ max}} = 556.0 - 542.0 = 14.0 \text{ FT.}$

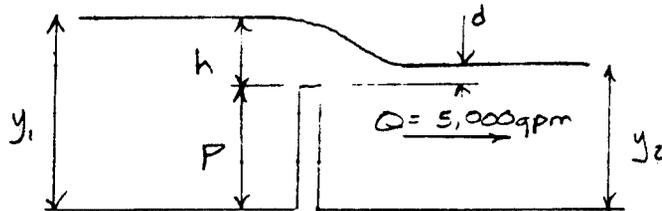
SUBMERSIBLE PUMP WITH 26"  $\phi$  STEEL PIPING

COMPUTE SYSTEM HEAD LOSSES:

LOSSES TO BE CONSIDERED

- a) WEIR LOSSES
- b) TRASHRACK LOSSES
- c) RCP FRICTION LOSSES
- d) INLET SUMP LOSSES
- e) PUMP PIPE LOSSES
- f) PUMP ELBOW LOSSES
- g) EXIT LOSS

## a) WEIR LOSSES



CASE 1: WATER ELEVATION = 545  $y_1 = 5.5 \text{ FT.}$   
 WEIR HEIGHT  $P = 1.75 \text{ FT.}$   
 CREST HEIGHT =  $h_1 = 3.75 \text{ FT}$

USING EM 110-2-5027, 30 SEPT 87 pg. 4-21

$$h = \left[ 0.3 \frac{Q}{L} \right]^{2/3}$$

Solving For  $Q_1$

$$Q_1 = (3.75)^{1.5} \left( \frac{14 \text{ FT}}{0.3} \right) = 339.9 \text{ cfs} = 152,092 \text{ gpm.}$$

USING HANDBOOK OF APPLIED HYDRAULICS, 3rd ed, DAVID S. JOHNSON

$$\frac{Q}{Q_1} = \left[ 1 - \left( \frac{d}{h} \right)^{1.5} \right]^{0.385}$$

Solving For  $d$

$$d = \left[ 1 - \left( \frac{5,000}{152,092} \right)^{1/0.385} \right]^{2/3} 3.75 = 3.749$$

$$h_c = h - d = 3.75 - 3.749 = 0.001 \text{ FT.}$$

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 88 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>7 of   |

CASE 2: WATER ELEVATION = 542  
 WEIR HEIGHT = P = 1.75 FT.  
 CREST HEIGHT = h = 0.75

$$Q = (0.75)^{1.5} \left( \frac{14 \text{ FT}}{0.3} \right) = 30.31 \text{ cfs} = 13,603 \text{ gpm}$$

$$d = \left[ 1 - \left( \frac{5,000}{13,603} \right)^{1.385} \right]^{2/3} 0.75 = 0.712 \text{ FT}$$

$$h_L = h - d = 0.75 - 0.712 = \underline{0.038 \text{ FT.}}$$

b. TRASHRACK LOSSES

CONTROLLING CASE IS WHEN REFUGE = EL. 542.0

ELEVATION ENTERING TRASHRACK = 542 - 0.25 = EL. 541.75

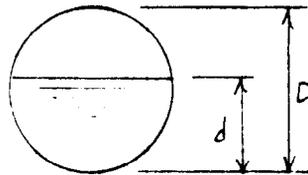
$$V_{T.R.} = \frac{11.14 \text{ FT}^3/s}{(6 \text{ FT})(541.75 - 539.5 \text{ FT})} = 0.825 \text{ FT/s}$$

$$\frac{V^2}{2g} = \frac{(0.825 \text{ FT/s})^2}{64.4 \text{ FT/s}^2} = 0.011 \text{ FT}$$

$$H_{L.T.R.} = 0.1 \frac{V^2}{2g} = 0.001 \text{ FT.}$$

|             |                               |            |         |
|-------------|-------------------------------|------------|---------|
| Subject     | ANDALUSIA REFUGE PUMP STATION | Date       | JULY 88 |
| Computed by | WGH                           | Checked by | DJH     |
|             |                               | Sheet      | 8 of    |

C. REINFORCED FRICTION LOSSES



$D = 4 \text{ FT}$   
 $d = 541.75 - 539.5 = 2.25 \text{ FT}$   
 $Q = 5,000 \text{ gpm}$   
 $L = 45 \text{ FT.}$

Check for critical depth REF. EM1110-2-1602, PLATE II

FOR  $Q = 11.14 \text{ cfs}$ ,  $D = 4 \text{ FT}$

$y_c/D = 0.345$

$y_c = 0.345(4) = 1.38 \text{ FT.}$

SINCE  $y_c < d$ , SUBCRITICAL FLOW O.K.

CHECK AREA

REF. - U.S. DEPT OF INTERIOR BUREAU OF RECLAMATION - HYDRAULIC & EXCAVATION TABLES

AT  $y_c$

FOR  $d/D = \frac{2.25}{4} = 0.563$

$Q = 1.7505(A)^{2.5} = 56.018 \text{ cfs}$

$h_v = 0.2296(A) = 0.9184 \text{ FT} \therefore V = 7.6906 \text{ fps}$

AND  $A = \frac{Q}{V} = \frac{56.018}{7.6906} = 7.28 \text{ FT}^2$

COMPUTE VELOCITY ACTUAL

$V = \frac{Q}{A} = \frac{11.14}{7.28} = 1.53 \text{ fps}$

WETTED PERIMETER =  $R \left[ \pi + \frac{2}{180} \left( \sin^{-1} \frac{0.25}{2} \right) \right] = 1.0798 \pi R$

Subject

ANDALUSIA REFUGE PUMP STATION

Date

JULY 88

Computed by

WGH

Checked by

DJH

Sheet

9 of

COMPUTE HYDRAULIC RADIUS

$$R = \frac{\text{AREA}}{\text{W. PERIMETER}}$$

$$R = \frac{7.28 \text{ FT}^2}{1.0798 \pi (2 \text{ FT})} = 1.073 \text{ FT}$$

USING MANNING EQUATION

n = 0.013 FOR CONCRETE PIPE

$$H_L = S = \left( \frac{nV}{1.49 R^{2/3}} \right)^2 (45 \text{ FT})$$

$$H_{L \text{ pipe}} = \left[ \frac{0.013 (1.53 \text{ FPS})}{1.49 (1.073 \text{ FT})^{2/3}} \right]^2 (45 \text{ FT})$$

$$H_{L \text{ pipe}} = 0.007 \text{ FT.}$$

d, e, f, g) COMPUTE PUMP ASSOCIATED LOSSES

$$\text{PUMP PIPE VELOCITY} = 11.14 \frac{\text{FT}}{\text{S}} \left( \frac{4}{\pi (2.167 \text{ FT})^2} \right) = 3.02 \frac{\text{FT}}{\text{S}}$$

$$H_{\text{VEL}} = \frac{V^2}{2g} = \frac{(3.02)^2}{2(32.2)} = 0.142 \text{ FT.}$$

