PART VII - PUMP STATION SYSTEM

PART VII

PUMP STATION SYSTEM

A. STAGE-FREQUENCY RELATIONSHIPS

1. GENERAL

In order to evaluate the performance of the levee pump stations, it is important to establish the simultaneous occurrence probability of river stage and local rainfall intensity. This relationship is important because it greatly affects the capacity of the discharge structure.

2. KANSAS RIVER

The stage-frequency relationship for the Kansas River was established by using gaging station data collected by the Corps of Engineers for the past 29 years. The gaging station is located immediately downstream from the Tuttle Creek Boulevard drainage system/Poyntz Avenue pump station outlet. The raw data from the gaging station is shown in Appendix II and is summarized in Table VII-1. This information was supplemented by additional information from the 1984 Flood Insurance Study. The relationship is plotted graphically in Figure 1.

TABLE VII-1

RIVER STAGE STATISTICS
OCTOBER 1964 - NOVEMBER 1993

River Stage	Number of Occasions	Number of Different Years	Number of Different Days
1014	1 (1993)	1	3
1013	1 (1993)	1	6
1012	1 (1993)	1	7
1011	1 (1993)	1	8
1010	1 (1993)	1	12
1009	1 (1993)	1	14
1008	2 (1993 & 1973)	2	18
1007	2 (1993 & 1973)	2	22
1006	3 (1993, 1987, 1973)	3	26
1005	3 (1993, 1987, 1973)	3	38
1004	7	5	58
1003	9	6	84
1002	15	10	148
1001	21	15	228
1000	36	16	319

The Kansas River reached an elevation of 1,019.26 feet at this gaging station on July 13, 1951. This is the highest river stage recorded since the installation of a gage at this site in the early 1900's. The river was not regulated with upstream dams in 1951. The highest stage recorded at this site since the construction of upstream dams in the early 1960's was 1,014.92 feet on July 26, 1993.

The average Kansas River stage on a year-to-year basis is indicated in Table VII-2. The average river elevation for the period from 1964 through 1993 was 993.27.

TABLE VII-2

KANSAS RIVER ANNUAL AVERAGE STAGE
1964 - 1993

Year	Elevation
1964	991.39 (3 month record)
1965	993.38
1966	992.22
1967	993.25
1968	992.36
1969	996.69
1970	992.18
1971	993.04
1972	995.00
1973	997.32
1974	993.77
1975	992.48
1976	992.89 (8 month record)
1977	no recordings)
1978	993.23
1979	994.46 (9 month record)
1980	992.39
1981	991.99
1982	993.69
1983	993.04
1984	992.37
1985	993.74
1986	993.64 (11 month record)
1987	994.86
1988	991.06
1989	991.35
1990	991.41
1991	990.74
1992	992.43
1993	998.54

3. WILDCAT CREEK

The following table summarizes the stage-frequency relationship for Wildcat Creek at South Manhattan Avenue. It is based on information from the 1981 Flood Insurance Study for the City of Manhattan.

TABLE VII-3

STAGE-FREQUENCY RELATIONSHIP
WILDCAT CREEK AT SOUTH MANHATTAN BOULEVARD

Return Frequency	Stage
10 Year	1012.4'*
50 Year	1016.5'*
100 Year	1019.8'*
500 Year	1026.4'*

* Data from 1981 Flood Insurance Study

B. SYSTEM DESCRIPTIONS

1. SOUTH MANHATTAN AVENUE PUMP STATION

This facility is located at the intersection of South Manhattan Avenue and the levee on the north side of Wildcat Creek. The system is fed from the north by three storm drains which are 36, 72, and 84 inches in diameter. The 10-cfs pump station has a total of 16 acre-feet of available storage divided among four different detention ponds. These ponds have a bottom elevation of 1,010.0 feet with a storage depth of 5.5 feet. The pump station and detention ponds were constructed in the early 1960's as part of the flood protection system.

