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Storm Water Management
Using a High Density Rainfall Network
Along With Long Term Records

A Dissertation

Submitted to Graduate Faculty of the
University of New Orleans
In Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
in
Engineering and Applied Science

by

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ABSTRACT

The United States Weather Bureau had published Technical Paper No. 40 (TP-40) in 1961 which provides a rainfall atlas for the United States. These rainfall frequencies have been used by engineers throughout the United States including Jefferson Parish, Louisiana. Rainfall from Audubon and the New Orleans International Airport rain gauge stations were used with the Log Pearson Method to provide rainfall frequency for Jefferson Parish, Louisiana.

The results from the frequency rainfall that were developed for this research along with the current Jefferson Parish design storm rainfall were applied to a typical urban development to evaluate the extent of flooding.

Log Person Method, Rainfall Frequency, Audubon Rain Gauge Station, New Orleans International Airport Rain Gauge Station, Annual Series, Partial Duration Series, Area Rainfall Frequency

Chapter 1 - Introduction

1.1 Introduction

Rainfall is the principal part of the hydrologic cycle and its magnitude and duration and affects the design and studies of hydraulic structures such as dams, culverts, bridges, spillways, urban and highway planning and development, planning of flood control and water management projects.

Rainfall intensity or magnitude produces precipitation over an area and is governed by certain atmospheric conditions. These conditions require the presence of moisture in the atmosphere and some mechanism to cool the air sufficiently to cause condensation.

The first recorded measurements of rainfall and surface flow were made in the 17th century by Perrault, who compared measured rainfall to the estimated flow of the Seine River to the show that the two were related. Perrault's findings were published in 1967. (Pierre Perrault, 1967)

The first extended rainfall frequency study in the United States was by Yarnell (1935) in the early 1930's and was presented in the form of maps for several combinations of return periods and durations for the continental United States.

From 1900 to 1930 (Naghavi, 1993) was the period where government agencies increased their efforts in hydrologic research; also a number of technical societies were organized for the advancement of the science of hydrology. For example, the Bureau of Reclamation (1902), the Forest Service (1906), the U.S. Army Engineers Waterways Experiment Station (1928). Today, the National Climate Data Service (NCDC) of the National Weather Service (NWS) is responsible for compiling weather information.

The U.S. Weather Bureau updated earlier their work and published it as TP-40 in 1961 (Hershfield, 1961) with the use of additional rainfall data. This rainfall atlas contains 50 maps of the United States with contour lines of rainfall amounts for durations varying from 30 minutes to 24 hours and return periods from two to one hundred years. A supplement to TP-40 Hydro-35 was published by the National Oceanic and Atmospheric Administration (NOAA) of the National Weather Service (NWS) in 1977. This publication provides rainfall contour maps for 5 to 60 minute durations and 2 to 100

year return periods for eastern and central United States. This set of maps is a useful addition to TP-40 for estimating the design storm of short durations or developing intensity duration frequency (I-D-F) charts. There are few states such as (Naghavi, 1993) Pennsylvania and Arizona that have undertaken a similar study. However, results from these studies are only applicable to those states. Published reports with regard to precipitation in Louisiana includes Louisiana rainfall, published by the Louisiana Department of Public Works in 1952 and 24 hour rainfall frequency maps and I-D-F curves by Louisiana Department of Transportation.

Since then, over 40 years of additional data has become available. The quality of collecting precipitation data has improved along with the number of gauges has increased significantly throughout the U.S. New statistical methods and techniques have been developed. However, such advances and improvements have not yet been used to update this widely used TP-40. Due to the relatively short period of records and the small number of rain gauges available at the time of preparation of TP-40, the desired accuracy and resolution was not obtained. Also, the TP-40 maps consist of widespread contours and lack details needed for more accurate design of drainage structures in a particular watershed because these maps were developed for the entire country not by particular state.

1.2 Problem Statement

1) Outdated rainfall frequency maps

Since 1980, Jefferson Parish has been using a 10 year 24 hour storm frequency for the design of their drainage system. The frequency is obtained from TP-40 (Hershfield, 1961, Table 1.1A) which is based on Gumbel distribution. This method has been shown in practice to systematically underestimate the large, infrequent events (Wilks, 1993).

Table 1.1A – Rainfall Depth Based on Technical Paper No. 40

Return Period	Duration (Hours)				
Years	**1**	**2**	**6**	**12**	**24**
2	2.4	3.0	4.0	5.0	6.0
5	3.0	3.8	5.1	6.5	7.6

10	3.5	4.3	6.2	8.0	9.2
25	4.0	5.0	7.0	9.0	10.8
50	4.2	5.5	8.0	10.0	12.0
100	4.5	6.25	9.0	11.0	13.3

The Louisiana Department of Highways for the design of highways and bridges uses the Hydraulics Manual (1987) as published by the department. This manual divides the State into three (3) regions. Jefferson Parish is in Region 1 and provides rainfall depth. (Table 1.1B)

2) Increased rainfall intensity and frequency

Extreme weather events in a changing climate are of increasing concern. The impressive magnitudes of recent heavy rainfalls and flooding have raised questions about the impact of climate changes in the region (Keim, 1999).

The topography of Jefferson Parish is such that requires construction of artificial levee systems to protect the parish from the Mississippi River and Lake Pontchartrain because without them, the parish would be subject to flooding. This levee system that protects the parish from outside creates a situation where virtually all of the precipitation that falls within the levee system must be pumped outside the confines of the drainage boundaries.

3) Continued growth results in increased runoff

In Jefferson Parish, Louisiana, not only are heavy rainfall events a serious problem, but the current growth and development of the parish is a concern. The increase in urbanization results in an increase in the volume of water available to contribute to runoff due to more impervious areas, such as parking lots, streets, buildings and houses.

Table 1.1A – Rainfall Depth Based on Technical Paper No. 40

Return Period Years	Duration (Hours) 1	2	6	12	24
2	2.4	3.0	4.0	5.0	6.0
5	3.0	3.8	5.1	6.5	7.6
10	3.5	4.3	6.2	8.0	9.2
25	4.0	5.0	7.0	9.0	10.8
50	4.2	5.5	8.0	10.0	12.0
100	4.5	6.25	9.0	11.0	13.3

The Louisiana Department of Highways for the design of highways and bridges uses the Hydraulics Manual as published by the department. This manual divides the state into three (3) regions. Jefferson Parish is in Region 1 and provides rainfall depth. (Table 1.1B)

Table 1.1B – Rainfall Depth Based on Louisiana DOTD Hydraulics Manual

Return Period Years	Duration (Hours) 6	12	24
2	3.5	4.1	4.8
5	4.6	5.6	6.5
10	5.5	6.7	7.8
25	6.6	8.2	9.6
50	7.6	9.5	11.1
100	8.6	10.9	12.6

Rainfall depth for each region is the average of all rainfall in that region. This results in lower values for the coastal region. Currently for the state highway projects when the average daily traffic (ADT) is less than 400, 10 year return period is used. As (Louisiana Department of Transportation and Development, Hydraulics Manual) highway traffic increases, or the area is more developed, the return period increases so that in some conditions a 50 year return period may be used.

Chapter 2 - Objectives

2.1 Objectives of this Research effort

The purpose of this dissertation is to analyze the precipitation records for Jefferson Parish to evaluate heavy rainfall events with respect to the long-term climate record to address the following questions:

1) What are the long term trends in the rainfall events in Jefferson Parish?
2) Is the frequency distribution based on the latest annual maximum rainfall in Jefferson Parish significantly different for the one in current use?
3) What are the appropriate rainfall frequency and area distribution curves for Jefferson Parish?
4) What are the implications of long term trends in rainfall intensity on storm water management in an urban setting?

2.2 Approaches and Assumptions

In determining maximum two or more consecutive hours of rainfall in a day, typically the values are determined using rainfall data starting at 12:00 a.m. until the next day at the same time. For example, if rainfall starts at 10:00 p.m. and continues until 2:00 a.m. the next day maximum when calculating two hour rainfall, one has to consider the total rainfall that occurs between 11:00 p.m. and 1:00 a.m. The same applies in trying to find the maximum six hour rainfall we should continue to the next day. This process avoids underestimating the amount of rainfall and in this research, whenever the storm duration exceeds two hours total rainfall, it is calculated by adding consecutive rainfall hours into the next day.

(Keim and Muller, 1992) summed two consecutive days of precipitation in their research to minimize the problems associated with the discrete observations of continuous rainfall over short periods. The resulting data was to be used to investigate the fluctuation of heavy rainfall.

Two methods of frequency analysis were used in TP-40 (Naghavi, 1993). One method, using the partial duration series, includes all the high values greater than a

certain base value. The other uses the annual series which consists only of the highest value for each year. The partial duration series and the annual series differ in the lower return periods of 10 years and less.

One of the objectives of this research is to estimate the magnitude or intensity of rainfall for a given duration and return periods. For both annual and partial duration data, TP-40 (Hershfield, 1961) employed the Gumbel distribution. This has caused underestimation of the precipitation amount (Wilks, 1993).

(Keim, Faiers, 2000) in comparing several probability distribution methods for western Texas concluded that the Gumbel distribution provided the worst fit and the SRCC method fit the extreme rainfall data for the area. (Naghavi, 1993). Evaluating various distribution methods for Louisiana concluded that the Log Pearson Type III distribution is the most appropriate probability distribution for Louisiana. The Log Pearson Type III distribution with partial duration data was used in this research.

Jefferson Parish was selected to apply these methods in order to evaluate the results.

The Log Pearson Type III along with the partial duration series were used to analyze the rainfall data from Audubon and New Orleans International Airport rain gauge stations. The results are to be used to develop I-D-F curves for Jefferson Parish and evaluate the existing drainage design requirements.

Chapter 3 - Literature Review

3.1 Historic Development of Jefferson Parish Drainage System

Jefferson Parish, Louisiana was established in 1825 and was named in honor of Thomas Jefferson commemorating his role in purchasing the Louisiana Territory from France in 1803. The parish originally extended from present day Felicity Street in New Orleans to the St. Charles Parish line. As Orleans Parish grew, it annexed from Jefferson Parish established areas such as the Garden District, Lafayette, Jefferson and Carrollton. The present boundary was set in 1874 and the seat of the parish government was transferred to the West Bank, Gretna, where it has remained.

Most of the population of Jefferson is in the urbanized metropolitan area, which has relatively flat topography with ground elevations varying from slightly above to about five (5) feet below sea level. Flood protection is provided by a system of levees, floodwalls, canals and drainage pump stations. Storm water runoff is conveyed by gravity through a system of subsurface lines and canals into the suction bays of various pump stations then pumped to surrounding water bodies outside of the flood protection system.

The Department of Drainage is responsible for the administration, coordination and implementation of major drainage and flood control projects, programs and operations, as well as the construction and maintenance of 47 drainage pump stations containing 130 pumps throughout the Jefferson Parish drainage system.

Jefferson Parish is divided by the Mississippi River into the East Bank and the West Bank (Figure 3-1). The East Bank of Jefferson Parish is one large basin that is interconnected. There are four (4) major pump stations. One can assign a basin to each of the pump stations. There is another 2,455 acres, Hoey's basin, that is drained directly into Orleans Parish. The total drainage area of the East Bank is 31,733 acres that includes Hoey's basin. Currently, the total pumping capacity of the East Bank pumping stations is 20,535 cubic feet per second. In terms of rainfall intensity that is 0.39 inches/hour presently and after the SELA projects will increase to 0.54 inches/hour.

The West Bank has three (3) distinct drainage basins, east of the Harvey Canal, west of the Harvey Canal, and west of Bayou Segnette. The total area for the West Bank is 48,483 acres. The total pumping capacity for the West Bank is 18,849 cubic feet per

second and it is projected to increase to 26,049 cubic feet per second after SELA projects. Crown Point, Lafitte and Barataria are served by a system of multiple ring-levees and 14 remote lift stations containing 20 pumps with a total capacity of 460 cfs.

The East Bank pumping capacity, in terms of rainfall intensity is 0.5 inches/hour presently and is to increase to 0.74 inches/hour after completion of the drainage project currently underway. The West Bank pumping capacity in terms of rainfall intensity is 0.39 inches/hour presently and after completing the drainage improvements is projected to increase it to 0.54 inches/hour.

There are approximately 340 miles of canals, waterways, drainage ditches, cross drains, culverts and 1,465 miles of street subsurface drainage system and 52 drainage pump stations.

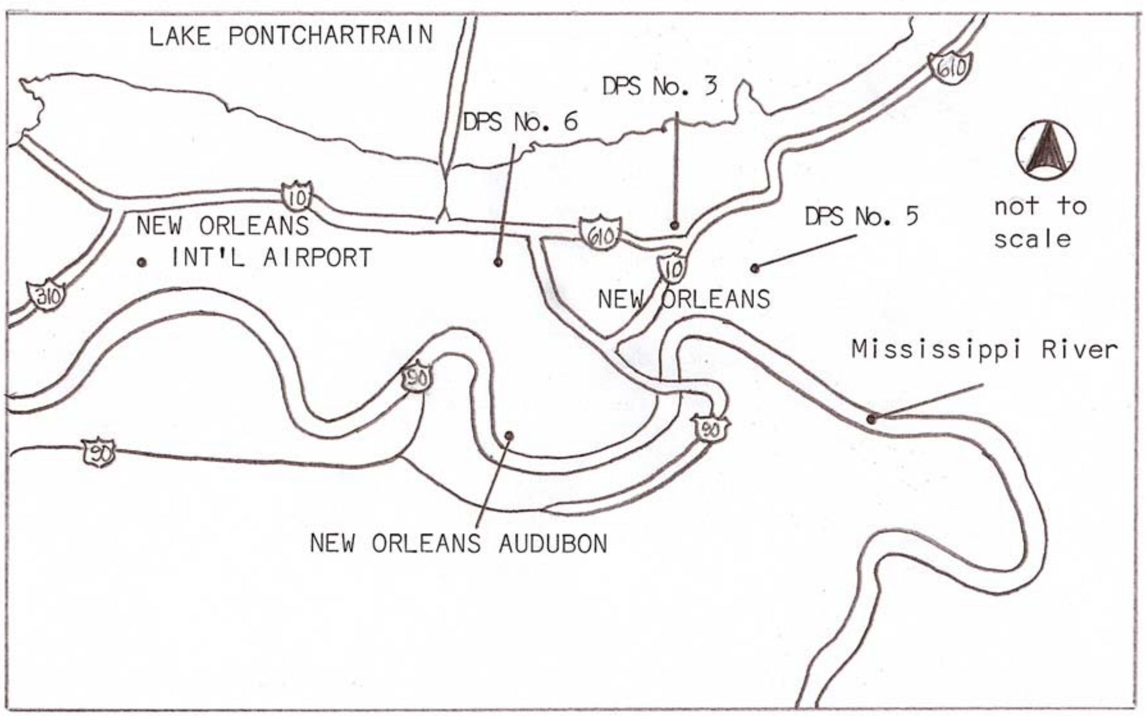


Figure 3.1. Audubon and New Orleans International Airport Rain Gauge Stations

3.2 Evaluation of the Growth of Jefferson Parish

Once a largely rural area of farms, dairies and vast tracts of undeveloped land, Jefferson Parish today is New Orleans' first suburb – a bedroom community west of the

city that received the first great migration of middle class families from the1950's to 1970's.

The parish's largest community is Metairie. In 1958, the first span of the Crescent City Connection opened providing Jefferson for the first time with bridge access over the Mississippi River to New Orleans. Ferry boats provided the only link between the banks.

Jefferson Parish statistical data (www.jeffparish.net) shows that as of 2000, the population of the parish was 455,466. However, after the 2005 hurricane season, Orleans Parish was devastated and Jefferson Parish escaped with some minor flooding. This resulted in a population shift to Jefferson with the occupancy of all available dwellings and exacerbated the already increasing growth in the parish.

3.3 Management of Water Quality in Urban Environment

In urban and suburban areas, much of the land surface is covered by buildings and pavement which do not allow rain to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The storm water runoff carries pollutants such as oil, dirt, chemicals and lawn fertilizers directly to streams and rivers where they seriously harm water quality.

To protect surface water quality and ground water resources, sections 401 and 402 of the Clean Water Acts provide for a number of programs to improve the water quality such as the National Pollutant Discharge Elimination System (NPDES) and the Nonpoint Source Pollution Control Program. The NPDES permit program regulates any discharge by point sources from municipalities serving a population of 100,000 or more.

Congress has continued its focus on efforts on nonpoint sources. The Coastal Zone Act Reauthorization Amendment of 1990 (CZARA) was to address several concerns including impact of nonpoint source pollution on coastal waters.

3.4 Inadvertent Rain Gauge Inconsistencies and Their Effect on Hydrologic Analysis

Consistent rainfall data is, perhaps, the most significant ingredient in developing accurate hydrologic analysis (Curtis and Bornash, 1996). Without consistent rainfall data

from storm to storm or even within storms, accurate stream flow simulations and forecasts are extremely difficult to achieve. Rainfall records are rarely scrutinized to the degree necessary to develop an "engineered" data set that best indexes the true rainfall entering the watershed.

The National Weather Service has used several types of rain gauges or weather stations to measure precipitation. An eight-inch diameter rain gauge is the observation equipment standard for all cooperative rainfall observers and consists of a metal cistern inside a larger metal cylinder. The inner tube catches the rainfall and the observer measures the accumulated liquid with an extended ruler. When the ruler is removed from the cylinder, the rainfall amount is determined by the level of the water inside the cylinder wetted on the ruler. (Yang, Goodison and Metcalf, 1998).

Among other known systematic errors, the greatest source of bias in precipitation observation is caused by wind shields. To reduce the wind-induced undercatch, wind shields of various types were introduced and used with national precipitation gauges. It is acknowledged that changes in instrumentation may introduce a discontinuity into a precipitation time series since the gauge measurement is affected by gauge design, including particularly whether the gauge is equipped with a wind shield. Numerous experimental studies clearly show that a shielded gauge can catch up to 50% more precipitation than its unshielded counterpart for the same environmental conditions.

In the United States, the use of Alter wind shields was adopted in the late 1940's at some (20-40%) of the gauges at first-order climate stations; however, prior to 1948 wind shields were absent.

Inconsistent rainfall records had been brought about by a variety of actions, many of them well intentional and most of them quite inadvertent. Rain gauges have been moved to make accommodation to build walkways, beautify an area that would require rain gauges to be relocated.

The height of the rain gauge above ground can have a dramatic effect on gauge catch. As the height increases, the wind speed increases, resulting in an increase in under catch. Gauges located in an area with variable protection relative to different wind directions will produce different results.

Unfortunately, there are so many factors, which can influence the accuracy of precipitation measurements. The best that can be expected is that the gauging equipment will operate close to the scale of reality and with a degree of consistency, which will provide a stable index to the rainfall runoff process.

If the precipitation is overvalued by 5% compared to being undervalued by 5%, these relatively small changes in precipitation produce errors, which are inversely related to the quantity of runoff. (Curtis and Bornash, 1996). Windshields of various types have shown that they improve gauge catch of precipitation (Yang, Goodison, Metcalfe, Louie, Leavesley, Emerson, Hanson, Golubev, Elomaa, Gunther, Pangburn, Kang and Milkovic, 1999) and use of wind shields on precipitation gauges for snowfall measurement is more effective than for rain. On an average, shielded gauges measure 20-70% more snow than unshielded gauges which is not a problem in Jefferson Parish since snowfall is rarely an event.

3.5 Geographic Patterns and Relationship to TP-40

Frequency-magnitude relationships of heavy rainfall events are commonly utilized in design projects by providing useful guidelines (Keim and Muller, 1993) to engineers, planners and hydrologists about future expected storm events. The findings (Sorrel and Hamilton, 1989) indicate that the 24-hour 100 year value from TP-40 was exceeded over three times in Michigan and Angel and Hoff (1991) found that Illinois and Wisconsin had almost twice as many as 100 year 24 hour events as anticipated by TP-40.

In the south central United States, the extreme precipitation events (SRCC Technical Report 97-1) and the floods they generate have occurred frequently in 1980 to 1990. Examples are:

June 26 – July 1, 1989 – rainfall up to 20 inches from Tropical Storm Allison

November 7, 1989 – heavy rain of up to 19 inches fell in the New Orleans area

May 1995 – 10 to 20 inches of rain over much of metropolitan New Orleans accompanied by significant flooding over much of low lying New Orleans and Slidell, Louisiana.

Increasing frequency of events (Keim and Muller, 1993) in the recent decades has been noted in various studies and reports. Belville and Stewart (1983) found an unusual

number of rainfall events in excess of 10 inches in Louisiana in 1982 and 1983. Also, the recent magnitude of New Orleans storms were found to be significantly larger than storms over the preceding 100 years and heavy rainfall events appear to be increasing in frequency (Keim and Muller, 1992). Muller and Faiers (1984) had found earlier that most record peaks stages on rivers in the east-central climate division of Louisiana have occurred since 1970 and early 1980's. Several of the Regional Climate Centers (RCCs) have undertaken re-evaluation of extreme rainfall frequency-magnitude relationships within the respective regions.

The Southern Regional Climate Center (SRCC) evaluated extreme rainfall frequency-magnitude relationships to TP-40(Faiers, Keim and Muller, 1997).

Over all, storm magnitudes did not vary greatly between the two studies. However, this report shows a complex spatial pattern with the shifts in the regions of extreme rainfall maxima from southeastern to southwestern Louisiana.

SCRC (Southern Regional Climate Center) selected 27 first-order National Weather Service stations, in the six states study area (Texas, Oklahoma, Arkansas, Tennessee, Mississippi and Louisiana). Frequency maps were developed and compared to TP-40. It was concluded that the magnitude of extreme events vary in systematic patterns geographically for all durations and return periods, with minimum intensities along the Gulf Coast in the vicinity of the Texas and Louisiana border, decreasing gradually to the northeast and north and much more rapidly toward the northwest and southwest.

The report found that the magnitude of rainfall is greater than TP-40 across most of Louisiana, Mississippi and Tennessee with the greater increase of about 10 percent for the longer return periods from 25 to 100 years.

3.6 Methods of Probability

One of the objectives of data analysis is to describe the problem under scrutiny by using available sample observations to identify the most appropriate population distribution function. This is important because if we can select a probability distribution function to describe the distribution of the data, then we can make inferences based on

the known statistical properties of the distribution selected (Edward A. McBean & Frank A. Rovers).

The most widely used climatological atlas for precipitation in the United States is Technical Paper 40 (TP-40) (Hershfield, 1961). This standard work was based on the Gumbel (Fisher-Tippet Type I) distribution to annual data with an average length of 22.6 years. It has been found that TP-40 often underestimates the largest extreme rainfall amounts which are most needed in engineering design. Whether this underestimation for the long return periods results from inadequacy of the Gumbel distribution or insufficient length of records, it is widely agreed that updates and revision of this document is warranted (Wilks, 1993).

(Wilks, 1993) studied performance of three-parameter probability distributions representing annual and partial duration precipitation data at stations in northeastern and southeastern United States. The conventional two-parameter Gumbel distribution was also applied and found to underestimate precipitation amounts for both the annual and partial duration series. Particular attention was made to the right tail or right side of the distribution which there is no data available. Beta-K distribution was found to best describe the annual series and Beta-P distribution was found to be best for the partial duration series.

For both the annual and partial duration series, the conventionally employed Gumbel distribution is seen to underestimate precipitation amounts for the high return periods. It appears that an important contributor to the apparent underestimation of TP-40 derives from lack of fit and poor sampling characteristics of the Gumbel distribution (Daniel E. Wilks, 1993). Recent research suggests that other techniques other than the Gumbel distribution (TP-40) may be more appropriate with best alternatives varying between regions.

Keim and Faiers (1999) evaluated various techniques for the deviation of heavy rainfall estimates in areas located in western Texas.

In this study, seven different techniques of return period estimates are examined, including five probability distributions and two regression methods. The probability distributions include: Gumbel, Log Pearson Type III, Beta-P, three parameter log normal

and four parameter Wakeby distribution. Two alternative regression methods include the Huff-Angel and Southern Regional Climate Center Method.

This research concludes that no single technique clearly provided the best fit to the date in the region. However, the conventionally used Gumbel distribution provides the worst fit of the seven techniques investigated in the region and consistently underestimates the 50 and 100 year rainfall magnitudes.

The Southern Region Climate Center Method (SRCC) was determined to be as the best single probability distribution fit to the extreme rainfall data for the study region.

3.7 Uncertainty of Probability Function

Statistical concepts and methods are routinely utilized for approaching a number of problems in engineering hydrology. For example, annual rainfall over a basin is a random occurrence that is generally described by probability laws. Objectives of rainfall frequency analysis are to estimate the magnitude or intensity of an extreme rainfall event for a given duration and return period.

Wilks, (1993) finds that both annual and partial duration data, using Gumbel Distribution, underestimates precipitation amounts on the right side of distribution. Some of the differences evidently result from the distribution not being fit to the same data sample. This may explain some of the discrepancies, other contributions for the lack of fit may include poor sampling characteristics of the Gumbel distribution. (Keim and Faiers, 1996).

The usual approach to distribution fittings is to fit as many distributions as possible to determine the best fit. Lowing (1987) recommends information relating to the physical nature of the variable being fitted and the skew of the sample set are used to narrow down the choice of a distribution, then goodness-of-fit tests are used to select the best fitting distribution from reduced set of distributions.

Naghavi, et al (1993) evaluated river distributions and three parameter estimation methods for the Louisiana Rainfall data. These methods include: 2-parameter log normal, 3-parameter log normal Pearson types, Log Pearson Type III, extreme value Type 1 (Gumbel), method of moment, maximum likelihood estimate and the method of maximum entropy. The results indicated that Log Pearson Type III distribution is the most appropriate probability distribution for the Louisiana extreme rainfall data.

3.8 Fluctuations of Heavy Rainfall Magnitudes in New Orleans, Louisiana

During the period between 1980 and 1990, heavy rainstorms were recorded in New Orleans. Records of the rain gauge station at Audubon shows 10.7 inches for April 1988, 12.2 inches for November 1989 and 12.4 inches for June 1991. These events started speculation that the increase in rainfall was resulting from greenhouse warming. This was supported by the fact that five (5) out of ten (10) greatest two day point rainfall totals ever recorded within New Orleans since 1871 have occurred since 1978 (Keim, 1990).

One of research papers (Keim and Muller, 1993) with primary focus of rare rainfall storms investigated the validity of this speculation. Data from the new federal site (New Orleans WSFO City 166659) and (Audubon 16664) were used. Both sites have a similar annual series. Time series of annual maximum two-day storms showed a fluctuating storm magnitude through time. A long-time trend was not found in the series. However, clusters of years with very severe storms were apparent in the record and the change in the storm series was suspected to have been caused by a shift in atmospheric circulation patterns. This study finds that during the period between 1980 and 1990, the rainfall events in the study area have been extraordinary; however they are similar to storms recorded during periods from 1927 and 1948.

The southeastern region of the United States seems to have had a considerable number of extremes. Keim, (1999) studied the apparent changing magnitudes of rainstorms in the southeastern United States, which includes 27 rain gauge stations with average length of records of 92 years.

Through the use of annual storm series, researchers were seeking to determine whether long term trends in storm magnitudes exists in the southeast and to examine whether fluctuation in annual temperatures are related to these changes.

Analysis of the greatest storms recorded in all locations collectively showed a strong coastal orientation and most were at least partially induced by disturbed tropical weather. These data (Keim, 1999) also showed a strong summer and early fall seasonality and were temporally clustered in 1920, 1980 and the 1970's. This clustering

of extraordinary events suggests that anomalies in atmospheric circulation patterns may be associated with the generation of these events.

In studying the changing frequency of heavy rainfall in New Orleans, (Keim and Muller, 1993) collected rainfall records of New Orleans between 1900 and 1991. The heavy rainfall events were classified as frontal, tropical or other. Frontal events were defined when frontal systems were in such proximity to New Orleans that they clearly generated the rainfall event. Tropical events are those induced by any tropical disturbance ranging from relatively weak easterly waves to rare but severe hurricanes. The "other" category includes all events that were not frontal or tropical. This study concludes that the majority of events are generated by frontal weather situations. About less than a third of all events were induced by tropical disturbance. The record of storm events for New Orleans suggests that events may be increasing in frequency and that the number of events since 1975 has been unusual. The frequency series of heavy rainfall events shows extended periods of above and below normal frequencies. These periods may have an association with changing larger-scale upper air phenomena.

Louisiana has experienced significant increases in precipitation and runoff over the last 100 years (Keim, Faiers and Muller, 1995). Generally, projecting increases in precipitation across the region are likely concentrated in the winter-spring season in the northern half of the state. In southern Louisiana, increases in precipitation are likely to be concentrated in the summer-autumn. Rohi and Keim, (1994) found out that changing temperature was significantly correlated with the number of rain days along with other events. The number of rain days was found to be strongly associated with the number of extreme events than the annual precipitation total.

3.9 Seasonal Patterns of Heavy Rainfall

In most studies, rainfall events are investigated regardless the season when they occur and estimates of hourly rainfall are determined based on one of the probability methods. However, the storm events differ throughout the year, especially at sites near the Gulf Coast.

Seasonal changes in atmospheric circulation lead to changes in the local and regional precipitation climates. Research shows distinct seasonality of heavy rainfall in

New Orleans (Keim and Muller, 1993). Additionally, Hershfield (1961) documented inter-monthly variations in the probability of experiencing extreme rainfall events based on annual storm data in regions of the eastern United States.

Keim and Faiers, (1996) examined the heavy rainfall distribution by season in Louisiana. The findings conclude that heavy rainfall events are produced in all seasons in Louisiana, there are seasonal differences in their generating mechanisms and magnitudes extracted by season differ significantly. Extreme heavy rainfall events in winter and spring are primarily generated by frontal weather systems while summer and fall events have high proportions of events produced by Gulf tropical disturbance and air mass conditions. Quantile estimates are largest in spring along Louisiana coastal areas except Lake Charles while winter estimates are smallest at all sites except New Orleans.

In another paper (Keim, 1996) investigated seasonal patterns of heavy rainfall events along southeastern United States. In this report, rainfall data from Covington, Louisiana were used. This report concluded that events produced by cold fronts are particularly elevated at Covington in spring because they tend to stall along the Louisiana coastline or along the continental shelf allowing prolonged rainfall to occur in the area. In the summer, frontal systems are too far to the north to affect this portion of the region with regularity.

In an attempt to develop a climatic calendar, (Muller, 1997) used climalogical data for the rain gauge station at New Orleans International Airport for the period 1971 to 1974. This hourly data was organized into tables representing monthly frequencies of weather types. Each day is placed into one of the eight weather types. Due to limited duration of data, the study is attempting to provide for future studies. However, in analysis of rainfalls for duration, the study indicates that 45% of rainfalls were caused by frontal Gulf returns or when a cold front from the west or north is located within a zone extending out about 500 km from New Orleans.

Chapter 4 - Methodology and Approaches

4.1 Rainfall Data Collection

Before beginning an analysis of precipitation, the methods by which rainfall is measured and the limitations must be considered. The types of rain gauges that have been used in the collection of precipitation in Jefferson Parish and the New Orleans area are the standard gauge, recording gauge and the tipping bucket gauge.

The standard gauge is 23 inches high (Fetter, 1988) and has an eight-inch diameter opening to catch rainfall. The recording gauge also has an eight-inch opening that delivers the precipitation to a collecting bucket that rests upon a spring balance. As the bucket fills, movement is transmitted to a pen arm that records the rainfall on a chart. The tipping bucket gauge utilizes two separate compartments, which are situated beneath a ten-inch funnel. When one compartment is filled to its capacity, it tips and is replaced under the funnel by the empty compartment, each tip of the bucket is recorded on a graph.

There has been a good network of rain gauges in the vicinity of Jefferson Parish. The earliest rain gauge station became operational in 1836, since then a number of rain gauges were installed within the vicinity of New Orleans and Jefferson Parish. Some of these rain gauges were operated and maintained by the National Climate Data Service (NCDC) as part of the National Weather Service network and some were property of the Sewerage and Water Board of New Orleans. Table 4.1 lists individual NCDC stations with available period of records. Jefferson Parish also has installed rain gauge stations throughout the parish, however, these stations are relatively new and they have 10 to 15 years of records. Tables 4.2A and 4.2B list the rain gauges on the east bank and west bank of the Mississippi River.

Table 4.1 – NCDC Rain Gauge Stations in Jefferson Parish and Orleans Parish

Station Name	Period of Record	ID
New Orleans Algiers	01 July 1946 to present	166666
New Orleans Alvin Callender Field	01 April 1947 to present	---
New Orleans Audubon	01 July 1946 to present	166664
New Orleans Carrollton	01 Oct. 1945 to present	166667
New Orleans D P S 3	03 July 1946 – 31 Dec. 1990	166675
New Orleans D P S 5	01 July 1946 – 31 Dec. 1990	166672
New Orleans Eastover	01 July 1961 – 01 May 2002	166668
New Orleans International Airport	01 May 1946 to present	166660
New Orleans Jefferson	01 July 1946 – 30 June 1978	166671
New Orleans Lakefront Airport	30 Mar. 1934 to present	166667
New Orleans Menefee Airport	01 Mar. 1932 – 30 Mar. 1934	---
New Orleans Nas	11 Nov. 1942 – 30 Nov. 1957	---
New Orleans Pines Village	01 July 1954 – 30 June 1961	166678
New Orleans S & WB	01 Jan. 1978 – 31 Dec. 1990	166670
New Orleans WSFO City	01 June 1888 – 24 Apr. 1979	166659
New Orleans Water Plant	01 July 1946 – 31 Dec. 1990	166669

Table 4.2A – Jefferson Parish Rain Gauge Stations Maintained by the Department of Public Works

EAST BANK

Station	No.
DPS 1: Bonnabel	1
DPS 2: Suburban	2
DPS 3: Elmwood	3
DPS 4: Duncan	4
DPS 5: Parish Line	5
North Arnoult DPS	6
Clearview DPS	7
Taft South DPS	8
Upper Kraak DPS	9
Cumberland DPS	10
Canal St. DPS	11
Canal #10 & W. Esplanade	12
Duncan & Veterans	13
Soniat & Bellgrove	14
Napoleon DPS	15
Hoey's Cut & 17th St. Canal	16
Transcontinental & West Metairie	17
Upland & Sheldon	18
Manguno & Gail	19
Irving & St. Mary	20
Camp Plauche (Yenni Bldg.)	21
Transcontinental & Veterans	22
Shrewsbury & R.R.	23
Ridgewood & Fairmont	24

Table 4.2A - continued

Canal St. & Focis	25
W. William David & W. Esplanade	26
Veterans & Suburban	27
Market & Sauve	28
David Dr. & York	29
River Ridge at the River	30

Table 4.2B – Jefferson Parish Rain Gauge Stations Maintained by the Department of Public Works

WEST BANK

Station	No.
Cousins DPS	31
Planters DPS	32
Bayou Segnette DPS	33
Hero DPS	34
Harvey DPS	35
Wego #1 DPS	36
Wego #2 DPS	37
Estelle DPS	38
New Estelle DPS	39
Mt. Kennedy DPS	40
New Ames DPS	41
Lake Catherine #1 DPS	42
Lake Catherine #2 DPS	43
Westminster DPS	44
Oak Cove DPS	45
Crown Point DPS	46
Church DPS	47

Table 4.2B - continued

Gloria Dr. DPS	48
Goose Bayou DPS	49
Orange DPS	50
Rosethorne DPS	51
Marrero St. DPS	52
Perkins St. DPS	53
Fleming Canal DPS	54
Carmalite DPS (@Jones Pt.)	55
Oak Trailer DPS	56
Highway 45 DPS	57
Oak Drive DPS	58
Oakwood Canal & Carol Sue	59
Barataria & College	60
Huber Canal & WB Expressway	61
Gretna Courthouse	62
EOC/Marr WWTP	63
Bridge City @ The Circle	64
Patriot & Ave. G	65
41st & Gardere	66
Stonebridge & Trapp	67
Bannerwood & Brookwood	68
Live Oak	69
Terry Pkwy & Stumpf	70
Pailet DPS	71

Available records maintained by NCDC are not continuous and some of the rain gauge stations were abandoned at later dates. Numerous station relocations have occurred with regard to the New Orleans network and to complicate the matter, several

station identification numbers were duplicated during varying time periods for different stations.

The following are descriptions of rain gauge stations whose historical records were used.

Audubon (NCDC Identification Number 166664) (1893 to present)

Audubon rain gauge station, which is located in Audubon Park (Figure 4.1), New Orleans, has the longest period of records of all the stations currently in operation. Precipitation is measured with a standard gauge at an elevation of four feet above the ground. The station was relocated twice, but never left the confines of Audubon Park. Daily rainfall data is available from 1963 to present. There are no published daily precipitation values from January 1944 through July 1945.

Figure 4.1 Audubon NCDC Weather Observation Station (166664)

New Orleans International Airport (Figure 4.2 Courtesy of NCDC) is located in Jefferson Parish and has been in service from May 1, 1946 continuously to the present. Precipitation is measured with a standard gauge at an elevation of four feet above the ground. Hourly rainfall data is available from 1946 to the present. Data quality is consistent through time.

Figure 4.2 New Orleans International Airport Weather Observation Station (166660)

4.2 Frequency of Extreme Events

Duration Analysis

A duration curve (Warren Viessman, Jr., Mark Hammer, 1985) is a plot that shows the percentage of time that an event is likely to equal or exceed some specified value of interest. The basic time unit used in preparing a flow duration curve will greatly affect its appearance. For most studies, mean daily data are used. If extreme floods are primary concerns, it is customary to use only the maximum annual floods or maximum

annual rainfall for a defined interval. Such a series ignores the second-and-lower-order events of each year, which may be even greater than annual events of other years. This problem can be overcome by using partial duration series that is not a true distribution series since the events are defined in terms of their magnitude rather than their occurrence.

After either the partial or annual series is compiled, the items or events are arranged in descending order of magnitude and assigned an order number “M” the plotting formula is:

$$T = \frac{(n + 1)}{M} \tag{4-1}$$

T is the return period or recurrence interval in years and n is the number of years of record.

The recurrence interval is based on the probability that the given rainfall event will be equaled or exceeded in any given year. This statistical technique provides an estimate to determine the probability of the occurrence of a given precipitation event.

4.3 Log Pearson Type III Distribution

Karl Pearson (McBean and Rovers, 1998) proposed a general equation for a distribution that fits many distributions, including normal, beta and gamma distributions by choosing appropriate values for the distributional parameters. A form of the Pearson distribution is known as the Pearson Type III Distribution when used with the logarithms of the data they are referred to as the Log-Pearson Type III Distribution.

The Pearson Type III Distribution is particularly useful for hydrologic investigations because the third parameter, the skewness, permits the fitting on non-normal samples to the distribution. When the skewness is zero, the Distribution becomes a two-parameter distribution that is identical to the log normal distribution.

The procedure and terminology that was used to develop the frequency analysis using the Distribution is summarized as the following:

Arithmetic mean: the arithmetic mean of set of observations is the sum of their values (E x) divided by the number of observations (n):

$$M = \frac{E\ x}{n} \quad (4\text{-}2)$$

Variance: is a measure of how spread out a distribution is; it is computed as the average squared deviation of each number from its mean.

$$\sigma = \frac{\Sigma(x - M)^2}{n} \quad (4\text{-}3)$$

Standard Deviation: statistical term describing the measure of spread of values in a distribution and is calculated as the square root of the variance

Standard Deviation =

$$\sigma^2 = \frac{\Sigma(x-m)^2}{(n-1)} \quad (4\text{-}4)$$

Large standard deviation indicates that the data points are far from the mean and a small standard deviation indicates that they are clustered closely around the mean.

Skew coefficient =

$$C_s = \frac{n * \Sigma^n (\log R - \text{avg}(\log R))^3}{(n\text{-}1)(n\text{-}2)\ (\sigma \log R)^3} \quad (4\text{-}5)$$

R indicates the amount of rainfall.

To solve for the skew coefficients, first we create a spreadsheet and arrange the rainfall data in descending order. At this point, we can use the functions in Excel to calculate standard deviations, variances and the skew coefficients. Or, we create a second column with the log of each rainfall. We calculate the average rainfall and

average log for the second column (Avg(log)). The third column will consist of (log R – avg (log R)^2 for each row, then we calculate the sum of the columns. The fourth column will consist of [log R – avg (log R)]^3, we then calculate the sum for the column. From previous equations, we calculate variance, standard deviation and the skew coefficient. Using the frequency factor table (Haan, 1997) and the skew coefficient to find value K for the 2, 5, 10, 25, 50 and 100 years recurrence interval. If the skew coefficient is between two given skew coefficients in the table, then we can extrapolate between two numbers to get the appropriate value. Then calculate predicted rainfall.

Log RTr = avg (log R) + [(K(Tr,Cs)] σ log R

Tr is recurrence interval

4.4 Modified Log Pearson Method

To improve the fit to the higher peak rainfall, Log Pearson Method was modified. (Giron, 2002) the mod log transformed the base flow factor and skewness was adjusted to minimize the error between the log transformed and predicted for the floods with Tr>2. This was to result in a more conservative estimate of flooding. However, this method did not improve the fit.

4.5 Testing Difference of Rainfall Records

In this research, rainfall data from Audubon and New Orleans International Airport has been utilized. As it is demonstrated on Table 4.4, the average monthly rainfall varies from one station to the other. This monthly variation is presented in Figures 4.3 through 4.5. In order to determine if there is a significant difference between sampling records collected from the two locations, we use statistical tests such as the F-test and the T-test (McBean and Rovers, 1998).