PIPE LOSS ~ 0.3 H<sub>v</sub> / 100 FTELBOW ~ 0.33 H<sub>v</sub>EXIT ~ 1.0 H<sub>v</sub>INLET SUMP ~ 0.2 H<sub>v</sub>

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 89 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>10 of  |

$$\text{PIPE LENGTH} = 556 - 540.67 - \frac{70}{12} + 10 \text{ FT} = 19.50 \text{ FT}$$

$$H_{L, \text{pump}} = 0.142 \left( 0.3 \left( \frac{19.5}{100} \right) + 0.33 + 1.0 + 0.2 \right)$$

$$H_{L, \text{pump}} = 0.225 \text{ FT}$$

COMPUTE SYSTEM LOSS

$$H_{L, \text{SYST.}} = H_{L, \text{weir}} + H_{L, \text{T.R.}} + H_{L, \text{PIPE}} + H_{L, \text{PUMP}}$$

$$H_{L, \text{SYST.}} = 0.038 \text{ FT} + 0.001 \text{ FT} + 0.007 \text{ FT} + 0.225 \text{ FT}$$

$$H_{L, \text{SYSTEM}} = 0.272 \text{ FT.}$$

$$\text{PUMP TDH} = 14 + 0.272 = 14.272 \text{ FT.}$$

PUMP SELECTION :

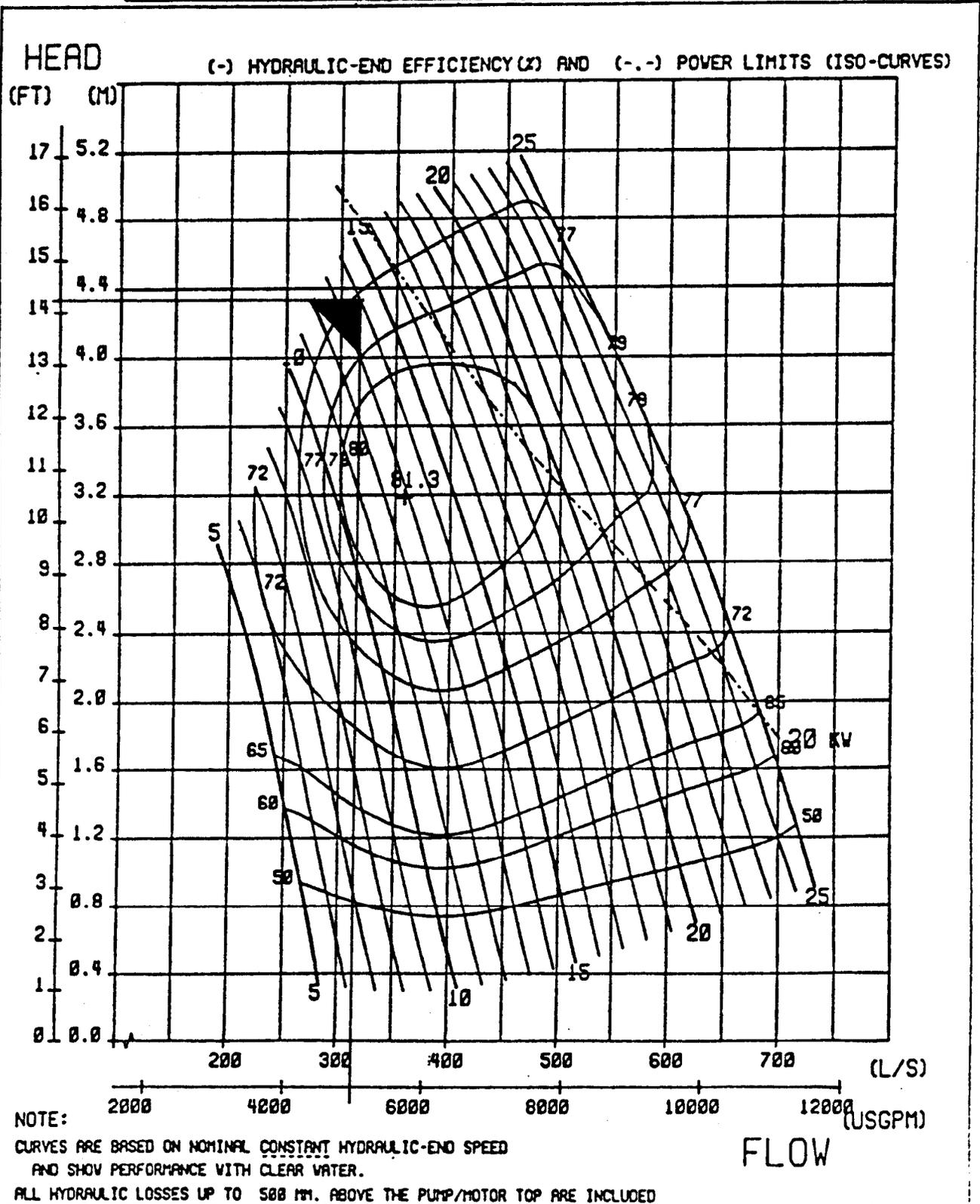
FLYGT - 7050, 20 KW, 700 RPM, 4 BLADE,  
13° BLADE ANGLE, CURVE 03-700B4  
Q = 5,000 gpm @ 14.2 FT. @ 77% eff.

CHECK MAXIMUM RECOMMENDED PUMP SPEED

$$N = \frac{N_s H^{3/4}}{\sqrt{Q}} = \frac{15,000 (14.3 \text{ FT})^{0.75}}{\sqrt{5,000}}$$

$$N = 1,560 \text{ RPM} > 700 \text{ RPM} \quad \text{O.K.}$$

|                   |                             |          |      |
|-------------------|-----------------------------|----------|------|
| PERFORMANCE CURVE |                             | PROD.    | 7050 |
|                   |                             | CURVE NO |      |
| FREQ              | NOMINAL HYDRAULIC-END SPEED |          |      |
| 60 HZ             | 700 RPM                     |          |      |



|  |                   |                      |
|--|-------------------|----------------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 88      |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>12 of<br>12 |

LOAD STUDY

EXISTING POWER SYSTEM - HIGH VOLTAGE 7620 VOLT, 1 $\phi$   
 POWER STATION SYSTEM - SECONDARY VOLTAGE 480/277/ 3 $\phi$

SUBMERSIBLE PUMP LOAD REQUIREMENTS

PUMP A = 7.4 KW = 10 H.P.

PUMP B = 17.4 KW = 25 H.P.