Under normal conditions, the drainage system gravity flows into Wildcat Creek and provides approximately a two-year level of service based on analysis of the existing system under current land use conditions. However, when the water in the creek reaches a 50-year stage (1,016.5' ±), no gravity release from the system or detention ponds is possible. At that time any discharge from the ponds must be through the 10-cfs pump station. Under these circumstances, with no gravity flow, even a one-hour, one-year frequency storm will exceed the available storage capacity. However, the initial Corps of Engineers' Design Criteria only required storage capacity for a one-hour storm of 0.85 inch, which is approximately

65% of the intensity of a one-year storm, coincident with a 50-year stage in Wildcat Creek.

To put the capacity of this system in perspective, an approximate level of protection, or level of service, provided by the existing system can be determined by estimating the "probability of exceedance" of the design event. Although there are many variables that can be considered, the probability of the design precipitation occurring simultaneously with the design river stage can be conservatively estimated by the product of their individual chances of occurring. Assuming that a 0.85-inch, one-hour storm occurs twice a year, its annual probability of occurrence is 2 while the annual probability of a 50-year river stage is 0.02. The probability of exceedance of the design conditions, therefore, would be (2)(0.02), or 0.04, annually which would be equivalent to a 25-year return frequency.

This analysis appears to be supported by the fact that the pump station in this part of the flood protection system has only been used once since the system was installed. This usage was during July of 1993 and the system performed well at that time. The main storm on the evening of July 18, 1993 had an approximate return frequency of 2 years (2.0" over a period of 90 minutes) when the elevation of Wildcat Creek was approximately 1,012.3, roughly the 10-year stage. City staff released the water from the detention ponds by a combination of pump station flow and gravity flow.

2. POYNTZ AVENUE PUMP STATION

a. System Operation

This facility currently consists of two 10-cfs storm water pump stations, located approximately 1400 feet north of the existing K-177 Kansas River Bridge, which are connected to a 10'x 10' RCB through the levee. Upstream drainage is collected in the large channel, called the Riverside Drain, along the east side of Tuttle Creek Boulevard and flows across the frontage road and Highway 24 through a 12'x 10' RCB. The facilities also include the existing ponding area shown in Figure 2. The original levee system, built in the early 1960's, included only one 10-cfs pump station. The second was added in the mid 1970's when it was converted from use with the old sewage treatment plant which was abandoned at this site.

The diversion structure, also shown in Figure 2, was added in the mid 1970's as well. This structure, which is located just east of the water treatment plant, is closed whenever the Poyntz Avenue pump station is activated. This action causes all flow from the double 7'x 5' RCB, which passes by the north side of the water treatment plant, to be diverted northward through 72 inch pipes under Hayes Drive, near Casement Road, and through the levee.

Like the South Manhattan Ave. station, the Poyntz Ave. pump station was designed for a 0.85-inch, one-hour storm coinciding with a 50-year stage on the Kansas River although storage capacity for the Poyntz Ave. station was much greater. Corps of Engineer documents show that 315 acre-feet of detention storage were available upstream of this pump station when the system was initially constructed. Because of development in the area east of Tuttle Creek Boulevard since then, however, there are now only about 33 acre-feet located south of the diversion structure and approximately 49 acre-feet located north of the diversion structure, all below elevation 1,005.0 which is the approximate elevation of the frontage road near Sarber Lane. Businesses along the frontage road have predominately kept the first floor elevations at or above elevation 1,007.0.

The 1965 Operation and Maintenance Manual, written by the Corps of Engineers, recommended that pumping be initiated at a river stage of 1,000.0 while the subsequent 1974 Storm Drainage Master Plan for the City of Manhattan recommended that the pump station be activated at elevation 999.0, A review of the updated Kansas River stage-frequency relationship reveals that the river can be expected to reach elevation 999.0 somewhat more frequently than once per year. However, if water on the city side of the levee rises rapidly and reaches an elevation higher than the river, the gravity flow gate can be opened simultaneously with the pump operation to release flood waters into the river. Some gravity flow is achievable up to a river stage of 1,005.0, which has a return frequency of approximately five years, without water in the storage area overtopping the frontage road near Sarber Lane.