The F-test is the sampling distribution of the ratio of two independent, unbiased estimates of variance of a normal distribution (McBean and Rovers, 1998). The larger the value of F, the less likely the samples are drawn from the same population.

The T-test or student test determines if a sample differed from its population mean and allows calculation of the confidence level for the mean. In order to determine if there are significant differences between the average monthly rainfall data for the Audubon and New Orleans International Airport, we perform the F-test for annual rainfall.

$$F = \frac{\text{greater estimate of the variance of the population}}{\text{lesser estimate of the variance of the population}} \quad (4\text{-}6)$$

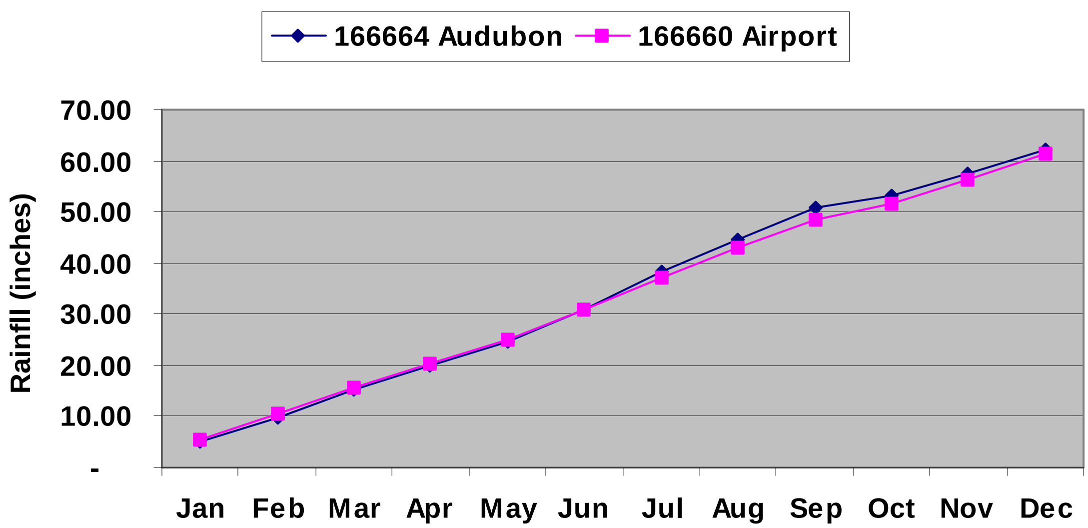


Figure 4.3 Cumulative Average Monthly Rainfall for Station 166664 (Audubon) and Station 166660 (N.O. International Airport)

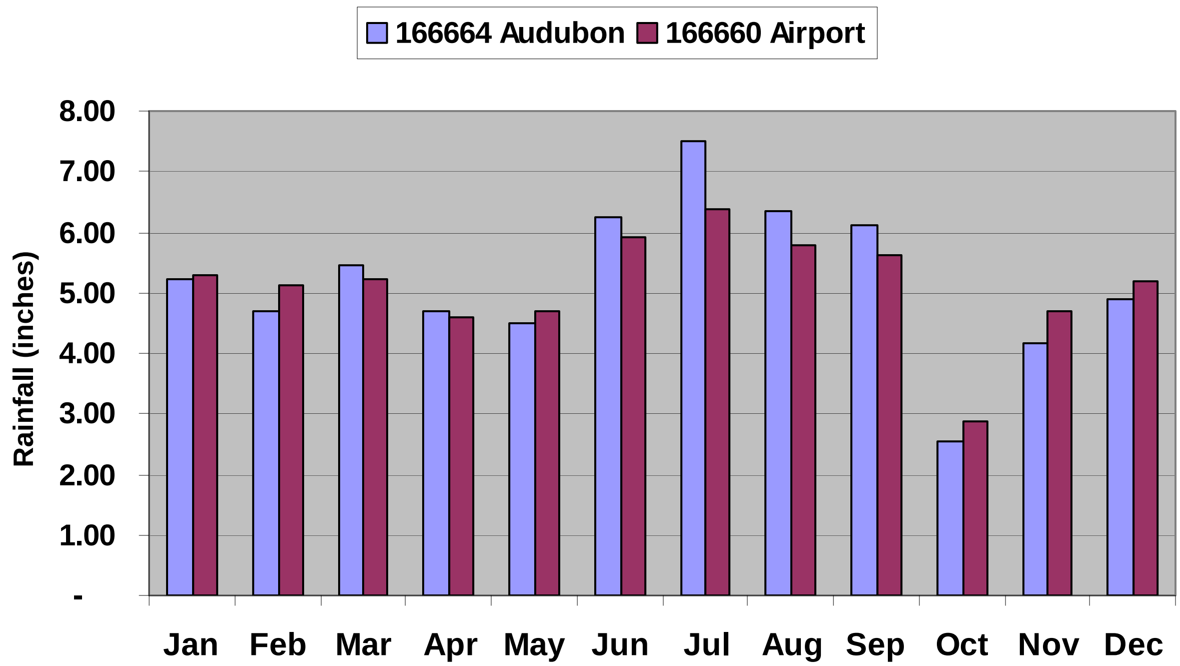


Figure 4.4 Average Monthly Rainfall for New Orleans International Airport and Audubon Rainfall Stations

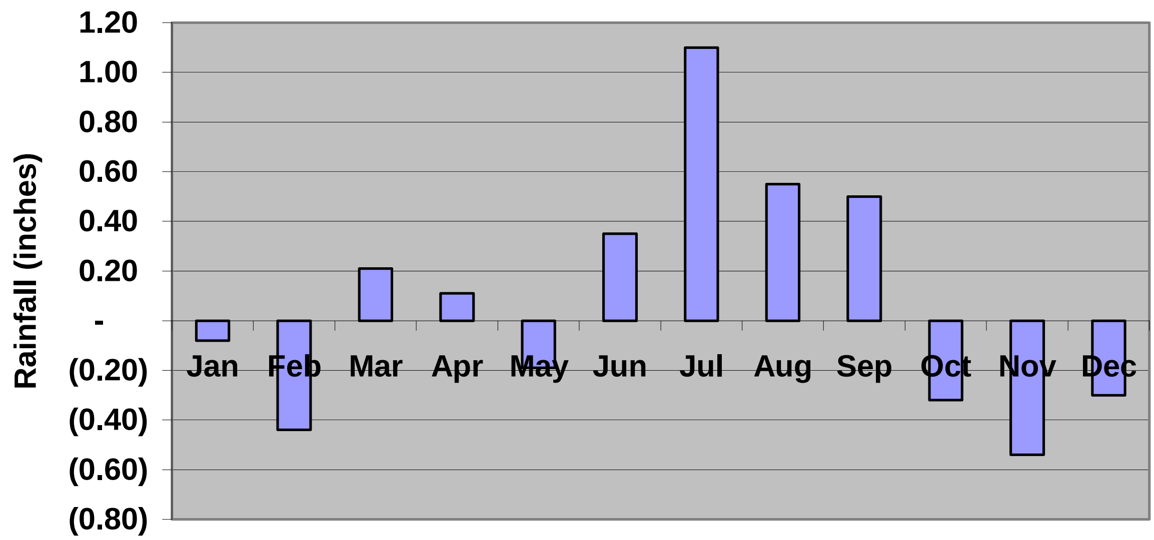


Figure 4.5 Monthly Variation of Rainfall for Station 166664 (Audubon) and Station 166660 (New Orleans International Airport)

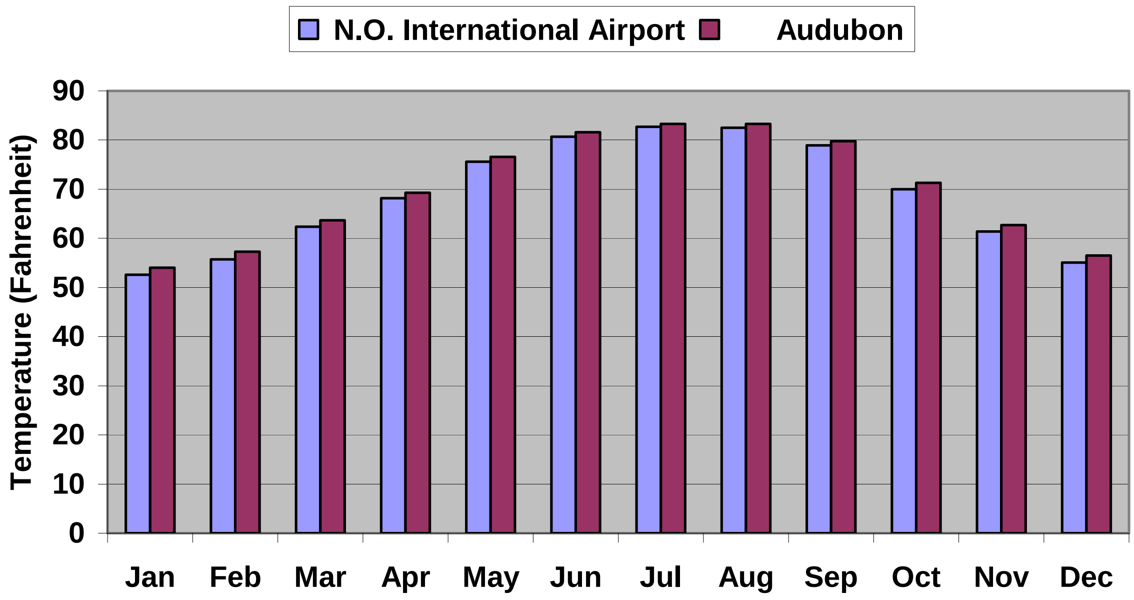


Figure 4.6 Average Monthly Temperatures

The t-test is calculated

$$t^* = \frac{|\bar{x} - \mu|}{s\sqrt{n}} \tag{4-7}$$

Table 4.3 Average Monthly Temperature (degrees F) for Audubon and New Orleans International Airport

(1947 to 2002)

	Audubon	New Orleans International Airport
January	52.60	54.00
February	55.70	57.30
March	62.40	63.70
April	68.20	69.30

May	75.60	76.60
June	80.70	81.60
July	82.70	83.30
August	82.50	83.30
September	78.90	79.80
October	70.00	71.30
November	61.40	62.70
December	55.10	56.50
Mean	64.22	69.95
Variance	126.36	120.24
Standard Deviation	11.24	10.97

Table 4.4 Average Monthly Rainfall for Audubon and New Orleans International Airport Rain Gauge Stations (1947 to 2002)

	Audubon	New Orleans International Airport
January	5.18	5.29
February	4.64	5.12
March	5.45	5.23
April	4.90	4.58
May	4.50	4.68
June	6.26	5.91
July	7.36	6.39
August	6.33	5.80
September	6.12	5.62
October	2.56	2.88
November	4.16	4.69
December	4.94	5.18
Mean	5.20	5.11
Variance	1.70	0.79
Standard Deviation	1.30	0.89

A low value of t* from equation 4-7 indicates little differences between means and a high value of t* indicates a large difference. Degrees of freedom is a value representing the size of the sample involved in the test. When t_c is calculated from a single random variable of size n, the degrees of freedom are n-1.

To determine the significant difference between the monthly average rainfall between the two stations, we perform the F-test. We obtain the variances from Table 4.4.

$$\text{calculate F ratio} = \frac{(1.70)}{(0.79)} = 2.15$$

Degree of Freedom of larger variance estimate = 12 - 1 = 11
Degree of Freedom of smaller variance estimate = 12 - 1 = 11
From (Fisher and Yates, 1963) with $\alpha = 5$ percent F – test = 2.15 < 2.9
There is not a statically significant difference between the variance and the t-test can be utilized. Now we proceed to apply the t-test using the standard deviation from Table 4.4.

Calculating pooled variance:

$$S^2 = \frac{(n_1-1)\, S_1^2 + (n_2-1)\, S_1^2}{n_1 + n_2 - 2} \tag{4-8}$$

$$\frac{11(1.272)^2 + 11(.888)^2}{22} = 1.2$$

The formula for the standard error of difference of the two means is:

$$S_m = \sqrt{S^2\,(1/n_1 + 1/n_2)} \tag{4-9}$$

$$S_m = \sqrt{(1.21)^2\,(1/12 + 1/12)} \quad = \; 0.491$$

The T-statistic is then calculated using two parameters in the following formula:

$$T^* = \frac{\text{(absolute value)[(mean of station 1) – (mean of station 2)]}}{S_m} \qquad (4\text{-}10)$$

The standard error of difference of the two means is then:

And the t-test is then calculated as (4-5)

$$T^* = \frac{5.19 - 5.11}{0.491} = \; 0.163$$

With the degrees of freedom 12 + 12 – 2 = 22 and one-sided test and 95 percent confidence level:

From Table (Fisher and Yates, 1963, p. 53) $t_c = 1.717$ and $t^* < tc$ indicating there is no evidence of a difference in the average monthly rainfall data between the Audubon and New Orleans International Airport rain gauge stations.

Now we try to compare the average monthly rainfall data from two stations to determine if there are significant differences between the monthly rainfall data.

Degrees of Freedom

56 + 56 -2 = 110

Table 4.5 Significant Differences Between Average Monthly Rainfall at Audubon and New Orleans International Airport

	F RATIO	F_{cr}	t*	t_c (5%, one sided)	t_c (10%, one sided)
Jan	1.05	<1.56	0.15	<1.67	<1.29
Feb	1.23	<1.56	0.84	<1.66	<1.29
Mar	1.00	<1.56	0.37	<1.66	<1.29
Apr	1.46	<1.56	0.42	<1.66	<1.29
May	1.21	<1.56	0.21	<1.66	<1.29
Jun	1.24	<1.56	0.47	<1.66	<1.29
Jul	1.49	<1.56	1.67	=1.66	>1.29
Aug	1.38	<1.56	0.96	<1.66	<1.29
Sep	1.14	<1.56	0.65	<1.66	<1.29
Oct	1.20	<1.56	0.73	<1.66	<1.29
Nov	1.71	>1.56	0.74	<1.66	<1.29
Dec	1.06	<1.56	0.56	<1.66	<1.29

The summary results of the F-test and T-test are presented in Table 4.5 with detailed calculations shown on Table 4.6 Appendix "A." The results indicate that the month of November failed the F-test, which indicates there is a statistical difference in the variance. The results for the t-test indicate that with a 5% level of significance and the one sided test, other than the month of July, there are no significant differences between the rainfall data for the two stations. Using a 10% level of significance and the one sided test, the only month that failed the test is July. However at a 25% level, the value of t_c is 0.67 which results indicate the months of February, July, August, October and November have significant differences between the rainfall date from the two stations. These results are based on using the limits Table (Fisher and Yates, 1963, p. 55).

Next we examine the maximum monthly 24 hour rainfall between the Audubon and New Orleans International Airport rain gauges. The summary results are provided in Table 4.7 and detailed calculations are shown in Table 4.8 of "Appendix "A."

Table 4.7 Significant Differences Between Maximum Monthly 24 Hour Rainfall at Audubon and New Orleans International Airport

	F RATIO	F_{cr}	t*	t_c (5%, one sided)	t_c (10%, one sided)
Jan	1.26	<1.69	0.52	<1.68	<1.30
Feb	1.28	<1.69	0.20	<1.68	<1.30
Mar	1.31	<1.69	0.77	<1.68	<1.30
Apr	1.48	<1.69	0.39	<1.68	<1.30
May	1.23	<1.69	0.45	<1.68	<1.30
Jun	1.78	>1.69	0.46	<1.68	<1.30
Jul	1.02	<1.69	1.33	<1.68	>1.30
Aug	1.21	<1.69	0.24	<1.68	<1.30
Sep	1.29	<1.69	0.17	<1.68	<1.30
Oct	1.43	<1.69	0.86	<1.68	<1.30
Nov	2.35	>1.69	0.56	<1.68	<1.30
Dec	1.06	<1.69	0.21	<1.68	<1.30

The results of the tests indicate that the variances for the months of June and November are significant statistical differences between the variance of rainfall data from the two stations. Results from the t-test for both 5% and 10% do not show any significant differences between the data for the two stations with exception for July.

In order to evaluate seasonal rainfall patterns of Audubon and New Orleans International Airport rain gauge stations, the F-test and t-test were applied. Rainfall patterns were divided into frontal (December to May) and tropical (June to November). To apply the F-test and t-test, the variances and the mean for monthly rainfall were computed for each station as shown on Tables 4.9 and 4.10 Appendix "A." The variance for each season is calculated by summing variances of a six month period and dividing by six. The same was applied to calculate the mean for six months. For the 56 years of records available, the degree of freedom is:

Frontal (December to June)

$$56 + 56 - 2 = 110$$

and

$$\alpha = 5\%$$

$$\text{F-ratio} = \frac{11.63}{11.22} = 1.036 < 1.56 \text{ (Fisher and Yates, 1963)}$$

$$s^2 = \frac{(56-1)(11.63)^2 + (56-1)(11.22)^2}{(56 + 56 - 2)} = 130.5$$

$$S_m = \sqrt{130.5\,(1/56 + 1/56)} = 2.16$$

$$t^* = \frac{5.01 - 4.9}{2.16} = 0.05 < 1.66 \text{ (McCuen, 1985)}$$

Tropical (June to November)

Audubon vs. New Orleans International Airport

$$\text{F-ratio} = \frac{11.87}{11.47} = 1.04 < 1.56 \text{ (Fisher and Yates, 1963)}$$

$$s^2 = \frac{(56-1)(11.87)^2 + (56-1)(11.47)^2}{56 + 56 - 2} = 2.5$$

$$S_m = \sqrt{2.5\,(1/56 + 1/56)} = 0.29$$

$$t^* = \frac{5.49 - 5.22}{0.29} = 0.091 < 1.66 \quad \text{(McCuen, 1985)}$$

These results indicate that with $\alpha = 5$ percent there is no evidence of significant differences in the seasonal rainfall data. Critical values for the t-distribution for 10 and 25 percent levels of significance for a one sided test is 1.29 and 0.67 which indicates there are no significant differences between the seasonal patterns.

In 1998, the United States Environmental Protection Agency studied the Heat Island effect of the Baton Rouge area. Work was performed by the National Aeronautics and Space Administration (NASA). They used aerial photos of Baton Rouge using thermal imagery and identified the hotspots (United States Environmental Protection Agency, 2007).

The Department of Energy's Lawrence Bekely National Laboratory (LBNL) modeled Baton Rouge's ground air temperature as opposed to surface temperature measured by thermal images (United States Environmental Protection Agency, 2007). LBNL simulation indicates that Baton Rouge's Heat Island ranges from 3.6 to 7.2 degrees Fahrenheit. It was reported that Baton Rouge's climate, which is similar to that in New Orleans, is humid and subtropical throughout most of the year. Heavy rains and high humidity are a consequence of its coastal location. The relative short distance to the coast allows maritime air masses from the Gulf of Mexico to alleviate summer heat and shorter winter cold spells.

Since there are no studies available that evaluate New Orleans/Jefferson Parish's Heat Island effect, one can conclude that due to the close proximity of New Orleans to Baton Rouge, the Heat Island effects are similar with the same causes. Therefore, the

difference in the temperature and rainfall at Audubon and New Orleans International Airport can be attributed in part to the Heat Island effect.

In evaluating statistically significant differences in rainfall in Louisiana, the (Van Cooten, 2004) study included southwest Louisiana and southern Mississippi. The study area was enclosed by a polyline from New Iberia, Louisiana to Angola, Louisiana to Brookhaven, Mississippi to Leakesville, Mississippi to Pascagoula, Mississippi. Rainfall records for 94 Louisiana stations and 42 southern Mississippi stations were collected. The scope of this research included determining if there are no significant differences in mean monthly rainfall in Louisiana stations. To accomplish this task, the rainfall stations were assembled into eight groups. The T-test and F-test were applied to these groups for 12, 6 and 3 month intervals in various combinations. The results from the group identified as SS contained the rainfall data from New Orleans International Airport and Audubon rain gauges.

The results indicate that for the twelve month interval no significant difference between the group comprised of Metairie DPS 6, Algiers, New Orleans Audubon Park, DPS 3/London, DPS 5/Jourdan, DPS 13/Eastover, Moisant, New Orleans Jefferson, New Orleans WB City, New Orleans Dublin and St. Bernard and adjoining groups was found. For the six month interval, this group shows a statistically significant difference in the average monthly rainfall bordering the beginning and end of hurricane season. For the three month interval, for the winter and spring, a statistically significant difference was found; however, for the tropical months of June – September, no statistically significant difference was found. Research concluded that consideration should be given in planning since the Mississippi River typically is at its flood stage during the spring season. The differences in the monthly averages will affect the forecasting of flood conditions.

4.6 Power Spectrum Method

Fourier analysis allows us to isolate certain frequency ranges. MATLAB (Storey) makes it easy to translate a signal from the time domain to frequency domain. A Fourier series takes a signal and decomposes it into a sum of sines and cosines of different frequencies.

The total annual rainfall for the Audubon rain gauge station was used for this analysis. This would provide a maximum amount of continuous data: using shorter rainfall durations would have resulted in numerous zero rainfalls, which would affect the results. Figure 4.7 represents the total annual rainfall for Audubon. The average annual rainfall for Audubon is approximately 60 inches. There are periods that the Audubon rain gauge station receives more than this amount. Some of these periods last from 2 to 14 years. Using the power spectrum method as shown on Figure 4.8, we can see the number of cycles which vary from two to twelve years consistent with actual rainfall data.

To investigate fluctuations of excessive rainfall, the moving average method is used. The moving average (methword.wolfrom.com/moving average.htm) is one of the oldest and most popular techniques to smooth the data so that trends are more discernable. A moving average, averages data in a specified period that ”moves” in order to stay current with the present. A 200 day moving average, for example, moves so that it always represents the average of the best 200 days. Figure 5.25 represents 5, 10 and 20 year moving averages for the annual maximum rainfall at the Audubon rain gauge station. The short term cycles are shown on five year moving average and the long term cycles are shown on 20 year moving averages. The five year moving average shows seven cycles lasting 16 to 17 years. The ten year running average shows five cycles for the same period. The twenty year running average is simply a straight line and does not indicate any variation.

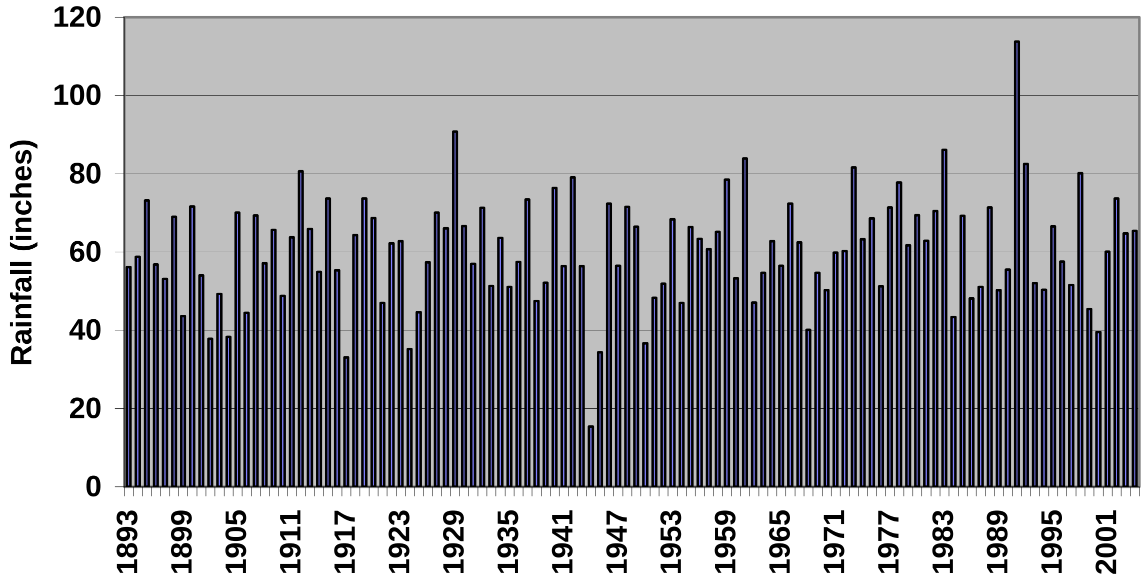


Figure 4.7 Total Annual Rainfall for Audubon Rain Gauge Station

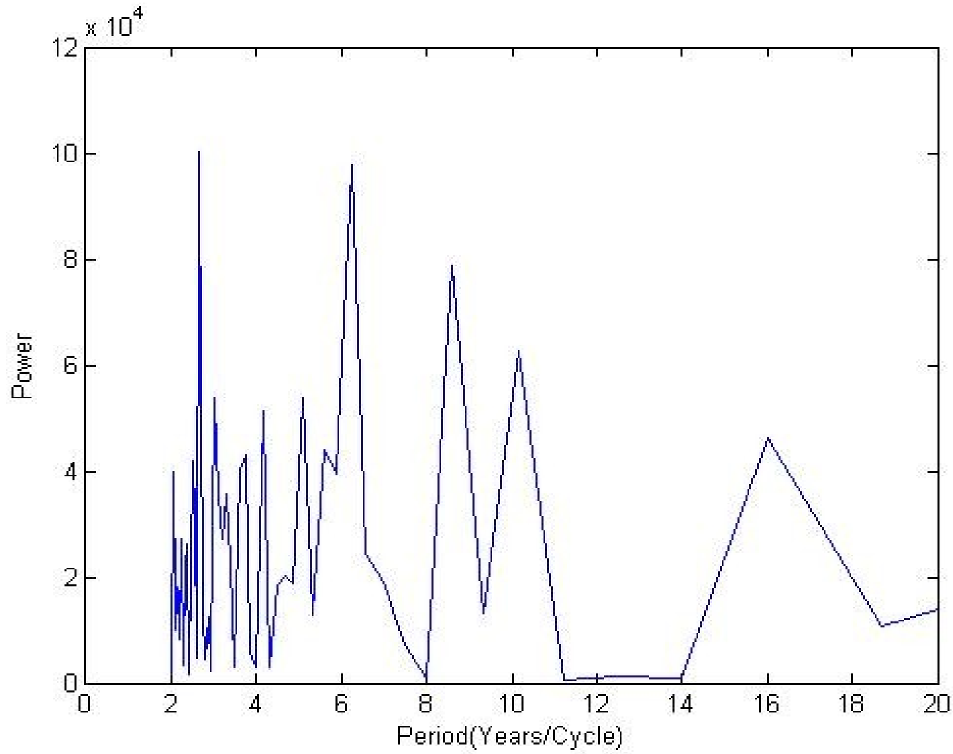
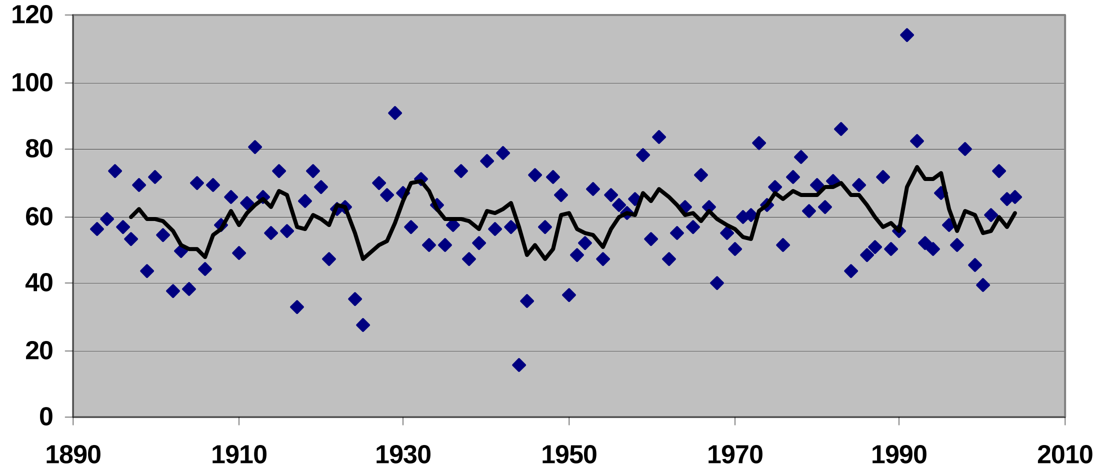
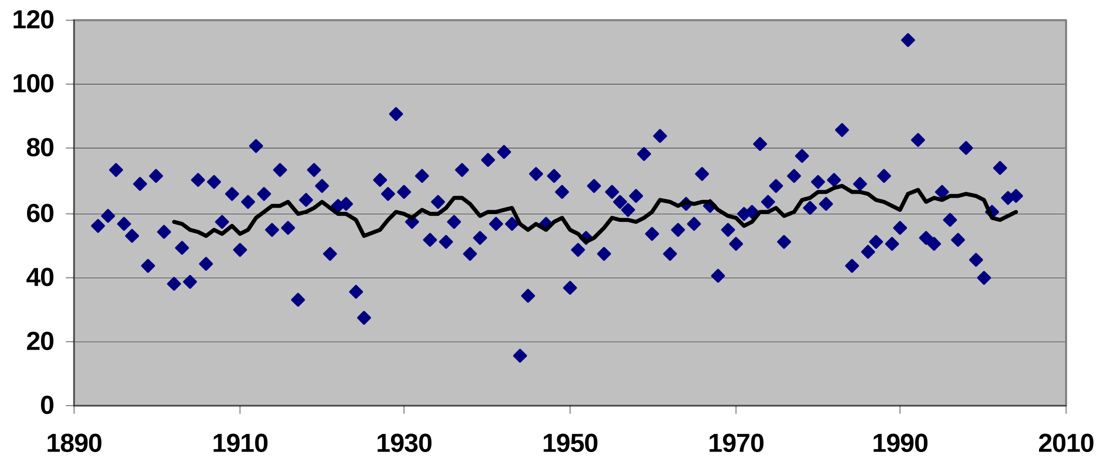


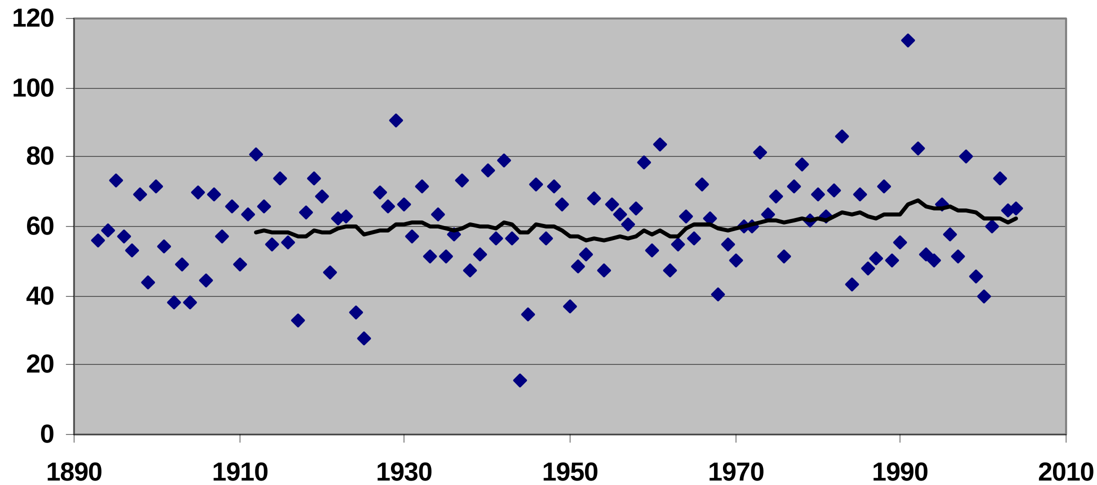
Figure 4.8 Power Spectrum of Annual Rainfall at Audubon Rain Gauage Staion (1893-2004)



5 Year Moving Average



10 Year Moving Average



20 Year Moving Average

Figure 4.9 Moving Average, Audubon Rain Gauge for Maximum Annual Rainfall

4.7 Using Rainfall Data to Determine Areas Versus Rainfall Relationships

When a high density rainfall network is available, such as Jefferson Parish's network of rain gauges, the Theissen Method (Felter, 1988) can be used to determine the average depth of the rainfall over the areas covered for any duration (Stal and MGhee, 1979). In this method, the rain gauge stations are drawn on a map of the drainage basin. Adjacent stations are connected by a network of lines. A perpendicular line is drawn at the mid point of each line connecting two stations and extensions of the perpendicular bisectors, are used to draw polygons around each station (Feptor, 1988). Then an area for each polygon is determined. Now we can set up a table consisting of a list of stations, amount of 24 hour rainfall, net area, percent of total area and weighted rainfall. To develop a 24 hour area rainfall curve for the East Bank of Jefferson Parish, the existing network of rain gauges were used. The area in square miles for each polygon was calculated (Figure 4.10). Table 4.11 provides a list of rainfall gauge stations which are located in the East Bank of Jefferson Parish. Based on historical records from these stations, several rainfall events were used. For each event, contributing rainfall was calculated. The contributing rainfall is found by dividing the cumulative volume of rainfall by the cumulative sum of the area. Figure 4.11 provides the area versus the rainfall for the East Bank of Jefferson Parish. The highest curve should be used to determine the rainfall depth over an area.

Table 4.11 List of Jefferson Parish East Bank Rain Gauge Stations Used To Prepare Area Versus Rainfall Relationships

Bonnabel	Suburban	Elmwood
Duncan	Parish Line	N. Arnoult
Shrewsbury & RR	Upland & Sheldon	Manguno & Gail
David & York	Irving & St. Mary	Yenni Building
Market & Sauve	Vacuum Lift Station	Canal 10 & West Esplanade
Taft South	Canal Street	Duncan Canal & 31st
Soniat & Bellgrove	Upper Kraak	Ridgewood & Fairmont
Transcontinental & Veterans		

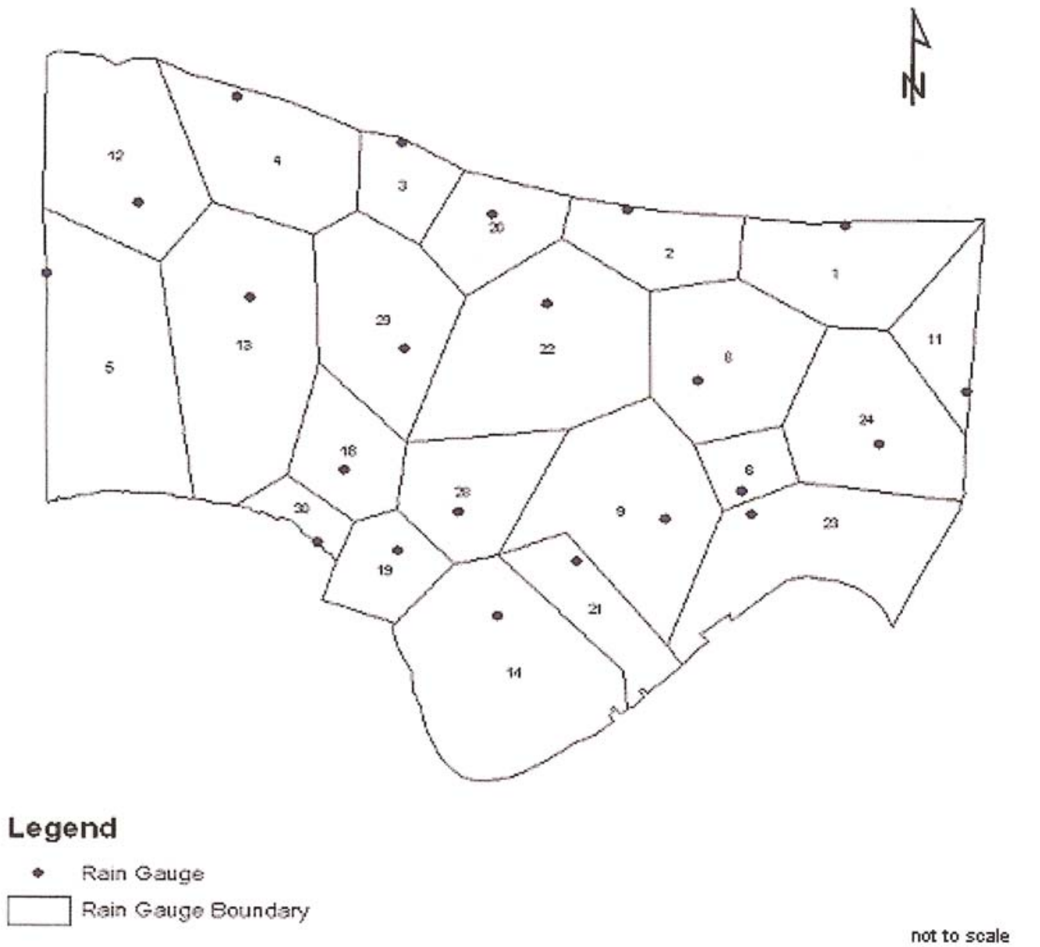


Figure 4.10 Theissen Poligram Based on the Rain Gauge Network of the East Bank of Jefferson Parish

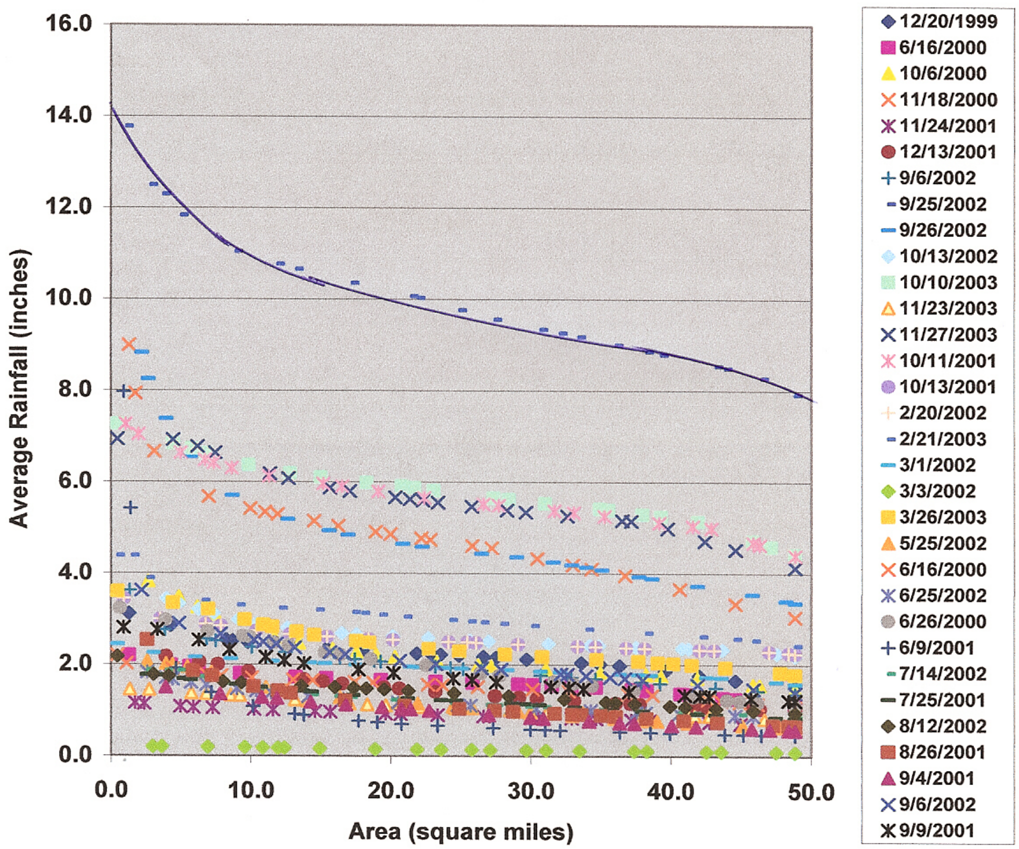


Figure 4.11 Average 24 Hour Rainfall for East Bank of Jefferson Parish

Chapter 5 – Analysis of Data

5.1 Annual Station Statistics

In this study, rainfall data from the Audubon and New Orleans International Airport rain gauges were utilized. The oldest rain gauge station (National Oceanic and Atmospheric Administration, National Climate Data Center), with recorded data back to 1836, commonly known as the New Federal (New Orleans WSFO 166659), was moved in 1979 to Slidell, Louisiana. (Faiers, Keim, and Hirschboeck, 1993)

Figure 5.1 summarizes the total annual rainfall for the Audubon, New Orleans International Airport and New Federal rain gauges. Figures 5.2 through 5.5 reports maximum 24 hours annual rainfall and the cumulative effect on the maximum 24 hour annual rainfall for the Audubon and New Orleans International Airport rain gauges.