ASSUME ONLY ONE WILL BE PUMPING AT ANY GIVEN TIME

$$I_L = \frac{17.4(1000)}{480 \sqrt{3} (.95)} = 22.0 \text{ AMP}$$

GIVEN A 25 HP MOTOR ON THE PUMP

$I_L = 34 \text{ AMP}$       NEC TABLE 430-150

SIZE BRANCH CIRCUIT CONDUCTOR FOR PUMP B      NEC TABLE 310-16

$I_{FL} = (34)(1.25) = 42.5 \text{ AMP}$       SELECT # 8  $I = 50$

SIZE BRANCH CIRCUIT CONDUCTOR FOR PUMP A (10 H.P.)

$I_{FL} = (14 \text{ A})(1.25) = 17.5 \text{ amp}$       SELECT # 12  $I = 25$

POWER REQUIREMENT FOR PUMP B

$(746)(25 \text{ HP})(1.25) = 23.3 \text{ KVA}$

Subject

ANDALUSIA REFUGE PUMP STATION

Date

JULY 83

Computed by

WCH

Checked by

DJH

Sheet

13 of

## SUMP PUMP LOAD REQUIREMENTS

$\frac{3}{4}$  H.P. CLASS G, 240 V, 1 $\phi$ , 60 HZ, 1800 RPM

$$I_L = \frac{(0.75 \text{ HP})(1000)}{(240 \text{ V})(0.65)} = 4.8 \text{ A}$$

USING NEC TABLE 430-148  $I_L = 6.9 \text{ A}$

SIZE BRANCH CIRCUIT CONDUCTOR FOR SUMP PUMP

$$I_{FL} = (6.9 \text{ A})(1.25) = 8.65 \text{ A} \quad \text{SELECT \# 12 AWG}$$

POWER REQUIREMENT FOR SUMP PUMP

$$(746)(0.75 \text{ HP})(1.25) = 0.70 \text{ KVA}$$

## SLUICE GATE LOAD REQUIREMENTS

ASSUME

3 H.P. CLASS S, 3 $\phi$ , 480 V, 60 HZ, 1200 RPM

$$I_L = \frac{(3 \text{ HP})(1000)}{(480)\sqrt{3}(.75)} = 4.8 \text{ A}$$

USING NEC TABLE 430-150  $I_L = 4.8 \text{ A}$

SIZE BRANCH CIRCUIT CONDUCTOR FOR SLUICE GATE

$$I_{FL} = (4.8 \text{ A})(1.25) = 6.0 \text{ A} \quad \text{SELECT \# 12 AWG}$$

POWER REQUIREMENT

$$(746)(3 \text{ HP})(1.25) = 2.8 \text{ KVA}$$

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 93 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>14 of  |

DETERMINE TRANSFORMER SIZE

$$\text{LOAD}_{\text{MAX}} = 23.3 \text{ KVA} + 0.7 \text{ KVA} + 2.8 \text{ KVA} = 26.8 \text{ KVA}$$

CHOOSE A 37.5 KVA, 1 $\phi$

DETERMINE SIZE OF MAIN BREAKER OR FUSE

$$I = 2.5(34 \text{ AMP}) + \frac{4.8 \text{ A}}{2\sqrt{3}} + 4.8 \text{ A}$$

$$I = 92 \text{ AMP}$$

CHOOSE 150 A BUS

100 A BREAKER

3 - #3 AWG MAIN FEEDER WITH #6 AWG GRD.

Subject

ANDALUSIA REFUGE PUMP STATION

Date

JULY 88

Computed by

WGH

Checked by

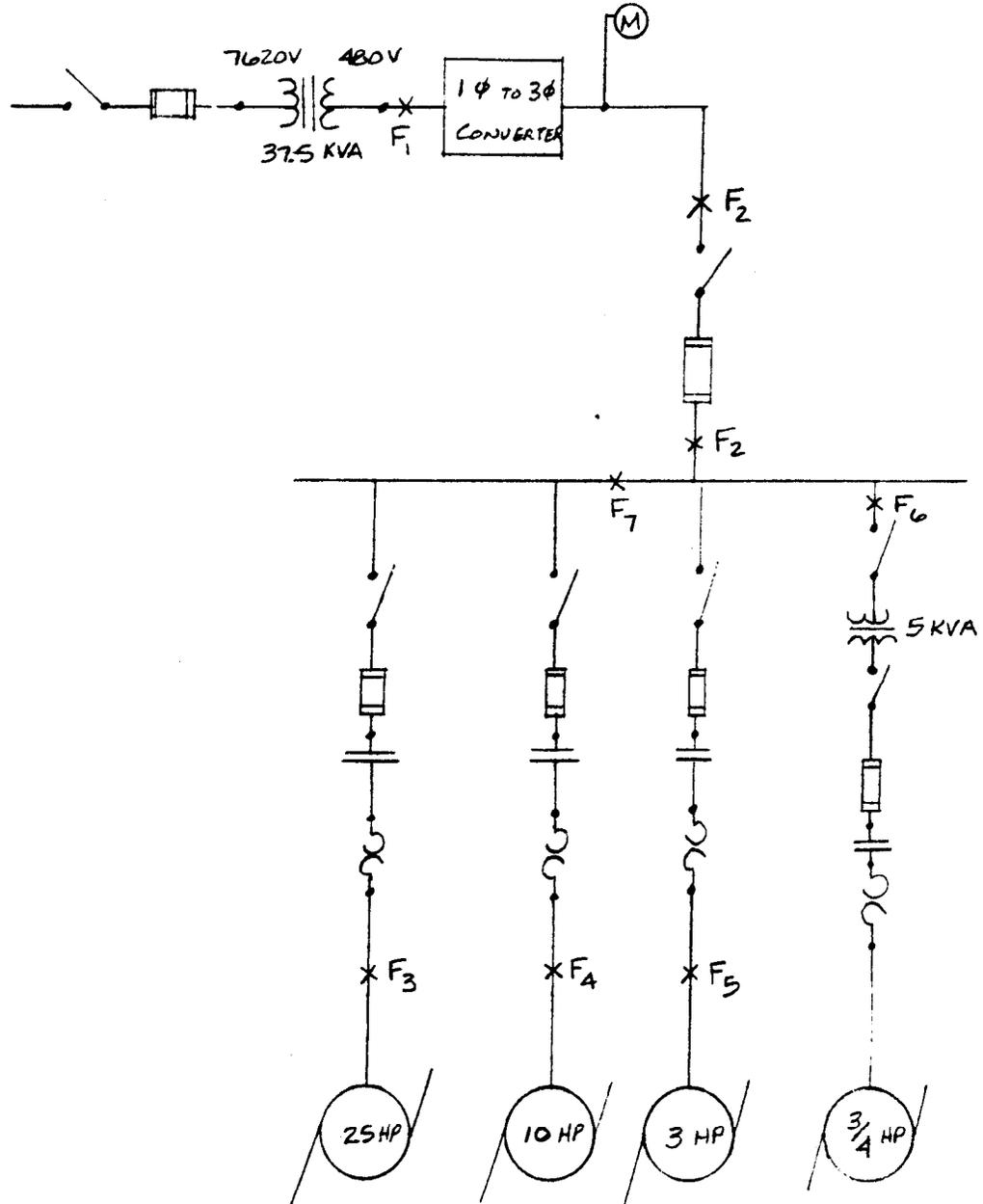
DJH

Sheet

of

15

FAULT STUDY



|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 89 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>16 of  |