A critical time for the drainage system in this area occurs, therefore, when a local storm coincides with a high Kansas River stage resulting in the gravity flow gate being closed and the pump station activated. At this time, the interior drainage must be either pumped into the river, or retained in the storage provided by the Riverside Drain channel and adjacent areas. The 49 acre-feet of storage north of the diversion structure will not be available since the diversion structure will be closed prior to that time when the pump station is activated. Analysis of the existing system indicates that, under normal conditions when all flow to the river is by gravity, the system is capable of handling a 10-year, one-hour storm thus providing a 10-year level of protection to the area along the Riverside Drain; however, once the flood gate is closed and all stormwater must be stored and pumped by the two 10-cfs pumps, the system is capable of handling only a one-year, one-hour storm without overtopping the frontage road.

To illustrate the inadequacy of the Poyntz Avenue pump station to handle the simultaneous occurrence of certain events, a storm which occurred on the evening of July 17, 1993 was considered. This event filled the available ponding area for the Poyntz Avenue pump station and flooded the frontage road in that area. This is the highest elevation flood waters have reached in this ponding area since the levee was constructed. The special conditions which led to this flooding event, along with some of the results, are indicated below.

1) The Kansas River was at an elevation of 1004.07 (4 ± year frequency) at 8:00 a.m. on July 17 which meant that the gravity gate at the Poyntz Avenue station was closed to keep river water from flowing into the City.

2) A total precipitation depth of 2.76 inches occurred on the evening of July 17 and before 8:00 a.m. on the 18th. A large portion of the rain fell within a 1½-hour period on the evening of the 17th. Records do not exist which allow accurate determination of a return frequency for this local storm; however, if it is assumed that approximately two inches of rain fell in the most

intense 90 minute period, this would be equivalent to a two-year storm.

3) The river elevation rose to 1,007.31 by 8:00 a.m. on July 18.

4) The flood water at the intersection of the frontage road and Sarber Lane rose to an elevation of approximately 1,006.8 according to local businessmen. Water was nearly two feet deep on the frontage road. Most businesses in this area were inches above the flood waters, although Motel 6 did get water on the first floor.

5) Because the river was at a beginning elevation of 1,004.07, City staff was able to open the gravity gate and release some water into the river as the level rose on the city side. When gravity flow is possible, it is much more effective than the pumped flow which is occurring simultaneously. However, by 8:00 a.m. on July 18, the river had risen so that gravity flow was not possible.

This situation apparently was the result of a local storm with a two-year return frequency coinciding with a four-year frequency stage on the Kansas River. It is difficult to assign a return frequency to this specific event since it is dependent upon a certain storm occurring simultaneously with a certain river stage; however, it may be noted that this is the only time flood waters have reached the frontage road during the 30 years since the levee system, upstream dams, and pump station have been in existence.

The flooding within the levee could have been significantly worse if the river had been at elevation 1,007.0 (10-year frequency) before the storm event which would not have allowed any gravity flow release. Under those circumstances, even a one-year, three-hour storm would have required 77 acre-feet of storage which would have exceeded the available storage of 57 acre-feet at elevation 1,006.8 (1993 flood elevation).

b. Improvement Alternatives

In order to increase the level of protection to the area along the Riverside Drain when no gravity flow from the drainage system is possible, either increased pumping capacity or increased storage capacity, or both, will be required. Relying on additional pumping only, the station capacity will need to be increased to 70 cfs to provide the 10-year level of protection equal to the existing drainage system under normal conditions. In addition to the increased protection during a storm, the larger pump station will also reduce the time required to pump out the storage area when gravity flow to the river is not possible, from 68 hours at the existing 20-cfs capacity to only 20 hours . This will help minimize the risk to the "Frontage Road-Sarber Lane" area which is extremely vulnerable to a repeat storm while the ponding area is partially filled from a previous storm.