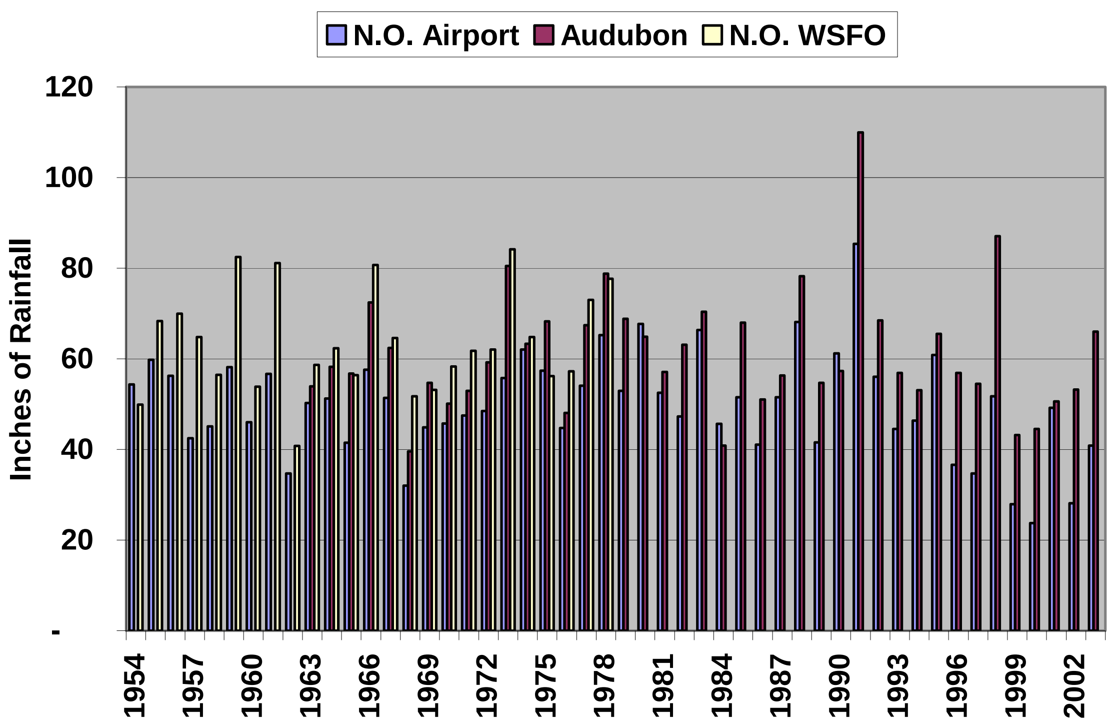


Figure 5.1 Annual Rainfall Audubon, New Orleans International Airport, & New Orleans WSFO

Figures 5.9A along with Tables 5.9B, and 5.9C through 5.23 (Appendix "B") represents calculations and presentations of results for various rainfall frequencies using the Log Pearson and Modified Log Pearson methods. Figures 5.6 and 5.7 present the summary results of rainfall frequencies for the two rain gauge stations. Figure 5.8 presents rainfall frequencies based on TP-40 values. Summary results for the Audubon and New Orleans International Airport and Tables 5.1 and 5.2 depict the amount of rainfall for each return period. Since we have 112 years of 24 hour rainfall data for the Audubon rain gauge station, the Log Pearson methods were used to determine the rainfall for various return periods. Figure 5.24 (Appendix "B") shows the results.

Table 5.1 Amount of Rainfall for New Orleans International Airport Rain Gauge Station (Using Log Pearson)

Return Period (Years)	1 Hour	2 Hour	6 Hour	12 Hour	24 Hour
2	2.14	2.48	3.42	4.03	4.76
5	2.60	3.48	4.88	5.72	6.71
10	2.98	4.30	6.11	7.08	8.20
25	3.55	5.53	8.01	9.12	10.27
50	4.06	6.60	9.72	10.90	12.00
100	4.62	7.83	11.70	12.89	13.84

Table 5.2 Amount of Rainfall for Audubon Rain Gauge Station (Using Log Pearson)

Return Period (Years)	1 Hour	2 Hour	6 Hour	12 Hour	24 Hour
2	2.30	3.23	4.54	5.52	6.80
5	2.91	4.00	5.74	6.97	8.50
10	3.45	4.54	6.61	8.00	9.70
25	4.23	5.26	7.89	9.39	11.50
50	4.93	5.82	8.73	10.49	12.50
100	5.73	6.41	9.73	11.65	13.70

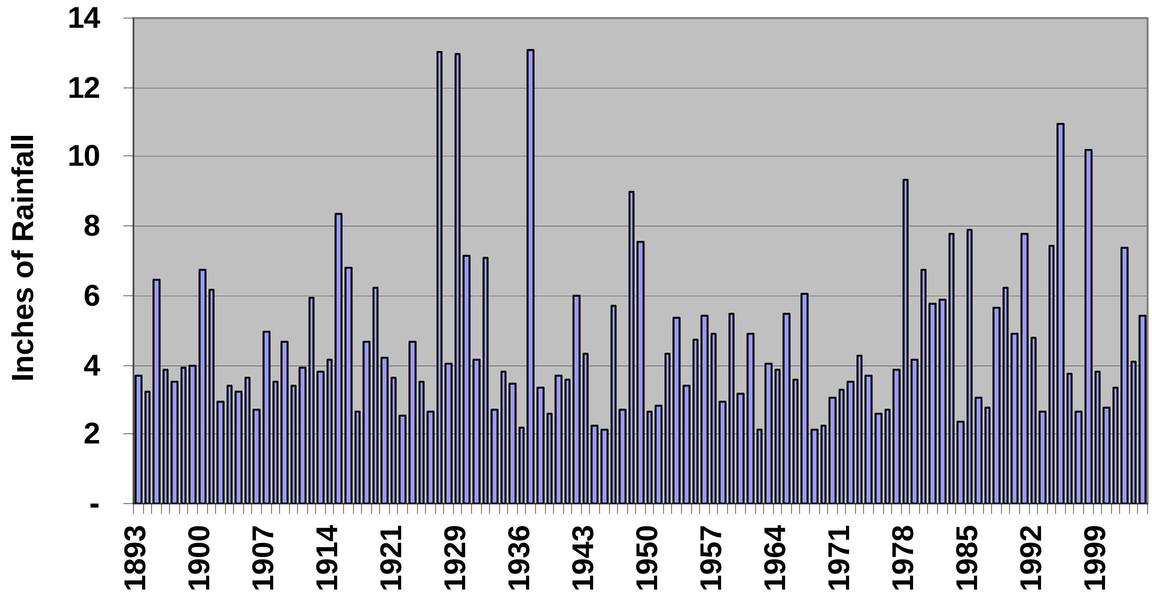


Figure 5.2 Maximum 24 Hour Annual Rainfall at Audubon Rain Gauge Station (166664)

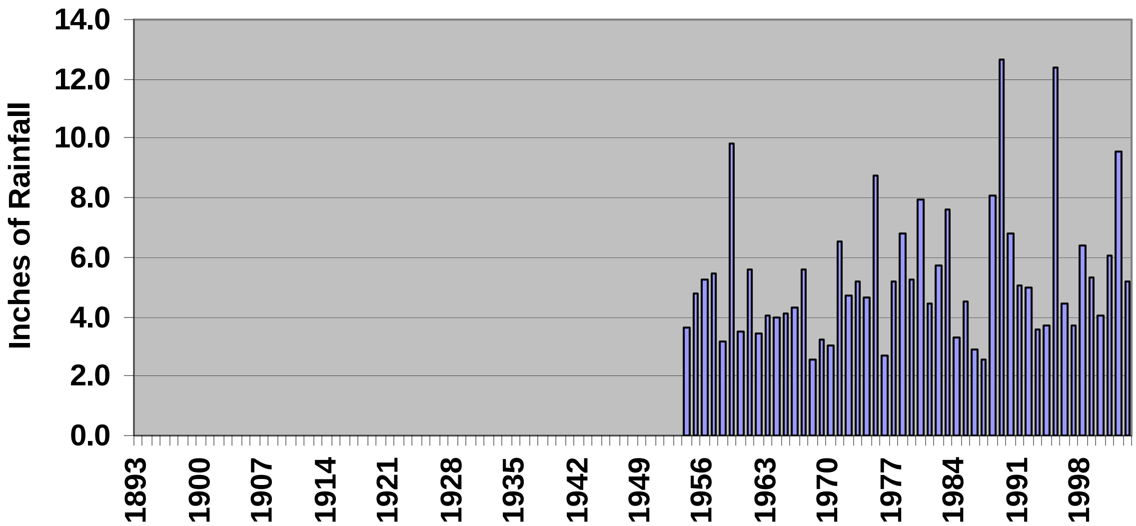


Figure 5.3 Maximum 24 Hour Annual Rainfall New Orleans International Airport Rain Station Gauge (166660)

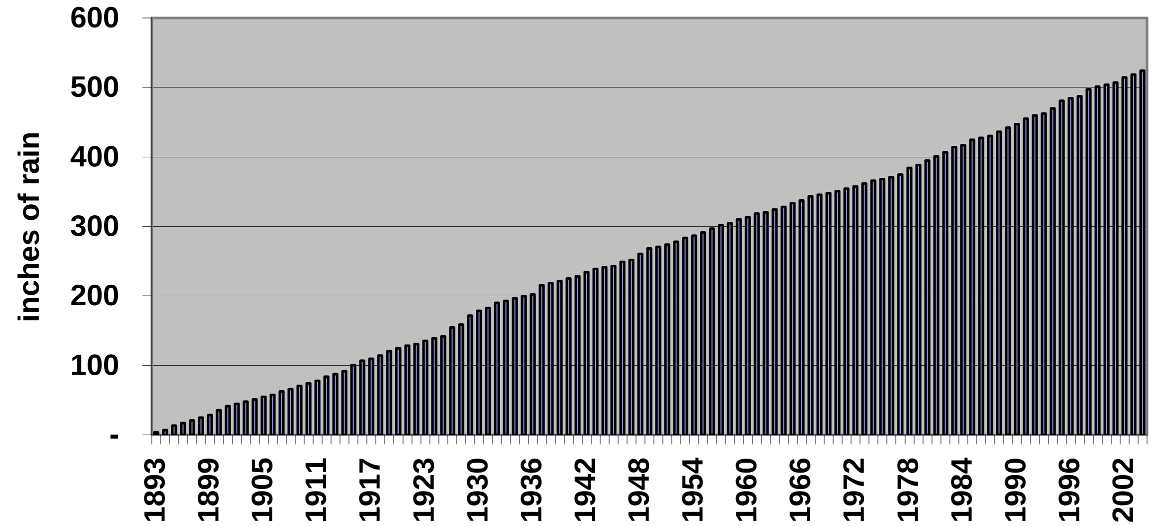


Figure 5.4 Accumulative Highest Annual 24 Hour Rainfall for Audubon Rain Gauge Station (166664)

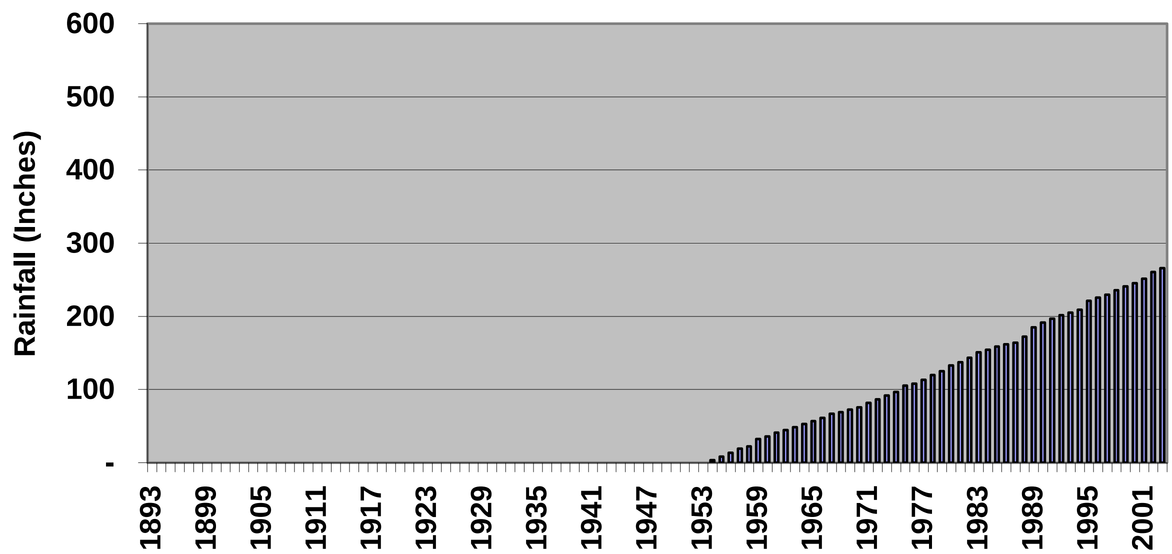


Figure 5.5 Maximum 24 Hour Annual Rainfall at New Orleans International Airport Rain Gauge Station (166660)

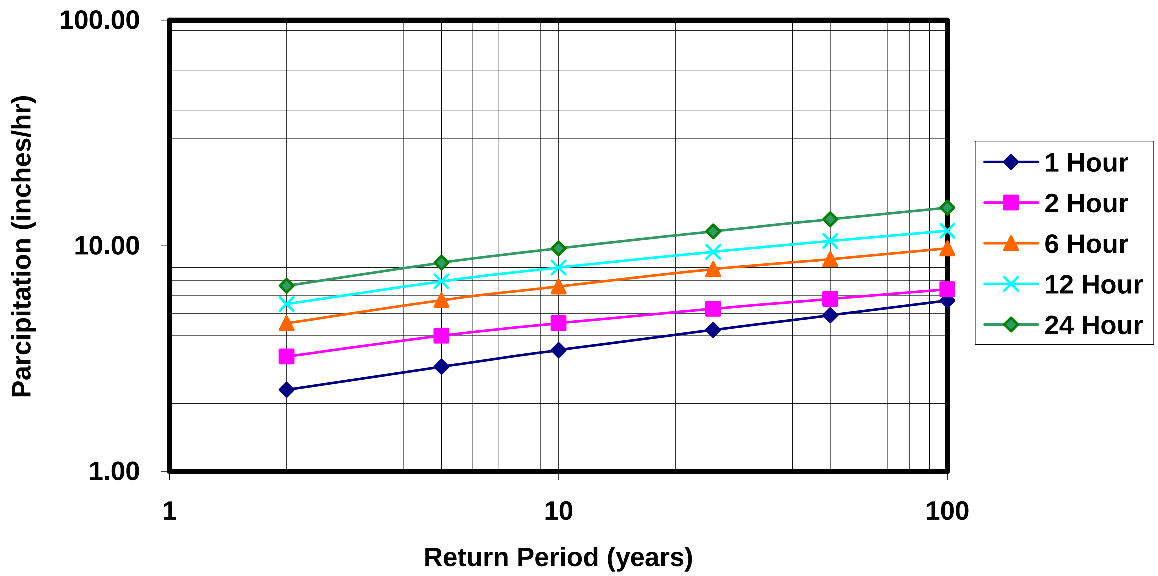


Figure 5.6 Rainfall Distribution Based on Station No:166664 Results (log Person Type III)

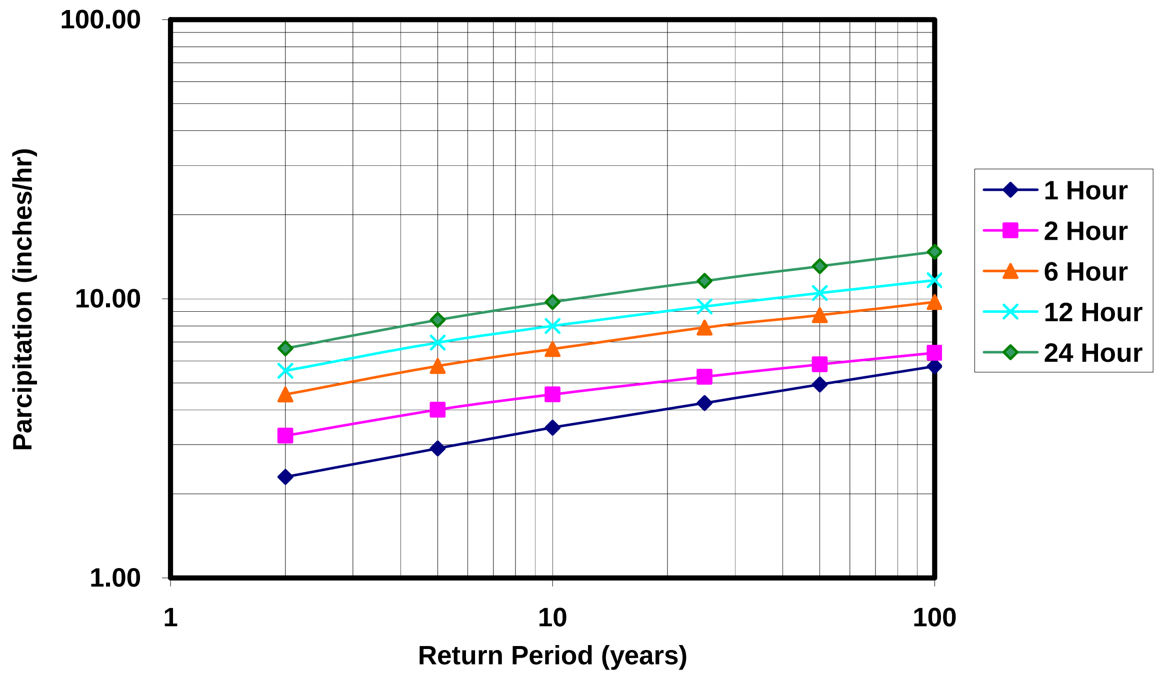


Figure 5.7 Rainfall Distribution Based on Station NO:166660 Results (log Person Type III)

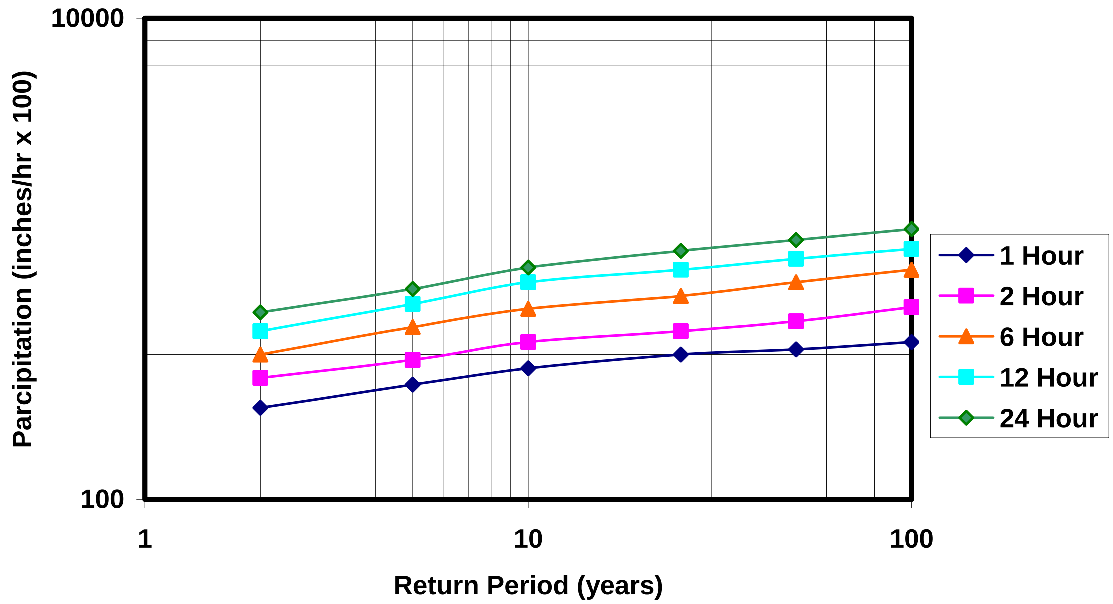


Figure 5.8 Rainfall Frequency Using Rainfall Frequency Atlas of United States Technical Paper No. 40

5.2 Rainfall Intensity Duration – Frequency Curves

The assessment of extreme precipitation is an important problem in hydrologic risk analysis and design. The intensity-duration-frequency (I-D.F) is an important tool for the design and evaluation of hydraulics structures when a rainfall-runoff model is used. Once we have IDF curves, then the corresponding rainfall intensity (inches/hour) can be obtained.

For each rainfall duration 1, 2, 6, 12, 24 hour quantities for six return periods (2, 5, 10, 25, 50 and 100). The value of rainfall intensity, for each return period, is calculated by dividing the rainfall by its corresponding duration (Naghavi, 1993). Figure 5.25 represents the IDF curves for Jefferson Parish. The following equation represents the IDF curves (Modern Sewer Design, 1980):

$$I = a(D + b)^{c} \qquad (5\text{-}1)$$

where a, b, c are three constant parameters, I is the rainfall intensity (inches/hour) for a given return period, D is rainfall duration in hours. The estimated parameters are shown in Table 5.3.

Table 5.3 Parameters for the IDF Curves
(Log Pearson Type III Method)

Return Periods (Years)	a	b	c
2	3.09	.484	-.749
5	3.18	.530	-.763
10	4.34	.325	-.731
25	5.60	.421	-.773
50	5.93	.273	-.764
100	6.57	.195	-.767

For any rainfall duration and return period, the corresponding rainfall intensity can be obtained from the I-D-F curves. Figure 5.23 was prepared based on results from rainfall data for the Audubon rain gauge station.

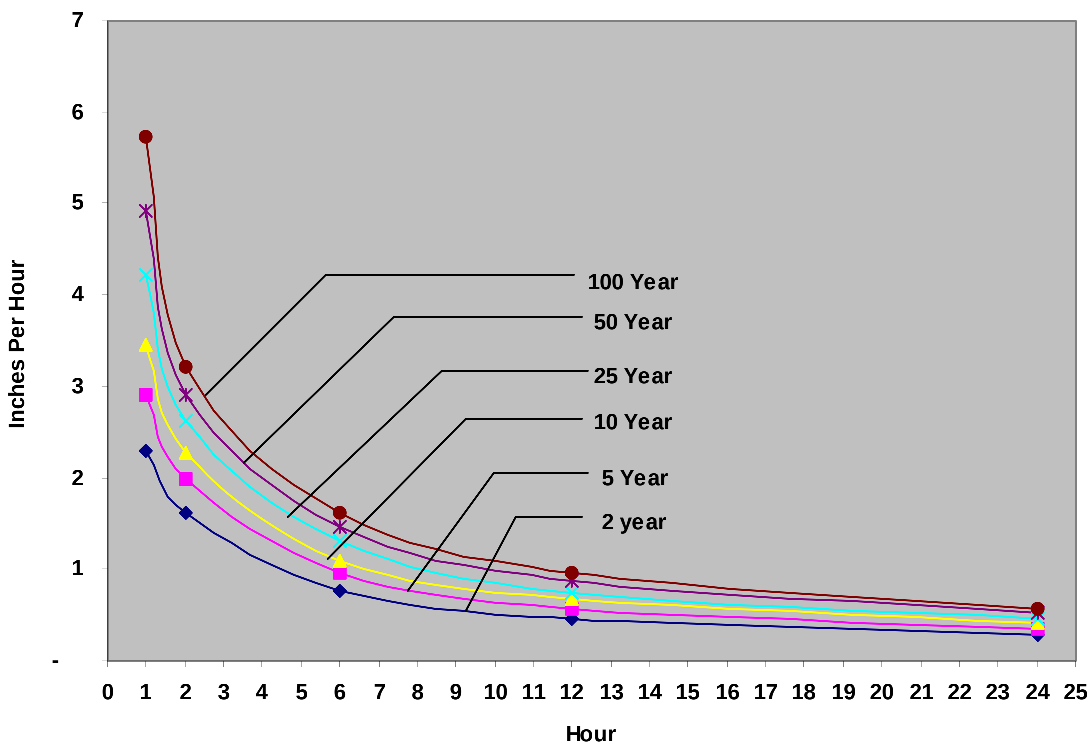


Figure 5.25 I.D.F. Curves for Jefferson Parish
(Log Pearson Type III Method)

5.3 Application of Storm Water Model

One of the major elements affecting Jefferson Parish or any urban area is flooding caused by runoff from excessive rainfall. One of the factors that affects the hydraulic design is the amount of rainfall used in the calculation for sizing of the drainage system. Currently, Jefferson Parish uses 24 hour, 10 year rainfall frequency in design of drainage system. The design rainfall is 9.2 inches. This policy has been in place since 1980.

To evaluate the effectiveness of the current rainfall frequency curve that the Parish uses, a typical urban development is used which consists of 23 acres with several catch basins as shown in Figure 5.26. XP-SWMM Storm Water Management Model (Storm Water Management Model, 2003) with rainfall frequencies that were calculated from the Audubon rain gauge station was used to determine the hydraulic effects of runoff. Additionally, XP-SWMM Model was run with the existing curve for comparison purposes.

XP-SWMM is a software package for modeling storm water and wastewater flows and pollutants. It is used to simulate a natural rainfall-runoff process. It can perform continuous or event simulations with or without the inclusion of water quality computations. To simulate the hydrologic cycle, the user may select the design storm or actual storm event. Design storms for any duration and return periods may be created from:

- SCS Method
- Chicago Storm
- Huff Distributions
- ARDR Temporal Patterns
- User Defined Distributions.

There are numerous methods available for computing storm runoff hydrographies for events such as:

- Non-linear runoff routing
- SCS unit hydrograph using a curve number with curve linear or triangular unit hydrographs

- Nash unity hydrograph
- Rational method
- Modified rational method
- EPA RTK unit hydrograph for RDI.

To set up the storm water model, the model basin is divided into several catchments and physical attributes are entered into tables. These data include size, length or shape of pipes, elevation invert slopes, outfalls and any other existing conditions that would affect the runoff. Then the data are processed with one of the rainfall events that was presented earlier.

Since Jefferson Parish uses a 10 year, 24 hour rainfall for the design of their drainage system, only results from a 24 hour rainfall analysis are discussed in this section. Output data include numerous graphs for the flow, velocity and hydraulic grade line for each node. Results can be viewed in three dimensions. Users may navigate by zooming or changing the viewing location.

The limits of the study area (approximately 23 acres) is shown on Figure 5.26. Based on the field information, the entire watershed was divided into sub-areas to identify the theoretical overland flow patterns. Each sub-area contains a reference number which will be used to identify hydraulic data in the model analysis.

The Chicago storm was selected for the rainfall block of XP-SWMM model. The synthetic hyetograph computed by the Chicago method (Modern Sewer Design, 1980) is based on the parameter of an assumed intensity-duration-frequency relationship in the form:

$$i = \frac{a}{(t + c)^b} \tag{5-2}$$

where

i = average rainfall intensity (inch/hour)

t = storm duration (minutes)

a, b, c = constants depending on the units employed and return frequency of the storm

The rising and receding legs of hyetograph are described by the following equations:

After the peak (5-3a)

$$i_a = \frac{a\left[(1-b)\frac{t_a}{1-r} + c\right]}{\left(\frac{t_a}{1-r} + c\right)^{1+b}}$$

Before the peak (5-3b)

$$i_b = \frac{a\left[(1-b)\frac{t_b}{r} + c\right]}{\left(\frac{t_b}{r} + c\right)^{1+b}}$$

Where

t_a = time after peak

t_b = time before peak

r = ratio time the peak occurs to the total time

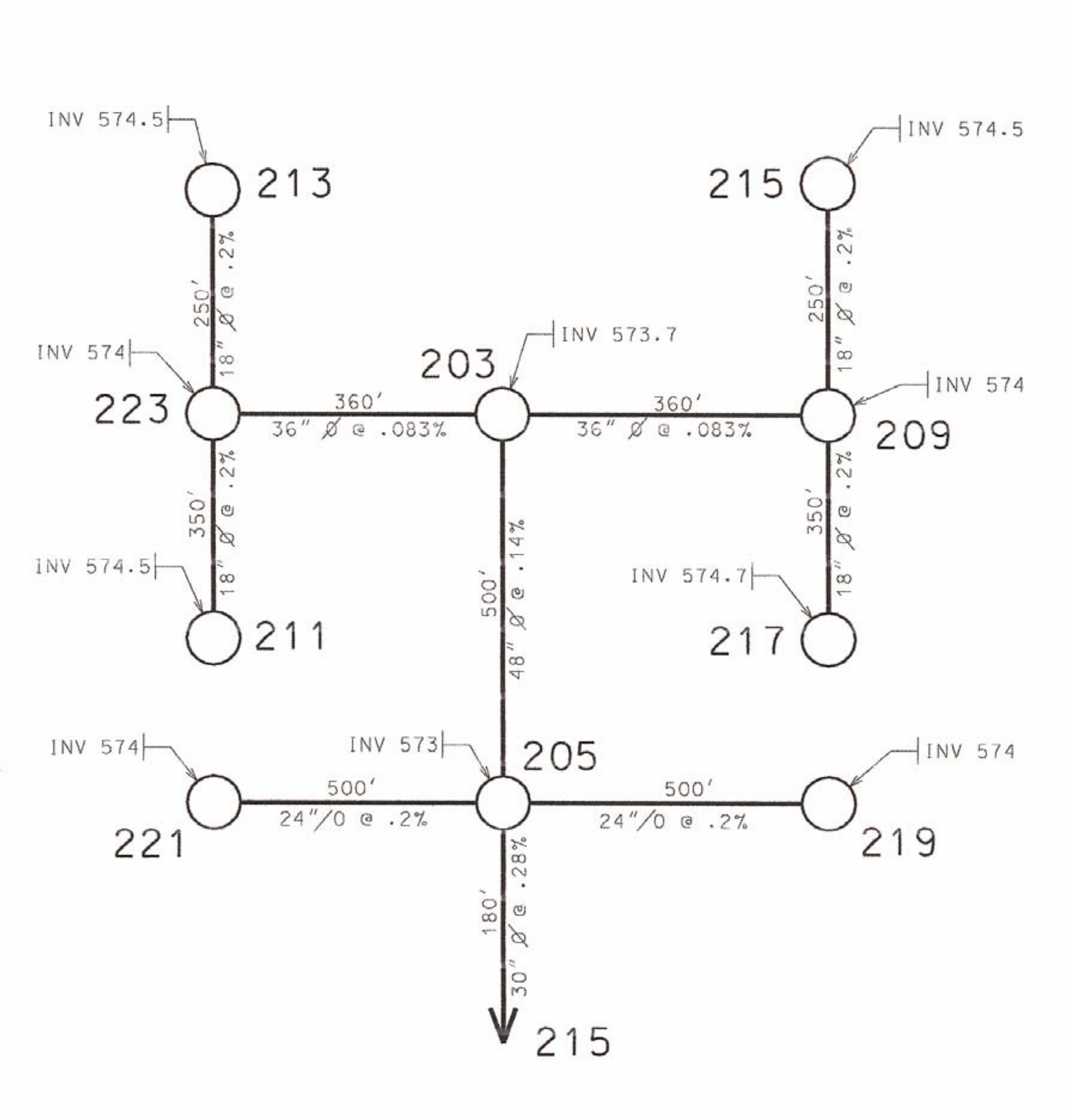


Figure 5.26 Drainage Network as Analyized by SWMM Model

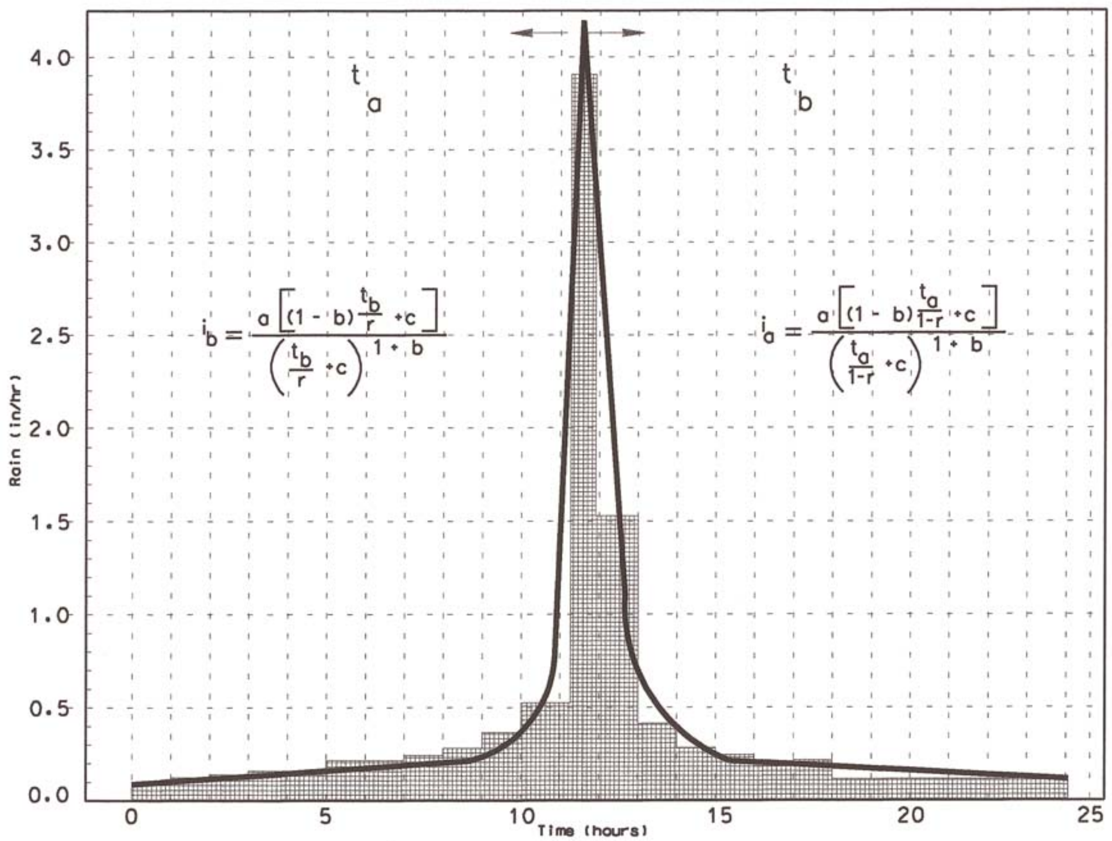


Figure 5.27 Synthetic Rainfall Hyetograph (XP-SWMM)

The current Jefferson Parish 10 year, 24 hour design storm of 9.2 inches was used with XP-SWMM Model. A copy of input and output results have been included in Appendix "D." Additional figures have been provided to summarize the maximum flow, stage outfall and Chicago Storm Distribution. The maximum stage at the outfall is 574.96 feet and the maximum flow is 61.87 cubic feet per second. The maximum intensity of rainfall is 3.8 inches per hour.

Since the 24 hour duration rainfalls are being evaluated, rainfall values for 2, 5, 10, 25, 50 and 100 year return periods were used with XP-SWMM Model. These rainfall values were calculated using the Log Pearson Method from rainfall data for the Audubon rain gauge station. The rainfall hyetograph and maximum flow volumes are included in Appendix "C." Table 5.4 summarizes the output results for the six return periods.

Table 5.4 Summary Results of Storm and Wastewater Management Model for 24 hour 10 Year Rainfall Frequency

Return Period Year	Rainfal (inches)	Rainfall Intensity (inch per hour)	Outfall (ft)	Max Flow (cu. ft. per second)	Flooded Volume (cu.ft.)
2	6.64	2.8	574.88	58.83	5,150
5	8.40	3.5	574.94	61.58	49,669
10	9.73	4.1	575.00	62.58	187,229
25	11.58	4.8	575.00	62.98	224,690
50	13.10	5.5	574.98	62.71	285,920
100	14.75	6.2	575.00	62.71	335,814

Rainfall from Log Pearson Type III is applied to each sub-area. The XP-SWMM Model produces a hydrograph at each node or junction (entrance to the pipe network). The hydraulic block of the program was used to route the rainfall through the network of pipes. All culverts sizes, types and length were entered into the model. The volume of flooding in Table 5.4 refers to the total volume of water above the ground elevation where the flooded pond storage area starts. Ground elevations vary from a high of 582 feet to a low of 580.5 feet.

The results indicate an increase in rainfall contributed to an increase in the volume of flooding. For the 5 year return period, maximum flooding occurs at node 211 with 1.2 inches of flooding. For the 100 year return period, the volume of flooding results in 6 to 9 inches of flooding over the entire study area.

Figure 5.27 shows actual rainfall records in which there are many shorter duration rainfalls than the current Jefferson Parish 24 hour design storm. However, these storms have caused major flooding throughout Jefferson Parish.

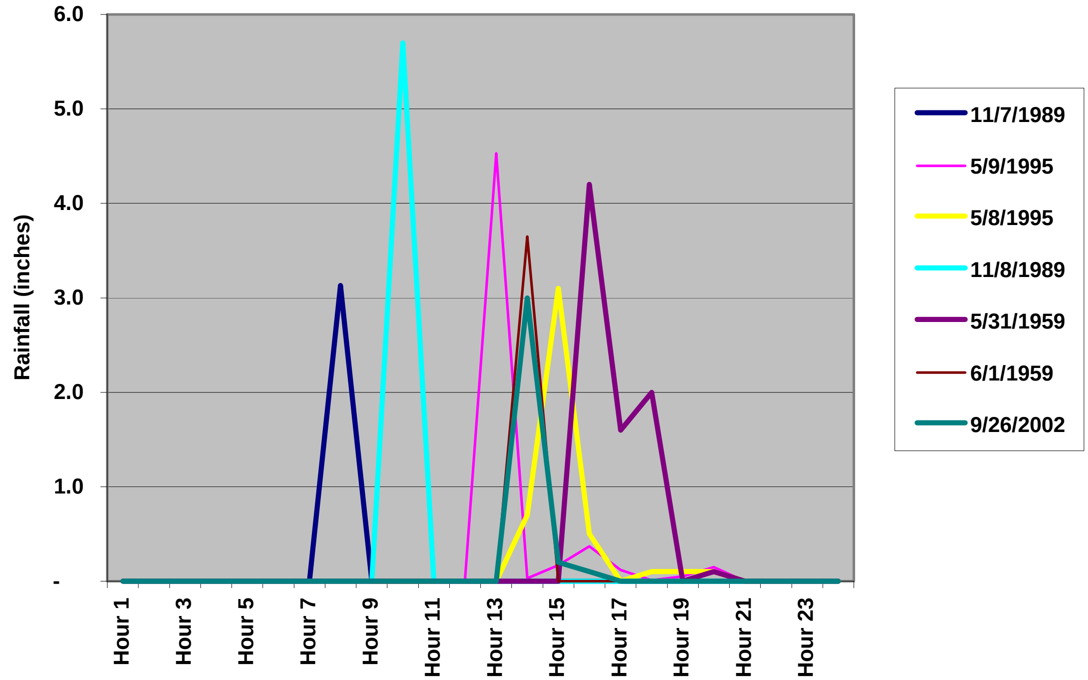


Figure 5.28 Historical Short Duration Rainfall Events

To evaluate the affects of short duration rainfall, a rainfall event that occurred on November 8, 1989 resulting in 5.8 inches of rainfall in 2 hours was selected for analysis. The XP-SWMM Model was used with the 5.8 inch rainfall. The output file with hyetograph, stage elevation and maximum flows are provided in Appendix "E." Table 5.5 compares the results that were generated by the model for a 10 year return period, a 24 hour Jefferson Parish design storm and the two hour duration rainfall that was selected from historical records.

Table 5.5 Summary Results of 10 Year, 24 Hour Rainfall Duration

	Rainfall (Inches)	Rainfall Intensity (inch/hour)	Outfall (ft)	Max Flow (cubic ft/second)	Flooded Volume (cu-ft)
Jefferson Parish	9.20	3.9	574.96	61.87	79,042
Log Pearson Method	9.73	4.1	575.00	62.58	187,229
Short Duration	5.80	5.6	574.98	62.71	236,201

The intensity for the short duration rain is very largely due to its being less than an hour. This illustrates that there are shorter duration events that can result in a significant increased flooding.

Chapter 6 - Discussion of Results

6.1 Implications of High Density Rainfall Network Results

Using rainfall data from the network of various rain gauges throughout East Jefferson Parish, the depth area relationship for a maximum 24 hour rainfall was developed. For this graphical presentation, rainfall from 22 rain gauge stations located throughout the East Bank of Jefferson Parish were used. There are six other rain gauge stations, however, due to mechanical problems, the data was not available. Using the Theissen Method, the rainfall depth versus area curves were developed. For East Jefferson Parish only, a maximum 24 hour frequency was developed since the current Parish design storm is based on 24 hours. Typically, adjustments need to be made for the influence of a mountainous area. In the case of Jefferson Parish, it is considered flat so this is not a factor.

The depth area curve indicates when we compare a design storm frequency for a small drainage area to a large drainage basin, the rainfall values decrease. In considering a development area of one square mile or less, a 24 hour design storm should be approximately 14 inches. The area of East Jefferson Parish consists of approximately 50 square miles of which 3.5 square miles is Hoey's Basin which drains directly into New Orleans and remaining area is divided into four segments, approximately 10 to 15 square miles each. For these large drainage basins, a 24 hour design storm should be between 10 and 11 inches of rainfall. This variation of design storm considers that over a large area, storms can be averaged, however, small areas should be able to withstand thunderstorms or high intensity storms which result in local flooding.

6.2 Log Pearson Type III Analysis

For this research, the Log Pearson method was used to analyze the rainfall data from the Audubon and New Orleans International Airport rain gauge stations. Merit of the Log Pearson Distribution is that frequency factor for the normal distribution is a function of skewness. The Log Pearson distribution is a three-parameter distribution that provides the flexibility to fit to the total of the data distribution (Edward A. McBean and Frank A. Fovers, 1998).

There are many ways to assemble the data. The selection can be based on personal preference, availability of data or purpose of data. However, when extreme events are the primary concern, it is common to use annual events. In this case, it is maximum annual rainfall. Such a series ignore the second and lower order events of each year which may be even higher than the annual rainfall of other years. To overcome this shortfall an alternative method known as partial duration series has been provided. This method is not a true distribution series since the event is defined in terms of its magnitude rather than its occurrence.