SYSTEM BASE - 500 MVA

PUMP B FEEDER - 3-# 8 AWG

$$C = 1230$$

$$R = 0.778 \text{ ohm/ft} \times 10^3$$

PUMP A FEEDER - 3 # 12 AWG

$$C = 617$$

$$R = 1.98 \text{ ohm/ft} \times 10^3$$

SUMP & SLUICE FEEDER - 3 # 12 AWG

$$C = 617$$

$$R = 1.98 \text{ ohm/ft} \times 10^3$$

BUS FEEDER - 3 # 3 AWG

$$C = 3830$$

$$R = 0.245 \text{ ohm/ft} \times 10^3$$

Z TRANSFORMER = 2 %

AT  $F_1$

$$I_{sc} = \frac{(37.5 \text{ KVA})(1000)}{480(0.02)} = 3906 \text{ AMP AT TRANSFORMER SECONDARY}$$

AT  $F_2$

$$f = \frac{1.73 L I}{C V} = \frac{1.73(50)(3906 \text{ A})}{3830(480)} = 0.1838$$

$$I_{F_2} = 3906 \left( \frac{1}{1+0.1838} \right) = 3300 \text{ AMP}$$

AT  $F_3$

$$f = \frac{1.73(20)(3300 \text{ A})}{(480)(1230)} = 0.1934$$

$$I_{F_3} = 3300 \left( \frac{1}{1+0.1934} \right) = 2765 \text{ AMP}$$

|  |                   |                 |
|--|-------------------|-----------------|
| Subject<br>ANDALUSIA REFUGE PUMP STATION |                   | Date<br>JULY 88 |
| Computed by<br>WGH                       | Checked by<br>DJH | Sheet<br>17 of  |

$$\text{AT } F_4 \quad f = \frac{1.73(20)(3300A)}{(480V)(617)} = 0.3855$$

$$I_{F_4} = 3300 \left( \frac{1}{1+0.3855} \right) = 2382 \text{ AMP}$$

$$\text{AT } F_5 \quad f = \frac{1.73(20)(3300A)}{(480V)(617)} = 0.3855$$

$$I_{F_5} = 3300 \left( \frac{1}{1+0.3855} \right) = 2382 \text{ AMP}$$

$$\text{AT } F_6 \quad f = \frac{2(10FT)(3300)}{480(617)} = 0.2229$$

$$I_{F_6} = 3300 \left( \frac{1}{1+0.2229} \right) = 2700 \text{ AMP}$$

CONCLUSIONS: ALL EQUIPMENT SHALL BE RATED FOR 10,000 AMP RMS

|   |                          |                        |
|---|--------------------------|------------------------|
| Subject<br><b>ANDALUSIA REFUGE PUMP STATION</b> |                          | Date<br><b>JULY 88</b> |
| Computed by<br><b>WGH</b>                       | Checked by<br><b>DJH</b> | Sheet<br><b>18</b> of  |

PUMP STATION OPERATING ENERGY COST

DRAINAGE AREA = 925 ACRE

STATION CAPACITY PUMP A = 3500 GPM = 15.75 ACRE FT / DAY

STATION CAPACITY PUMP B = 5,000 GPM = 22.5 ACRE FT / DAY

| TIME PERIOD | OPERATION | PUMP | INITIAL VOL. ACRE-FT | RAINFALL (IN) | RUNOFF C=5 (ACRE-FT) | EVAPOR. (ACRE-FT) | EVENT VOL. (ACRE-FT) | TOTAL (A-FT) |
|-------------|-----------|------|----------------------|---------------|----------------------|-------------------|----------------------|--------------|
| JUNE        | DRAWDOWN  | B    | 42                   | 4.32          | 166.5                | - 16.8            | 2.1 *                | 193.9        |
| JULY        | DRAWDOWN  | B    | 0                    | 4.88          | 188.1                | - 17.5            | 2.1 *                | 172.7        |
| AUG         | DRAWDOWN  | B    | 0                    | 3.76          | 144.9                | - 14.9            | 2.1 *                | 132.1        |
| SUBTOTAL    |           |      |                      |               |                      |                   |                      | 498.6        |
| SEPT        | FILL      | A    | 180                  | 3.74          | - 288.3              | 38.5              |                      | 0            |
| OCT         | FILL      | A    | 0                    | 2.70          | - 208.0              | 38.5              |                      | 0            |
| NOV         | FILL      | A    | 0                    | 2.16          | - 166.5              | 38.5              |                      | 0            |
| SUBTOTAL    |           |      |                      |               |                      |                   |                      | 0            |

\* VOLUME IS BASED ON DURATION OF EVENT CAUSING OVERFLOWING EL. 550.0 REQUIRING A SECOND DRAWDOWN - (5%)(42) = 2.1 ACRE FT.

$$PUMP\ B\ RUN\ TIME = (498.6 \frac{ACRE-FT}{YR}) (\frac{DAY}{22.5\ ACRE-FT}) = 22.16 \frac{DAY}{YR} = 532 \frac{HR}{YR}$$

$$PUMP\ A\ RUN\ TIME = (0 \frac{ACRE-FT}{YR}) (\frac{DAY}{15.75\ ACRE-FT}) = 0 \frac{DAY}{YR} = 0 \frac{HR}{YR}$$

POWER REQUIREMENT - ASSUME 5 HR RUN TIME FOR MAINTENANCE & TESTING / YR

$$P_{PUMP} = (17.4\ KW) (532 + 5 \frac{HR}{YR}) + (7.4\ KW) (0 + 5 \frac{HR}{YR}) = 9,378\ KW\ HR / YR$$

$$P_{HEATERS\ \&\ CONTROLS} = (0.3\ KW) (24 \frac{HR}{DAY}) (365 \frac{DAY}{YR}) = 2,628\ KW\ HR / YR$$

$$AVERAGE\ OPERATING\ COST = (9,378 \frac{KW\ HR}{YR} + 2,628 \frac{KW\ HR}{YR}) (\$0.093 / KW\ HR)$$

$$OPERATING\ COST = \$1,117.00 / YR. \quad SAY \quad \$1200 / YR$$

**SEDIMENTATION STUDY**

A

P

P

E

N

D

I

X

G

UPPER MISSISSIPPI RIVER SYSTEM  
ENVIRONMENTAL MANAGEMENT PROGRAM  
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT  
POOL 16 MISSISSIPPI RIVER MILES 462 TO 463  
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX G  
SEDIMENTATION STUDY

A sedimentation study was conducted to evaluate sedimentation in Dead Slough and in the Refuge area during the period 1936 through 1987. The scope of this study, as presented in this appendix, consisted of determining net erosion from 1936 (pre-lock and dam) through 1987, estimating annual adjacent watershed erosion/deposition, evaluating estimated river source sedimentation, and evaluating proposed project impacts on sedimentation.