Additional storage capacity in the area would increase the level of protection even further. Any meaningful increases to the storage capacity are very difficult, however, since the area is largely developed. One potential area is shown on Figure 2. This site is already owned by the City and was previously used for water treatment plant lime sludge drying beds before new drying beds were constructed farther north several years ago. Adding the 56 acre-feet in the proposed ponding area to the existing capacity and increased pumping rates, conditions in the "Frontage Road-Sarber Lane" area will be improved even more during periods of no gravity flow. Analyzing these conditions in terms of the probability of exceedance and using the 5-year river stage as the design event (the elevation at which gravity flow ceases), the improved facilities will handle a 10-year, one-hour storm thus providing a 50-year level of protection to the buildings along the frontage road which is greater than the existing system provides under normal conditions. Table VII-4 summarizes the flood elevations resulting from a one-hour duration storm and a five-year river stage with the various improvements.

TABLE VII-4

IMPROVED PUMP STATION SYSTEM PERFORMANCE

Storm Return Period (Yrs.)	Pumping Rate (cfs)	Peak Water Elevation Without Addtl. Storage	Peak Water Elevation With Addtl. Storage
2	20	1005.79	1002.89
10	20	1007.89	1005.51
2	70	1005.39	Not Required
10	70	1007.41	1005.09

In order to develop the proposed storage site into a temporary storm water detention area, however, it will be necessary to remove the remaining lime sludge from the old lagoons. This material, because of its depth, could be very wet requiring special removal techniques, and its composition may limit disposal options due to environmental constraints.