Rainfall frequency curves provided in the Technical Paper No. 40 (Hershfield, 1961) were based on annual series. This standard work was based on fitting Gumbel distributions to annual extreme data with average length of 22.6 years. It has been found that TP-40 often underestimates the largest extreme rainfall amount most needed in the engineering design (Daniel S. Wilks, 1993). Both annual and partial duration series were used in analyzing the rainfall data for Audubon rain gauge results are provided in Table 6.1.

Results indicate that at lower return periods (2 to 25 years) partial duration series results in higher rainfall than annual series. For the higher return periods of 50 and 100 years, results are revised which makes the annual series to provide higher rainfall. In comparison, this study was based on 20 additional years of rainfall data, then TP-40. One reason could be attributed to the effect of standard deviation used in the Log Pearson method. For the same set of data, the partial duration series has a lower standard deviation than the annual series.

Table 6.1 Comparison of Partial Duration Series To Annual Series for Audubon Rain Gauge Station

Rain (Inches)

Return Period	One Hour		Two Hours		Six Hours		12 Hours		24 Hours	
Year	Partial	Annual	Partial	Annual	Partial	Annual	Partial	Annual	Partial	Annual
2	2.30	1.95	3.23	2.75	4.54	3.83	5.52	4.33	6.80	5.00
5	2.91	2.73	4.00	3.76	5.74	5.40	6.97	6.20	8.50	7.14
10	3.45	3.34	4.54	4.49	6.61	6.53	8.00	7.61	9.70	8.80
25	4.23	4.24	5.26	5.46	7.89	8.08	9.39	9.60	11.30	11.20
50	4.93	5.02	5.82	6.23	8.73	9.32	10.49	11.25	12.50	13.22
100	5.73	5.90	6.41	7.03	9.73	10.64	11.65	13.03	13.70	15.45

6.3 Rainfall Trends

Since rainfall data collected for the Audubon is different from the New Orleans International Airport rain gauge station, statistical analysis was done to determine if there are significant differences between the two stations. These analysis included the F-test and t-test. Results with a five percent level of significance indicated that when comparing average monthly rainfall data, the months of July and November rainfall data is significantly different between the two stations. However, at the 25 percent one-sided test for the months of February, July, August, October and November, there is a significant difference between the rainfall data between the two rain gauge stations. When comparing the monthly maximum 24 hour rainfall, the months of June and November fail the F-test indicating a significant statistical difference between the two stations. Next, the statistical test was performed to detect seasonal differences. Rainfall data from the two rain gauge stations were divided in two, frontal (December to May) and Tropical (June to November). The F-test and t-tests were applied and no significant difference between the seasonal data were found.

To evaluate the statistically significant differences in rainfall data in Louisiana (Van Cooten, 2004) collected rainfall data from several rain gauge locations throughout southwest Louisiana and southern Mississippi. First, to determine if there was a significant difference in the twelve month rainfall data, the F-test and t-test were performed. Test results for the Audubon and New Orleans International Airport rain gauge stations did not find any significant difference in the rainfall data. In the next series of test stations the Shapiro-Wilk test had determined as having a normal distribution of their respective twelve monthly means. The Audubon and New Orleans International Airport rain gauges were included with a group of seven rain gauge stations. The F-test and t-tests were applied to a combination of groups to determine if the rainfall data are significantly different from one group to another group. The findings indicated that there are statistically significant differences in the mean monthly rainfall average over six months for the Audubon group and the other groups show a transitory pattern (Van Cooten, 2004). The statistical results showed evidence for the existence of

hurricane season precipitation micro-climates when the Audubon group is compared to the Lafayette or Galliano area groups. The winter/spring group showed a statistically significant difference in average monthly rainfall for the intensity of November-April, December, May, January and June.

6.4 Comparison of Results (Log Pearson Type III, TP-40, etc)

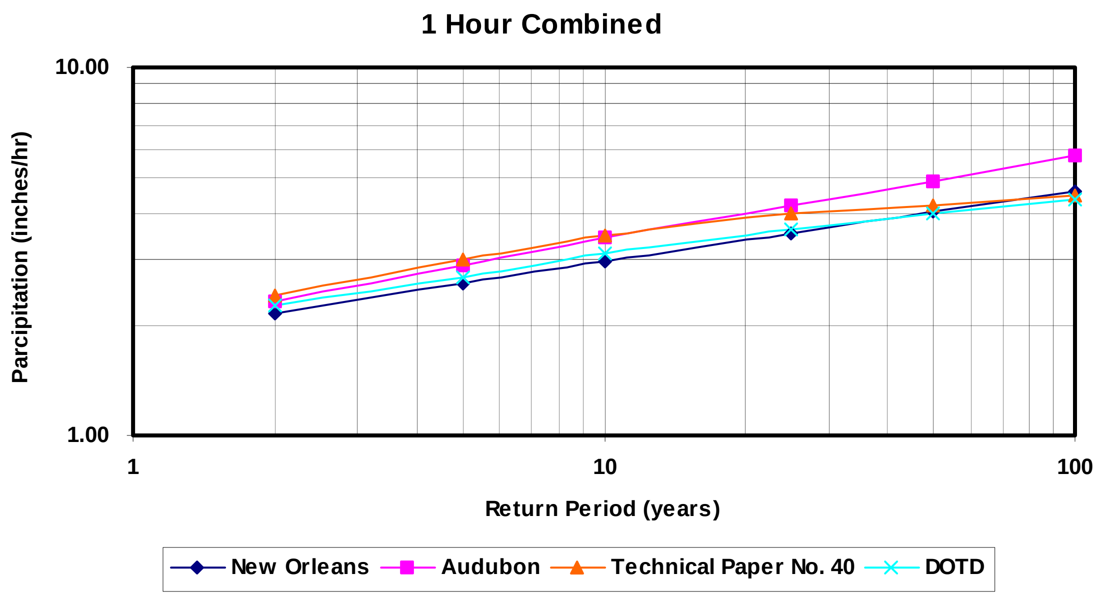


Figure 6.1 Summary Results for 1 Hour Duration Rainfall

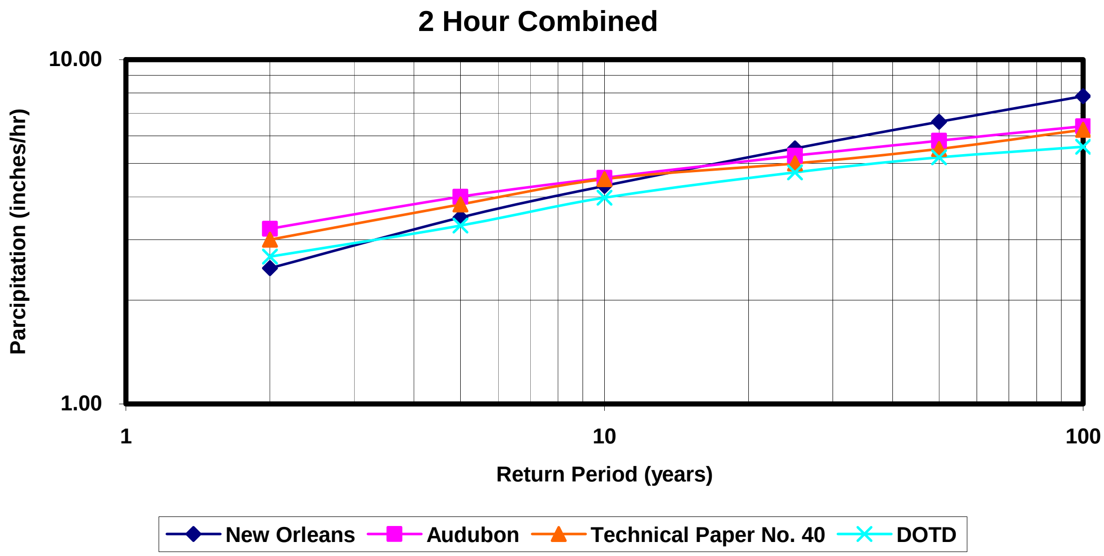


Figure 6.2 Summary Results for 2 Hour Duration Rainfall

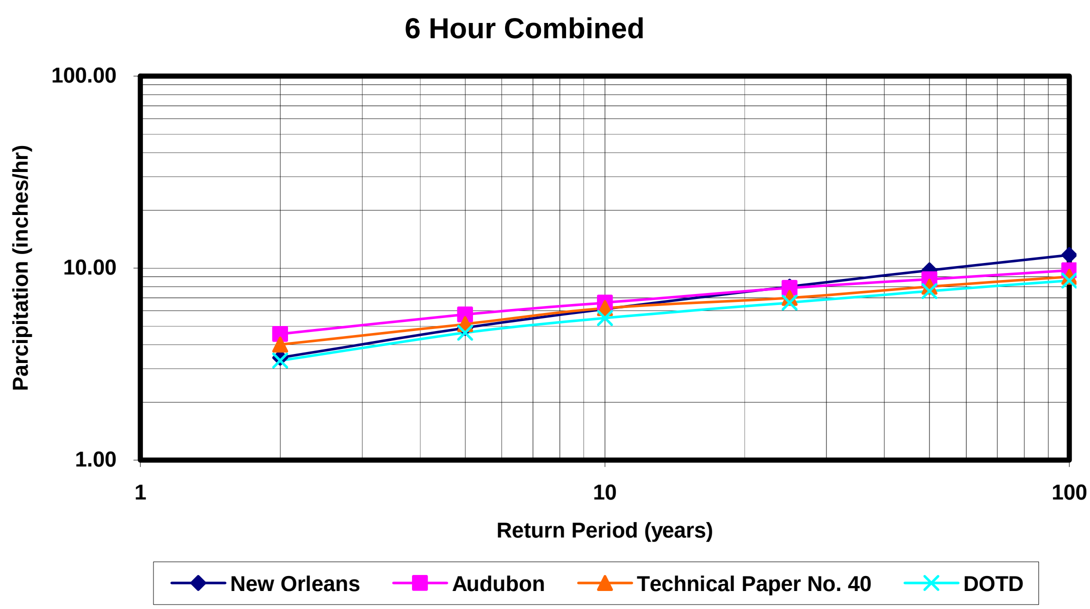


Figure 6.3 Summary Results for 6 Hour Duration Rainfall

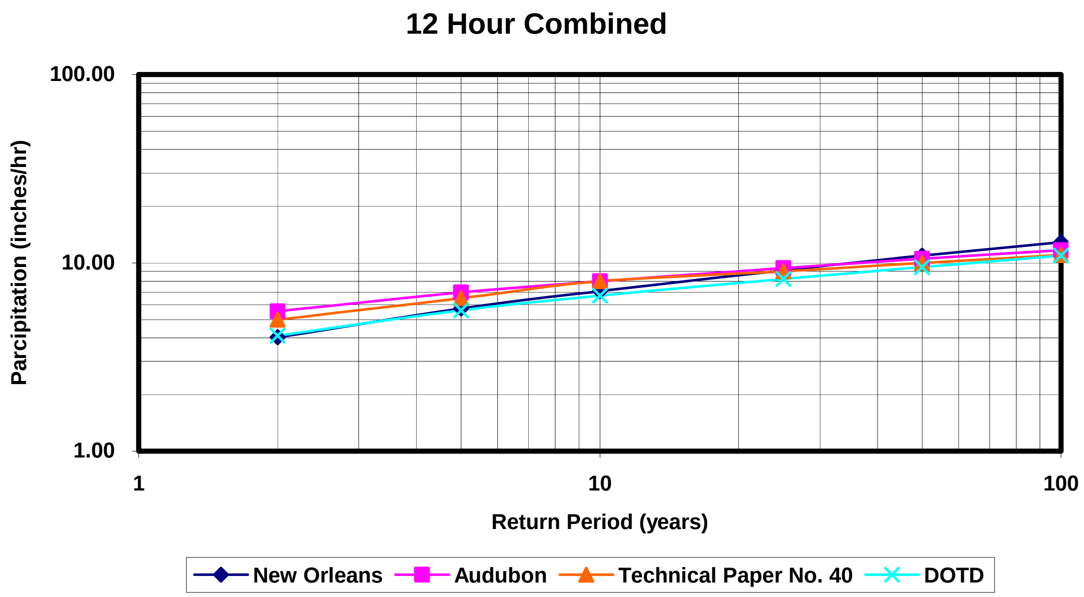


Figure 6.4 Summary Results for 12 Hour Duration Rainfall

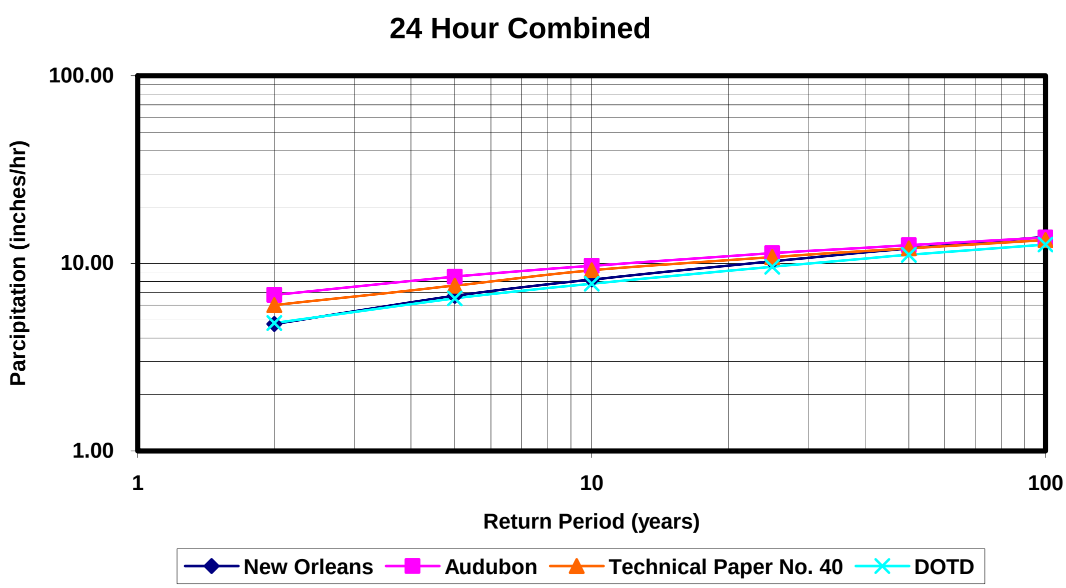


Figure 6.5 Summary Results for 24 Hour Duration Rainfall

Rainfall frequency curves for Jefferson Parish were developed using the Log Pearson method. A summary of the results has been shown on Figures 6.1 through 6.5. Included in the Figures are Technical Paper No. 40 and the Louisiana Department of

Transportation and Development (DOTD) rainfall frequency curves. The Louisiana Department of Transportation and Development rainfall frequency curves under-estimates the amount of rainfall for Jefferson Parish. The TP-40 frequency curves at lower return periods underestimate the amount of rainfall however, at higher return periods are closer to the calculated amount of rainfall for the Audubon and New Orleans International Airport rain gauges. In these figures, rainfall for both rain gauge stations are calculated using the Log Pearson method and the partial duration series and results for the Audubon rain gauge provides higher frequency curves than the New Orleans International Airport with the exception of two durations which are above 25 year return periods is higher than Audubon. In an earlier section, one of the possible reasons for the difference in rainfall between the two stations was attributed to the Heat Island Affect. One effect of Heat Island would be to increase convective lift in the summer; which could result in increased thunderstorms. It should be noted that the Audubon rain gauge station is located in a park surrounded by trees and greenery whereas the New Orleans International Airport is located within the airport boundary without any trees or vegetation. Table 4.3 illustrates the average monthly temperature for the two stations. The Audubon station has a lower average monthly temperature throughout the year than the New Orleans International Airport. The difference is consistent through the year. These differences may be a contributing factor to the rainfall difference between the two stations.

6.5 Implications of Findings for Flooding

The XP-SWMM Model was used to analyze the current Jefferson Parish rainfall frequency and rainfall frequency that was developed by this research for 10 year return and 24 hour duration. A summary of the results was provided on Table 5.4. The rainfall difference between the two frequencies is 0.5 inch, however, the amount of flooding is increased by 108,187 cubic feet. In order to evaluate the validity of the 10 year return period and the 24 hour duration, we turn to shorter duration storms that have provided flooding in Jefferson Parish. Figure 5.28 represents several short duration storms. These storms lasted from two to four hours, with rainfall intensity of 3 to 5.8 inches. The storm event that occurred on November 8, 1998 was selected for further analysis. The XP-

SWMM Model was used to analyze this storm event. A copy of output file has been provided in Appendix "D" and the summary results are shown on Table 6.2.

Table 6.2 Summary Results of Jefferson Parish Design Stormed selected Short Duration Storm

Storm Event	Rainfall (inches)	Intensity (inch/hr)	Stage (Ft)	Maximum Flow (cubic ft/sec)	Flood Volume (cubic feet)	Total Volume (cubic feet)
Jefferson Parish	9.2	3.9	574.95	61.70	79,042	533,318
11/08/1989 Rain Event	5.8	56.0	574.98	62.71	236,201	422,352

The results indicate that the shorter event of 5.8 inches produced more extensive flooding. The flooding occurred at every node. In comparison there was minor flooding with 9.2 inches of rainfall at five nodes. The total volume of runoff is much higher for the larger storms however, is spread over a longer period of time. The November 8, 1989 event actually was part of a two day storm that resulted in 16.01 inches of rainfall over 48 hours which resulted in massive flooding in Jefferson Parish. This type of rainfall event is not considered to be representative of Jefferson Parish weather but it does occur. From 1980 to 1989, five (5) such events lasting from 24 to 48 hours dropped approximately 10 to 16 inches of rain on Jefferson Parish. In studying the fluctuations of heavy rainfall in New Orleans (Barry D. Keim and Robert A. Muller, 1992), indicated that the possibility exists that the magnification of annual storms in New Orleans were a manifestation of global change and may give an indication as to the future of a heavy rainfall regime in New Orleans.

The current Jefferson Parish design storm does not consider storms of short duration with high intensity rainfall. Of course the use of a larger rainfall return period would encompass such rainfall events.

Chapter 7 – Conclusions

Conclusions

1) What are the long term rainfall events in Jefferson Parish?

This objective was accomplished by statistical analysis of rainfall data for the Audubon and the New Orleans International Airport rain gauge stations. These two stations are located approximately nine miles from each other. The Audubon station is located in an urban area within the boundaries of a park surrounded by trees and vegetation. The New Orleans International Airport rain gauge station is located in a rural area near airport runways and away from trees and vegetation. The statistical analysis indicates a significant difference for the monthly average rainfall in July and November for the data from the two stations. Statistical analysis also shows for the maximum 24 hour rainfall during the months of June, July and November, there are also significant differences between the data for the two stations. The two stations are relatively close to each other and the difference in the rainfall data may be attributed to the surrounding environments at each station. Additional research could validate this hypothesis.

2) Is the frequency distribution based on the latest annual maximum rainfall in Jefferson Parish significantly different for the one in current use?

This was accomplished by evaluating historical annual rainfall records for the Audubon rain gauge station which shows periods of heavy rainfall followed by periods of lower than average annual rainfall. Analysis of these annual records indicate that these cycles are approximately 16 to 17 years long. There is no evidence to relate these fluctuations of rainfall patterns to global climate changes or greenhouse gases; they may simply be due to normal fluctuations of weather patterns. However, if fluctuations of rainfall of this magnitude continue to increase, Jefferson Parish would need to increase its drainage capacity to be able to handle the additional runoff.

3) *What are the appropriate rainfall frequency and area distribution curves for Jefferson Parish?*

Rainfall frequencies and area distribution curves for Jefferson Parish were developed and have been included in this research. The area distribution curves serve as an additional tool to an engineer to adjust the rainfall based on the size of the development.

4) *What are the implications of long term trends in rainfall intensity on storm water management?*

To evaluate the level of flooding, rainfall frequency developed from this research and current Jefferson Parish design rainfall, a short duration rainfall was applied to a typical development. The results indicate that the current design rainfall provides the lowest level of flood protection. The analysis also shows that small areas are subjected to significantly increased flooding due to short duration high intensity events that may not result in a large rainfall when averaged over 24 hours.

Recommendations

1) Statistical analysis of the rainfall data indicates there is a difference between Audubon and New Orleans International Airport rain gauge stations. Additional research of this variation is recommended.
2) A review and update of the Louisiana Department of Transportation and Development Hydraulics Manual to update the rainfall frequency is recommended.
3) Consideration should be given to updating the design rainfall frequency and possibly increasing it to a 25 year return period for urban developments in order to account for short duration high intensity events.
4) Consideration shall be given to include as part of the design review the use of the area distribution curve.
5) Research should be conducted to develop methodologies to incorporate flood frequency analysis and projected annual damage costs.

References

1. Belville, J.D. and Stewart, N.O. (1983) Extreme Rainfall Events in Louisiana: New Orleans Type," Preprints, Conference on Hydrometeorology (Tulsa), American Meteorology Society, Boston, Massachusetts.
2. Beyer, W. H. (1966) CRC Handbook of Tables for Probability and Statistics (Cleveland, OH: Chemical Rubber Company).
3. Bureau of Reclamation http://www.cbo.gov/ftpdoc.cfm?index=46&type=0&sequence=3
4. Cassidy and Chaudhry (1998), Exceedance Probability Tables 2-3, 2-4 in Roberson
5. Chapter 2, Birth of Soil Mechanics at the Waterway Experiment Station, 1930-1941. http://gsl.erdc.usace.army.mil/gl-history/Chap2.htm
6. Curtis, D. C. and Bornash, R. J. (1996) Inadvertent Rain Gauge Inconsistencies and Their Effect on Hydrologic Analysis. California-Nevada Alert Users Group Conference, Ventura CA, My 15-17, 1996. PP 1-4.
7. Department of Drainage. www.JeffParish.net
8. Faiers, G. E., Keim, B. and Hirschboeck, K. K. (1994) A Synopic Evaluation of Frequencies and Intensities of Extreme Three and 24-Hour Rainfall in Louisiana. Professional Geographer. 156-163.
9. Fetter, C.W. Applied Hydrogeology. (1988) Second Edition. Merrill Publishing Company. A Bell & Howell Information Company.
10. Fisher, R. A. and Yates, F. Statistical Tables for Biological Agricultural and Medical Research, 6th Edition, 1963, pp. 55-56.
11. Frequency Factors for Gummer and Log-Pearson Type III Distribution (Haan 1977). http://ewest.oregonstate.edu/streamflow/mainpage/skew.htm.
12. Giron, E. (2002) Regional Flood Analysis in Honduras. Thesis. University of New Orleans, Louisiana.
13. Gregory E. Faiers, Barry D. Kiem, and Robert A. Muller. 1997. Rainfall Frequency/Magnitude Atlas for the South-Central United States. Southern Regional Climate Center, Department of Geography and Anthropology, Louisiana State University.
14. Grow, E. L., Davis, F. A. and Maxfield, M. W. Statistics Manual (New York: Dover Publications Inc. 1960).
15. Habib, E., Krayewski, W., Kruger, A. Quantification of Sampling Errors of Tipping-Bucket Rain Gauge Measurements for Water Projects. Paris, France, United Nations Educational Scientific and Cultural Organization.
16. Heat Island Effect. United States Environmental Protection Agency. http://www.epa.gov/heatislands/pilot/baton_rouge.html.
17. Hershfield, D. M. (1961) Technical Paper No. 40 Rainfall Frequency Atlas of the United States. For Duration From 30 Minutes to 24 Hours and Return Periods From 1 to 100 Years. Engineering Division, Soil Conservation Service. U. S. Department of Agriculture.

18. Keim, B. (1990) Synoptic Weather, Frequency, and Magnitude Analyses of Heavy Rainfall in New Orleans Louisiana: 1871 – 1989. Thesis. University of New Orleans. Department of Geography and Anthropology.

19. Keim, B. (1994) Temporal and Synoptic Analyses of Heavy Rainfall in the Southeastern United States. 1994. Dissertation. Louisiana State University. Department of Geography and Anthropology.

20. Keim, B. (1996) Spatial, Synoptic, and Seasonal Patterns of Heavy Rainfall in the Southeastern United States. Physical Geography. 17, 4. pp. 313-328.

21. Keim, B. (1999) Precipitation Annual Maxima as Measure of Change in Extreme Rainfall Magnitudes in the Southeastern United States over the Past Century. Southeastern Geographer. Vol. XXXIX, No. 2, 235-245.

22. Keim, B. and Muller, R. (1992) Temporal Fluctuations of Heavy Rainfall Magnitudes in New Orleans, Louisiana 1871-1991. American Water Resources Association. Vol. 28, No. 4. 721-730.

23. Keim, B. and Muller, R. (1993) Frequency of Heavy Rainfall Events in New Orleans, Louisiana 1900 to 1991. Southeastern Geographic. Vol. XXXIII. pp. 159-171.

24. Keim, B., Faiers, G., Muller, R., Grymes III, John, Rohli, R. (1995) Long-Term Trends of Precipitation and Runoff in Louisiana, USA. Department of Geography, University of New Hampshire and Gregory, Southern Regional Climate Center, Department of Geography and Anthropology, Louisiana State University, Baton Rouge. International Journal of Climatology, Vol. 15, 531-541.

25. Keim, B., Faires, G. (1996) Heavy Rainfall Distributions by Season in Louisiana: Synoptic Interpretations and Quantile Estimates. Water Resource Bulletin Vol. 32, No. 1, 117-124.

26. Keim, B., Faires, G. (1999) A Comparison of Techniques to Produce Quantile Estimates of Heavy Rainfall in Arid and Mountainous Environments: A Test Case in Western Texas. Journal of Arid Environments. 44: 267-275.

27. Linsley, Jr., R. K., Kohler, M. and Pavlhus, J. L. Hydrology for Engineers. 1958.

28. Louisiana Department of Transportation and Development Hydraulics Manual, 1987.

29. Lowing, M.J., 1987 Case Book of Methods for Computing Hydrological Parameters.

30. McBean, E. A. and Rovers, F. A. (1998) Statistical Procedures for Analysis of Environmental Monitoring Data & Risk Management. Upper Saddle River: Prentice-Hall.

31. McCuen, R. H. Statistical Methods for Engineers. 1985.

32. Modern Sewer Design, published by American Iron and Steel Institute, First Edition 1980.

33. Moving Average, http://mathworld.wolfram.com/movingaverage.html.

34. Muller, R. A. (1976) A Synoptic Climatology for Environmental Baseline Analysis: New Orleans. Department of Geography and Anthropology and Center for Wetland Resources. Louisiana State University. Journal of Applied Meteorology. Volume 16. 20-32.

35. Naghavi, B. (1993) Temporal and Spatial Characteristics of Annual Maximum Precipitation in Louisiana. Dissertation. Louisiana State University. Department of Civil Engineering.

36. Naghavi, B., Singh, V.P., Yu, F.X. (1991) LA DOTD 24-hour Rainfall Frequency Maps and I-D-F Curves (Summary Report). Louisiana Transportation Research Center and Louisiana State University.

37. National Museum of Forest Service History www.nmfs-history.net.

38. National Oceanic and Atmospheric Administration, National Climate Data Center. http://www.ncdc.noaa.gov/ca/climate/stationlocater.html.

39. Oregon State University. Analysis Techniques: Flood Analysis Example with Daily Data (Log-Pearson Type III Distribution). (2007) http://water.oregonstate.edu/streamflow/analysis/flooding/example:htm.

40. Perrault, P. (1967) On the Origin of Springs. Hafner Publishing Co.

41. Research. 6th Edition. Edinburgh: Oliver and Boyd, 1963.

42. Rohi, R. V. and Kiem, B. (1994) Spatial and Temporal Characteristics of Extreme – High - Summer - Temperature Events in the South Central United States. Physical Geography, 15, 4, pp 310-374.

43. Rudolf, B., A Practicable Method For “On-Event” Correction of Precipitation Data For Systematic Gauge Measuring Errors.

44. Snedecor, G. W. and Cochran, W. G. Statistical Methods. Sixth Edition. 1967. Iowa State University Press.

45. Steel, E.W. and McGhee, T.J. Water Supply and Sewerage, 1979, Fifth Edition, McGraw-Hill Book Company.

46. Storm Water Management Model With XP Graphical Interface, XP Software Version 8.87, Oct. 2003.

47. Story, B. D. Computing Fourier Series and Power Spectrum with MATLAB. Faculty.oline.edu/bstory/notes/fourier.pdf.

48. Van Cooten, S. (2004) Statistical Analysis of Seasonal Precipitation for the Lake Pontchartrain Basin and Associated Waters. Dissertation. University of New Orleans, Louisiana.

49. Viessman, Jr., W. and Hammer M. S. Water Supply and Pollution Control, 1985. Fourth Edition. Harper & Row, Publishers, New York.

50. Wilks, D.S. (1993) Comparison of Three-Parameter Probability Distribution for Representing Annual Extreme and Partial Duration Precipitation Series. Water Resources Research. Vol. 29. No. 10 pages 3543-3549.

51. Yang, D., Goodison, B. E., Metcalfe, J. R., Golubev, V. S., Bates, R., Pangburn, T., Hanson, C. L. (1998) Accuracy of NW 8” Standard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison. Journal of Atmosphere and Oceanic Technology. Vol. 15. pp 54-68.

52. Yang, D., Goodison, B.E., Metcalfe, J. R., Louie, P. Leavesley, G., Emerson, D., Hanson, C. L., Golubev, V. S., Elomaa, E., Gunther, T., Pangur, T., Kang, E., Milkovic, J. (1999). Quantification of Precipitation Measurement Discontinuity Induced by Wind Shields on National Gauges. Water Resources Research. Vol. 35, No. 2, 491-508.

53. Yarnell, D. L. (1935) Rainfall – Intensity – Frequency Data. Miscellaneous Publication No. 204, U. S. Department of Agriculture, Washington, D.C.

Appendix A

Table 4.6 Significant Difference Between Average Monthly Rainfall at Audubon and New Orleans International Airport

	Jan		Feb		Mar		Apr		May		Jun	
	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660
1947	9.46	8.30	2.73	2.84	6.47	6.24	9.01	7.38	5.46	4.11	6.73	3.65
1948	5.58	5.72	1.08	1.96	18.46	19.09	1.97	1.49	3.99	1.74	3.07	1.28
1949	3.26	2.78	4.73	2.85	12.96	8.13	9.73	8.78	0.84	0.99	5.49	4.37
1950	2.29	3.93	1.47	4.08	4.37	5.63	6.68	7.30	1.52	2.76	4.53	5.97
1951	2.30	5.49	2.18	1.98	7.40	7.74	6.70	7.79	1.57	1.66	5.44	2.98
1952	3.66	2.70	8.71	8.06	5.49	5.06	5.32	4.82	3.81	5.79	3.85	1.12
1953	2.36	2.56	5.50	7.10	4.95	3.53	8.25	5.94	1.28	1.39	10.78	7.22
1954	3.80	3.96	0.54	1.34	3.21	2.22	0.58	2.29	3.72	4.45	3.43	3.16
1955	9.22	7.13	3.46	5.16	-	0.24	6.12	4.81	5.09	5.38	4.59	4.42
1956	2.07	2.37	7.94	7.27	3.60	3.66	4.30	4.16	2.82	2.37	10.47	6.68
1957	1.53	1.55	2.60	2.88	7.47	8.19	10.80	6.79	2.68	1.24	6.64	7.41
1958	6.38	6.78	4.22	3.96	9.05	6.98	3.48	2.00	9.28	6.70	5.52	2.81
1959	3.51	3.71	11.58	10.56	3.79	3.82	3.84	3.18	9.72	14.33	7.40	6.76
1960	4.87	3.34	4.43	4.77	4.70	3.68	5.82	5.69	3.47	3.30	2.09	1.68
1961	7.63	6.94	10.13	9.00	8.78	8.53	3.97	2.88	7.88	6.46	10.48	8.01
1962	3.47	4.19	2.84	1.02	1.28	1.60	4.95	2.66	0.83	1.31	10.91	8.87
1963	4.59	5.21	5.50	5.90	1.03	1.00	1.16	1.84	0.62	3.17	8.45	4.16
1964	10.15	9.60	5.34	5.35	6.33	5.45	9.66	5.66	1.66	1.69	2.91	5.52
1965	7.43	4.48	4.97	5.25	3.89	1.95	0.97	0.33	3.77	3.62	3.68	2.21
1966	12.69	12.62	9.40	10.11	2.47	1.90	6.08	4.92	8.07	9.31	2.11	2.10
1967	3.36	4.22	7.74	6.80	1.76	1.60	2.75	2.18	3.01	3.56	6.59	2.40
1968	0.99	0.54	3.18	3.02	1.79	3.49	3.38	3.59	3.49	4.13	6.93	3.69
1969	3.28	3.12	4.48	4.80	6.96	7.08	3.97	6.04	5.05	5.51	2.70	2.47
1970	3.93	2.53	2.44	2.28	7.29	7.22	0.75	0.43	5.60	4.68	4.05	4.97
1971	2.03	1.13	4.58	4.87	3.92	3.61	0.74	1.53	2.59	1.38	3.39	8.02
1972	5.83	6.98	5.53	6.03	5.45	6.07	1.43	1.64	4.43	6.31	1.90	3.10
1973	2.36	2.68	4.98	5.40	10.17	12.17	11.30	10.47	4.14	4.68	7.36	6.08
1974	8.11	8.46	3.34	5.53	4.74	6.64	4.30	5.52	9.60	9.84	1.58	3.83
1975	3.47	2.95	4.81	3.64	4.66	5.32	4.97	6.69	9.10	8.03	14.44	12.28
1976	2.03	2.61	3.06	3.85	2.61	3.08	0.75	0.28	6.25	5.58	6.14	3.36
1977	5.30	5.62	2.59	2.75	6.07	3.96	4.04	6.38	1.90	2.59	0.39	1.74
1978	10.67	13.63	2.70	2.53	3.47	2.67	3.15	3.44	12.61	9.72	10.47	7.82
1979	5.73	5.55	12.44	12.49	4.56	3.31	5.10	4.90	5.64	4.38	2.22	0.23
1980	5.95	6.37	2.95	3.09	8.11	10.08	20.24	16.12	7.99	9.65	1.22	3.69
1981	1.20	0.94	7.98	8.34	1.97	2.70	3.67	2.28	3.10	5.35	16.98	8.47
1982	1.89	2.76	5.94	7.88	3.41	2.56	9.72	5.86	3.33	1.19	2.79	5.43
1983	2.83	3.31	7.92	12.59	4.25	4.88	14.76	14.86	5.17	3.71	9.41	10.64
1984	3.59	4.10	5.26	5.27	3.39	4.90	2.04	1.72	2.43	3.54	2.91	7.21
1985	4.84	4.83	6.28	9.28	7.14	7.07	0.64	2.11	1.44	1.16	2.94	4.56
1986	3.71	3.49	4.57	2.93	2.89	1.88	1.43	1.50	1.04	1.61	6.69	8.87
1987	7.57	8.88	5.36	7.38	5.67	4.39	1.23	2.27	3.11	3.46	10.05	15.01
1988	3.42	3.74	7.28	11.31	8.16	8.90	11.54	9.25	2.40	1.68	6.29	11.28
1989	2.04	2.47	0.07	0.15	6.78	7.14	2.87	3.20	2.32	3.50	4.40	8.22
1990	7.05	7.59	7.00	11.45	5.57	5.98	2.54	4.59	7.22	5.87	4.41	1.01
1991	19.80	19.25	3.08	5.42	6.60	6.27	17.13	15.29	14.20	14.28	17.90	10.71
1992	11.00	9.94	10.10	8.73	6.10	6.69	1.42	2.52	1.00	0.95	7.30	9.52
1993	6.44	6.21	2.16	2.34	6.19	5.65	4.62	6.82	6.08	7.23	4.61	4.96
1994	3.13	3.25	0.61	0.54	3.91	4.82	1.73	2.83	9.10	3.67	7.59	9.35
1995	3.92	3.66	5.24	4.94	9.89	7.89	5.94	3.81	15.79	21.18	3.13	2.84
1996	3.96	4.66	3.67	1.56	3.86	2.97	5.13	3.87	3.03	1.37	4.95	8.60
1997	5.00	6.32	4.67	6.88	3.76	2.57	5.80	4.91	5.20	5.03	4.08	6.97
1998	17.14	19.28	4.51	4.28	8.31	5.97	1.49	4.39	0.34	0.43	3.80	3.38
1999	3.82	3.20	0.41	0.92	4.47	4.60	0.04	0.30	3.50	3.37	11.90	12.20
2000	1.83	2.25	0.66	1.81	2.20	2.41	1.06	1.13	0.04	0.07	7.43	5.46
2001	2.78	3.05	1.30	1.59	9.19	8.07	0.25	1.08	2.28	6.85	17.87	17.62
2002	3.80	3.29	1.73	2.76	3.97	3.58	2.90	2.14	0.39	3.04	4.94	4.83
VARIANCE	13.93	14.69	8.22	10.12	9.73	9.70	18.35	12.56	12.28	14.85	16.57	13.33
MEAN	5.18	5.29	4.64	5.12	5.45	5.23	4.90	4.58	4.50	4.65	6.26	5.91
F RATIO	1.05		1.23		1.00		1.46		1.21		1.24	
tcr	<1.56		<1.56		<1.56		<1.56		<1.56		<1.56	
S2	14.31		9.17		9.72		15.46		13.56		14.95	
Sm	0.71		0.57		0.59		0.74		0.70		0.73	
t*	0.15		0.84		0.37		0.42		0.21		0.47	
tc	<1.67		<1.67		<1.67		<1.67		<1.67		<1.67	