Baseline elevations were established from 1936 plane table topographic maps. Additional sections were taken by survey crews during 1987. Eleven ranges were used to construct cross sections of this area. Elevations in 1936 were compared with present elevations in 1987 to show net changes in elevation. Table G-1 provides a summary of net sedimentation.

The two predominant sedimentation sources are the Mississippi River and upland erosion. Adjacent watersheds were studied to estimate approximate soil loss from these areas. Estimates were derived from the Universal Soil Loss Equation, reference: Predicting Rainfall Erosion Losses, USDA, Handbook Number 537, December 1978. Estimated adjacent watershed erosion is presented in table G-2.

TABLE G-1

Andalusia Refuge and Dead Slough Total Sedimentation

| Range   | Station    | Total Sediment<br>Deposition in<br>Andalusia Refuge &<br>Dead Slough<br>1936-1987 |                                      | Dead Slough Sediment<br>Deposition, 1936-1987<br>Below Elevation 545.0<br>(Flat Pool) |                            |
|---------|------------|---|--------------------------------------|---|----------------------------|
|         |            | Average<br>Depth,<br>Ft   | Average<br>Annual<br>Depth,<br>In/Yr | Average<br>Depth,<br>Ft   | Annual<br>Average<br>In/Yr |
| A       | 15+15      | 2.1   | 0.49                                 | 2.9   | 0.68                       |
| B       | 23+75      | 2.3   | 0.54                                 | 3.8   | 0.90                       |
| C       | 30+75      | 2.5   | 0.58                                 | 2.7   | 0.63                       |
| D       | 38+25      | 1.7   | 0.40                                 | 3.9   | 0.91                       |
| E       | 45+75      | 1.7   | 0.40                                 | 4.2   | 1.00                       |
| F       | 2+75.15CE  | 2.2   | 0.53                                 | -   | -                          |
| G       | 4+55.62CE  | 2.3   | 0.54                                 | -   | -                          |
| H       | 8+88.12CE  | 2.4   | 0.56                                 | -   | -                          |
| I       | 12+70CE    | 2.5   | 0.58                                 | -   | -                          |
| J       | 16+16.26CE | 2.2   | 0.52                                 | -   | -                          |
| K       | 20+75CE    | 2.2   | 0.52                                 | -   | -                          |
| OVERALL |            | 2.2   | 0.52                                 |   | 0.82 in/yr                 |

TABLE G-2

Estimated Sediment from Adjacent Watersheds

| Watershed | Area,<br>Ac | Watershed<br>Gross Erosion |        |          | Delivery<br>Ratio<br>1/ | Sediment Yield 2/ |          |
|-----------|-------------|----------------------------|--------|----------|-------------------------|-------------------|----------|
|           |             | T/Ac/Yr                    | T/Yr   | Ac-Ft/Yr |                         | T/Yr              | Ac-Ft/Yr |
| A         | 519         | 13                         | 6,800  | 3.9      | .55                     | 3,700             | 2.2      |
| B         | 774         | 16                         | 12,000 | 6.9      | .55                     | 6,600             | 3.8      |
| C         | 208         | 10                         | 2,100  | 1.2      | .65                     | 1,400             | 0.8      |
| D         | 1,152       | 13                         | 15,000 | 8.6      | .48                     | 7,200             | 4.2      |
| Total     | 2,653       | -                          | 35,900 | 20.6     | -                       | 18,900            | 11.0     |

<sup>1</sup> Reference: "Sediment Delivery Ratios vs. Drainage Area," USDA, Soil Conservation Service, drawing number 5, N-30,509, dated October 1970.

<sup>2</sup> Sediment Yield = Gross Erosion x Delivery Ratio. Sediment yield is the portion of the gross watershed erosion that actually reaches the watershed mouth.

Net river sedimentation was estimated by subtracting the adjacent watershed sedimentation (table G-2) from the net sedimentation (table G-1). Results of this comparison and potential reductions in sedimentation due to proposed project features are presented in table G-3.

TABLE G-3

Comparison of River Versus Upland Erosion Sedimentation

| <u>Sedimentation Source</u> | <u>Existing Conditions</u> |             | <u>Sediment Reduction into Andalusia Refuge Due to Proposed Project</u> |            |
|-----------------------------|----------------------------|-------------|---|------------|
|                             | <u>Ac-Ft/Yr</u>            | <u>%</u>    | <u>Ac-Ft/Yr</u>   | <u>%</u>   |
| Adjacent Watershed          | 11.0                       | 64.7        | 4.2   | 24.7       |
| River                       | <u>6.0</u>                 | <u>35.3</u> | <u>0.0</u>  | <u>0.0</u> |
| Net                         | 17.0                       | 100.0       | 4.2   | 24.7       |

ILLINOIS DEPARTMENT OF CONSERVATION  
FISHERIES INVESTIGATION OF DEAD SLOUGH

A

P

P

E

N

D

I

X

H

MISSISSIPPI RIVER  
INVESTIGATIONS

County Rock Island  
Location from \_\_\_\_\_  
nearest town 7 mi. West of Andalusia  
Date May 16, 1988

Station Sampled Dead Slough/Andalusia Pool No. or Name 16  
Refuge

Stations Location in River Miles 462.4-463.0

UMRCC Habitat Classification: Tailwater \_\_\_\_\_ Lake X Pond \_\_\_\_\_  
Main channel \_\_\_\_\_ Main channel border \_\_\_\_\_ Side channel \_\_\_\_\_ Slough X

Time Temp. Rec. 1:40<sup>PM</sup> Temperature: Air \_\_\_\_\_ °F, Water Surface 13 c °F

Water Color Clear Sky(weather) Cloudy Wind W-15mph

Turbidity: Secchi To bottom = 1.5' : Cause: \_\_\_\_\_

Chemistry: pH 8.0 Alkalinity 137 Other Cond: 580 DO: 11.2

Water Level: Low X Normal \_\_\_\_\_ High \_\_\_\_\_ Flood \_\_\_\_\_

Velocity(ft./sec.) 0 Max. Depth 18" Avg. Depth 12"  
Max. Width 100 yds. Min. Width 100 yds. Avg. Width 100 yds.