C. RECOMMENDATIONS

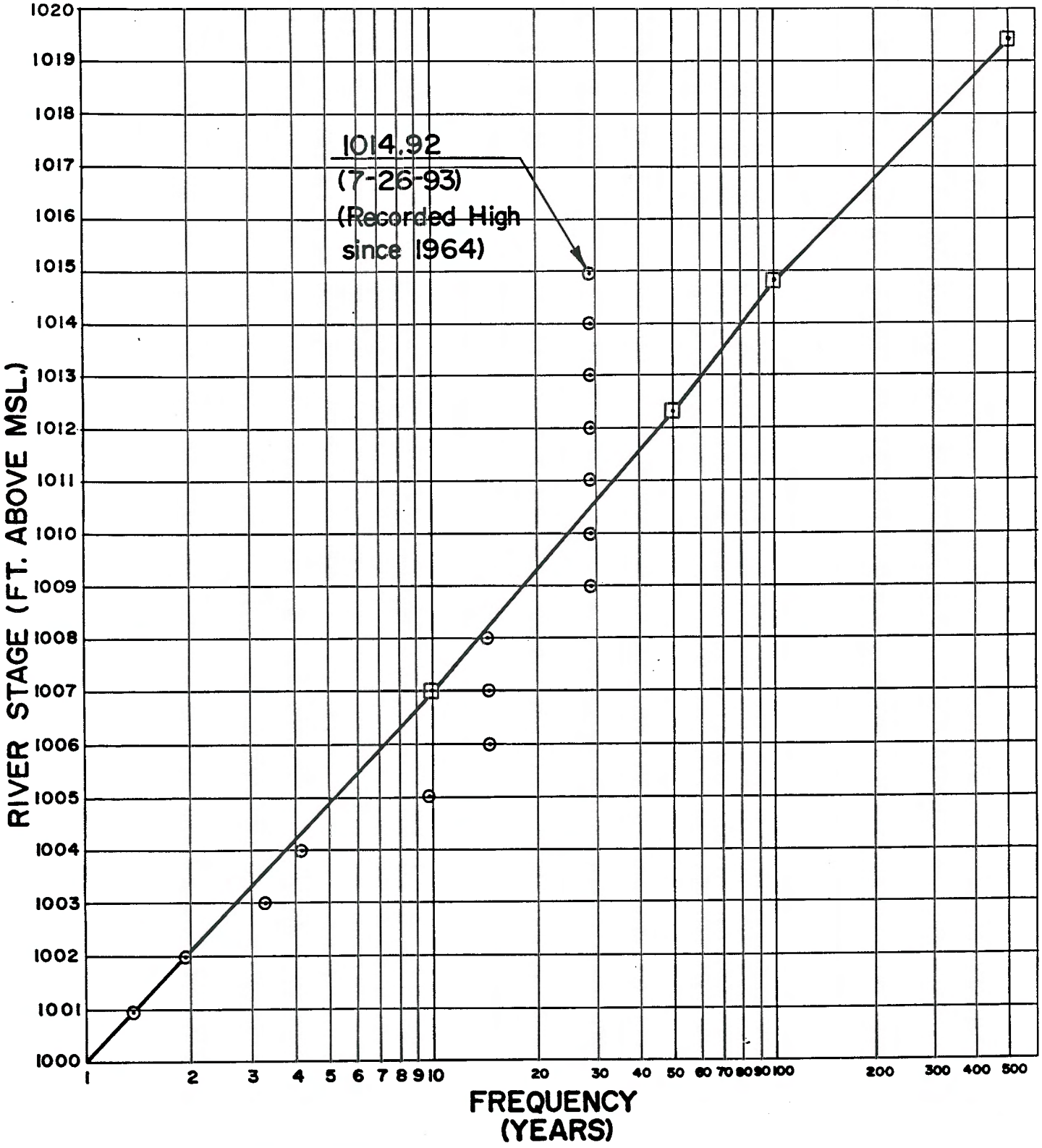
1. SOUTH MANHATTAN PUMP STATION

While the South Manhattan system's overall capacity is somewhat limited, it does exceed the limits of the initial Corps of Engineers Design Criteria; no problems have been reported; and the estimated 25-year level of protection it provides in essence exceeds the design criteria for storm drainage system components. Therefore, no modifications are recommended for this pump station-detention pond facility at this time.

2. POYNTZ AVENUE PUMP STATION

In order to provide increased flood protection for the commercial area east of Tuttle Creek Boulevard, we recommend a new 70-cfs pump station be constructed at this location. The estimated cost of the new pump station is $265,000. In addition, if the increased level of protection is deemed warranted by the City, the proposed ponding area can be developed for an estimated cost of $414,000 exclusive of special material handling and disposal costs. These facilities have been included in the list of recommended improvement projects presented in Part VI of this report.