	Jul		Aug		Sep		Oct		Nov		Dec	
	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660
1947	3.59	4.18	5.62	4.23	0.47	3.40	2.82	1.66	11.48	14.58	7.26	9.59
1948	8.80	4.48	9.84	5.79	15.26	13.53	1.25	1.07	5.18	13.72	5.73	5.31
1949	9.86	6.01	5.97	3.63	8.05	5.19	3.53	4.27	0.20	0.21	5.37	5.36
1950	9.57	7.20	3.64	4.34	3.67	0.98	1.11	1.18	1.29	0.91	6.81	6.12
1951	3.69	3.45	6.15	4.93	4.00	7.04	0.57	1.11	3.54	3.00	2.92	3.17
1952	10.48	6.23	5.15	2.00	2.81	2.81	-	-	2.24	3.00	6.62	6.86
1953	10.50	10.44	8.14	4.88	1.25	0.24	0.43	0.51	3.71	10.39	8.69	8.93
1954	11.93	11.46	3.22	5.40	6.63	6.66	4.52	5.46	1.93	2.04	5.88	6.02
1955	7.81	9.96	9.69	11.77	9.50	4.53	1.59	0.90	3.67	2.74	2.93	2.81
1956	5.51	6.65	6.32	4.99	10.89	8.02	1.44	1.90	1.49	1.78	6.49	6.49
1957	3.65	5.12	5.54	7.57	10.34	10.21	1.90	2.15	4.49	4.15	3.06	3.09
1958	10.80	9.12	6.37	3.19	6.63	6.57	0.93	0.89	1.07	1.10	1.40	1.46
1959	20.30	7.96	3.66	4.53	3.56	3.47	8.18	6.45	1.09	1.14	1.85	2.58
1960	5.67	4.26	8.25	6.51	3.89	4.11	4.39	4.90	0.55	0.60	5.12	4.17
1961	9.06	10.38	4.81	7.26	7.04	8.90	0.75	0.51	6.61	8.66	6.74	6.01
1962	4.33	4.70	6.26	2.41	5.36	2.52	1.77	3.29	2.75	1.96	2.31	4.47
1963	5.93	6.40	5.11	2.12	6.45	7.35	-	-	10.15	7.85	5.73	5.25
1964	6.38	5.90	5.63	3.88	3.88	4.93	4.64	3.50	3.26	3.51	2.96	3.10
1965	5.41	5.26	7.75	6.34	8.68	10.03	1.24	1.03	1.75	1.49	6.94	7.35
1966	9.97	9.42	7.95	2.84	6.03	5.55	2.06	3.15	0.49	0.72	5.04	5.44
1967	7.94	6.42	8.94	7.51	5.31	3.73	5.55	3.79	0.54	0.45	8.93	10.77
1968	2.37	4.96	3.35	4.78	1.92	2.44	0.43	1.40	5.00	4.97	7.28	6.14
1969	8.36	6.64	8.18	7.80	3.18	1.08	0.55	0.51	1.60	1.73	6.36	5.26
1970	6.50	3.70	5.91	10.21	6.18	4.25	3.73	4.94	0.91	0.85	2.99	4.28
1971	10.29	4.55	4.82	5.75	16.91	16.74	0.82	0.58	3.45	2.63	6.26	6.64
1972	6.23	3.90	3.73	4.92	5.28	3.29	4.70	4.64	8.47	8.45	7.30	8.65
1973	6.11	5.94	7.25	3.37	11.94	11.07	2.91	5.07	4.14	4.04	8.92	8.31
1974	6.12	5.66	6.47	6.70	6.42	7.58	0.69	2.26	6.30	5.88	5.60	4.89
1975	6.89	8.35	8.08	10.11	2.65	3.97	2.76	4.00	3.77	11.35	2.98	3.81
1976	5.68	5.67	4.42	1.69	0.80	1.57	5.55	5.08	5.40	5.80	8.59	8.81
1977	5.78	2.91	17.82	16.12	9.64	13.48	4.53	4.33	9.42	8.77	3.93	4.15
1978	9.31	10.34	11.30	14.68	2.83	2.98	0.01	0.01	6.42	4.67	4.80	4.42
1979	7.50	11.43	6.94	4.57	5.15	4.55	0.87	1.49	4.03	4.27	2.52	3.07
1980	4.30	4.84	2.67	1.68	6.34	6.31	4.97	5.87	3.00	3.85	1.69	1.54
1981	4.99	1.92	9.63	11.10	3.47	4.78	1.55	2.03	0.79	1.10	7.54	5.50
1982	10.89	13.07	8.66	1.92	6.21	5.40	4.34	3.84	4.52	5.45	8.75	10.26
1983	5.82	2.95	7.58	6.29	8.88	5.72	3.23	4.88	5.56	6.32	10.68	9.15
1984	8.88	3.86	5.18	9.51	3.12	3.79	2.69	2.84	1.70	2.80	2.21	2.53
1985	12.47	6.92	4.56	6.37	6.07	5.74	2.90	13.20	1.54	0.96	3.79	4.78
1986	3.04	3.60	8.10	6.74	4.68	1.42	2.67	2.87	6.21	7.90	4.60	5.05
1987	4.60	6.38	5.54	5.05	2.74	1.29	0.58	0.72	2.95	2.92	3.40	2.88
1988	7.26	6.78	7.03	7.53	10.48	5.86	2.37	2.87	3.20	1.26	1.95	3.94
1989	9.07	8.34	2.80	3.31	2.07	4.53	0.99	0.51	12.90	19.81	3.95	6.28
1990	3.06	2.30	1.60	2.45	4.78	4.55	2.68	2.38	3.03	3.21	5.15	9.67
1991	16.00	13.15	6.30	7.86	2.59	3.44	1.21	1.88	2.91	2.19	4.60	2.63
1992	5.20	5.75	11.00	9.64	8.93	6.63	0.26	0.55	14.79	15.27	5.44	5.68
1993	2.70	5.77	3.17	2.26	3.64	2.47	4.40	3.67	2.77	2.43	2.48	2.90
1994	5.74	8.95	5.01	4.59	4.81	5.61	2.50	2.30	3.18	1.39	4.27	4.61
1995	7.01	6.44	4.79	3.26	0.90	0.69	2.10	1.31	3.58	4.24	4.29	5.07
1996	8.99	10.32	7.76	8.76	3.94	3.96	1.20	2.59	4.19	3.10	6.88	5.55
1997	7.18	3.94	3.32	2.25	2.45	0.81	1.63	1.36	6.80	8.09	2.04	2.55
1998	8.65	6.56	6.04	8.30	22.22	18.98	1.83	1.82	3.53	3.40	2.27	2.25
1999	4.92	4.05	4.73	5.21	5.73	2.87	3.93	5.46	0.41	0.28	2.81	3.85
2000	1.49	1.38	2.57	2.35	5.40	6.50	1.95	1.10	11.68	11.72	3.26	2.70
2001	6.58	6.97	6.84	7.41	4.90	6.30	4.84	5.13	2.68	2.54	3.38	2.90
2002	11.14	4.54	7.34	4.09	15.97	14.23	12.20	10.09	4.68	5.10	4.62	4.82
VARIANCE	11.37	7.61	7.26	10.04	18.01	15.76	4.81	6.07	10.74	18.41	5.09	5.37
MEAN	7.36	6.39	6.33	5.80	6.12	5.62	2.56	2.88	4.16	4.69	4.94	5.18
F RATIO	1.49		1.38		1.14		1.26		1.71		1.06	
tcr	<1.56		<1.56		<1.56		<1.56		>1.56		<1.56	
S2	9.49		8.65		16.88		5.44		14.57		5.23	
Sm	0.58		0.56		0.78		0.44		0.72		0.43	
t*	1.67		0.96		0.65		0.73		0.74		0.56	
tc	>1.67		<1.67		<1.67		<1.67		<1.67		<1.67	

Table 4.8 Significant Difference Between Maximum Monthly 24 Hour Rainfall at Audubon and New Orleans International Airport

	Jan		Feb		Mar		Apr		May		Jun	
	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660
1963	2.63	3.20	2.56	2.31	1.00	0.97	0.48	1.59	0.39	2.71	2.52	1.55
1964	3.61	3.98	1.84	1.85	3.88	2.49	3.65	2.35	0.60	1.50	1.24	1.69
1965	6.75	4.12	2.42	2.35	1.84	0.84	1.09	0.84	1.66	1.59	1.55	1.00
1966	3.98	3.07	2.43	2.49	1.61	0.93	2.02	1.85	4.92	3.76	1.48	0.86
1967	1.31	1.76	6.90	5.58	1.45	1.18	2.72	2.18	0.90	0.88	3.23	0.91
1968	1.47	1.54	1.36	1.13	0.90	2.47	1.68	1.88	2.16	0.93	3.31	1.40
1969	1.91	2.33	1.19	1.41	3.40	3.20	0.90	1.83	1.58	2.17	1.44	0.05
1970	1.57	1.16	1.31	1.40	3.40	2.96	0.29	0.31	2.71	2.01	2.06	2.06
1971	0.87	0.80	1.54	2.17	1.56	1.75	1.54	1.74	1.46	0.93	1.42	2.26
1972	2.09	2.57	1.35	1.55	1.95	2.08	0.68	1.01	2.53	4.70	1.79	4.70
1973	0.88	0.81	2.25	1.86	5.60	5.20	5.59	4.22	2.20	2.04	1.59	2.25
1974	2.49	2.35	1.80	3.77	3.75	4.64	2.94	3.80	3.74	3.10	1.16	1.39
1975	1.78	1.05	2.57	1.72	1.54	1.83	2.52	2.98	3.41	3.61	3.65	2.67
1976	1.01	1.57	1.74	2.53	1.40	1.58	0.50	0.62	2.70	2.20	1.60	1.09
1977	3.10	1.70	1.00	1.25	2.30	1.33	3.10	5.18	1.40	1.56	0.40	1.19
1978	4.80	6.08	1.50	0.99	3.00	1.60	2.70	2.40	10.40	6.79	2.70	3.40
1979	2.40	1.80	5.60	5.25	3.00	2.02	3.40	2.40	3.20	1.50	1.20	1.45
1980	2.80	2.35	3.00	2.39	3.40	3.25	7.00	7.95	5.40	5.79	0.70	1.79
1981	0.40	0.42	4.90	4.42	0.20	1.38	2.40	1.44	-	3.15	5.90	3.25
1983	2.70	1.61	-	3.88	2.10	0.88	9.40	4.20	2.60	0.68	3.20	1.44
1984	1.00	2.77	1.40	4.85	0.20	2.83	5.70	7.63	0.20	5.31	3.10	2.41
1985	1.80	0.90	3.30	1.33	2.90	2.33	0.20	0.88	0.80	2.30	0.80	2.89
1986	1.40	1.72	1.80	3.69	1.90	3.29	1.20	0.85	2.10	0.81	3.50	1.87
1987	2.50	1.41	1.50	1.50	2.50	0.92	1.10	1.23	1.40	0.72	2.10	2.92
1988	1.50	2.11	3.80	2.07	2.40	2.24	10.50	1.96	1.80	1.20	3.00	2.55
1989	1.00	1.71	0.20	3.89	5.30	2.96	1.00	8.08	1.20	0.94	1.60	7.40
1990	3.40	1.06	2.30	0.11	2.30	3.69	1.20	1.42	7.20	1.34	2.00	1.97
1991	5.10	3.19	2.80	3.44	2.30	3.44	4.40	1.69	3.80	2.55	12.60	1.19
1992	3.10	5.02	5.30	2.68	2.60	2.61	0.80	4.16	0.60	3.54	2.40	4.50
1993	3.00	2.92	1.30	3.26	2.60	3.27	2.00	1.27	3.70	0.31	1.50	3.65
1994	1.00	2.29	0.40	1.17	3.10	2.09	0.80	2.16	7.90	3.56	2.20	1.40
1995	2.30	0.97	2.90	0.26	3.30	3.67	4.30	1.36	6.10	1.04	3.70	1.93
1996	2.40	1.93	0.50	1.76	2.00	2.73	3.20	2.69	1.70	12.40	1.40	1.45
1997	2.60	1.92	1.90	0.89	1.50	1.49	2.70	2.52	1.80	1.14	1.80	1.25
1998	5.20	2.72	1.60	2.27	4.60	0.94	4.00	1.65	0.70	1.55	2.10	2.39
1999	2.90	4.77	0.40	1.49	3.40	2.40	2.60	3.68	2.20	0.43	5.20	1.45
2000	0.80	1.67	0.60	0.59	1.50	2.26	1.10	2.17	-	2.34	2.60	5.33
2001	1.10	0.82	1.30	1.46	4.20	1.26	0.10	0.61	1.90	0.05	2.00	1.70
2002	2.00	1.49	1.20	0.50	1.80	3.46	3.30	1.07	0.60	5.02	1.60	6.05
2003	0.40	1.24	4.30	1.17	2.20	1.60	3.10	2.13	1.60	1.48	4.80	2.00
2004	1.80	1.75	2.30	2.22	2.10	2.09	3.70	4.10	9.60	1.56	1.70	3.72
VARIANCE	1.93	1.53	2.29	1.80	1.45	1.10	5.34	3.62	6.19	5.02	4.01	2.25
MEAN	2.31	2.16	2.16	2.22	2.49	2.30	2.72	2.54	2.70	2.47	2.53	2.35
F RATIO	1.26		1.27		1.32		1.48		1.23		1.78	
tcr	<1.69		<1.69		<1.69		<1.69		<1.69		>1.69	
S2	1.73		2.05		1.28		4.48		5.61		3.13	
Sm	0.29		0.32		0.25		0.47		0.52		0.39	
t*	0.52		0.20		0.77		0.39		0.45		0.46	
tc	<1.68		<1.68		<1.68		<1.68		<1.68		<1.68	

	Jul		Aug		Sep		Oct		Nov		Dec	
	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660	166664	166660
1963	1.59	1.31	2.60	0.98	2.40	3.01	0.01	0.01	4.62	4.04	3.07	2.48
1964	1.48	1.19	2.26	1.97	1.55	2.75	2.23	2.24	1.27	1.62	2.35	2.52
1965	2.41	2.27	3.61	1.90	5.06	4.07	1.12	0.70	1.00	1.21	2.15	2.55
1966	3.84	4.30	3.59	4.29	2.63	1.86	1.22	2.41	0.23	0.41	1.64	1.58
1967	2.24	2.24	2.00	1.82	2.36	2.29	3.69	2.54	0.45	0.28	3.41	3.45
1968	1.15	1.18	0.98	2.40	0.85	1.06	0.14	0.97	1.25	1.17	2.57	2.55
1969	1.90	2.43	2.24	3.06	1.58	1.05	0.94	0.92	0.85	0.90	2.28	1.95
1970	1.37	1.88	1.97	2.51	2.69	1.54	1.99	1.99	0.70	0.55	1.57	3.01
1971	4.01	1.08	0.61	1.49	5.44	6.50	0.47	0.55	3.01	2.06	2.51	2.28
1972	1.82	0.94	1.48	1.38	2.20	1.48	2.50	3.23	2.87	2.99	3.47	2.74
1973	1.76	2.16	4.32	1.33	2.98	2.41	0.73	2.60	1.82	1.75	4.66	4.85
1974	1.97	1.75	1.80	1.85	3.61	3.46	0.63	1.89	2.06	2.01	2.25	1.86
1975	1.35	2.46	2.60	4.82	0.80	1.21	2.37	3.44	1.34	8.72	1.70	1.18
1976	2.50	1.01	2.50	1.60	2.50	0.95	0.20	2.67	1.90	2.00	3.10	2.72
1977	2.40	0.79	3.30	4.18	3.40	4.98	2.50	2.08	2.50	2.17	2.90	2.55
1978	2.80	3.40	2.80	4.83	0.80	1.30	0.20	0.46	4.30	4.00	3.20	2.58
1979	2.50	2.53	1.90	2.11	1.50	2.23	1.40	1.49	2.40	2.04	1.10	0.82
1980	1.40	1.85	1.70	0.74	2.20	2.77	0.10	1.84	2.30	2.38	2.30	2.38
1981	1.30	0.80	2.70	2.57	2.40	2.14	1.30	0.98	0.60	0.82	2.30	1.25
1983	1.60	2.92	2.50	1.72	5.10	2.46	2.10	1.43	1.40	1.86	4.40	5.71
1984	0.30	1.77	1.20	1.82	1.60	3.00	1.40	2.87	0.80	2.25	0.90	5.48
1985	2.30	1.01	3.70	3.33	2.20	1.80	5.00	1.05	0.80	1.71	1.60	1.07
1986	1.20	3.27	3.10	2.91	1.60	1.54	1.40	4.51	2.30	0.60	1.80	2.94
1987	1.80	1.37	2.90	2.36	1.50	0.44	0.60	1.14	1.70	2.86	1.80	2.36
1988	2.10	1.88	3.80	1.30	3.80	0.90	1.60	0.90	3.40	1.86	0.60	1.89
1989	2.70	2.13	1.90	2.16	1.50	1.95	0.70	1.46	7.60	0.63	2.80	2.39
1990	1.30	2.86	1.70	1.81	1.70	1.82	1.50	0.25	1.50	12.66	3.20	3.14
1991	3.40	0.59	1.90	1.51	1.00	2.50	0.70	1.50	1.40	1.85	2.70	6.81
1992	3.40	3.38	1.80	3.29	-	1.51	0.20	0.77	4.90	1.35	3.20	1.26
1993	1.50	2.17	1.90	4.96	2.20	4.08	2.80	2.39	2.10	3.95	0.90	2.32
1994	1.00	2.12	1.40	0.53	2.80	0.88	1.10	2.80	2.40	0.95	1.80	0.98
1995	2.20	1.64	4.60	2.51	0.40	3.18	1.60	0.62	1.60	0.96	2.70	1.89
1996	2.20	2.39	1.40	2.19	1.50	0.40	0.50	0.78	1.90	1.60	4.30	2.57
1997	2.20	4.42	1.30	1.44	1.50	1.58	0.70	1.08	3.20	1.67	1.60	2.76
1998	2.60	1.19	1.80	0.78	12.50	0.53	1.10	1.03	1.70	3.68	1.20	1.15
1999	4.10	1.65	3.90	2.20	2.00	6.41	2.00	1.25	0.40	1.61	2.40	0.69
2000	1.50	0.88	1.30	2.61	2.20	1.37	2.10	2.75	3.60	0.50	1.10	1.88
2001	2.20	0.58	2.20	1.46	1.90	3.04	4.20	0.92	1.70	4.01	1.50	0.96
2002	1.40	3.09	2.60	2.67	0.50	1.83	4.70	3.34	1.90	1.07	1.90	0.93
2003	4.50	1.99	3.00	1.64	3.00	9.55	3.60	2.93	4.00	1.67	4.00	1.82
2004	-	3.50	-	1.54	-	2.61	-	3.73	-	5.16	-	0.89
VARIANCE	0.93	0.95	1.01	1.22	4.19	3.25	1.64	1.14	2.20	5.18	1.11	1.81
MEAN	2.08	2.01	2.31	2.26	2.38	2.45	1.54	1.77	2.09	2.33	2.32	2.37
F RATIO	1.02		1.21		1.29		1.44		2.35		1.63	
tcr	<1.69		<1.69		<1.69		<1.69		>1.69		<1.69	
S2	0.94		1.12		3.72		1.39		3.69		1.46	
Sm	0.21		0.23		0.43		0.26		0.42		0.27	
t*	0.33		0.24		0.17		0.86		0.56		0.21	
tc	<1.68		<1.68		<1.68		<1.68		<1.68		<1.68	

Table 4.9 Computing F and T Test for Seasonal Patterns, Audubon Rain Gauge Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1947	9.46	--	6.47	--	5.46	6.73	3.59	5.62	0.47	2.82	11.48	7.26
1948	5.58	1.08	18.46	1.97	3.99	3.07	8.80	--	--	--	--	5.73
1949	--	--	12.96	9.73	0.84	5.49	9.86	5.97	8.05	--	0.20	5.37
1950	2.29	1.47	4.37	--	1.52	4.53	9.57	3.64	--	1.11	1.29	--
1951	2.30	2.18	7.40	6.70	1.57	5.44	3.69	6.15	--	0.57	3.54	2.92
1952	3.66	8.71	--	5.32	3.81	3.85	10.48	5.15	--	--	2.24	--
1953	2.36	5.50	4.95	--	--	10.78	10.50	8.14	1.25	0.43	--	8.69
1954	3.80	0.54	3.21	0.58	3.72	3.43	11.93	3.22	6.63	4.52	1.93	--
1955	9.22	3.46	-	6.12	5.09	4.59	--	9.69	9.50	1.59	3.67	2.93
1956	2.07	7.94	3.60	4.30	2.82	10.47	5.51	6.32	10.89	1.44	1.49	6.49
1957	1.53	2.60	7.47	10.80	2.68	6.64	3.65	5.54	10.34	1.90	4.49	3.06
1958	6.38	4.22	9.05	3.48	9.28	5.52	10.80	6.37	6.63	0.93	1.07	1.40
1959	3.51	11.58	3.79	3.84	9.72	7.40	20.30	3.66	3.56	8.18	1.09	1.85
1960	4.87	4.43	4.70	5.82	3.47	2.09	5.67	8.25	3.89	4.39	0.55	5.12
1961	7.63	10.13	8.78	3.97	7.88	10.48	9.06	4.81	7.04	0.75	6.61	6.74
1962	3.47	2.84	1.28	4.95	0.83	10.91	4.33	6.26	5.36	1.77	2.75	2.31
1963	4.59	5.50	1.03	1.16	0.62	8.45	5.93	5.11	6.45	--	10.15	5.73
1964	10.15	5.34	6.33	9.66	1.66	2.91	6.38	5.63	3.88	4.64	3.26	2.96
1965	7.43	4.97	3.89	0.97	3.77	3.68	5.41	7.75	8.68	1.24	1.75	6.94
1966	12.69	9.40	2.47	6.08	8.07	2.11	9.97	7.95	6.03	2.06	0.49	5.04
1967	3.36	7.74	1.76	2.75	3.01	6.59	7.94	8.94	5.31	5.55	0.54	8.93
1968	0.99	3.18	1.79	3.38	3.49	6.93	2.37	3.35	1.92	0.43	5.00	7.28
1969	3.28	4.48	6.96	3.97	5.05	2.70	8.36	8.18	3.18	0.55	1.60	6.36
1970	3.93	2.44	7.29	0.75	5.60	4.05	6.50	5.91	6.18	3.73	0.91	2.99
1971	2.03	4.58	3.92	0.74	2.59	3.39	10.29	4.82	16.91	0.82	3.45	6.26
1972	5.83	5.53	5.45	1.43	4.43	1.90	6.23	3.73	5.28	4.70	8.47	7.30
1973	2.36	4.98	10.17	11.30	4.14	7.36	6.11	7.25	11.94	2.91	4.14	8.92
1974	8.11	3.34	4.74	4.30	9.60	1.58	6.12	6.47	6.42	0.69	6.30	5.60
1975	3.47	4.81	4.66	4.97	9.10	14.44	6.89	8.08	2.65	2.76	3.77	2.98
1976	2.03	3.06	2.61	0.75	6.25	6.14	5.68	4.42	0.80	5.55	5.40	8.59
1977	5.30	2.59	6.07	4.04	1.90	0.39	5.78	17.82	9.64	4.53	9.42	3.93
1978	10.67	2.70	3.47	3.15	12.61	10.47	9.31	11.30	2.83	0.01	6.42	4.80
1979	5.73	12.44	4.56	--	5.64	2.22	7.50	6.94	5.15	0.87	4.03	2.52
1980	5.95	2.95	8.11	20.24	7.99	1.22	4.30	2.67	6.34	4.97	3.00	1.69
1981	1.20	7.98	1.97	3.67	3.10	16.98	4.99	9.63	3.47	1.55	0.79	7.54
1982	1.89	5.94	3.41	9.72	3.33	2.79	10.89	8.66	6.21	4.34	4.52	8.75
1983	2.83	7.92	4.25	14.76	5.17	9.41	5.82	7.58	8.88	3.23	5.56	10.68
1984	3.59	5.26	3.39	2.04	2.43	2.91	8.88	5.18	3.12	2.69	1.70	2.21
1985	4.84	6.28	7.14	0.64	1.44	2.94	12.47	4.56	6.07	--	1.54	3.79
1986	3.71	4.57	2.89	1.43	1.04	6.69	3.04	8.10	4.68	2.67	6.21	--
1987	7.57	5.36	5.67	1.23	3.11	10.05	--	5.54	2.74	0.58	2.95	--
1988	3.42	7.28	8.16	11.54	2.40	6.29	7.26	7.03	10.48	2.37	3.20	1.95
1989	2.04	0.07	6.78	2.87	2.32	4.40	9.07	2.80	2.07	0.99	12.90	3.95
1990	7.05	7.00	5.57	2.54	7.22	4.41	3.06	--	4.78	2.68	3.03	5.15
1991	19.80	3.08	6.60	17.13	14.20	17.90	16.00	6.30	2.59	1.21	2.91	4.60
1992	11.00	10.10	6.10	1.42	1.00	7.30	5.20	11.00	8.93	0.26	14.79	5.44
1993	6.44	2.16	6.19	4.62	6.08	4.61	--	3.17	3.64	4.40	2.77	2.48
1994	3.13	0.61	3.91	1.73	--	7.59	5.74	5.01	4.81	--	3.18	4.27
1995	3.92	5.24	9.89	5.94	15.79	3.13	7.01	4.79	0.90	2.10	3.58	4.29
1996	3.96	3.67	3.86	5.13	3.03	4.95	8.99	7.76	3.94	1.20	4.19	6.88
1997	5.00	4.67	3.76	--	5.20	4.08	7.18	3.32	2.45	1.63	6.80	2.04
1998	17.14	4.51	8.31	1.49	0.34	3.80	8.65	6.04	22.22	1.83	3.53	2.27
1999	3.82	0.41	4.47	0.04	--	11.90	4.92	4.73	5.73	3.93	0.41	2.81
2000	1.83	0.66	2.20	1.06	0.04	7.43	1.49	2.57	5.40	1.95	11.68	3.26
2001	2.78	1.30	9.19	0.25	2.28	17.87	6.58	6.84	--	4.84	2.68	3.38

2002	3.80	1.73	3.97	2.90	0.39	4.94	11.14	7.34	15.97	12.20	4.68	4.62
Average	5.21	4.68	5.44	4.69	4.49	6.26	7.49	6.35	6.12	2.66	4.15	4.88
Avg Mean	4.90					5.78						
Variance	14.12	8.46	9.91	19.50	12.36	16.57	11.44	6.88	17.68	5.06	11.12	5.40
Avg Var.	11.63					11.52						
Stand. Dev.	3.76	2.91	3.15	4.42	3.52	4.07	3.38	2.62	4.20	2.25	3.33	2.32
Avg Stand.	3.34					3.31						

Table 4.10 Computing F and T Test for Seasonal Patterns, New Orleans International Airport Rain Gauge Station

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1947	8.30	2.84	6.24	7.38	4.11	3.65	4.18	4.23	3.40	1.66	14.58	9.59
1948	5.72	1.96	19.09	1.49	1.74	1.28	4.48	5.79	13.53	1.07	13.72	5.31
1949	2.78	2.85	8.13	8.78	0.99	4.37	6.01	3.63	5.19	4.27	0.21	5.36
1950	3.93	4.08	5.63	7.30	2.76	5.97	7.20	4.34	0.98	1.18	0.91	6.12
1951	5.49	1.98	7.74	7.79	1.66	2.98	3.45	4.93	7.04	1.11	3.00	3.17
1952	2.70	8.06	5.06	4.82	5.79	1.12	6.23	2.00	2.81	-	3.00	6.86
1953	2.56	7.10	3.53	5.94	1.39	7.22	10.44	4.88	0.24	0.51	10.39	8.93
1954	3.96	1.34	2.22	2.29	4.45	3.16	11.46	5.40	6.66	5.46	2.04	6.02
1955	7.13	5.16	0.24	4.81	5.38	4.42	9.96	11.77	4.53	0.90	2.74	2.81
1956	2.37	7.27	3.66	4.16	2.37	6.68	6.65	4.99	8.02	1.90	1.78	6.49
1957	1.55	2.88	8.19	6.79	1.24	7.41	5.12	7.57	10.21	2.15	4.15	3.09
1958	6.78	3.96	6.98	2.00	6.70	2.81	9.12	3.19	6.57	0.89	1.10	1.46
1959	3.71	10.56	3.82	3.18	14.33	6.76	7.96	4.53	3.47	6.45	1.14	2.58
1960	3.34	4.77	3.68	5.69	3.30	1.68	4.26	6.51	4.11	4.90	0.60	4.17
1961	6.94	9.00	8.53	2.88	6.46	8.01	10.38	7.26	8.90	0.51	8.66	6.01
1962	4.19	1.02	1.60	2.66	1.31	8.87	4.70	2.41	2.52	3.29	1.96	4.47
1963	5.21	5.90	1.00	1.84	3.17	4.16	6.40	2.12	7.35	-	7.85	5.25
1964	9.60	5.35	5.45	5.66	1.69	5.52	5.90	3.88	4.93	3.50	3.51	3.10
1965	4.48	5.25	1.95	0.33	3.62	2.21	5.26	6.34	10.03	1.03	1.49	7.35
1966	12.62	10.11	1.90	4.92	9.31	2.10	9.42	2.84	5.55	3.15	0.72	5.44
1967	4.22	6.80	1.60	2.18	3.56	2.40	6.42	7.51	3.73	3.79	0.45	10.77
1968	0.54	3.02	3.49	3.59	4.13	3.69	4.96	4.78	2.44	1.40	4.97	6.14
1969	3.12	4.80	7.08	6.04	5.51	2.47	6.64	7.80	1.08	0.51	1.73	5.26
1970	2.53	2.28	7.22	0.43	4.68	4.97	3.70	10.21	4.25	4.94	0.85	4.28
1971	1.13	4.87	3.61	1.53	1.38	8.02	4.55	5.75	16.74	0.58	2.63	6.64
1972	6.98	6.03	6.07	1.64	6.31	3.10	3.90	4.92	3.29	4.64	8.45	8.65
1973	2.68	5.40	12.17	10.47	4.68	6.08	5.94	3.37	11.07	5.07	4.04	8.31
1974	8.46	5.53	6.64	5.52	9.84	3.83	5.66	6.70	7.58	2.26	5.88	4.89
1975	2.95	3.64	5.32	6.69	8.03	12.28	8.35	10.11	3.97	4.00	11.35	3.81
1976	2.61	3.85	3.08	0.28	5.58	3.36	5.67	1.69	1.57	5.08	5.80	8.81
1977	5.62	2.75	3.96	6.38	2.59	1.74	2.91	16.12	13.48	4.33	8.77	4.15
1978	13.63	2.53	2.67	3.44	9.72	7.82	10.34	14.68	2.98	-	4.67	4.42
1979	5.55	12.49	3.31	4.90	4.38	0.23	11.43	4.57	4.55	1.49	4.27	3.07
1980	6.37	3.09	10.08	16.12	9.65	3.69	4.84	1.68	6.31	5.87	3.85	1.54
1981	0.94	8.34	2.70	2.28	5.35	8.47	1.92	11.10	4.78	2.03	1.10	5.50
1982	2.76	7.88	2.56	5.86	1.19	5.43	13.07	1.92	5.40	3.84	5.45	10.26
1983	3.31	12.59	4.88	14.86	3.71	10.64	2.95	6.29	5.72	4.88	6.32	9.15
1984	4.10	5.27	4.90	1.72	3.54	7.21	3.86	9.51	3.79	2.84	2.80	2.53
1985	4.83	9.28	7.07	2.11	1.16	4.56	6.92	6.37	5.74	13.20	0.96	4.78
1986	3.49	2.93	1.88	1.50	1.61	8.87	3.60	6.74	1.42	2.87	7.90	5.05

1987	8.88	7.38	4.39	2.27	3.46	15.01	6.38	5.05	1.29	0.72	2.92	2.88
1988	3.74	11.31	8.90	9.25	1.68	11.28	6.78	7.53	5.86	2.87	1.26	3.94
1989	2.47	0.15	7.14	3.20	3.50	8.22	8.34	3.31	4.53	0.51	19.81	6.28
1990	7.59	11.45	5.98	4.59	5.87	1.01	2.30	2.45	4.55	2.38	3.21	9.67
1991	19.25	5.42	6.27	15.29	14.28	10.71	13.15	7.86	3.44	1.88	2.19	2.63
1992	9.94	8.73	6.69	2.52	0.95	9.52	5.75	9.64	6.63	0.55	15.27	5.68
1993	6.21	2.34	5.65	6.82	7.23	4.96	5.77	2.26	2.47	3.67	2.43	2.90
1994	3.25	0.54	4.82	2.83	3.67	9.35	8.95	4.59	5.61	2.30	1.39	4.61
1995	3.66	4.94	7.89	3.81	21.18	2.84	6.44	3.26	0.69	1.31	4.24	5.07
1996	4.66	1.56	2.97	3.87	1.37	8.60	10.32	8.76	3.96	2.59	3.10	5.55
1997	6.32	6.88	2.57	4.91	5.03	6.97	3.94	2.25	0.81	1.36	8.09	2.55
1998	19.28	4.28	5.97	4.39	0.43	3.38	6.56	8.30	18.98	1.82	3.40	2.25
1999	3.20	0.92	4.60	0.30	3.37	12.20	4.05	5.21	2.87	5.46	0.28	3.85
2000	2.25	1.81	2.41	1.13	0.07	5.46	1.38	2.35	6.50	1.10	11.72	2.70
2001	3.05	1.59	8.07	1.08	6.85	17.62	6.97	7.41	6.30	5.13	2.54	2.90
2002	3.29	2.76	3.58	2.14	3.04	4.83	4.54	4.09	14.23	10.09	5.10	4.82
Average	5.29	5.12	5.23	4.58	4.65	5.91	6.39	5.80	5.62	2.88	4.69	5.18
Avg Mean	5.01					5.22						
Variance	14.69	10.12	9.70	12.56	14.85	13.33	7.61	10.04	15.76	6.08	18.41	5.37
Avg Var.	11.22					11.87						
Stand. Dev.	3.83	3.18	3.12	3.54	3.85	3.65	2.76	3.17	3.97	2.46	4.29	2.32
Avg Stand.	3.31					3.38						

Appendix B

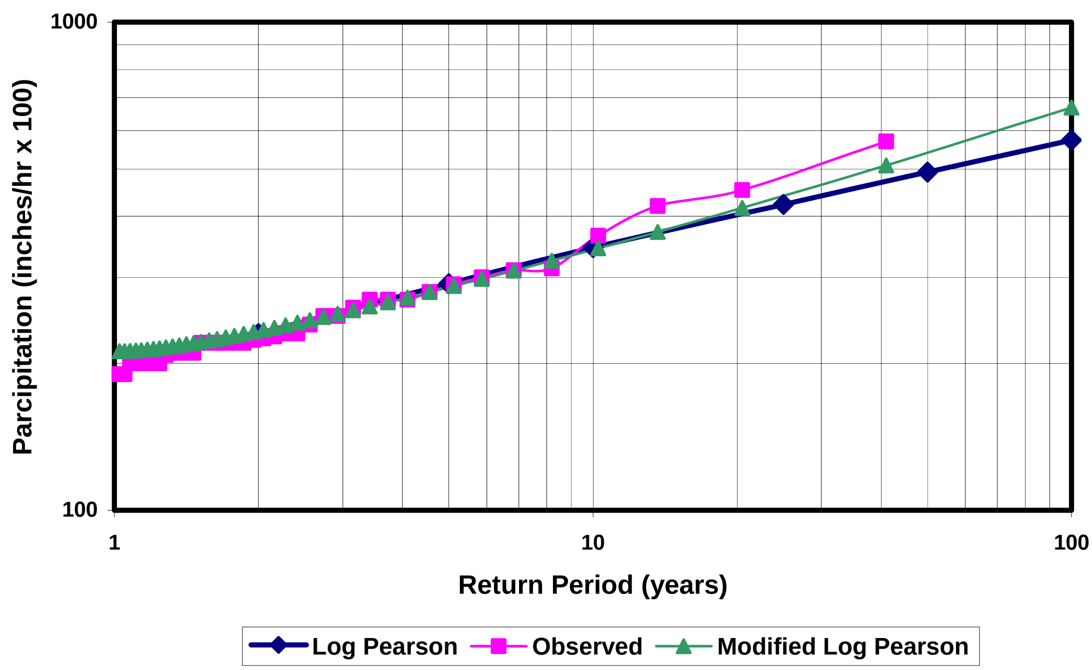


Figure 5.9A 1 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Partial Series)

Table 5.9B 1 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log Pearson Analysis III

Return Period	K(.1.5)	K(1.6)	Slop	K(1.55)	Rain
2	(0.240)	(0.254)	(0.014)	(0.2470)	2.30
5	0.690	0.675	(0.015)	0.6830	2.91
10	1.333	1.329	(0.004)	1.3350	3.45
25	2.146	2.163	0.017	2.1550	4.23
50	2.743	2.780	0.037	2.7600	4.93
100	3.330	3.388	0.058	3.3590	5.73

Table 5.9C 1 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	570	5.70	0.756	0.135	0.0494676	42.00	0.02	0.18
2	453	4.53	0.656	0.071	0.0191015	25.50	0.08	0.09
3	420	4.20	0.623	0.055	0.0128895	17.00	0.18	0.07
4	365	3.65	0.562	0.030	0.0052235	12.75	0.31	0.04
5	313	3.13	0.496	0.011	0.0012168	10.20	0.49	0.01
6	310	3.10	0.491	0.011	0.0010793	8.50	0.71	0.01
7	300	3.00	0.477	0.008	0.0006893	7.29	0.96	0.01
8	290	2.90	0.462	0.005	0.0003989	6.38	1.25	0.01
9	280	2.80	0.447	0.003	0.0001989	5.67	1.59	0.00
10	270	2.70	0.431	0.002	0.0000772	5.10	1.96	0.00
11	270	2.70	0.431	0.002	0.0000772	4.64	2.37	0.00
12	270	2.70	0.431	0.002	0.0000772	4.25	2.82	0.00
13	260	2.60	0.415	0.001	0.0000180	3.92	3.31	0.00
14	250	2.50	0.398	0.000	0.0000008	3.64	3.84	0.00
15	250	2.50	0.398	0.000	0.0000008	3.40	4.41	0.00
16	240	2.40	0.380	0.000	-0.0000006	3.19	5.02	0.00
17	230	2.30	0.362	0.001	-0.0000198	3.00	5.67	0.00
18	230	2.30	0.362	0.001	-0.0000198	2.83	6.35	0.00
19	227	2.27	0.356	0.001	-0.0000352	2.68	7.08	0.00
20	225	2.25	0.352	0.001	-0.0000490	2.55	7.84	0.00
21	223	2.23	0.348	0.002	-0.0000663	2.43	8.65	0.00
22	220	2.20	0.342	0.002	-0.0000996	2.32	9.49	0.00
23	220	2.20	0.342	0.002	-0.0000996	2.22	10.37	0.00
24	220	2.20	0.342	0.002	-0.0000996	2.13	11.29	0.00
25	220	2.20	0.342	0.002	-0.0000996	2.04	12.25	0.00
26	220	2.20	0.342	0.002	-0.0000996	1.96	13.25	0.00
27	220	2.20	0.342	0.002	-0.0000996	1.89	14.29	0.00
28	210	2.10	0.322	0.004	-0.0002949	1.82	15.37	0.00
29	210	2.10	0.322	0.004	-0.0002949	1.76	16.49	0.00
30	210	2.10	0.322	0.004	-0.0002949	1.70	17.65	0.00
31	210	2.10	0.322	0.004	-0.0002949	1.65	18.84	0.00
32	208	2.08	0.318	0.005	-0.0003537	1.59	20.08	0.00
33	200	2.00	0.301	0.008	-0.0006758	1.55	21.35	0.01
34	200	2.00	0.301	0.008	-0.0006758	1.50	22.67	0.01
35	200	2.00	0.301	0.008	-0.0006758	1.46	24.02	0.01
36	200	2.00	0.301	0.008	-0.0006758	1.42	25.41	0.01
37	200	2.00	0.301	0.008	-0.0006758	1.38	26.84	0.01
38	200	2.00	0.301	0.008	-0.0006758	1.34	28.31	0.01
39	190	1.90	0.279	0.012	-0.0013321	1.31	29.82	0.01
40	190	1.90	0.279	0.012	-0.0013321	1.28	31.37	0.01
41	190	1.90	0.279	0.012	-0.0013321	1.24	32.96	0.01
	Average	**2.533**	**0.389**					
			Sum	**0.460**	**0.080**			

variance	0.011
standard deviation	0.11
skew coefficient	1.55

Figure 5.10A 2 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Partial Series)

Table 5.10B 2 Hour Rainfall for rain guage station No:166664 at Audubon using Log-Person Analysis III

Return Period	K(.60)	K(.7)	Slope	K(.67)	Rain
2	(0.099)	(0.116)	(0.017)	(0.111)	3.23
5	0.800	0.790	(0.010)	0.793	4.00
10	1.328	1.333	0.005	1.332	4.54
25	1.939	1.967	0.028	1.959	5.26
50	2.359	2.407	0.048	2.393	5.82
100	2.755	2.824	0.069	2.803	6.41

Table 5.10C 2 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	580	5.80	0.763	0.059	0.0142783	42.00	0.02	0.07
2	570	5.70	0.756	0.055	0.0129857	21.00	0.05	0.07
3	470	4.70	0.672	0.023	0.0034615	14.00	0.07	0.03
4	470	4.70	0.672	0.023	0.0034615	10.50	0.10	0.03
5	470	4.70	0.672	0.023	0.0034615	8.40	0.12	0.03
6	460	4.60	0.663	0.020	0.0028591	7.00	0.14	0.02
7	456	4.56	0.659	0.019	0.0026359	6.00	0.17	0.02
8	440	4.40	0.643	0.015	0.0018439	5.25	0.19	0.02
9	380	3.80	0.580	0.003	0.0002049	4.67	0.21	0.00
10	380	3.80	0.580	0.003	0.0002049	4.20	0.24	0.00
11	370	3.70	0.568	0.002	0.0001063	3.82	0.26	0.00
12	365	3.65	0.562	0.002	0.0000713	3.50	0.29	0.00
13	350	3.50	0.544	0.001	0.0000126	3.23	0.31	0.00
14	350	3.50	0.544	0.001	0.0000126	3.00	0.33	0.00
15	340	3.40	0.531	0.000	0.0000012	2.80	0.36	0.00
16	340	3.40	0.531	0.000	0.0000012	2.63	0.38	0.00
17	340	3.40	0.531	0.000	0.0000012	2.47	0.40	0.00
18	340	3.40	0.531	0.000	0.0000012	2.33	0.43	0.00
19	340	3.40	0.531	0.000	0.0000012	2.21	0.45	0.00
20	330	3.30	0.519	0.000	0.0000000	2.10	0.48	0.00
21	320	3.20	0.505	0.000	-0.0000039	2.00	0.50	0.00
22	320	3.20	0.505	0.000	-0.0000039	1.91	0.52	0.00
23	320	3.20	0.505	0.000	-0.0000039	1.83	0.55	0.00
24	313	3.13	0.496	0.001	-0.0000162	1.75	0.57	0.00
25	310	3.10	0.491	0.001	-0.0000256	1.68	0.60	0.00
26	310	3.10	0.491	0.001	-0.0000256	1.62	0.62	0.00
27	300	3.00	0.477	0.002	-0.0000835	1.56	0.64	0.00
28	290	2.90	0.462	0.003	-0.0001995	1.50	0.67	0.00
29	290	2.90	0.462	0.003	-0.0001995	1.45	0.69	0.00
30	280	2.80	0.447	0.005	-0.0003998	1.40	0.71	0.01
31	270	2.70	0.431	0.008	-0.0007160	1.35	0.74	0.01
32	262	2.62	0.418	0.011	-0.0010777	1.31	0.76	0.01
33	260	2.60	0.415	0.011	-0.0011861	1.27	0.79	0.01
34	258	2.58	0.412	0.012	-0.0013024	1.24	0.81	0.01
35	257	2.57	0.410	0.012	-0.0013637	1.20	0.83	0.01
36	250	2.50	0.398	0.015	-0.0018558	1.17	0.86	0.01
37	250	2.50	0.398	0.015	-0.0018558	1.14	0.88	0.01
38	250	2.50	0.398	0.015	-0.0018558	1.11	0.90	0.01
39	250	2.50	0.398	0.015	-0.0018558	1.08	0.93	0.01
40	247	2.47	0.393	0.016	-0.0021036	1.05	0.95	0.01
41	243	2.43	0.386	0.018	-0.0024725	1.02	0.98	0.02
	Average	**3.412**	**0.521**					
			Sum	**0.416**	**0.027**			

variance	0.0104
standard deviation	0.1020
skew coefficient	0.6693

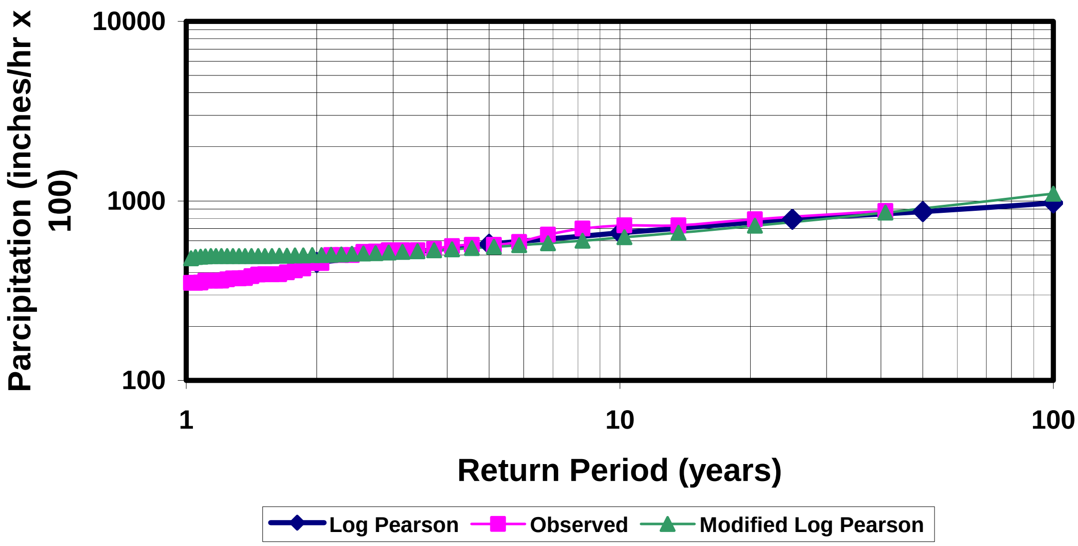


Figure 5.11A 6 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Partial Series)