Bottom types(%): Silt(muck) X Sand \_\_\_\_\_ Gravel \_\_\_\_\_ Rubble \_\_\_\_\_ Boulders \_\_\_\_\_ Bedrock \_\_\_\_\_

Type of Shoreline(%): Gravel bar \_\_\_\_\_ Sandbar \_\_\_\_\_ Mud flat \_\_\_\_\_ Rocky \_\_\_\_\_  
Steep Mud bank 100 Other \_\_\_\_\_

Aquatic Vegetation(% & type): 95% coverage coontail, curlyleaf, duckweed, potamogeton

Fish Habitat available: Brush X Logs X Stumps X Rock dikes \_\_\_\_\_  
Pile dikes \_\_\_\_\_ Gravel \_\_\_\_\_ Rip rap \_\_\_\_\_ Aquatic vegetation \_\_\_\_\_  
Other \_\_\_\_\_

Recent Angler Success No Access

Fish Population Analysis: Bag Seine Hauls (Size \_\_\_\_\_, No. \_\_\_\_\_);  
Hoop Net (No. \_\_\_\_\_ Size \_\_\_\_\_ Hrs. Set \_\_\_\_\_); Trap Net (No. \_\_\_\_\_ Size \_\_\_\_\_ Hrs. Set \_\_\_\_\_);  
Gill Net (No. \_\_\_\_\_ Size \_\_\_\_\_ Hrs. Set \_\_\_\_\_); Trammel Net (No. \_\_\_\_\_ Size \_\_\_\_\_ Hrs. Set \_\_\_\_\_);  
Electro-Fishing (Time 1:30<sup>AM</sup> 45 minutes, effeciency Poor)  
Toxicant (area treated \_\_\_\_\_ acres); Other \_\_\_\_\_

Fish condition: Some fin rot and lerneae, generally poor condition

Fish Diseases: \_\_\_\_\_

Number of species collected 10 Observed but not collected \_\_\_\_\_

Pollution \_\_\_\_\_

Fisherman usage No Access

Time on Job: 4.0 hrs. Personnel Involved Dan Sallee, Ed Walsh  
Reported by: Dan Sallee Date of Report 5/16/88

Additional Remarks and Map on Reverse Side: H-1

**FISH POPULATION ANALYSIS**

WATER (NAME) Miss., Dead Sl/Andalusia Ref.

(Condition factor & Length-Frequency Summary)

DATE OF COLLECTION 5/16/88

| Species           | ½" Group | Number | Percent of Total | Weight | Condition Factor | Rating |
|-------------------|----------|--------|------------------|--------|------------------|--------|
| Shortnose gar     | 553      | 1      | 100%             | 540    |                  |        |
| Bowfin            | 663      | 1      | 100%             | 2300   |                  |        |
| Gizzard shad      | 274      | 1      | 12.5             | 230    |                  |        |
|                   | 281      | 1      | 12.5             | 250    |                  |        |
|                   | 282      | 1      | 12.5             | 250    |                  |        |
|                   | 286      | 1      | 12.5             | 220    |                  |        |
|                   | 312      | 1      | 12.5             | 370    |                  |        |
|                   | 322      | 1      | 12.5             | 300    |                  |        |
|                   | 336      | 1      | 12.5             | 480    |                  |        |
|                   | 377      | 1      | 12.5             | 520    |                  |        |
|                   |          | 8      | 100%             |        |                  |        |
| Central mudminnow |          | 1      | (Preserved)      |        |                  |        |
| Carp              | 114      | 1      | 12.5             | 30     |                  |        |
|                   | 157      | 1      | 12.5             | 90     |                  |        |
|                   | 171      | 1      | 12.5             | 90     |                  |        |
|                   | 173      | 1      | 12.5             | 90     |                  |        |
|                   | 177      | 1      | 12.5             | 90     |                  |        |
|                   | 233      | 1      | 12.5             | 250    |                  |        |
|                   | 477      | 1      | 12.5             | 1180   |                  |        |
|                   | 616      | 1      | 12.5             | 2850   |                  |        |
|                   |          | 8      | 100%             |        |                  |        |

Sampling Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

COPIES TO: If State or Public — District, Area & Central offices.  
All Others — District Office Only.

ILLINOIS DEPARTMENT OF CONSERVATION  
DIVISION OF FISHERIES

COUNTY Rock Island

**FISH POPULATION ANALYSIS**

WATER (NAME) Miss., Dead Sl/Andalusia Ref

(Condition factor & Length-Frequency Summary)

DATE OF COLLECTION 5/16/88

| Species                  | 1/2" Group | Number | Percent of Total | Weight | Condition Factor | Rating |
|--------------------------|------------|--------|------------------|--------|------------------|--------|
| Golden shiner            | 67         | 1      | 16.6             | - -    |                  |        |
|                          | 73         | 1      | 16.6             | - -    |                  |        |
|                          | 88         | 1      | 16.6             | - -    |                  |        |
|                          | 89         | 1      | 16.6             | - -    |                  |        |
|                          | 92         | 1      | 16.6             | - -    |                  |        |
|                          | 95         | 1      | 16.6             | - -    |                  |        |
|                          |            | 6      | 100%             |        |                  |        |
| Smallmouth buffalo       | 132        | 1      | 16.6             | 30     |                  |        |
|                          | 138        | 1      | 16.6             | 40     |                  |        |
|                          | 145        | 1      | 16.6             | 50     |                  |        |
|                          | 147        | 2      | 33.3             | 100    |                  |        |
|                          | 165        | 1      | 16.6             | 70     |                  |        |
|                          |            | 6      | 100%             |        |                  |        |
| Bluegill                 | 65         | 1      | 2.5              | - -    |                  |        |
|                          | 73         | 1      | 2.5              | - -    |                  |        |
|                          | 77         | 1      | 2.5              | - -    |                  |        |
|                          | 78         | 1      | 2.5              | - -    |                  |        |
|                          | 82         | 1      | 2.5              | - -    |                  |        |
|                          | 84         | 1      | 2.5              | - -    |                  |        |
|                          | 93         | 1      | 2.5              | - -    |                  |        |
|                          | 96         | 1      | 2.5              | 20     |                  |        |
|                          | 97         | 1      | 2.5              | 20     |                  |        |
|                          | 101        | 1      | 2.5              | 20     |                  |        |
|                          | 103        | 1      | 2.5              | 20     |                  |        |
| 105                      | 1          | 2.5    | 20               |        |                  |        |
| 106                      | 1          | 2.5    | 25               |        |                  |        |
| (continued on next page) |            |        |                  |        |                  |        |

Sampling Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

COPIES TO: If State or Public — District, Area & Central offices.  
All Others — District Office Only.

ILLINOIS DEPARTMENT OF CONSERVATION  
DIVISION OF FISHERIES

COUNTY Rock Island

**FISH POPULATION ANALYSIS**

WATER (NAME) Miss., Dead Sl/Andalusia ef.