* * * * *

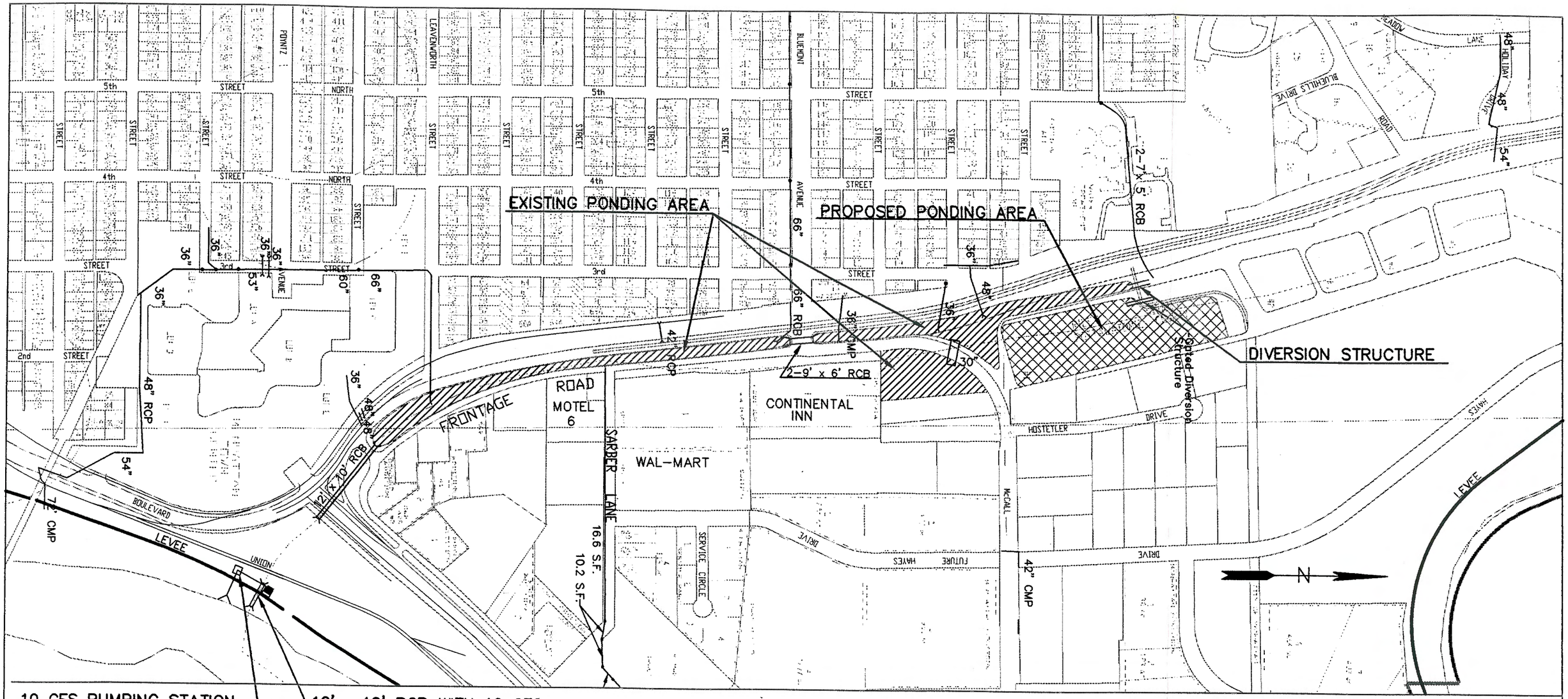


⊙ DATA FROM STREAM GAGE (1964 - 1993)

⊡ DATA FROM 1984 FLOOD INSURANCE STUDY

STAGE - FREQUENCY RELATIONSHIP

FIGURE 1 — KANSAS RIVER @ TUTTLE CREEK BLVD. STORM DRAIN OUTLET



10 CFS PUMPING STATION.
CONVERTED FROM OLD SEWAGE TREATMENT PLANT.

10' x 10' RCB WITH 10 CFS PUMPING STATION

EXISTING + PROPOSED PONDING AREA

ELEVATION	STORAGE VOLUME
* 1005 feet	74 Acre-Feet
✦ 1006.8 feet	113 Acre-Feet

* Approximate elevation of Frontage Road near Sarber Lane.
✦ Approximate elevation of 1993 flooding.

EXISTING PONDING AREA

ELEVATION	STORAGE VOLUME
* 1005 feet	33 Acre-Feet
✦ 1006.8 feet	57 Acre-Feet

* Approximate elevation of Frontage Road near Sarber Lane.
✦ Approximate elevation of 1993 flooding.

PROPOSED PONDING AREA
(EXCLUDING EXISTING)

ELEVATION	STORAGE VOLUME
* 1005 feet	41 Acre-Feet
✦ 1006.8 feet	56 Acre-Feet

* Approximate elevation of Frontage Road near Sarber Lane.
✦ Approximate elevation of 1993 flooding.

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FIGURE 2
POYNTZ AVE. PUMP STATION AND STORAGE POND SYSTEM