Table 5.11B 6 Hour Rainfall for rain guage station No:166664 at Audubon using Log Pearson Analysis III

Return Period	K(.7)	K(.8)	Slop	K(.71)	Rain
2	(0.116)	(0.132)	(0.016)	(0.118)	4.54
5	7.900	0.780	(7.120)	0.789	5.74
10	1.383	1.336	(0.047)	1.333	6.61
25	1.967	1.993	0.026	1.970	7.89
50	2.407	2.453	0.046	2.412	8.73
100	2.824	2.891	0.067	2.831	9.73

Table 5.11C 6 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	880	8.80	0.944	0.076	0.0207770	42.00	0.02	0.10
2	790	7.90	0.898	0.052	0.0118612	21.00	0.05	0.06
3	730	7.30	0.863	0.038	0.0072735	14.00	0.07	0.04
4	730	7.30	0.863	0.038	0.0072735	10.50	0.10	0.04
5	700	7.00	0.845	0.031	0.0054080	8.40	0.12	0.04
6	650	6.50	0.813	0.021	0.0029453	7.00	0.14	0.02
7	590	5.90	0.771	0.010	0.0010389	6.00	0.17	0.01
8	570	5.70	0.756	0.007	0.0006428	5.25	0.19	0.01
9	570	5.70	0.756	0.007	0.0006428	4.67	0.21	0.01
10	560	5.60	0.748	0.006	0.0004859	4.20	0.24	0.01
11	540	5.40	0.732	0.004	0.0002479	3.82	0.26	0.00
12	530	5.30	0.724	0.003	0.0001637	3.50	0.29	0.00
13	530	5.30	0.724	0.003	0.0001637	3.23	0.31	0.00
14	530	5.30	0.724	0.003	0.0001637	3.00	0.33	0.00
15	523	5.23	0.719	0.002	0.0001172	2.80	0.36	0.00
16	520	5.20	0.716	0.002	0.0001001	2.63	0.38	0.00
17	500	5.00	0.699	0.001	0.0000254	2.47	0.40	0.00
18	500	5.00	0.699	0.001	0.0000254	2.33	0.43	0.00
19	500	5.00	0.699	0.001	0.0000254	2.21	0.45	0.00
20	450	4.50	0.653	0.000	-0.0000044	2.10	0.48	0.00
21	450	4.50	0.653	0.000	-0.0000044	2.00	0.50	0.00
22	420	4.20	0.623	0.002	-0.0000994	1.91	0.52	0.00
23	410	4.10	0.613	0.003	-0.0001831	1.83	0.55	0.00
24	400	4.00	0.602	0.005	-0.0003077	1.75	0.57	0.00
25	390	3.90	0.591	0.006	-0.0004838	1.68	0.60	0.01
26	390	3.90	0.591	0.006	-0.0004838	1.62	0.62	0.01
27	390	3.90	0.591	0.006	-0.0004838	1.56	0.64	0.01
28	389	3.89	0.590	0.006	-0.0005048	1.50	0.67	0.01
29	380	3.80	0.580	0.008	-0.0007238	1.45	0.69	0.01
30	372	3.72	0.571	0.010	-0.0009711	1.40	0.71	0.01
31	370	3.70	0.568	0.010	-0.0010416	1.35	0.74	0.01
32	370	3.70	0.568	0.010	-0.0010416	1.31	0.76	0.01
33	365	3.65	0.562	0.012	-0.0012346	1.27	0.79	0.01
34	360	3.60	0.556	0.013	-0.0014532	1.24	0.81	0.01
35	360	3.60	0.556	0.013	-0.0014532	1.20	0.83	0.01
36	360	3.60	0.556	0.013	-0.0014532	1.17	0.86	0.01
37	359	3.59	0.555	0.013	-0.0015002	1.14	0.88	0.01
38	351	3.51	0.545	0.015	-0.0019188	1.11	0.90	0.01
39	350	3.50	0.544	0.016	-0.0019768	1.08	0.93	0.01
40	350	3.50	0.544	0.016	-0.0019768	1.05	0.95	0.01
41	350	3.50	0.544	0.016	-0.0019768	1.02	0.98	0.01
	Average	**4.836**	**0.670**					
			Sum	**0.505**	**0.038**			

variance	0.0126
standard deviation	0.1124
skew coefficient	0.7061

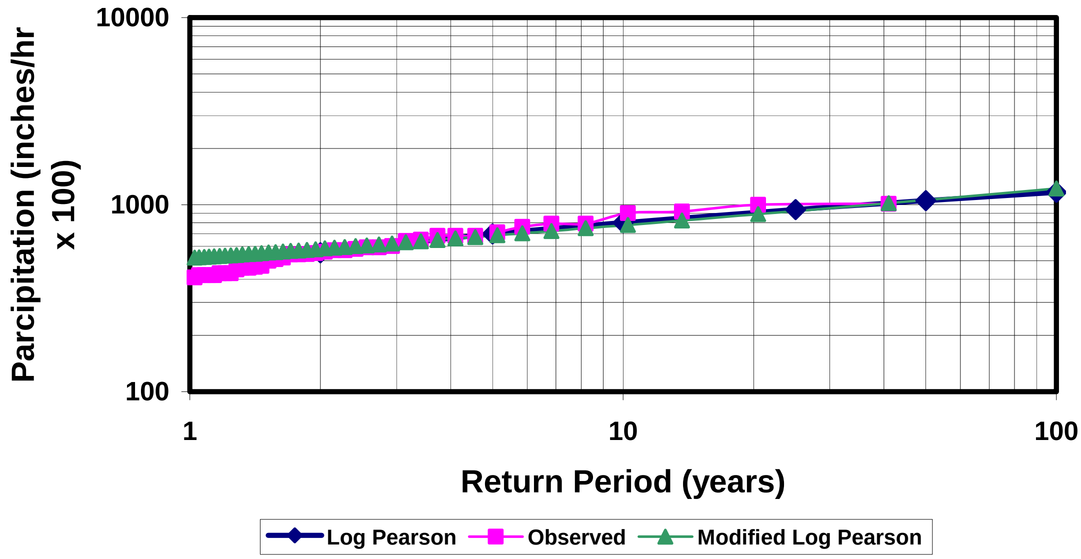


Figure 5.12A 12 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Partial Series)

Table 5.12B 12 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log Pearson Analysis III

Return Period	K(.6)	K(.7)	Slope	K(.64)	Rain
2	(0.099)	(0.116)	(0.0170)	(0.1058)	5.52
5	0.800	0.790	(0.0100)	0.7960	6.97
10	1.328	1.333	0.0050	1.3290	8.00
25	1.939	1.967	0.0280	1.9490	9.39
50	2.359	2.407	0.0480	2.3770	10.49
100	2.755	2.824	0.0690	2.7820	11.65

Table 5.12C 12 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1010	10.10	1.004	0.063	0.0157371	42.00	0.02	0.08
2	1000	10.00	1.000	0.061	0.0149369	21.00	0.05	0.08
3	920	9.20	0.964	0.044	0.0092693	14.00	0.07	0.05
4	900	9.00	0.954	0.040	0.0080622	10.50	0.10	0.05
5	790	7.90	0.898	0.021	0.0029799	8.40	0.12	0.02
6	790	7.90	0.898	0.021	0.0029799	7.00	0.14	0.02
7	760	7.60	0.881	0.016	0.0020527	6.00	0.17	0.02
8	710	7.10	0.851	0.010	0.0009278	5.25	0.19	0.01
9	680	6.80	0.833	0.006	0.0004890	4.67	0.21	0.01
10	680	6.80	0.833	0.006	0.0004890	4.20	0.24	0.01
11	680	6.80	0.833	0.006	0.0004890	3.82	0.26	0.01
12	650	6.50	0.813	0.004	0.0002074	3.50	0.29	0.00
13	640	6.40	0.806	0.003	0.0001443	3.23	0.31	0.00
14	600	6.00	0.778	0.001	0.0000146	3.00	0.33	0.00
15	590	5.90	0.771	0.000	0.0000050	2.80	0.36	0.00
16	590	5.90	0.771	0.000	0.0000050	2.63	0.38	0.00
17	580	5.80	0.763	0.000	0.0000009	2.47	0.40	0.00
18	570	5.70	0.756	0.000	0.0000000	2.33	0.43	0.00
19	570	5.70	0.756	0.000	0.0000000	2.21	0.45	0.00
20	560	5.60	0.748	0.000	-0.0000002	2.10	0.48	0.00
21	550	5.50	0.740	0.000	-0.0000024	2.00	0.50	0.00
22	544	5.44	0.736	0.000	-0.0000060	1.91	0.52	0.00
23	543	5.43	0.735	0.000	-0.0000068	1.83	0.55	0.00
24	541	5.41	0.733	0.000	-0.0000087	1.75	0.57	0.00
25	520	5.20	0.716	0.001	-0.0000537	1.68	0.60	0.00
26	510	5.10	0.708	0.002	-0.0000983	1.62	0.62	0.00
27	500	5.00	0.699	0.003	-0.0001642	1.56	0.64	0.00
28	470	4.70	0.672	0.007	-0.0005439	1.50	0.67	0.01
29	464	4.64	0.667	0.008	-0.0006632	1.45	0.69	0.01
30	460	4.60	0.663	0.008	-0.0007528	1.40	0.71	0.01
31	460	4.60	0.663	0.008	-0.0007528	1.35	0.74	0.01
32	450	4.50	0.653	0.010	-0.0010155	1.31	0.76	0.01
33	430	4.30	0.633	0.014	-0.0017391	1.27	0.79	0.01
34	430	4.30	0.633	0.014	-0.0017391	1.24	0.81	0.01
35	430	4.30	0.633	0.014	-0.0017391	1.20	0.83	0.01
36	420	4.20	0.623	0.017	-0.0022212	1.17	0.86	0.01
37	420	4.20	0.623	0.017	-0.0022212	1.14	0.88	0.01
38	420	4.20	0.623	0.017	-0.0022212	1.11	0.90	0.01
39	420	4.20	0.623	0.017	-0.0022212	1.08	0.93	0.01
40	408	4.08	0.611	0.020	-0.0029282	1.05	0.95	0.02
41	403	4.03	0.605	0.022	-0.0032695	1.02	0.98	0.02
	Average	**5.869**	**0.754**					
			Sum	**0.504**	**0.034**			

variance	0.0126
standard deviation	0.1122
skew coefficient	0.6400

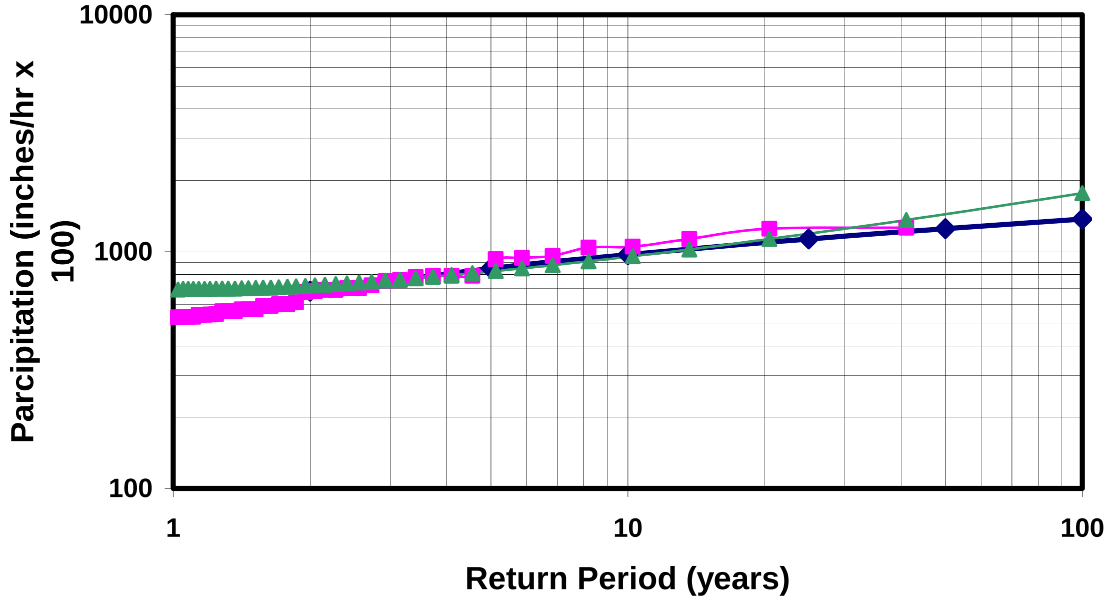


Figure 5.13A 24 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Partial Series)

Table 5.13B 24 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Analysis III

Return Period	K(.9)	K(1)	Slop	K(.91)	Rain
2	(0.148)	(0.164)	(0.016)	6.640	6.80
5	0.769	0.758	(0.011)	8.400	8.50
10	1.339	1.340	0.001	9.730	9.70
25	2.018	2.043	0.025	11.580	11.30
50	2.498	2.542	0.044	13.100	12.50
100	2.957	3.022	0.065	14.750	13.70

Table 5.13C 24 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1260	12.60	1.100	0.069	0.0179377	42.00	0.02	0.09
2	1250	12.50	1.097	0.067	0.0172357	21.00	0.05	0.08
3	1130	11.30	1.053	0.046	0.0098664	14.00	0.07	0.06
4	1050	10.50	1.021	0.033	0.0060874	10.50	0.10	0.04
5	1040	10.40	1.017	0.032	0.0056811	8.40	0.12	0.04
6	960	9.60	0.982	0.021	0.0029656	7.00	0.14	0.02
7	940	9.40	0.973	0.018	0.0024347	6.00	0.17	0.02
8	930	9.30	0.968	0.017	0.0021911	5.25	0.19	0.02
9	790	7.90	0.898	0.003	0.0002057	4.67	0.21	0.00
10	790	7.90	0.898	0.003	0.0002057	4.20	0.24	0.00
11	790	7.90	0.898	0.003	0.0002057	3.82	0.26	0.00
12	780	7.80	0.892	0.003	0.0001531	3.50	0.29	0.00
13	760	7.60	0.881	0.002	0.0000752	3.23	0.31	0.00
14	750	7.50	0.875	0.001	0.0000485	3.00	0.33	0.00
15	720	7.20	0.857	0.000	0.0000066	2.80	0.36	0.00
16	700	7.00	0.845	0.000	0.0000003	2.63	0.38	0.00
17	700	7.00	0.845	0.000	0.0000003	2.47	0.40	0.00
18	690	6.90	0.839	0.000	0.0000000	2.33	0.43	0.00
19	690	6.90	0.839	0.000	0.0000000	2.21	0.45	0.00
20	680	6.80	0.833	0.000	-0.0000002	2.10	0.48	0.00
21	675	6.75	0.829	0.000	-0.0000008	2.00	0.50	0.00
22	610	6.10	0.785	0.003	-0.0001512	1.91	0.52	0.00
23	600	6.00	0.778	0.004	-0.0002209	1.83	0.55	0.00
24	600	6.00	0.778	0.004	-0.0002209	1.75	0.57	0.00
25	590	5.90	0.771	0.005	-0.0003109	1.68	0.60	0.00
26	590	5.90	0.771	0.005	-0.0003109	1.62	0.62	0.00
27	570	5.70	0.756	0.007	-0.0005661	1.56	0.64	0.01
28	570	5.70	0.756	0.007	-0.0005661	1.50	0.67	0.01
29	570	5.70	0.756	0.007	-0.0005661	1.45	0.69	0.01
30	560	5.60	0.748	0.008	-0.0007390	1.40	0.71	0.01
31	560	5.60	0.748	0.008	-0.0007390	1.35	0.74	0.01
32	559	5.59	0.747	0.008	-0.0007582	1.31	0.76	0.01
33	544	5.44	0.736	0.011	-0.0010927	1.27	0.79	0.01
34	543	5.43	0.735	0.011	-0.0011184	1.24	0.81	0.01
35	541	5.41	0.733	0.011	-0.0011710	1.20	0.83	0.01
36	540	5.40	0.732	0.011	-0.0011979	1.17	0.86	0.01
37	530	5.30	0.724	0.013	-0.0014942	1.14	0.88	0.01
38	530	5.30	0.724	0.013	-0.0014942	1.11	0.90	0.01
39	530	5.30	0.724	0.013	-0.0014942	1.08	0.93	0.01
40	528	5.28	0.723	0.013	-0.0015595	1.05	0.95	0.01
41	520	5.20	0.716	0.015	-0.0018426	1.02	0.98	0.01
	Average	**7.137**	**0.839**					
			Sum	**0.495**	**0.048**			

variance	0.0124
standard deviation	0.1112
skew coefficient	0.9104

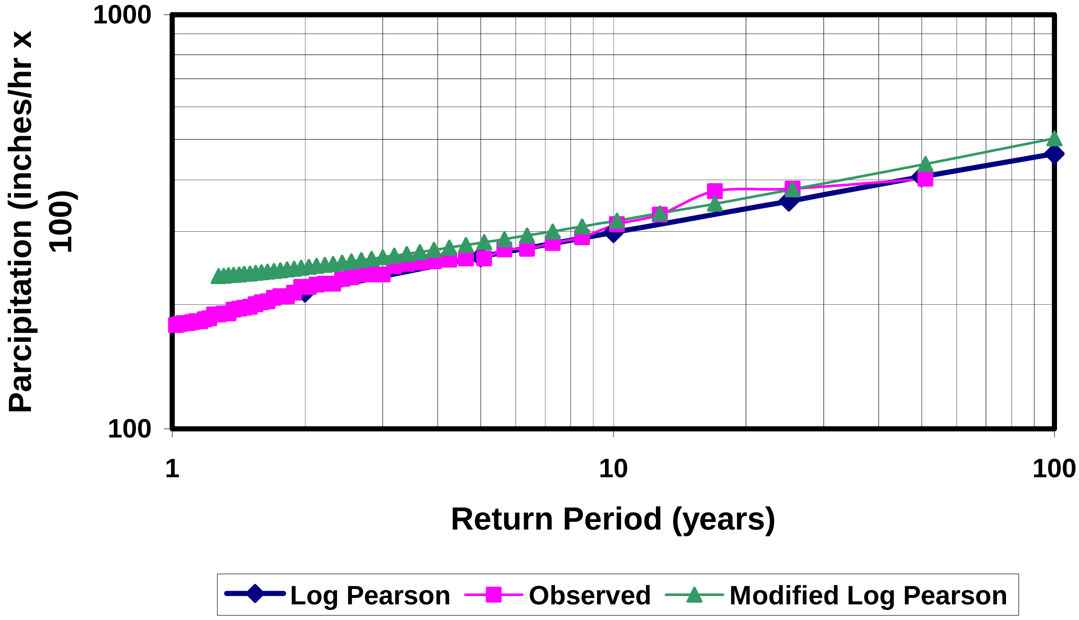


Figure 5.14A 1 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis (Partial Series)

Table 5.14B 1 Hour Rainfall for Rain Gauge Station No:166660 at New Orleans International Airport

Tr	K(1.7)	K(1.8)	Slop	K(1.07)	Rain
2	(0.268)	(0.282)	(0.014)	(0.269)	2.14
5	0.660	0.643	(0.017)	0.659	2.60
10	1.324	1.318	(0.006)	1.324	2.98
25	2.179	2.193	0.014	2.180	3.55
50	2.815	2.848	0.033	2.817	4.06
100	3.444	3.499	0.055	3.448	4.62

Table 5.14C 1 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	402	4.02	0.604	0.062	0.0154687	51.00	0.02	0.08
2	380	3.80	0.580	0.050	0.0113483	25.50	0.04	0.06
3	375	3.75	0.574	0.048	0.0104990	17.00	0.06	0.06
4	329	3.29	0.517	0.026	0.0042620	12.75	0.08	0.03
5	312	3.12	0.494	0.019	0.0026910	10.20	0.10	0.02
6	290	2.90	0.462	0.012	0.0012366	8.50	0.12	0.01
7	281	2.81	0.449	0.009	0.0008212	7.29	0.14	0.01
8	272	2.72	0.435	0.006	0.0005026	6.38	0.16	0.01
9	271	2.71	0.433	0.006	0.0004729	5.67	0.18	0.01
10	258	2.58	0.412	0.003	0.0001809	5.10	0.20	0.00
11	258	2.58	0.412	0.003	0.0001809	4.64	0.22	0.00
12	256	2.56	0.408	0.003	0.0001504	4.25	0.24	0.00
13	254	2.54	0.405	0.002	0.0001233	3.92	0.25	0.00
14	252	2.52	0.401	0.002	0.0000995	3.64	0.27	0.00
15	250	2.50	0.398	0.002	0.0000788	3.40	0.29	0.00
16	247	2.47	0.393	0.001	0.0000533	3.19	0.31	0.00
17	236	2.36	0.373	0.000	0.0000057	3.00	0.33	0.00
18	236	2.36	0.373	0.000	0.0000057	2.83	0.35	0.00
19	236	2.36	0.373	0.000	0.0000057	2.68	0.37	0.00
20	232	2.32	0.365	0.000	0.0000011	2.55	0.39	0.00
21	230	2.30	0.362	0.000	0.0000003	2.43	0.41	0.00
22	224	2.24	0.350	0.000	-0.0000001	2.32	0.43	0.00
23	224	2.24	0.350	0.000	-0.0000001	2.22	0.45	0.00
24	223	2.23	0.348	0.000	-0.0000003	2.13	0.47	0.00
25	220	2.20	0.342	0.000	-0.0000020	2.04	0.49	0.00
26	220	2.20	0.342	0.000	-0.0000020	1.96	0.51	0.00
27	213	2.13	0.328	0.001	-0.0000190	1.89	0.53	0.00
28	209	2.09	0.320	0.001	-0.0000426	1.82	0.55	0.00
29	209	2.09	0.320	0.001	-0.0000426	1.76	0.57	0.00
30	207	2.07	0.316	0.002	-0.0000597	1.70	0.59	0.00
31	203	2.03	0.307	0.002	-0.0001076	1.65	0.61	0.00
32	202	2.02	0.305	0.002	-0.0001228	1.59	0.63	0.00
33	200	2.00	0.301	0.003	-0.0001577	1.55	0.65	0.00
34	197	1.97	0.294	0.004	-0.0002225	1.50	0.67	0.00
35	196	1.96	0.292	0.004	-0.0002477	1.46	0.69	0.00
36	195	1.95	0.290	0.004	-0.0002750	1.42	0.71	0.00
37	194	1.94	0.288	0.005	-0.0003043	1.38	0.73	0.00
38	190	1.90	0.279	0.006	-0.0004443	1.34	0.75	0.01
39	190	1.90	0.279	0.006	-0.0004443	1.31	0.76	0.01
40	189	1.89	0.276	0.006	-0.0004856	1.28	0.78	0.01
41	189	1.89	0.276	0.006	-0.0004856	1.24	0.80	0.01
42	185	1.85	0.267	0.008	-0.0006789	1.21	0.82	0.01
43	184	1.84	0.265	0.008	-0.0007350	1.19	0.84	0.01
44	182	1.82	0.260	0.009	-0.0008571	1.16	0.86	0.01
45	182	1.82	0.260	0.009	-0.0008571	1.13	0.88	0.01
46	181	1.81	0.258	0.009	-0.0009236	1.11	0.90	0.01
47	180	1.80	0.255	0.010	-0.0009937	1.09	0.92	0.01
48	180	1.80	0.255	0.010	-0.0009937	1.06	0.94	0.01
49	179	1.79	0.253	0.010	-0.0010678	1.04	0.96	0.01
50	178	1.78	0.250	0.011	-0.0011458	1.02	0.98	0.01
	Average	**2.316**	**0.355**					
			Sum	**0.395**	**0.036**			

variance	0.0081
standard deviation	0.0898
skew coefficient	1.0716

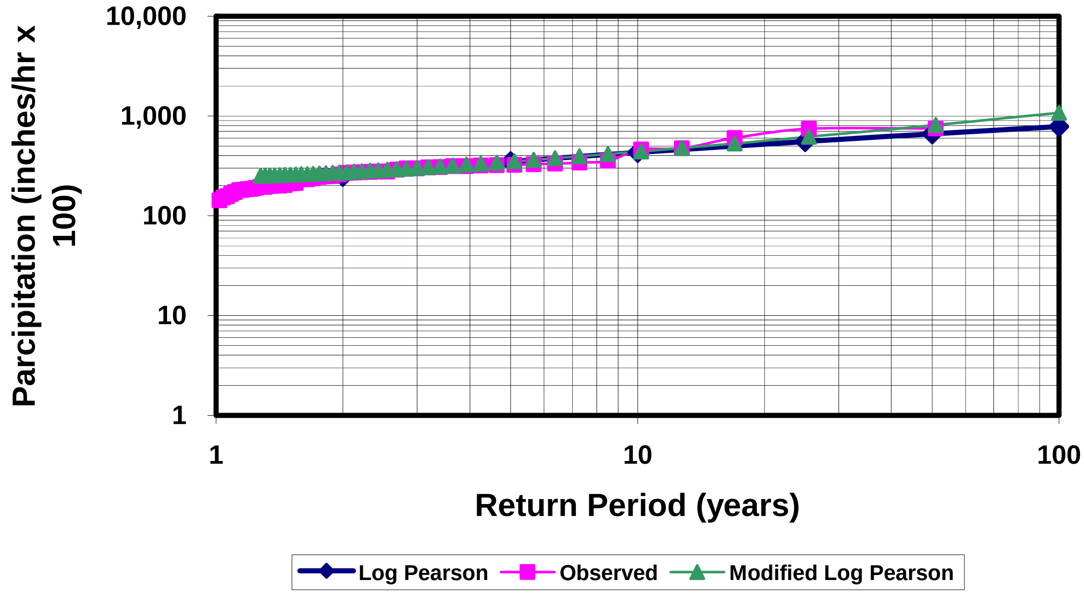


Figure 5.15A 2 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis (Partial Series)

Table 5.15B 2 Hour Rainfall for Rain Gauge Station No:166660 at New Orleans International Airport

Tr	K(.9)	K(.6)	Slop	K. (.97)	Rain
2	(0.148)	(1.640)	(1.492)	(0.149)	2.48
5	0.769	0.758	(0.011)	0.768	3.48
10	1.339	1.340	0.001	1.339	4.30
25	2.018	2.043	0.025	2.020	5.53
50	2.498	2.542	0.044	2.501	6.60
100	2.957	3.022	0.065	2.962	7.83

Table 5.15C 2 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	750	7.50	0.875	0.208	0.0948752	51.00	0.02	0.30
2	745	7.45	0.872	0.205	0.0930739	25.50	0.04	0.30
3	603	6.03	0.780	0.131	0.0471815	17.00	0.06	0.18
4	475	4.75	0.677	0.066	0.0171182	12.75	0.08	0.08
5	460	4.60	0.663	0.059	0.0144888	10.20	0.10	0.07
6	356	3.56	0.551	0.018	0.0023251	8.50	0.12	0.02
7	341	3.41	0.533	0.013	0.0014731	7.29	0.14	0.01
8	332	3.32	0.521	0.010	0.0010664	6.38	0.16	0.01
9	328	3.28	0.516	0.009	0.0009099	5.67	0.18	0.01
10	323	3.23	0.509	0.008	0.0007346	5.10	0.20	0.01
11	320	3.20	0.505	0.007	0.0006400	4.64	0.22	0.01
12	319	3.19	0.504	0.007	0.0006102	4.25	0.24	0.01
13	315	3.15	0.498	0.006	0.0004994	3.92	0.25	0.01
14	315	3.15	0.498	0.006	0.0004994	3.64	0.27	0.01
15	307	3.07	0.487	0.005	0.0003168	3.40	0.29	0.00
16	304	3.04	0.483	0.004	0.0002610	3.19	0.31	0.00
17	299	2.99	0.476	0.003	0.0001823	3.00	0.33	0.00
18	297	2.97	0.473	0.003	0.0001556	2.83	0.35	0.00
19	289	2.89	0.461	0.002	0.0000737	2.68	0.37	0.00
20	277	2.77	0.442	0.001	0.0000130	2.55	0.39	0.00
21	276	2.76	0.441	0.000	0.0000106	2.43	0.41	0.00
22	274	2.74	0.438	0.000	0.0000066	2.32	0.43	0.00
23	273	2.73	0.436	0.000	0.0000051	2.22	0.45	0.00
24	271	2.71	0.433	0.000	0.0000027	2.13	0.47	0.00
25	269	2.69	0.430	0.000	0.0000013	2.04	0.49	0.00
26	259	2.59	0.413	0.000	-0.0000002	1.96	0.51	0.00
27	249	2.49	0.396	0.001	-0.0000118	1.89	0.53	0.00
28	247	2.47	0.393	0.001	-0.0000181	1.82	0.55	0.00
29	245	2.45	0.389	0.001	-0.0000265	1.76	0.57	0.00
30	237	2.37	0.375	0.002	-0.0000865	1.70	0.59	0.00
31	232	2.32	0.365	0.003	-0.0001530	1.65	0.61	0.00
32	232	2.32	0.365	0.003	-0.0001530	1.59	0.63	0.00
33	212	2.12	0.326	0.009	-0.0007949	1.55	0.65	0.01
34	210	2.10	0.322	0.009	-0.0009057	1.50	0.67	0.01
35	203	2.03	0.307	0.012	-0.0013853	1.46	0.69	0.01
36	200	2.00	0.301	0.014	-0.0016406	1.42	0.71	0.01
37	200	2.00	0.301	0.014	-0.0016406	1.38	0.73	0.01
38	198	1.98	0.297	0.015	-0.0018295	1.34	0.75	0.01
39	194	1.94	0.288	0.017	-0.0022568	1.31	0.76	0.01
40	194	1.94	0.288	0.017	-0.0022568	1.28	0.78	0.01
41	190	1.90	0.279	0.020	-0.0027568	1.24	0.80	0.02
42	186	1.86	0.270	0.022	-0.0033385	1.21	0.82	0.02
43	185	1.85	0.267	0.023	-0.0034979	1.19	0.84	0.02
44	182	1.82	0.260	0.025	-0.0040121	1.16	0.86	0.02
45	181	1.81	0.258	0.026	-0.0041961	1.13	0.88	0.02
46	173	1.73	0.238	0.033	-0.0059224	1.11	0.90	0.03
47	165	1.65	0.217	0.041	-0.0081798	1.09	0.92	0.03

48	157	1.57	0.196	0.050	-0.0111002	1.06	0.94	0.04
49	152	1.52	0.182	0.056	-0.0133335	1.04	0.96	0.04
50	142	1.42	0.152	0.071	-0.0189663	1.02	0.98	0.05
	Average	**2.829**	**0.419**					
			Sum	**1.258**	**0.188**			

variance	0.0257
standard deviation	0.1602
skew coefficient	0.9716

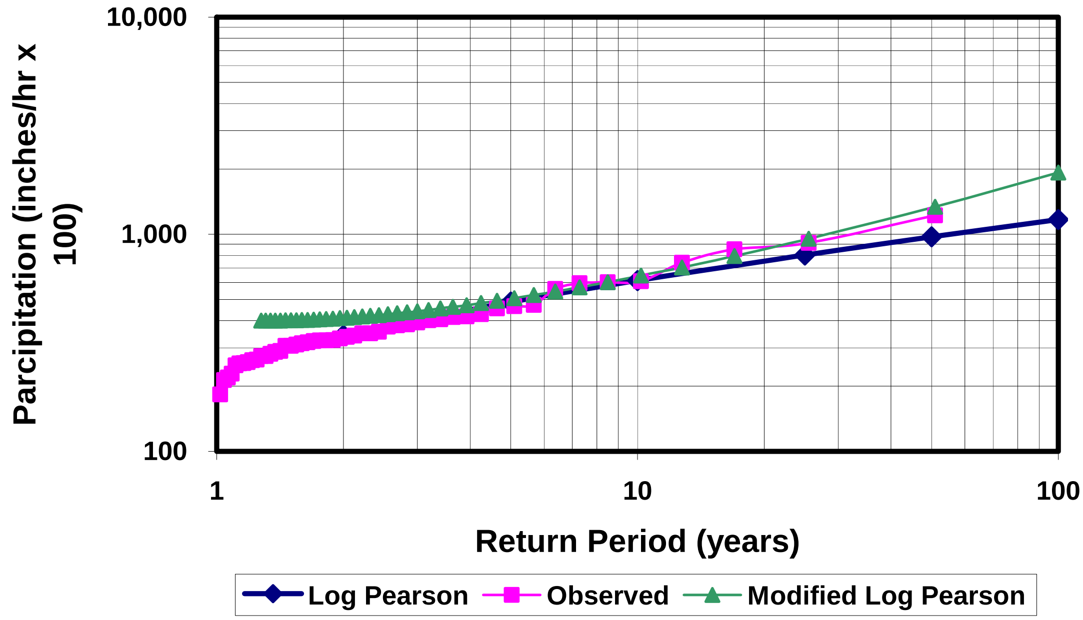


Figure 5.16A 6 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis (Partial Series)

Table 5.16B 6 hour Rainfall for Rain Gauge Station No:166660 at New Orleans International Airport

Return Period	K(.1)	K(.7)	Slope	K. (1.097)	Rain
2	(0.164)	(0.180)	(0.016)	(0.166)	3.42
5	0.758	0.745	(0.013)	0.757	4.88
10	1.340	1.341	0.001	1.340	6.11
25	2.043	2.066	0.023	2.045	8.01
50	2.542	2.585	0.043	2.546	9.72
100	3.022	3.087	0.065	3.028	11.70

Table 5.16C 6 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[\text{LogI-Avg(LogI)}]^2$	$[\text{LogI-Avg(LogI)}]^3$	Tr	1/Tr	Sum of Logs
1	1222	12.22	1.087	0.276	0.1451602	51.00	0.02	0.42
2	913	9.13	0.960	0.159	0.0634982	25.50	0.08	0.22
3	852	8.52	0.930	0.136	0.0502110	17.00	0.18	0.19
4	740	7.40	0.869	0.095	0.0291364	12.75	0.31	0.12
5	607	6.07	0.783	0.049	0.0108923	10.20	0.49	0.06
6	602	6.02	0.780	0.048	0.0103713	8.50	0.71	0.06
7	596	5.96	0.775	0.046	0.0097629	7.29	0.96	0.06
8	560	5.60	0.748	0.035	0.0065045	6.38	1.25	0.04
9	473	4.73	0.675	0.013	0.0014560	5.67	1.59	0.01
10	467	4.67	0.669	0.012	0.0012527	5.10	1.96	0.01
11	455	4.55	0.658	0.009	0.0008984	4.64	2.37	0.01
12	429	4.29	0.632	0.005	0.0003570	4.25	2.82	0.01
13	419	4.19	0.622	0.004	0.0002236	3.92	3.31	0.00
14	415	4.15	0.618	0.003	0.0001806	3.64	3.84	0.00
15	406	4.06	0.609	0.002	0.0001039	3.40	4.41	0.00
16	402	4.02	0.604	0.002	0.0000779	3.19	5.02	0.00
17	392	3.92	0.593	0.001	0.0000321	3.00	5.67	0.00
18	384	3.84	0.584	0.001	0.0000119	2.83	6.35	0.00
19	380	3.80	0.580	0.000	0.0000061	2.68	7.08	0.00
20	375	3.75	0.574	0.000	0.0000020	2.55	7.84	0.00
21	356	3.56	0.551	0.000	-0.0000010	2.43	8.65	0.00
22	350	3.50	0.544	0.000	-0.0000053	2.32	9.49	0.00
23	350	3.50	0.544	0.000	-0.0000053	2.22	10.37	0.00
24	341	3.41	0.533	0.001	-0.0000238	2.13	11.29	0.00
25	337	3.37	0.528	0.001	-0.0000389	2.04	12.25	0.00
26	331	3.31	0.520	0.002	-0.0000725	1.96	13.25	0.00
27	325	3.25	0.512	0.002	-0.0001223	1.89	14.29	0.00
28	324	3.24	0.511	0.003	-0.0001324	1.82	15.37	0.00
29	324	3.24	0.511	0.003	-0.0001324	1.76	16.49	0.00
30	322	3.22	0.508	0.003	-0.0001545	1.70	17.65	0.00
31	318	3.18	0.502	0.003	-0.0002063	1.65	18.84	0.00
32	315	3.15	0.498	0.004	-0.0002525	1.59	20.08	0.00
33	310	3.10	0.491	0.005	-0.0003453	1.55	21.35	0.00
34	306	3.06	0.486	0.006	-0.0004355	1.50	22.67	0.01
35	306	3.06	0.486	0.006	-0.0004355	1.46	24.02	0.01
36	290	2.90	0.462	0.010	-0.0009739	1.42	25.41	0.01
37	287	2.87	0.458	0.011	-0.0011131	1.38	26.84	0.01
38	281	2.81	0.449	0.013	-0.0014357	1.34	28.31	0.01
39	275	2.75	0.439	0.015	-0.0018242	1.31	29.82	0.01
40	275	2.75	0.439	0.015	-0.0018242	1.28	31.37	0.01
41	265	2.65	0.423	0.019	-0.0026437	1.24	32.96	0.02
42	263	2.63	0.420	0.020	-0.0028370	1.21	34.59	0.02
43	258	2.58	0.412	0.022	-0.0033682	1.19	36.25	0.02

44	255	2.55	0.407	0.024	-0.0037224	1.16	37.96	0.02
45	254	2.54	0.405	0.025	-0.0038467	1.13	39.71	0.02
46	249	2.49	0.396	0.027	-0.0045183	1.11	41.49	0.02
47	228	2.28	0.358	0.041	-0.0084379	1.09	43.31	0.03
48	219	2.19	0.340	0.049	-0.0108048	1.06	45.18	0.04
49	213	2.13	0.328	0.054	-0.0126721	1.04	47.08	0.04
50	183	1.83	0.262	0.089	-0.0267491	1.02	49.02	0.06
	Average	**3.960**	**0.562**					
			Sum	**1.369**	**0.241**			

variance	0.0279
standard deviation	0.1671
skew coefficient	1.0974

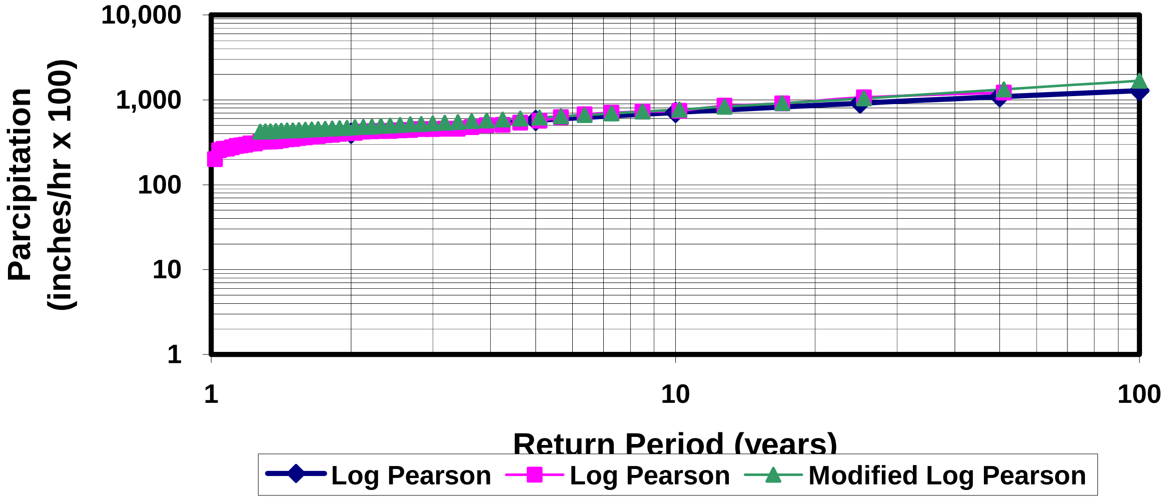


Figure 5.17A 12 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis (Partial Series)