(Condition factor & Length-Frequency Summary)

DATE OF COLLECTION 5/16/88

| Species                 | 1/2" Group | Number | Percent of Total | Weight | Condition Factor | Rating |
|-------------------------|------------|--------|------------------|--------|------------------|--------|
| Bluegill<br>(continued) | 107        | 1      | 2.5              | 25     |                  |        |
|                         | 108        | 2      | 5.0              | 60     |                  |        |
|                         | 109        | 1      | 2.5              | 30     |                  |        |
|                         | 115        | 1      | 2.5              | 40     |                  |        |
|                         | 118        | 1      | 2.5              | 40     |                  |        |
|                         | 126        | 1      | 2.5              | 40     |                  |        |
|                         | 134        | 2      | 5.0              | 120    |                  |        |
|                         | 137        | 1      | 2.5              | 80     |                  |        |
|                         | 148        | 1      | 2.5              | 90     |                  |        |
|                         | 152        | 1      | 2.5              | 100    |                  |        |
|                         | 153        | 3      | 7.5              | 285    |                  |        |
|                         | 155        | 1      | 2.5              | 100    |                  |        |
|                         | 156        | 1      | 2.5              | 100    |                  |        |
|                         | 158        | 1      | 2.5              | 100    |                  |        |
|                         | 160        | 1      | 2.5              | 100    |                  |        |
|                         | 166        | 2      | 5.0              | 230    |                  |        |
|                         | 167        | 1      | 2.5              | 130    |                  |        |
|                         | 172        | 2      | 5.0              | 310    |                  |        |
|                         | 178        | 2      | 5.0              | 310    |                  |        |
|                         | 212        | 1      | 2.5              | 260    |                  |        |
|                         |            | 40     | 100%             |        |                  |        |
| Largemouth bass         | 170        | 1      | 50.0             | 60     |                  |        |
|                         | 251        | 1      | 50.0             | 280    |                  |        |
|                         |            | 2      | 100%             |        |                  |        |

Sampling Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

COPIES TO: If State or Public — District, Area & Central offices.  
All Others — District Office Only.



**WATERFOWL OBSERVATION DATA  
FOR ANDALUSIA REFUGE**

A

P

P

E

N

D

I

X

I

The following waterfowl observation data originates from annual U.S. Fish and Wildlife Service aerial census counts made along the Upper Mississippi River. The records for Andalusia refuge are incomplete since during some counts the refuge area was not separated from other locations in Pool 16. Previous to 1987, Dead Slough was not included in the count since it was not part of the refuge until 1987.

| DATE     | MALL-<br>ARD | BLK | PINT | BWT | GWT | WLG | GAD | SHOV | SCAMP | RN | CANS | RH | RUDDY | GLD<br>EYE | BH | COM<br>MER | RB<br>MER | H<br>MER | CG  | SM<br>CG | GT<br>CG | BSG | COOT |
|----------|--------------|-----|------|-----|-----|-----|-----|------|-------|----|------|----|-------|------------|----|------------|-----------|----------|-----|----------|----------|-----|------|
| 10-27-87 | 400          | 20  | 80   |     | 50  | 200 | 80  | 75   | 50    |    |      |    |       |            |    |            |           |          | 40  |          |          |     | 650  |
| 11-2-87  | 525          | 15  | 20   |     | 50  | 80  | 30  | 100  | 200   | 75 | 30   |    |       | 5          |    |            |           |          | 50  |          |          |     | 600  |
| 11-9-87  | 400          | 25  |      |     |     | 50  | 30  |      | 200   | 40 |      |    |       | 30         |    | 10         |           |          | 50  |          |          |     | 200  |
| 11-17-87 | 475          | 25  | 60   |     |     | 100 |     |      | 125   | 40 |      |    | 40    | 20         | 35 |            |           |          |     |          |          |     | 75   |
| 11-23-87 | 350          | 15  |      |     |     |     |     |      | 250   | 40 | 30   |    |       | 125        | 30 | 40         |           |          | 100 |          |          |     |      |
| 12-02-87 | 225          | 25  |      |     |     |     |     |      | 325   | 75 | 25   |    | 75    | 175        | 60 | 50         |           | 20       | 80  |          |          |     |      |
| 12-16-87 | 200          | 15  |      |     |     |     |     |      |       |    |      |    |       | 350        |    | 125        |           | 15       | 125 |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |
|          |              |     |      |     | </  |     |     |      |       |    |      |    |       |            |    |            |           |          |     |          |          |     |      |

I-3

| DATE     | MALL-<br>ARD | BLK | PMT    | BWT | GWT | WLG | GAD | SNOW | SCAMP | RN | CANS | RH | Ruddy | GLD.<br>EYE | BH | COM<br>MER | RB<br>MER | H<br>MER | CG | SM<br>CG | GT.<br>CG | BSG | COOT | BAID<br>FACE |
|----------|--------------|-----|--------|-----|-----|-----|-----|------|-------|----|------|----|-------|-------------|----|------------|-----------|----------|----|----------|-----------|-----|------|--------------|
| 1-5-84   | 0            |     |        |     |     |     |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     |      |              |
| 2-20-84  | 30           |     |        |     |     |     |     |      |       |    |      |    |       | 50          |    | 15         |           |          |    |          |           |     |      | 2            |
| 3-5-84   | 175          | 15  |        |     |     |     |     |      |       |    |      |    |       | 75          |    | 20         |           |          | 25 |          |           |     |      |              |
| 3-21-84  | 500          | 40  |        |     |     |     |     |      | 225   | 75 |      |    |       | 80          |    | 40         |           |          | 50 |          |           |     |      | 3            |
| 4-11-84  |              | No  | CENSUS |     |     |     |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     |      |              |
| 9-4-84   | 40           |     |        | 60  |     |     |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     |      |              |
| 9-11-84  | 125          |     |        | 200 | 50  | 50  |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     |      |              |
| 10-29-84 | 175          | 10  |        |     | 125 | 80  |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     | 350  |              |
| 11-5-84  | 200          | 10  |        |     |     | 60  |     |      | 30    |    |      |    |       |             |    |            |           |          |    |          |           |     | 150  | 1            |
| 11-12-84 | 200          | 20  |        |     |     | 60  |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     | 75   | 1            |
| 11-20-84 | 80           | 5   |        |     |     |     |     |      | 60    | 30 |      |    |       | 40          |    | 15         |           |          |    |          |           |     |      | 2            |
| 11-26-84 | 125          | 10  |        |     |     |     |     |      |       |    |      |    |       | 15          |    |            |           |          |    |          |           |     |      | 2            |
| 12-3-84  | 125          | 15  |        |     |     |     |     |      |       |    |      |    |       | 30          |    | 10         |           |          |    |          |           |     |      | 2            |
| 12-10-84 | 40           |     |        |     |     |     |     |      |       |    |      |    |       |             |    |            |           |          |    |          |           |     |      | 2            |