Table 5.17B 12 Hour Rainfall for Rain Gauge Station No:166660 at New Orleans International Airport

Return Period	K(.8)	K(.9)	Slop	K(.818)	Rain
2	(0.132)	(0.148)	(0.016)	(0.135)	4.03
5	0.780	0.746	(0.034)	0.778	5.72
10	1.336	1.339	0.003	1.337	7.08
25	1.993	2.018	0.025	1.998	9.12
50	2.453	2.498	0.045	2.461	10.90
100	2.891	2.957	0.066	2.903	12.89

Table 5.17C 12 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at New Orleans International Airport Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1224	12.24	1.088	0.211	0.0970281	51.00	0.02	0.31
2	1066	10.66	1.028	0.160	0.0637556	25.50	0.04	0.22
3	903	9.03	0.956	0.107	0.0351010	17.00	0.06	0.14
4	852	8.52	0.930	0.091	0.0275909	12.75	0.08	0.12
5	740	7.40	0.869	0.058	0.0139914	10.20	0.10	0.07
6	731	7.31	0.864	0.056	0.0130859	8.50	0.12	0.07
7	703	7.03	0.847	0.048	0.0104587	7.29	0.14	0.06
8	676	6.76	0.830	0.041	0.0082033	6.38	0.16	0.05
9	625	6.25	0.796	0.028	0.0047089	5.67	0.18	0.03
10	567	5.67	0.754	0.016	0.0019680	5.10	0.20	0.02
11	538	5.38	0.731	0.011	0.0010774	4.64	0.22	0.01
12	506	5.06	0.704	0.006	0.0004370	4.25	0.24	0.01
13	502	5.02	0.701	0.005	0.0003801	3.92	0.25	0.01
14	476	4.76	0.678	0.002	0.0001201	3.64	0.27	0.00
15	458	4.58	0.661	0.001	0.0000346	3.40	0.29	0.00
16	457	4.57	0.660	0.001	0.0000317	3.19	0.31	0.00
17	454	4.54	0.657	0.001	0.0000239	3.00	0.33	0.00
18	451	4.51	0.654	0.001	0.0000174	2.83	0.35	0.00
19	441	4.41	0.644	0.000	0.0000042	2.68	0.37	0.00
20	435	4.35	0.638	0.000	0.0000011	2.55	0.39	0.00
21	431	4.31	0.634	0.000	0.0000002	2.43	0.41	0.00
22	429	4.29	0.632	0.000	0.0000001	2.32	0.43	0.00
23	426	4.26	0.629	0.000	0.0000000	2.22	0.45	0.00
24	421	4.21	0.624	0.000	-0.0000001	2.13	0.47	0.00
25	407	4.07	0.610	0.000	-0.0000065	2.04	0.49	0.00
26	403	4.03	0.605	0.001	-0.0000121	1.96	0.51	0.00
27	397	3.97	0.599	0.001	-0.0000256	1.89	0.53	0.00
28	385	3.85	0.585	0.002	-0.0000784	1.82	0.55	0.00
29	382	3.82	0.582	0.002	-0.0000986	1.76	0.57	0.00
30	375	3.75	0.574	0.003	-0.0001595	1.70	0.59	0.00
31	367	3.67	0.565	0.004	-0.0002573	1.65	0.61	0.00
32	361	3.61	0.558	0.005	-0.0003543	1.59	0.63	0.00
33	353	3.53	0.548	0.006	-0.0005215	1.55	0.65	0.01
34	346	3.46	0.539	0.008	-0.0007095	1.50	0.67	0.01
35	342	3.42	0.534	0.009	-0.0008370	1.46	0.69	0.01
36	333	3.33	0.522	0.011	-0.0011850	1.42	0.71	0.01
37	325	3.25	0.512	0.014	-0.0015764	1.38	0.73	0.01
38	323	3.23	0.509	0.014	-0.0016879	1.34	0.75	0.01
39	322	3.22	0.508	0.014	-0.0017458	1.31	0.76	0.01
40	318	3.18	0.502	0.016	-0.0019928	1.28	0.78	0.01
41	306	3.06	0.486	0.020	-0.0028964	1.24	0.80	0.02
42	306	3.06	0.486	0.020	-0.0028964	1.21	0.82	0.02
43	295	2.95	0.470	0.025	-0.0039777	1.19	0.84	0.02
44	291	2.91	0.464	0.027	-0.0044412	1.16	0.86	0.02
45	284	2.84	0.453	0.031	-0.0053547	1.13	0.88	0.03
46	276	2.76	0.441	0.035	-0.0065768	1.11	0.90	0.03
47	267	2.67	0.427	0.041	-0.0082125	1.09	0.92	0.03
48	263	2.63	0.420	0.043	-0.0090394	1.06	0.94	0.03
49	255	2.55	0.407	0.049	-0.0109007	1.04	0.96	0.04

50	199	1.99	0.299	0.109	-0.0357458	1.02	0.98	0.07
	Average	**4.599**	**0.628**					
			Sum	**1.354**	**0.177**			

variance	0.0276	0.0276
standard deviation	0.1662	0.1662
skew coefficient	0.8183	0.8183

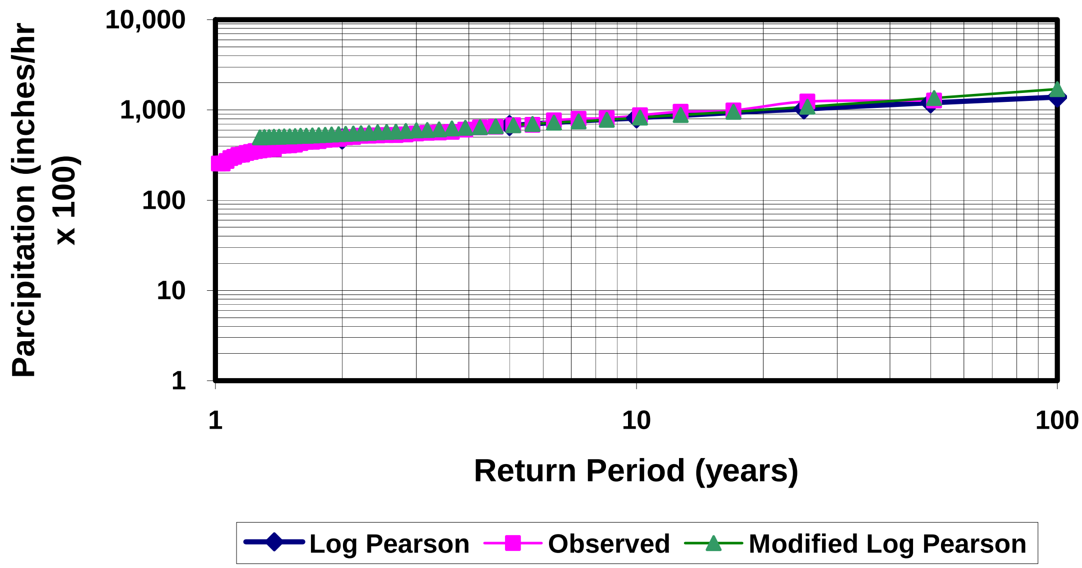


Figure 5.18A 24 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166660 at New Orleans International Airport Using Log-Pearson Type III Analysis (Partial Series)

Table 5.18B 24 Hour rainfall for Rain Gauge Station No:166660 at New Orleans International Airport

Tr	K(.5)	K(.6)	Slop	K(.512)	Rain
2	(0.083)	(0.099)	(0.016)	(0.085)	4.76
5	0.808	0.800	(0.008)	0.807	6.71
10	1.323	1.328	0.005	1.327	8.20
25	1.910	1.939	0.029	1.913	10.27
50	2.311	2.359	0.048	2.320	12.00
100	2.686	2.755	0.069	2.690	13.84

Table 5.18C 24 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166660 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1266	12.66	1.102	0.168	0.0689038	51.00	0.02	0.24
2	1240	12.40	1.093	0.161	0.0644590	25.50	0.04	0.23
3	986	9.86	0.994	0.091	0.0273823	17.00	0.06	0.12
4	955	9.55	0.980	0.083	0.0237725	12.75	0.08	0.11
5	872	8.72	0.941	0.062	0.0152620	10.20	0.10	0.08
6	808	8.08	0.907	0.046	0.0099306	8.50	0.12	0.06
7	795	7.95	0.900	0.043	0.0089859	7.29	0.14	0.05
8	763	7.63	0.883	0.036	0.0068652	6.38	0.16	0.04
9	681	6.81	0.833	0.020	0.0027841	5.67	0.18	0.02
10	679	6.79	0.832	0.019	0.0027090	5.10	0.20	0.02
11	650	6.50	0.813	0.015	0.0017473	4.64	0.22	0.02
12	641	6.41	0.807	0.013	0.0014968	4.25	0.24	0.01
13	605	6.05	0.782	0.008	0.0007118	3.92	0.25	0.01
14	571	5.71	0.757	0.004	0.0002642	3.64	0.27	0.00
15	560	5.60	0.748	0.003	0.0001730	3.40	0.29	0.00
16	558	5.58	0.747	0.003	0.0001589	3.19	0.31	0.00
17	546	5.46	0.737	0.002	0.0000895	3.00	0.33	0.00
18	533	5.33	0.727	0.001	0.0000402	2.83	0.35	0.00
19	528	5.28	0.723	0.001	0.0000275	2.68	0.37	0.00
20	525	5.25	0.720	0.001	0.0000212	2.55	0.39	0.00
21	520	5.20	0.716	0.001	0.0000130	2.43	0.41	0.00
22	518	5.18	0.714	0.000	0.0000104	2.32	0.43	0.00
23	516	5.16	0.713	0.000	0.0000082	2.22	0.45	0.00
24	502	5.02	0.701	0.000	0.0000006	2.13	0.47	0.00
25	496	4.96	0.695	0.000	0.0000000	2.04	0.49	0.00
26	477	4.77	0.679	0.000	-0.0000027	1.96	0.51	0.00
27	470	4.70	0.672	0.000	-0.0000085	1.89	0.53	0.00
28	464	4.64	0.667	0.001	-0.0000175	1.82	0.55	0.00
29	451	4.51	0.654	0.001	-0.0000561	1.76	0.57	0.00
30	442	4.42	0.645	0.002	-0.0001041	1.70	0.59	0.00
31	442	4.42	0.645	0.002	-0.0001041	1.65	0.61	0.00
32	430	4.30	0.633	0.003	-0.0002054	1.59	0.63	0.00
33	412	4.12	0.615	0.006	-0.0004668	1.55	0.65	0.01
34	404	4.04	0.606	0.007	-0.0006380	1.50	0.67	0.01
35	401	4.01	0.603	0.008	-0.0007127	1.46	0.69	0.01
36	398	3.98	0.600	0.009	-0.0007936	1.42	0.71	0.01
37	368	3.68	0.566	0.016	-0.0020300	1.38	0.73	0.01
38	367	3.67	0.565	0.016	-0.0020874	1.34	0.75	0.01
39	362	3.62	0.559	0.018	-0.0023932	1.31	0.76	0.02
40	356	3.56	0.551	0.020	-0.0028043	1.28	0.78	0.02
41	350	3.50	0.544	0.022	-0.0032681	1.24	0.80	0.02
42	342	3.42	0.534	0.025	-0.0039775	1.21	0.82	0.02
43	333	3.33	0.522	0.029	-0.0049150	1.19	0.84	0.02
44	320	3.20	0.505	0.035	-0.0065726	1.16	0.86	0.03
45	317	3.17	0.501	0.037	-0.0070127	1.13	0.88	0.03
46	301	3.01	0.479	0.046	-0.0097868	1.11	0.90	0.04
47	292	2.92	0.465	0.052	-0.0117102	1.09	0.92	0.04
48	272	2.72	0.435	0.067	-0.0171533	1.06	0.94	0.05

49	255	2.55	0.407	0.082	-0.0233759	1.04	0.96	0.06
50	255	2.55	0.407	0.082	-0.0233759	1.02	0.98	0.06
	Average	**5.319**	**0.692**					
			Sum	**1.367**	**0.112**			
	variance	0.0279		0.0279				
	standard deviation	0.1670		0.1670				
	skew coefficient	0.5123		0.5123				

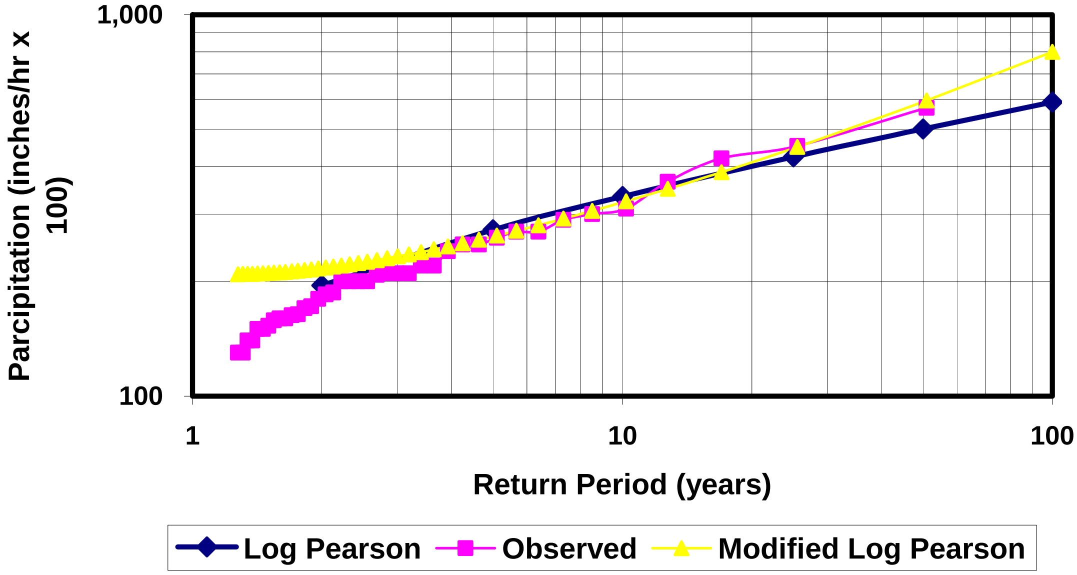


Figure 5.19A 1 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Annual Series)

Table 5.19B 1 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

Return Period	K(.9)	K(.1)	Slope	K(.9032)	Rain
2	(0.148)	(0.164)	(0.016)	(0.149)	1.95
5	0.769	0.758	(0.011)	0.769	2.73
10	1.339	1.340	0.001	1.339	3.34
25	2.018	2.043	0.025	2.019	4.24
50	2.498	2.542	0.044	2.499	5.02
100	2.957	3.022	0.065	2.959	5.90

Table 5.19C 1 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[\text{LogI-Avg(LogI)}]^2$	$[\text{LogI-Avg(LogI)}]^3$	Tr	1/Tr	Sum of Logs
1	570	5.70	0.756	0.191	0.0832804	42.00	0.02	0.27
2	453	4.53	0.656	0.114	0.0382458	21.00	0.05	0.15
3	420	4.20	0.623	0.092	0.0281145	14.00	0.07	0.12
4	365	3.65	0.562	0.059	0.0143694	10.50	0.10	0.07
5	310	3.10	0.491	0.030	0.0051048	8.40	0.12	0.03
6	300	3.00	0.477	0.025	0.0039401	7.00	0.14	0.03
7	290	2.90	0.462	0.021	0.0029378	6.00	0.17	0.02
8	270	2.70	0.431	0.013	0.0014120	5.25	0.19	0.01
9	270	2.70	0.431	0.013	0.0014120	4.67	0.21	0.01
10	260	2.60	0.415	0.009	0.0008791	4.20	0.24	0.01
11	250	2.50	0.398	0.006	0.0004886	3.82	0.26	0.01
12	250	2.50	0.398	0.006	0.0004886	3.50	0.29	0.01
13	240	2.40	0.380	0.004	0.0002274	3.23	0.31	0.00
14	220	2.20	0.342	0.001	0.0000126	3.00	0.33	0.00
15	220	2.20	0.342	0.001	0.0000126	2.80	0.36	0.00
16	210	2.10	0.322	0.000	0.0000000	2.63	0.38	0.00
17	210	2.10	0.322	0.000	0.0000000	2.47	0.40	0.00
18	210	2.10	0.322	0.000	0.0000000	2.33	0.43	0.00
19	208	2.08	0.318	0.000	0.0000000	2.21	0.45	0.00
20	200	2.00	0.301	0.000	-0.0000060	2.10	0.48	0.00
21	200	2.00	0.301	0.000	-0.0000060	2.00	0.50	0.00
22	200	2.00	0.301	0.000	-0.0000060	1.91	0.52	0.00
23	200	2.00	0.301	0.000	-0.0000060	1.83	0.55	0.00
24	187	1.87	0.272	0.002	-0.0001061	1.75	0.57	0.00
25	185	1.85	0.267	0.003	-0.0001407	1.68	0.60	0.00
26	180	1.80	0.255	0.004	-0.0002610	1.62	0.62	0.00
27	172	1.72	0.236	0.007	-0.0005853	1.56	0.64	0.01
28	170	1.70	0.230	0.008	-0.0006985	1.50	0.67	0.01
29	164	1.64	0.215	0.011	-0.0011357	1.45	0.69	0.01
30	163	1.63	0.212	0.011	-0.0012247	1.40	0.71	0.01
31	160	1.60	0.204	0.013	-0.0015231	1.35	0.74	0.01
32	160	1.60	0.204	0.013	-0.0015231	1.31	0.76	0.01
33	158	1.58	0.199	0.015	-0.0017506	1.27	0.79	0.01
34	153	1.53	0.185	0.018	-0.0024324	1.24	0.81	0.02
35	150	1.50	0.176	0.020	-0.0029295	1.20	0.83	0.02
36	150	1.50	0.176	0.020	-0.0029295	1.17	0.86	0.02
37	140	1.40	0.146	0.030	-0.0051821	1.14	0.88	0.02

38	140	1.40	0.146	0.030		-0.0051821		1.11	0.90	0.02
39	130	1.30	0.114	0.042		-0.0086446		1.08	0.93	0.03
40	130	1.30	0.114	0.042		-0.0086446		1.05	0.95	0.03
41	120	1.20	0.079	0.058		-0.0138233		1.02	0.98	0.04
	Average	**2.229**	**0.319**							
			Sum		**0.932**		**0.122**			
	variance	0.0233								
	standard deviation	0.1526								
	skew coefficient	0.9032								

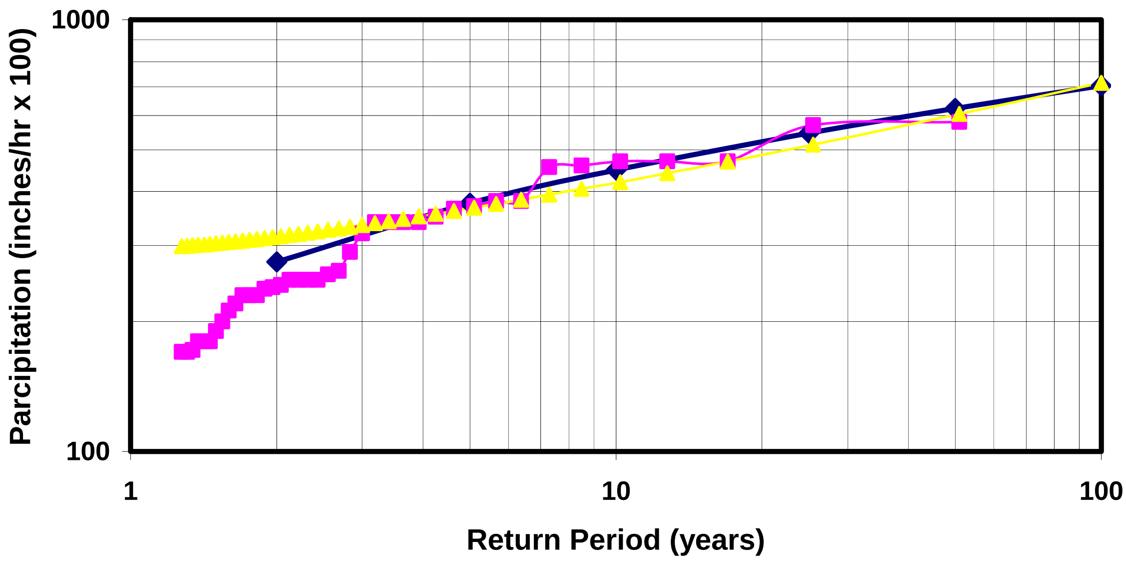


Figure 5.20A 2 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Annual Series)

Table 5.20B 2 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

Return Period	K(.3)	K(.4)	Slope	K(.329)	Rain
2	(0.050)	(0.066)	(0.016)	(0.055)	2.75
5	0.824	0.816	(0.008)	0.821	3.76
10	1.309	1.317	0.008	1.312	4.49
25	1.849	1.880	0.031	1.859	5.46
50	2.211	2.261	0.050	2.227	6.23
100	2.544	2.615	0.071	0.257	7.03

Table 5.20C 2 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	580	5.80	0.763	0.100	0.0314362	42.00	0.02	0.13
2	570	5.70	0.756	0.095	0.0292328	21.00	0.05	0.12
3	470	4.70	0.672	0.050	0.0112808	14.00	0.07	0.06
4	470	4.70	0.672	0.050	0.0112808	10.50	0.10	0.06
5	470	4.70	0.672	0.050	0.0112808	8.40	0.12	0.06
6	460	4.60	0.663	0.046	0.0099293	7.00	0.14	0.06
7	456	4.56	0.659	0.045	0.0094128	6.00	0.17	0.05
8	380	3.80	0.580	0.017	0.0022979	5.25	0.19	0.02
9	380	3.80	0.580	0.017	0.0022979	4.67	0.21	0.02
10	370	3.70	0.568	0.014	0.0017444	4.20	0.24	0.02
11	365	3.65	0.562	0.013	0.0014999	3.82	0.26	0.01
12	350	3.50	0.544	0.009	0.0008915	3.50	0.29	0.01
13	340	3.40	0.531	0.007	0.0005854	3.23	0.31	0.01
14	340	3.40	0.531	0.007	0.0005854	3.00	0.33	0.01
15	340	3.40	0.531	0.007	0.0005854	2.80	0.36	0.01
16	340	3.40	0.531	0.007	0.0005854	2.63	0.38	0.01
17	320	3.20	0.505	0.003	0.0001884	2.47	0.40	0.00
18	290	2.90	0.462	0.000	0.0000031	2.33	0.43	0.00
19	262	2.62	0.418	0.001	-0.0000257	2.21	0.45	0.00
20	257	2.57	0.410	0.001	-0.0000544	2.10	0.48	0.00
21	250	2.50	0.398	0.002	-0.0001241	2.00	0.50	0.00
22	250	2.50	0.398	0.002	-0.0001241	1.91	0.52	0.00
23	250	2.50	0.398	0.002	-0.0001241	1.83	0.55	0.00
24	250	2.50	0.398	0.002	-0.0001241	1.75	0.57	0.00
25	243	2.43	0.386	0.004	-0.0002408	1.68	0.60	0.00
26	240	2.40	0.380	0.005	-0.0003091	1.62	0.62	0.00
27	238	2.38	0.377	0.005	-0.0003616	1.56	0.64	0.00
28	230	2.30	0.362	0.007	-0.0006382	1.50	0.67	0.01
29	230	2.30	0.362	0.007	-0.0006382	1.45	0.69	0.01
30	230	2.30	0.362	0.007	-0.0006382	1.40	0.71	0.01
31	220	2.20	0.342	0.011	-0.0011709	1.35	0.74	0.01
32	212	2.12	0.326	0.015	-0.0017931	1.31	0.76	0.01
33	200	2.00	0.301	0.022	-0.0031631	1.27	0.79	0.02
34	190	1.90	0.279	0.029	-0.0048328	1.24	0.81	0.02
35	180	1.80	0.255	0.037	-0.0071390	1.20	0.83	0.03
36	180	1.80	0.255	0.037	-0.0071390	1.17	0.86	0.03
37	180	1.80	0.255	0.037	-0.0071390	1.14	0.88	0.03

38	172	1.72	0.236	0.045	-0.0095679	1.11	0.90	0.04
39	170	1.70	0.230	0.047	-0.0102713	1.08	0.93	0.04
40	170	1.70	0.230	0.047	-0.0102713	1.05	0.95	0.04
41	165	1.65	0.217	0.053	-0.0122209	1.02	0.98	0.04
	Average	**2.990**	**0.448**					
			Sum	**0.967**	**0.047**			

variance	0.0242
standard deviation	0.1555
skew coefficient	0.3286

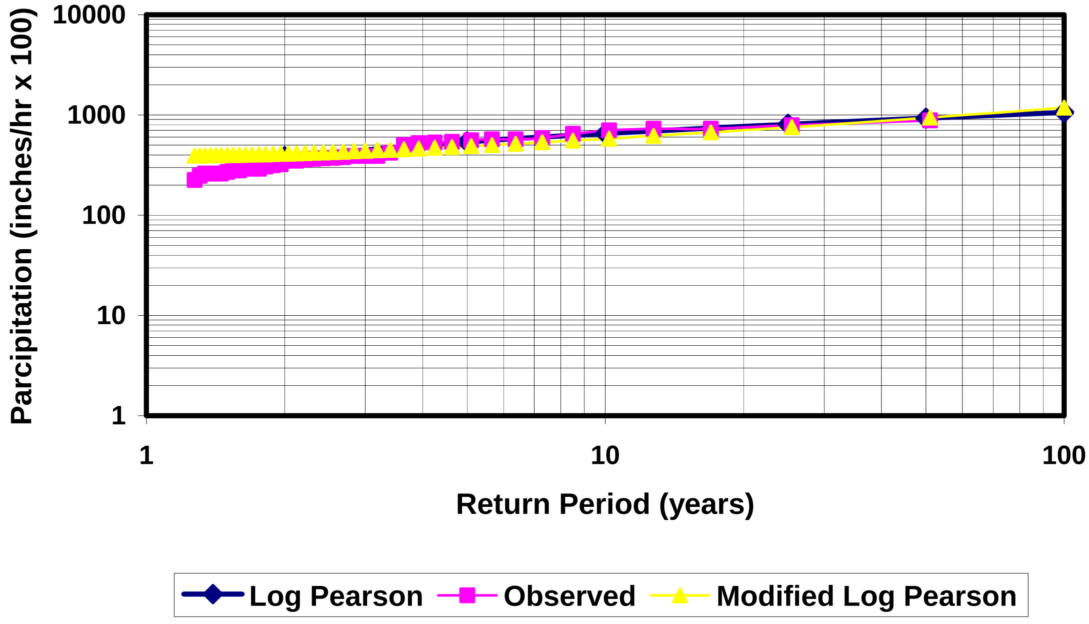


Figure 5.21A 6 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Annual Series)

Table 5.21B 6 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

Return Period	K(.3)	K(.4)	Slope	K(.3334)	Rain
2	(0.050)	(0.066)	(0.0160)	(0.0553)	3.83
5	0.824	0.816	(0.0080)	0.8213	5.40
10	1.309	1.317	0.0080	1.3120	6.53
25	1.849	1.880	0.0310	1.8590	8.08
50	2.211	2.261	0.0500	2.2280	9.32
100	2.544	2.615	0.0710	2.5680	10.64

Table 5.21C 6 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	[LogI-Avg(LogI)]^2	[LogI-Avg(LogI)]^3	Tr	1/Tr	Sum of Logs
1	880	8.80	0.944	0.124	0.0434013	42.00	0.02	0.17
2	790	7.90	0.898	0.093	0.0282530	21.00	0.05	0.12
3	730	7.30	0.863	0.073	0.0197414	14.00	0.07	0.09
4	730	7.30	0.863	0.073	0.0197414	10.50	0.10	0.09
5	700	7.00	0.845	0.064	0.0160110	8.40	0.12	0.08
6	650	6.50	0.813	0.048	0.0106273	7.00	0.14	0.06
7	590	5.90	0.771	0.032	0.0056204	6.00	0.17	0.04
8	570	5.70	0.756	0.027	0.0043163	5.25	0.19	0.03
9	570	5.70	0.756	0.027	0.0043163	4.67	0.21	0.03
10	560	5.60	0.748	0.024	0.0037334	4.20	0.24	0.03
11	540	5.40	0.732	0.019	0.0027052	3.82	0.26	0.02
12	530	5.30	0.724	0.017	0.0022594	3.50	0.29	0.02
13	523	5.23	0.719	0.016	0.0019741	3.23	0.31	0.02
14	500	5.00	0.699	0.011	0.0011881	3.00	0.33	0.01
15	420	4.20	0.623	0.001	0.0000275	2.80	0.36	0.00
16	390	3.90	0.591	0.000	0.0000000	2.63	0.38	0.00
17	390	3.90	0.591	0.000	0.0000000	2.47	0.40	0.00
18	389	3.89	0.590	0.000	0.0000000	2.33	0.43	0.00
19	380	3.80	0.580	0.000	-0.0000023	2.21	0.45	0.00
20	372	3.72	0.571	0.001	-0.0000114	2.10	0.48	0.00
21	370	3.70	0.568	0.001	-0.0000154	2.00	0.50	0.00
22	365	3.65	0.562	0.001	-0.0000291	1.91	0.52	0.00
23	359	3.59	0.555	0.001	-0.0000547	1.83	0.55	0.00
24	350	3.50	0.544	0.002	-0.0001176	1.75	0.57	0.00
25	350	3.50	0.544	0.002	-0.0001176	1.68	0.60	0.00
26	322	3.22	0.508	0.007	-0.0006185	1.62	0.62	0.01
27	314	3.14	0.497	0.009	-0.0008882	1.56	0.64	0.01
28	305	3.05	0.484	0.012	-0.0012864	1.50	0.67	0.01
29	290	2.90	0.462	0.017	-0.0022305	1.45	0.69	0.01
30	290	2.90	0.462	0.017	-0.0022305	1.40	0.71	0.01
31	290	2.90	0.462	0.017	-0.0022305	1.35	0.74	0.01
32	280	2.80	0.447	0.021	-0.0031056	1.31	0.76	0.02
33	280	2.80	0.447	0.021	-0.0031056	1.27	0.79	0.02
34	270	2.70	0.431	0.026	-0.0042274	1.24	0.81	0.02
35	260	2.60	0.415	0.032	-0.0056476	1.20	0.83	0.03
36	260	2.60	0.415	0.032	-0.0056476	1.17	0.86	0.03

37	260	2.60	0.415	0.032	-0.0056476	1.14	0.88	0.03
38	260	2.60	0.415	0.032	-0.0056476	1.11	0.90	0.03
39	248	2.48	0.394	0.039	-0.0078337	1.08	0.93	0.03
40	224	2.24	0.350	0.059	-0.0143150	1.05	0.95	0.04
41	181	1.81	0.258	0.112	-0.0377227	1.02	0.98	0.07
	Average	**4.227**	**0.593**					
			Sum	**1.142**	**0.061**			

variance	0.0285
standard deviation	0.1690
skew coefficient	0.3334

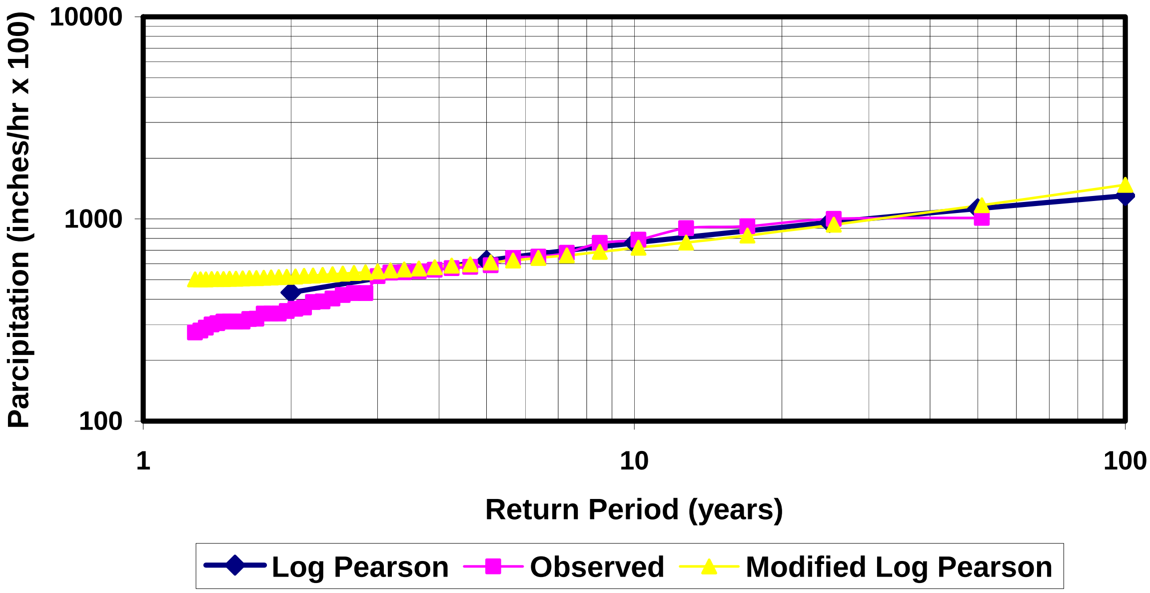


Figure 5.22A 12 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Annual Series)

Table 5.22B 12 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

Return Period	K(.4)	K(.5)	Slope	K(.4533)	Rain
2	(0.066)	(0.083)	(0.0170)	(0.0750)	4.33
5	0.816	0.808	(0.0080)	0.8117	6.20
10	1.317	1.323	0.0060	1.3200	7.61
25	1.880	1.910	0.0300	1.8960	9.60
50	2.261	2.311	0.0500	2.2880	11.25
100	2.615	2.686	0.0710	2.6530	13.03

Table 5.22C 12 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[\text{LogI-Avg(LogI)}]^2$	$[\text{LogI-Avg(LogI)}]^3$	Tr	1/Tr	Sum of Logs
1	1010	10.10	1.004	0.126	0.0445162	42.00	0.02	0.17
2	1000	10.00	1.000	0.123	0.0429076	21.00	0.05	0.17
3	920	9.20	0.964	0.099	0.0309226	14.00	0.07	0.13
4	900	9.00	0.954	0.093	0.0281864	10.50	0.10	0.12
5	790	7.90	0.898	0.061	0.0152006	8.40	0.12	0.08
6	760	7.60	0.881	0.053	0.0123107	7.00	0.14	0.07
7	680	6.80	0.833	0.033	0.0060881	6.00	0.17	0.04
8	650	6.50	0.813	0.027	0.0043309	5.25	0.19	0.03
9	640	6.40	0.806	0.024	0.0038161	4.67	0.21	0.03
10	590	5.90	0.771	0.015	0.0017690	4.20	0.24	0.02
11	580	5.80	0.763	0.013	0.0014628	3.82	0.26	0.01
12	570	5.70	0.756	0.011	0.0011898	3.50	0.29	0.01
13	560	5.60	0.748	0.010	0.0009492	3.23	0.31	0.01
14	550	5.50	0.740	0.008	0.0007400	3.00	0.33	0.01
15	544	5.44	0.736	0.007	0.0006291	2.80	0.36	0.01
16	543	5.43	0.735	0.007	0.0006117	2.63	0.38	0.01
17	520	5.20	0.716	0.004	0.0002887	2.47	0.40	0.00
18	430	4.30	0.633	0.000	-0.0000044	2.33	0.43	0.00
19	430	4.30	0.633	0.000	-0.0000044	2.21	0.45	0.00
20	420	4.20	0.623	0.001	-0.0000190	2.10	0.48	0.00
21	403	4.03	0.605	0.002	-0.0000888	2.00	0.50	0.00
22	390	3.90	0.591	0.003	-0.0002038	1.91	0.52	0.00
23	388	3.88	0.589	0.004	-0.0002279	1.83	0.55	0.00
24	365	3.65	0.562	0.008	-0.0006726	1.75	0.57	0.01
25	359	3.59	0.555	0.009	-0.0008524	1.68	0.60	0.01
26	350	3.50	0.544	0.011	-0.0011857	1.62	0.62	0.01
27	340	3.40	0.531	0.014	-0.0016612	1.56	0.64	0.01
28	340	3.40	0.531	0.014	-0.0016612	1.50	0.67	0.01
29	340	3.40	0.531	0.014	-0.0016612	1.45	0.69	0.01
30	321	3.21	0.507	0.021	-0.0029492	1.40	0.71	0.02
31	320	3.20	0.505	0.021	-0.0030336	1.35	0.74	0.02
32	310	3.10	0.491	0.025	-0.0039856	1.31	0.76	0.02
33	310	3.10	0.491	0.025	-0.0039856	1.27	0.79	0.02
34	310	3.10	0.491	0.025	-0.0039856	1.24	0.81	0.02
35	310	3.10	0.491	0.025	-0.0039856	1.20	0.83	0.02
36	305	3.05	0.484	0.027	-0.0045423	1.17	0.86	0.02
37	300	3.00	0.477	0.030	-0.0051589	1.14	0.88	0.02

38	290	2.90	0.462	0.035	-0.0065932	1.11	0.90	0.03
39	280	2.80	0.447	0.041	-0.0083350	1.08	0.93	0.03
40	274	2.74	0.438	0.045	-0.0095498	1.05	0.95	0.04
41	205	2.05	0.312	0.114	-0.0386685	1.02	0.98	0.08
	Average	**4.853**	**0.650**					
			Sum	**1.229**	**0.093**			

variance	0.0307
standard deviation	0.1753
skew coefficient	0.4533

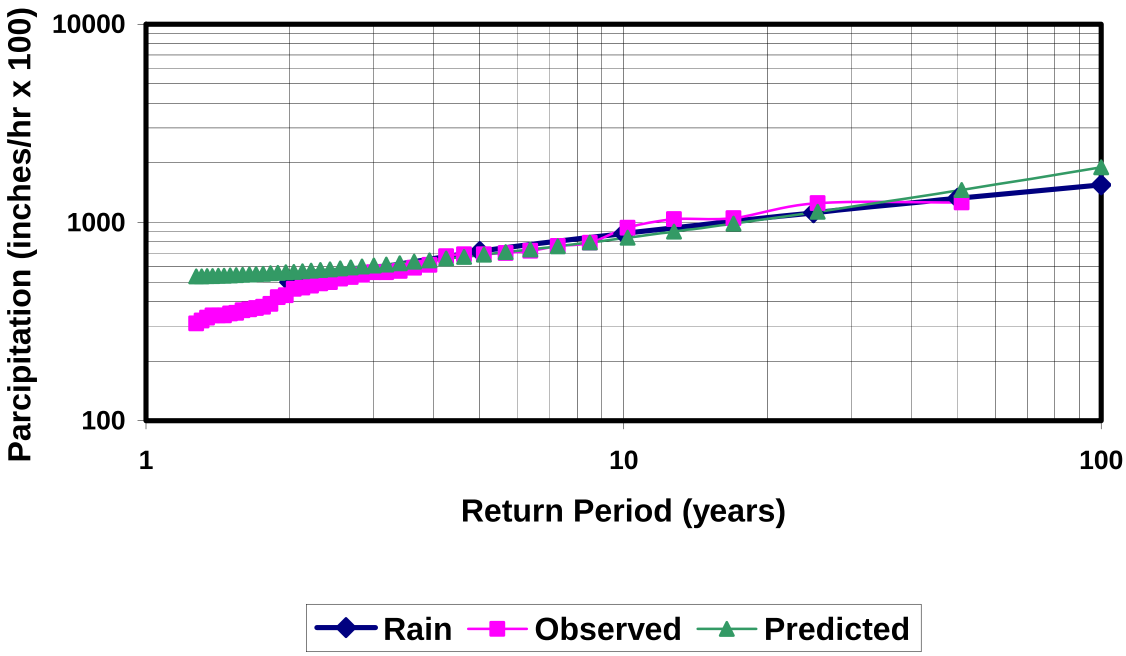


Figure 5.23A 24 Hour Precipitation Frequency Analysis for Rain Gauge Station NO:166664 at New Orleans Audubon Using Log-Pearson Type III Analysis (Annual Series)