AERIAL CENSUS DATA - ANDALUSIA REFUGE

| DATE     | MALL-<br>ARD | BLK | PINT                | BWT | GWT | WIG | GAD | SNOW | SCAMP | RN | CANS | RH | Ruddy | GLD<br>EYE | BH | Com<br>MER | RB<br>MER | H<br>MER | CG | Sm<br>CG | GT<br>CG | BSG | Coat |
|----------|--------------|-----|---------------------|-----|-----|-----|-----|------|-------|----|------|----|-------|------------|----|------------|-----------|----------|----|----------|----------|-----|------|
| 10-17-83 | 35           |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
| 10-25-83 | 150          | 10  |                     |     |     |     |     |      | 40    |    |      |    |       |            |    |            |           |          |    |          |          |     | 60   |
| 11-1-83  | ND           |     | CENSUS - HEAVY RAIN |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
| 11-8-83  | 75           | 10  |                     |     | 30  |     |     |      | 30    |    |      |    |       |            |    |            |           |          |    |          |          |     | 25   |
| 11-14-83 | 200          | 10  |                     |     |     | 75  |     |      | 50    |    |      |    |       |            |    |            |           |          |    |          |          |     | 25 1 |
| 11-21-83 | 100          | 5   |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     | 1    |
| 11-29-83 | 80           | 10  |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     | 1    |
| 12-8-83  | 25           |     |                     |     |     |     |     |      |       |    |      |    |       | 10         |    |            |           |          |    |          |          |     | 1    |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |
|          |              |     |                     |     |     |     |     |      |       |    |      |    |       |            |    |            |           |          |    |          |          |     |      |

7-1  
AERIAL CENSUS DATA - ANDALUSIA REFUGE

| DATE     | MALL-<br>ARD | BLK | PINT | BWT | GWT | WIG | GAD | SHOV | SCAMP | RN  | CANS | RH  | Ruddy | GLD<br>EYE | BH | COM<br>MER | RB<br>MER | H<br>MER | CG | SM<br>CG | GT<br>CG | BSG | COOT | BAND<br>EARLIE |
|----------|--------------|-----|------|-----|-----|-----|-----|------|-------|-----|------|-----|-------|------------|----|------------|-----------|----------|----|----------|----------|-----|------|----------------|
| 1-3-83   | 60           |     |      |     |     |     |     |      |       |     |      |     |       | 25         |    | 5          |           |          |    |          |          |     |      | 1              |
| 3-1-83   | 225          | 10  |      |     |     |     |     |      | 60    | 30  |      |     |       | 75         |    | 20         |           |          |    |          |          |     |      | 2              |
| 3-7-83   | 275          | 20  |      |     |     |     |     |      | 350   | 175 | 60   |     | 40    | 5          |    |            |           |          | 50 |          |          |     |      | 4              |
| 3-14-83  | 600          | 30  |      |     |     | 50  |     |      | 650   | 325 | 80   | 40  |       | 100        |    | 30         |           |          | 50 |          |          |     | 75   |                |
| 3-22-83  | 325          | 20  |      |     |     |     |     |      | 275   | 150 | 50   | 25  |       | 75         |    | 30         |           |          |    |          |          |     |      | 2              |
| 3-28-83  | 800          | 30  |      |     |     | 175 |     |      | 650   | 275 | 175  | 75  |       | 40         | 35 | 25         |           |          |    |          |          |     | 100  | 2              |
| 4-4-83   | 400          | 30  |      |     |     | 30  |     |      | 650   | 275 | 80   | 150 |       | 25         | 20 | 10         |           |          |    |          |          |     | 500  | 2              |
| 4-11-83  | 250          | 10  |      |     |     |     |     |      | 900   | 375 | 150  | 50  | 30    | 125        |    | 40         |           |          |    |          |          |     | 750  | 1              |
| 4-25-83  | 60           |     |      |     |     | 25  |     |      | 125   | 50  |      |     | 15    | 30         |    | 10         |           |          |    |          |          |     | 250  |                |
| 9-6-83   | 25           |     |      | 60  |     |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     |      |                |
| 9-13-83  | 50           |     |      | 80  | 30  |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     |      |                |
| 9-19-83  | 80           |     |      | 50  |     |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     | 25   |                |
| 9-26-83  | 60           |     |      | 30  |     |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     | 20   |                |
| 10-3-83  | 80           |     | 25   |     |     |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     | 30   |                |
| 10-11-83 | 35           |     |      |     |     |     |     |      |       |     |      |     |       |            |    |            |           |          |    |          |          |     | 30   |                |

AERIAL CENSUS DATA — ANDALUSIA REFUGE

| DATE     | MIN-L<br>ARD         | BLK | PIAT | BWT                           | GWT | WIG | GAD | SHOV | SCAMP | RN | CANS | RH | RODDY | G.D.<br>EYE | BH | LOM<br>MER | P.E.<br>MER | H<br>MER | LG | SM<br>CG | GT<br>CG | BSG | COOT | BALD<br>EAGLE |
|----------|----------------------|-----|------|-------------------------------|-----|-----|-----|------|-------|----|------|----|-------|-------------|----|------------|-------------|----------|----|----------|----------|-----|------|---------------|
| 9-14-82  | 20                   |     |      | 65                            |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 50   |               |
| 9-21-82  | 60                   |     |      |                               |     | 25  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 40   |               |
| 9-27-82  | 50                   |     |      | 30                            |     | 25  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 60   |               |
| 10-4-82  | 40                   |     |      |                               |     | 15  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 40   |               |
| 10-11-82 | 75                   |     | 25   |                               |     | 50  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 100  |               |
| 10-18-82 | 175                  |     |      |                               |     | 80  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 75   | 1             |
| 10-26-82 | 175                  | 5   |      |                               |     | 80  |     | 35   |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 75   |               |
| 11-4-82  | NO CENSUS DUE TO FOG |     |      |                               |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     |      |               |
| 11-8-82  | 225                  | 5   | 40   |                               |     | 80  |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     | 100  |               |
| 11-15-82 | 80                   | 25  |      |                               |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     |      | 1             |
| 12-6-82  | 80                   |     |      |                               |     |     |     |      | 30    |    |      |    |       | 10          |    | 10         |             |          |    |          |          |     |      | 1             |
| 12-13-82 | 200                  | 20  |      | MISS. RIVER ABOVE FLOOD STAGE |     |     |     |      |       |    |      |    |       | 75          |    | 25         |             |          |    |          |          | 2   |      |               |
|          |                      |     |      |                               |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     |      |               |
|          |                      |     |      |                               |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     |      |               |
|          |                      |     |      |                               |     |     |     |      |       |    |      |    |       |             |    |            |             |          |    |          |          |     |      |               |

ACTUAL CENSUS DATE — ANDALUSIA REFUGE