Table 5.23B 24 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

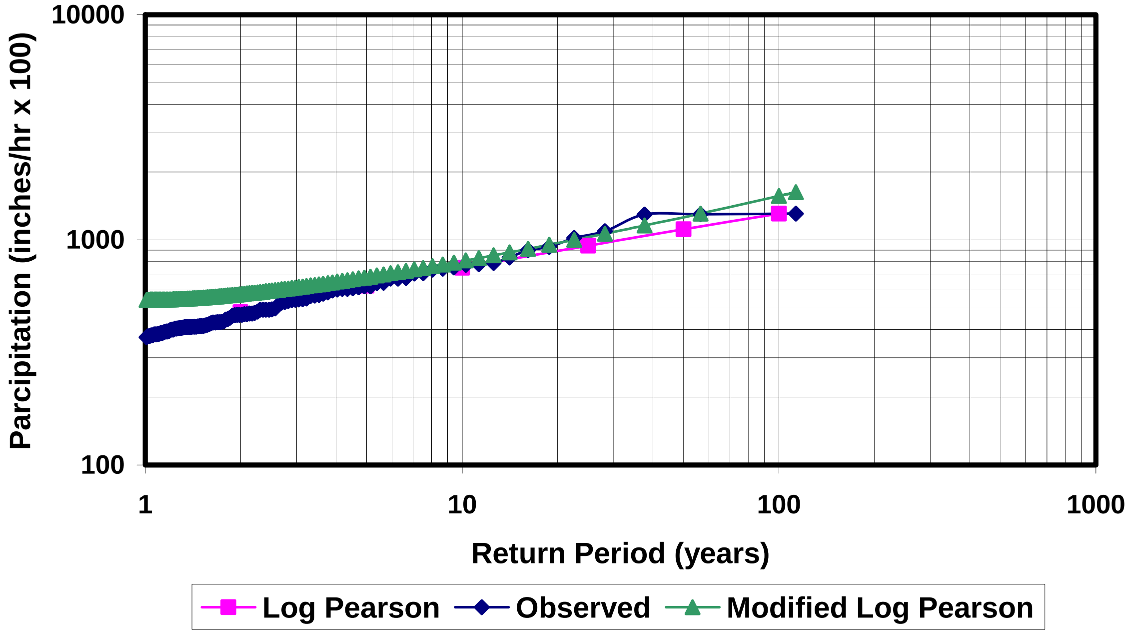
Return Period	K(.5)	K(.6)	Slope	K(.5923)	Rain
2	(0.083)	(0.099)	(0.0160)	(0.0978)	5.00
5	0.808	0.800	(0.0080)	0.8006	7.14
10	1.323	1.328	0.0050	1.3276	8.80
25	1.910	1.939	0.0290	1.9370	11.20
50	2.311	2.359	0.0480	2.3550	13.22
100	2.686	2.755	0.0690	2.7480	15.45

Table 5.23C 24 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1260	12.60	1.100	0.148	0.0568123	42.00	0.02	0.20
2	1250	12.50	1.097	0.145	0.0552918	21.00	0.05	0.20
3	1050	10.50	1.021	0.093	0.0284413	14.00	0.07	0.12
4	1040	10.40	1.017	0.091	0.0272953	10.50	0.10	0.12
5	940	9.40	0.973	0.066	0.0170112	8.40	0.12	0.08
6	790	7.90	0.898	0.033	0.0059972	7.00	0.14	0.04
7	760	7.60	0.881	0.027	0.0044815	6.00	0.17	0.03
8	720	7.20	0.857	0.020	0.0028265	5.25	0.19	0.02
9	700	7.00	0.845	0.017	0.0021544	4.67	0.21	0.02
10	690	6.90	0.839	0.015	0.0018566	4.20	0.24	0.02
11	690	6.90	0.839	0.015	0.0018566	3.82	0.26	0.02
12	675	6.75	0.829	0.013	0.0014567	3.50	0.29	0.01
13	610	6.10	0.785	0.005	0.0003341	3.23	0.31	0.01
14	590	5.90	0.771	0.003	0.0001655	3.00	0.33	0.00
15	570	5.70	0.756	0.002	0.0000637	2.80	0.36	0.00
16	560	5.60	0.748	0.001	0.0000335	2.63	0.38	0.00
17	560	5.60	0.748	0.001	0.0000335	2.47	0.40	0.00
18	544	5.44	0.736	0.000	0.0000076	2.33	0.43	0.00
19	530	5.30	0.724	0.000	0.0000006	2.21	0.45	0.00
20	520	5.20	0.716	0.000	0.0000000	2.10	0.48	0.00
21	500	5.00	0.699	0.000	-0.0000049	2.00	0.50	0.00
22	492	4.92	0.692	0.001	-0.0000138	1.91	0.52	0.00
23	480	4.80	0.681	0.001	-0.0000418	1.83	0.55	0.00
24	470	4.70	0.672	0.002	-0.0000843	1.75	0.57	0.00
25	462	4.62	0.665	0.003	-0.0001350	1.68	0.60	0.00
26	430	4.30	0.633	0.007	-0.0005610	1.62	0.62	0.01
27	420	4.20	0.623	0.009	-0.0007964	1.56	0.64	0.01
28	388	3.88	0.589	0.016	-0.0020538	1.50	0.67	0.01
29	375	3.75	0.574	0.020	-0.0028580	1.45	0.69	0.02
30	370	3.70	0.568	0.022	-0.0032248	1.40	0.71	0.02
31	365	3.65	0.562	0.024	-0.0036275	1.35	0.74	0.02
32	360	3.60	0.556	0.025	-0.0040685	1.31	0.76	0.02
33	350	3.50	0.544	0.030	-0.0050774	1.27	0.79	0.02
34	347	3.47	0.540	0.031	-0.0054160	1.24	0.81	0.03
35	340	3.40	0.531	0.034	-0.0062768	1.20	0.83	0.03
36	340	3.40	0.531	0.034	-0.0062768	1.17	0.86	0.03
37	340	3.40	0.531	0.034	-0.0062768	1.14	0.88	0.03

38	331	3.31	0.520	0.038	-0.0075428	1.11	0.90	0.03
39	320	3.20	0.505	0.044	-0.0093664	1.08	0.93	0.04
40	310	3.10	0.491	0.050	-0.0113272	1.05	0.95	0.04
41	290	2.90	0.462	0.064	-0.0162992	1.02	0.98	0.05
Average		**5.641**	**0.716**					
			Sum	**1.184**	**0.115**			

variance	0.0296
standard deviation	0.1721
skew coefficient	0.5923



4

Table 5.24B 24 Hour Rainfall for Rain Gauge Station No:166664 at Audubon Using Log-Person Analysis III

Return Period	K(1.3)	K(1.4)	Slope	K(.1.37)	Rain
2	(0.210)	(0.225)	(0.015)	(0.216)	4.77
5	0.719	0.705	(0.014)	0.714	6.26
10	1.339	1.337	(0.002)	1.339	7.52
25	2.108	2.128	0.020	2.115	9.44
50	2.666	2.706	0.040	2.681	11.14
100	3.211	3.271	0.060	3.233	13.10

Table 5.24C 24 Hour Precipitation Frequency Analysis for Rain Gauge Station No:166664 at Audubon Using Log-Pearson Type III Analysis

Rank	Maximums	inches	logI	$[LogI-Avg(LogI)]^2$	$[LogI-Avg(LogI)]^3$	Tr	1/Tr	Sum of Logs
1	1308	13.08	1.117	0.169	0.0693180	122.00	0.01	0.24
2	1300	13.00	1.114	0.167	0.0679779	61.00	0.02	0.23
3	1296	12.96	1.113	0.165	0.0673113	40.67	0.02	0.23
4	1094	10.94	1.039	0.111	0.0369910	30.50	0.03	0.15
5	1020	10.20	1.009	0.092	0.0277571	24.40	0.04	0.12
6	931	9.31	0.969	0.069	0.0182179	20.33	0.05	0.09
7	900	9.00	0.954	0.062	0.0153307	17.43	0.06	0.08
8	836	8.36	0.922	0.047	0.0101316	15.25	0.07	0.06
9	791	7.91	0.898	0.037	0.0071172	13.56	0.07	0.04
10	780	7.80	0.892	0.035	0.0064632	12.20	0.08	0.04
11	775	7.75	0.889	0.034	0.0061768	11.09	0.09	0.04
12	755	7.55	0.878	0.030	0.0050995	10.17	0.10	0.03
13	745	7.45	0.872	0.028	0.0046020	9.38	0.11	0.03
14	737	7.37	0.867	0.026	0.0042237	8.71	0.11	0.03
15	712	7.12	0.852	0.022	0.0031544	8.13	0.12	0.02
16	708	7.08	0.850	0.021	0.0029991	7.63	0.13	0.02
17	678	6.78	0.831	0.016	0.0019723	7.18	0.14	0.02
18	673	6.73	0.828	0.015	0.0018245	6.78	0.15	0.02
19	672	6.72	0.827	0.015	0.0017957	6.42	0.16	0.02
20	645	6.45	0.810	0.011	0.0011164	6.10	0.16	0.01
21	643	6.43	0.808	0.010	0.0010734	5.81	0.17	0.01
22	621	6.21	0.793	0.008	0.0006646	5.55	0.18	0.01
23	621	6.21	0.793	0.008	0.0006646	5.30	0.19	0.01
24	615	6.15	0.789	0.007	0.0005729	5.08	0.20	0.01
25	610	6.10	0.785	0.006	0.0005026	4.88	0.20	0.01
26	606	6.06	0.782	0.006	0.0004503	4.69	0.21	0.01
27	606	6.06	0.782	0.006	0.0004503	4.52	0.22	0.01
28	602	6.02	0.780	0.005	0.0004015	4.36	0.23	0.01
29	596	5.96	0.775	0.005	0.0003346	4.21	0.24	0.01
30	585	5.85	0.767	0.004	0.0002307	4.07	0.25	0.00
31	576	5.76	0.760	0.003	0.0001628	3.94	0.25	0.00
32	570	5.70	0.756	0.003	0.0001254	3.81	0.26	0.00
33	565	5.65	0.752	0.002	0.0000988	3.70	0.27	0.00
34	563	5.63	0.751	0.002	0.0000892	3.59	0.28	0.00
35	550	5.50	0.740	0.001	0.0000412	3.49	0.29	0.00
36	545	5.45	0.736	0.001	0.0000286	3.39	0.30	0.00
37	543	5.43	0.735	0.001	0.0000243	3.30	0.30	0.00
38	542	5.42	0.734	0.001	0.0000224	3.21	0.31	0.00
39	540	5.40	0.732	0.001	0.0000188	3.13	0.32	0.00
40	535	5.35	0.728	0.001	0.0000114	3.05	0.33	0.00
41	530	5.30	0.724	0.000	0.0000063	2.98	0.34	0.00
42	527	5.27	0.722	0.000	0.0000041	2.90	0.34	0.00
43	515	5.15	0.712	0.000	0.0000002	2.84	0.35	0.00
44	496	4.96	0.695	0.000	-0.0000011	2.77	0.36	0.00
45	492	4.92	0.692	0.000	-0.0000027	2.71	0.37	0.00
46	490	4.90	0.690	0.000	-0.0000038	2.65	0.38	0.00

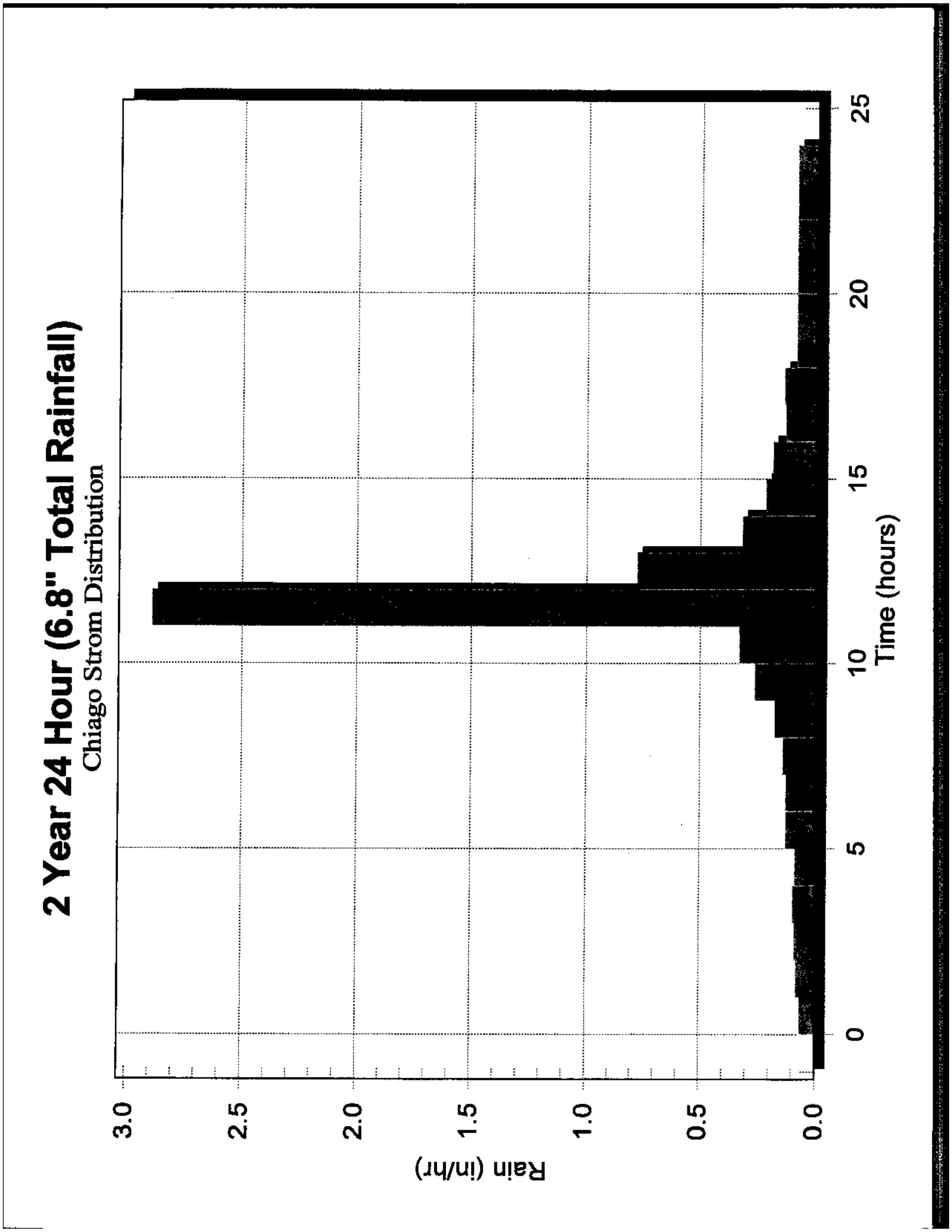
47	490	4.90	0.690	0.000	-0.0000038	2.60	0.39	0.00
48	490	4.90	0.690	0.000	-0.0000038	2.54	0.39	0.00
49	489	4.89	0.689	0.000	-0.0000045	2.49	0.40	0.00
50	480	4.80	0.681	0.001	-0.0000149	2.44	0.41	0.00
51	474	4.74	0.676	0.001	-0.0000271	2.39	0.42	0.00
52	471	4.71	0.673	0.001	-0.0000353	2.35	0.43	0.00
53	471	4.71	0.673	0.001	-0.0000353	2.30	0.43	0.00
54	467	4.67	0.669	0.001	-0.0000486	2.26	0.44	0.00
55	467	4.67	0.669	0.001	-0.0000486	2.22	0.45	0.00
56	465	4.65	0.667	0.001	-0.0000565	2.18	0.46	0.00
57	465	4.65	0.667	0.001	-0.0000565	2.14	0.47	0.00
58	464	4.64	0.667	0.002	-0.0000607	2.10	0.48	0.00
59	463	4.63	0.666	0.002	-0.0000652	2.07	0.48	0.00
60	460	4.60	0.663	0.002	-0.0000799	2.03	0.49	0.00
61	451	4.51	0.654	0.003	-0.0001378	2.00	0.50	0.00
62	445	4.45	0.648	0.003	-0.0001897	1.97	0.51	0.00
63	442	4.42	0.645	0.004	-0.0002203	1.94	0.52	0.00
64	434	4.34	0.637	0.005	-0.0003191	1.91	0.52	0.00
65	432	4.32	0.635	0.005	-0.0003480	1.88	0.53	0.00
66	431	4.31	0.634	0.005	-0.0003632	1.85	0.54	0.00
67	431	4.31	0.634	0.005	-0.0003632	1.82	0.55	0.00
68	430	4.30	0.633	0.005	-0.0003788	1.79	0.56	0.00
69	430	4.30	0.633	0.005	-0.0003788	1.77	0.57	0.00
70	427	4.27	0.630	0.006	-0.0004286	1.74	0.57	0.01
71	422	4.22	0.625	0.006	-0.0005218	1.72	0.58	0.01
72	420	4.20	0.623	0.007	-0.0005630	1.69	0.59	0.01
73	417	4.17	0.620	0.007	-0.0006291	1.67	0.60	0.01
74	415	4.15	0.618	0.008	-0.0006762	1.65	0.61	0.01
75	415	4.15	0.618	0.008	-0.0006762	1.63	0.61	0.01
76	415	4.15	0.618	0.008	-0.0006762	1.61	0.62	0.01
77	413	4.13	0.616	0.008	-0.0007259	1.58	0.63	0.01
78	412	4.12	0.615	0.008	-0.0007517	1.56	0.64	0.01
79	412	4.12	0.615	0.008	-0.0007517	1.54	0.65	0.01
80	411	4.11	0.614	0.008	-0.0007782	1.53	0.66	0.01
81	410	4.10	0.613	0.009	-0.0008053	1.51	0.66	0.01
82	410	4.10	0.613	0.009	-0.0008053	1.49	0.67	0.01
83	410	4.10	0.613	0.009	-0.0008053	1.47	0.68	0.01
84	410	4.10	0.613	0.009	-0.0008053	1.45	0.69	0.01
85	410	4.10	0.613	0.009	-0.0008053	1.44	0.70	0.01
86	407	4.07	0.610	0.009	-0.0008910	1.42	0.70	0.01
87	406	4.06	0.609	0.009	-0.0009211	1.40	0.71	0.01
88	406	4.06	0.609	0.009	-0.0009211	1.39	0.72	0.01
89	405	4.05	0.607	0.010	-0.0009518	1.37	0.73	0.01
90	403	4.03	0.605	0.010	-0.0010156	1.36	0.74	0.01
91	403	4.03	0.605	0.010	-0.0010156	1.34	0.75	0.01
92	400	4.00	0.602	0.011	-0.0011172	1.33	0.75	0.01
93	400	4.00	0.602	0.011	-0.0011172	1.31	0.76	0.01
94	398	3.98	0.600	0.011	-0.0011890	1.30	0.77	0.01
95	395	3.95	0.597	0.012	-0.0013031	1.28	0.78	0.01
96	392	3.92	0.593	0.013	-0.0014252	1.27	0.79	0.01
97	392	3.92	0.593	0.013	-0.0014252	1.26	0.80	0.01
98	390	3.90	0.591	0.013	-0.0015113	1.24	0.80	0.01
99	388	3.88	0.589	0.014	-0.0016012	1.23	0.81	0.01
100	385	3.85	0.585	0.014	-0.0017437	1.22	0.82	0.01

101	385	3.85	0.585	0.014	-0.0017437	1.21	0.83	0.01
102	383	3.83	0.583	0.015	-0.0018438	1.20	0.84	0.01
103	382	3.82	0.582	0.015	-0.0018955	1.18	0.84	0.01
104	381	3.81	0.581	0.016	-0.0019483	1.17	0.85	0.01
105	381	3.81	0.581	0.016	-0.0019483	1.16	0.86	0.01
106	381	3.81	0.581	0.016	-0.0019483	1.15	0.87	0.01
107	377	3.77	0.576	0.017	-0.0021708	1.14	0.88	0.01
108	377	3.77	0.576	0.017	-0.0021708	1.13	0.89	0.01
109	375	3.75	0.574	0.017	-0.0022891	1.12	0.89	0.02
110	373	3.73	0.572	0.018	-0.0024122	1.11	0.90	0.02
111	373	3.73	0.572	0.018	-0.0024122	1.10	0.91	0.02
112	370	3.70	0.568	0.019	-0.0026064	1.09	0.92	0.02
	Average	**5.332**	**0.706**					
			Sum	**1.797**	**0.308**			

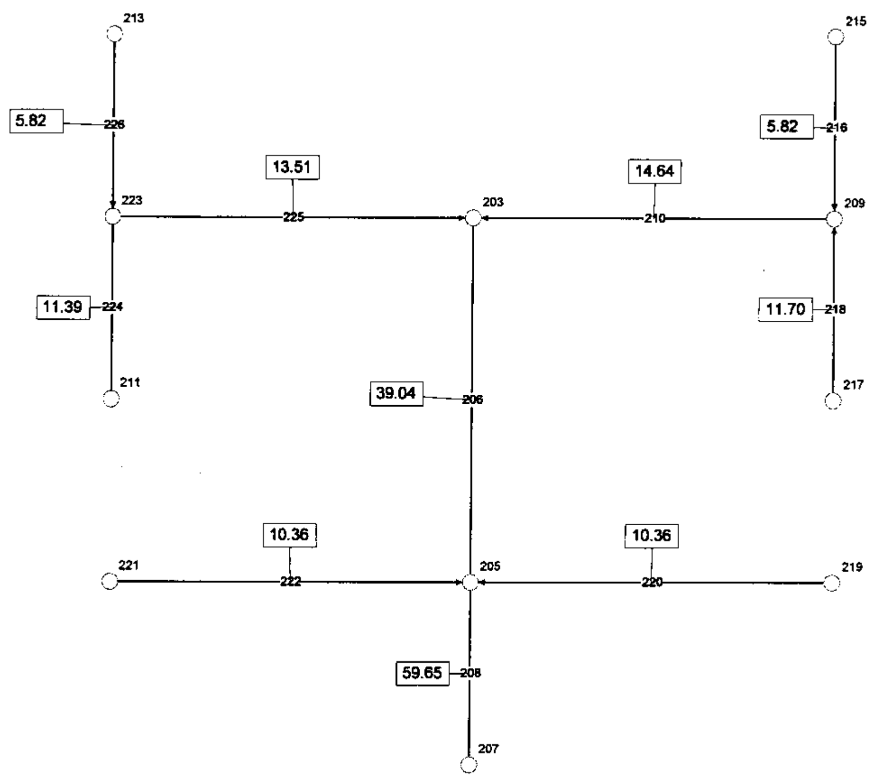
variance 0.0162
standard deviation 0.1272
skew coefficient 1.3701

Appendix C

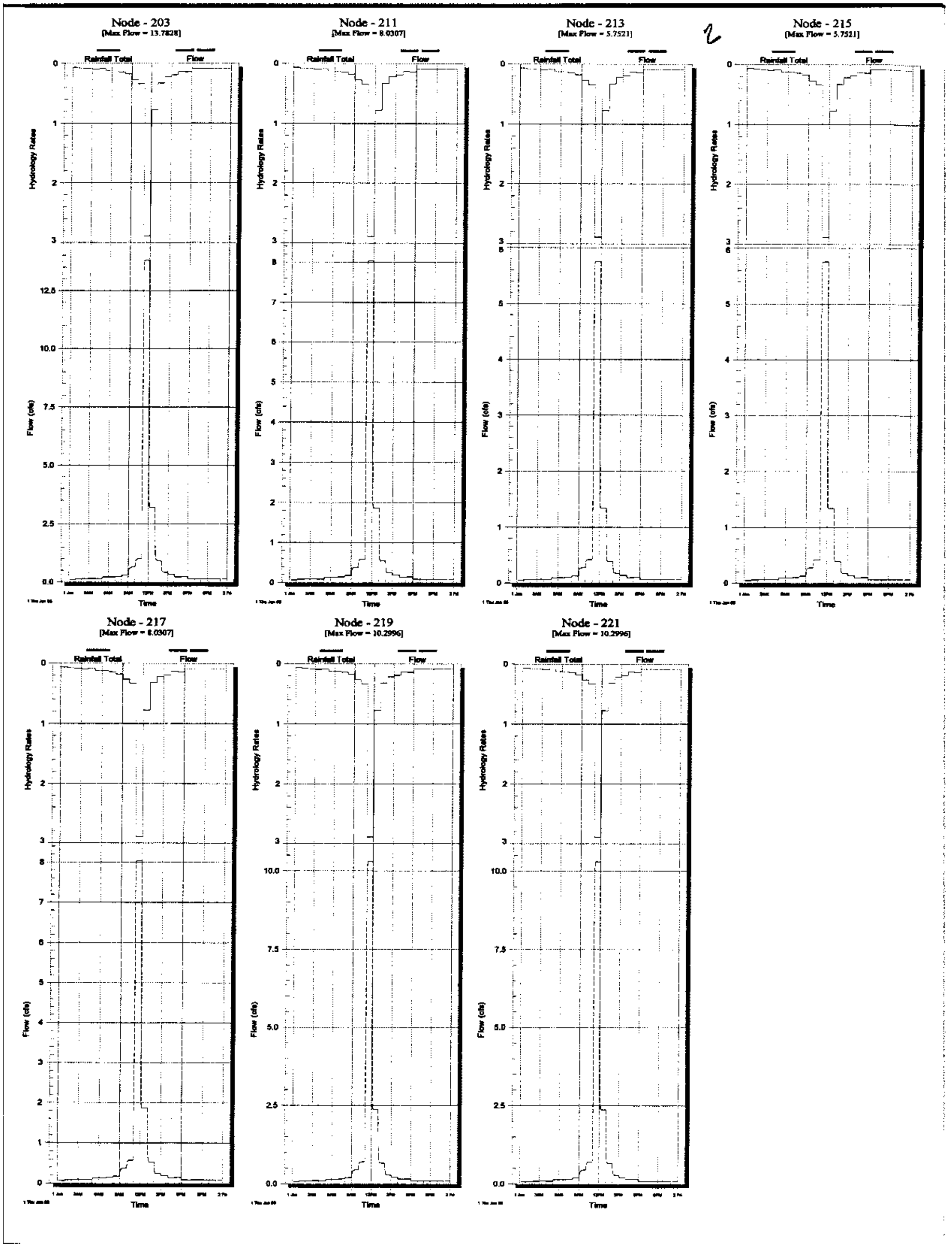
RAINFALL INTENSITIES USING CHICAGO STROM DISTIBUTION FOR AUDUBON RAIN GAUGE



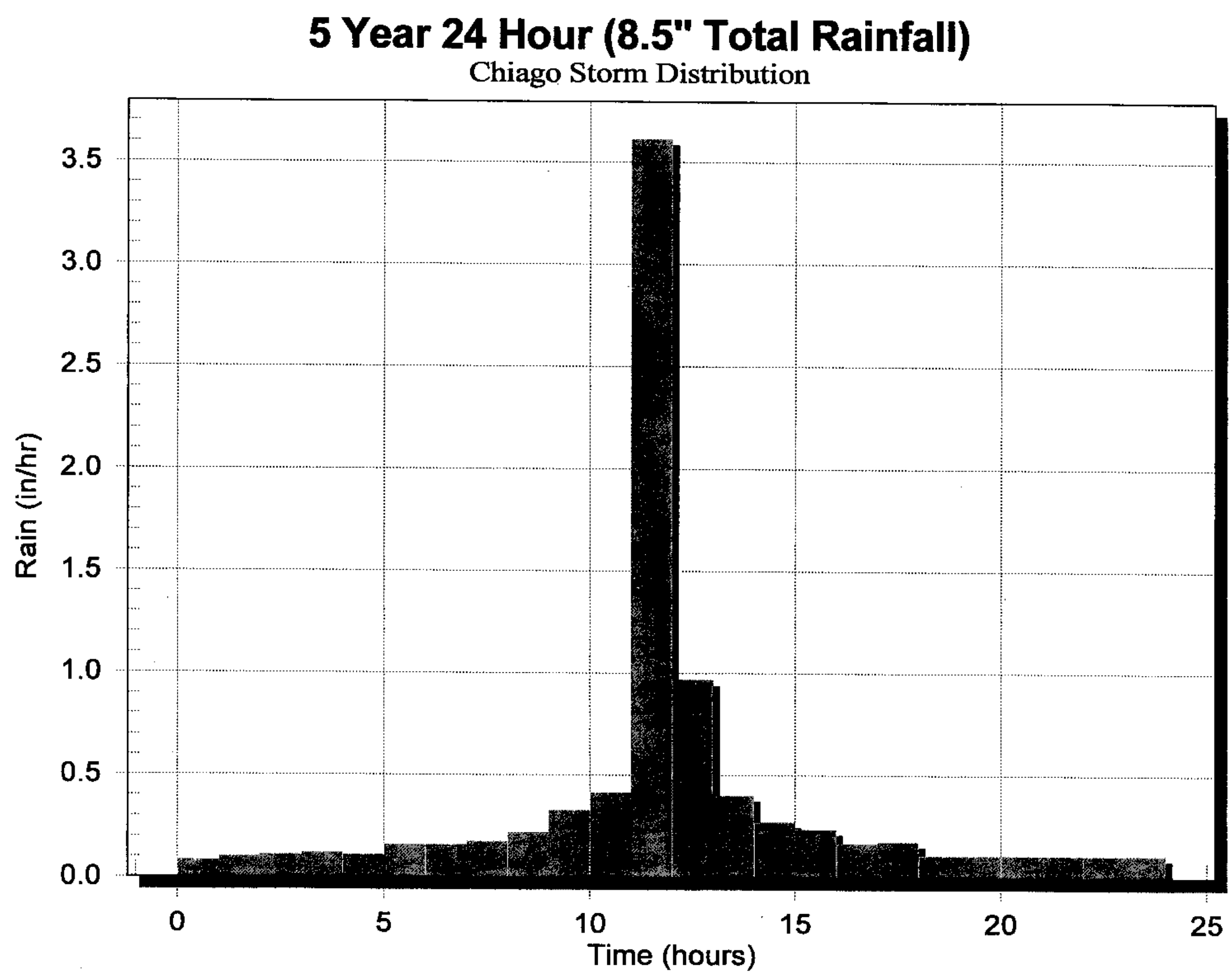
2 Year 24 Hour (6.8" Total Rainfall)
Chiago Strom Distribution
Rain (in/hr)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

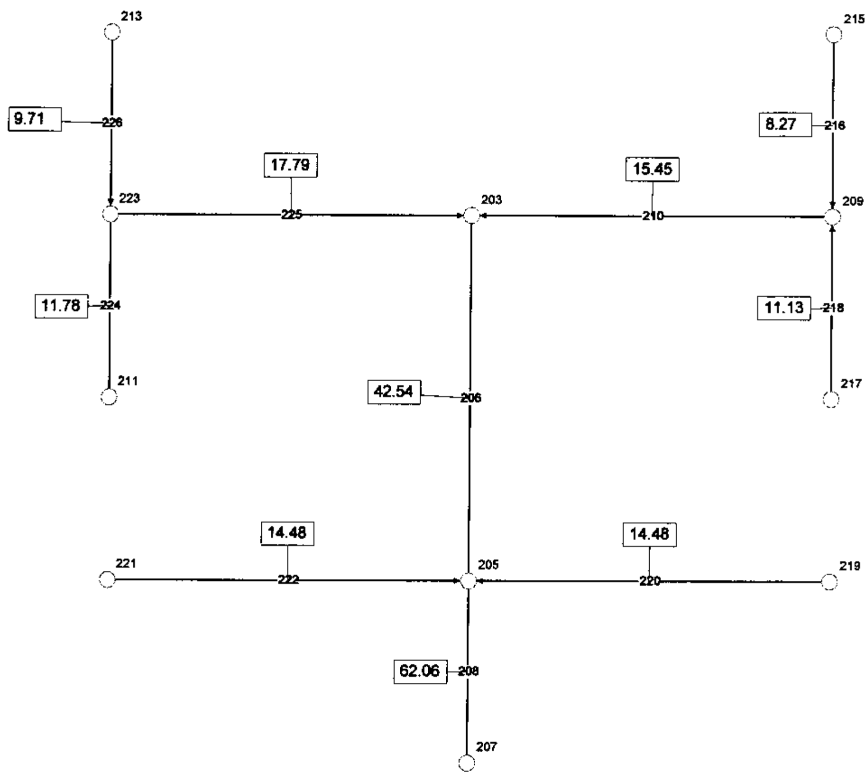


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 2Year 24 Hour (6.8" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1

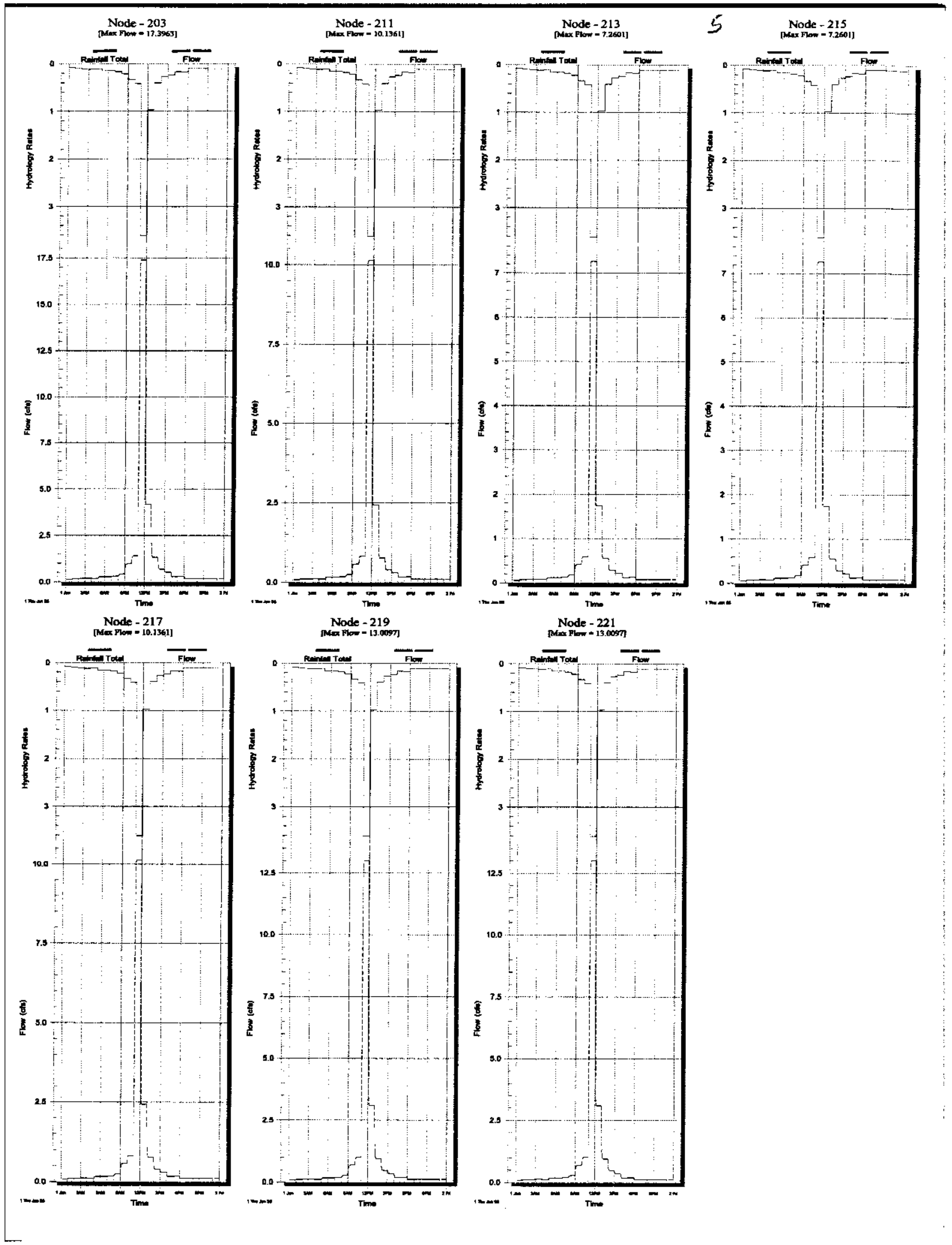


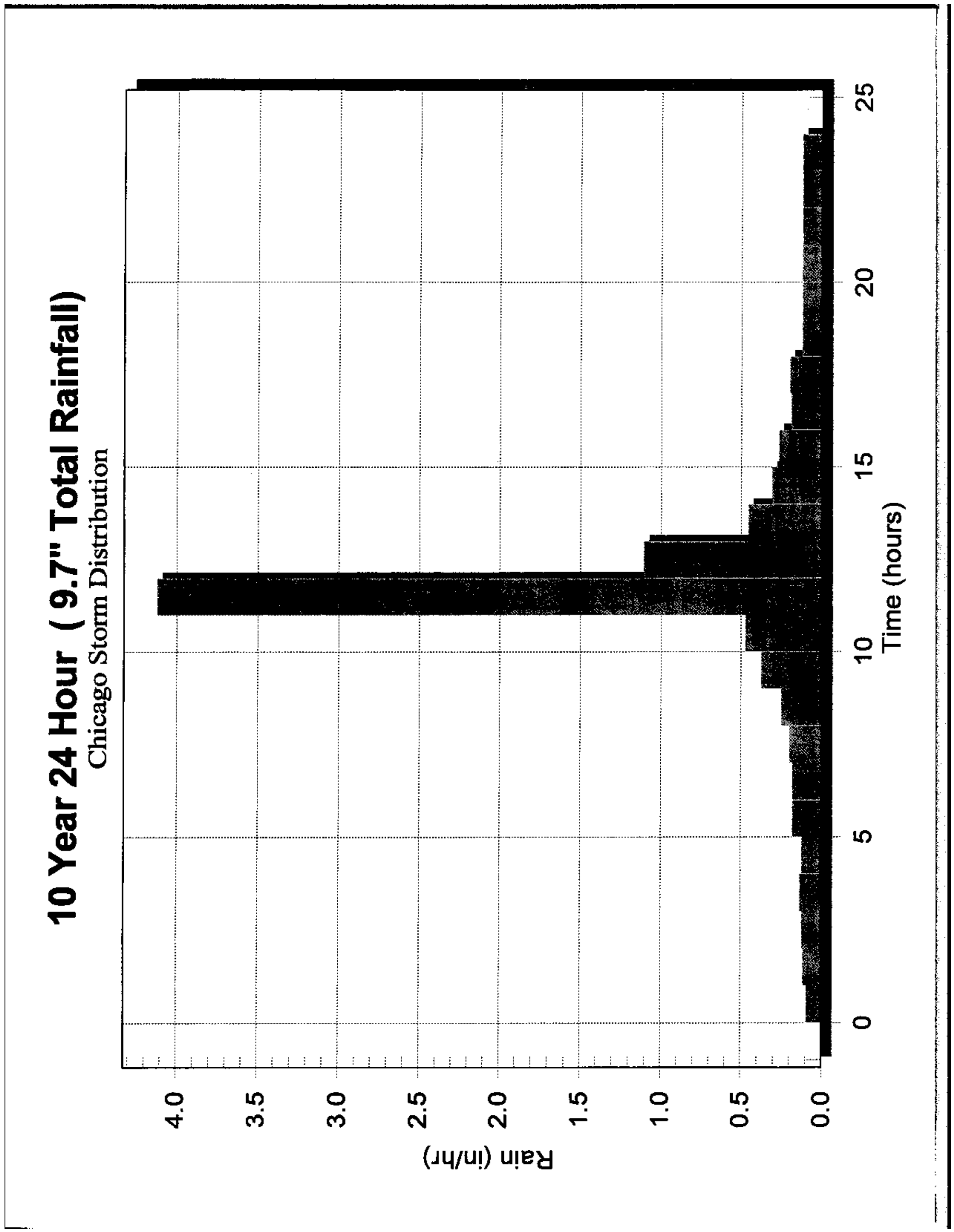
Node - 203
[Max Flow = 13.7828]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 211
[Max Flow = 8.0307]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 213
[Max Flow = 5.7521]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 215
[Max Flow = 5.7521]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 217
[Max Flow = 8.0307]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 219
[Max Flow = 10.2996]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
Node - 221
[Max Flow = 10.2996]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time


5 Year 24 Hour (8.5" Total Rainfall)
Chiago Storm Distribution
Rain (in/hr)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

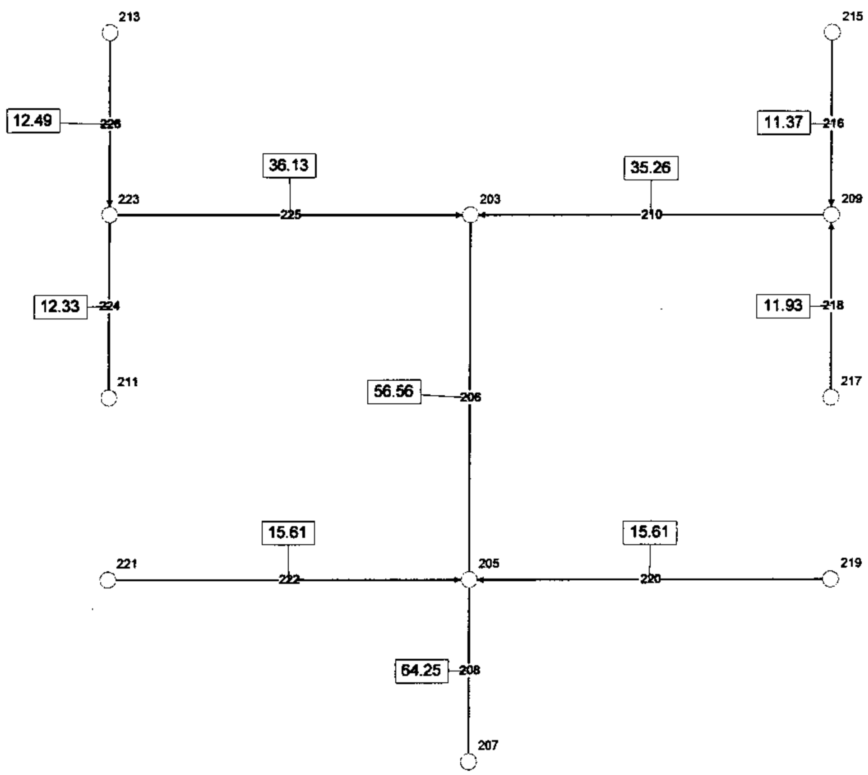


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 5 Year 24 Hour (8.5" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1

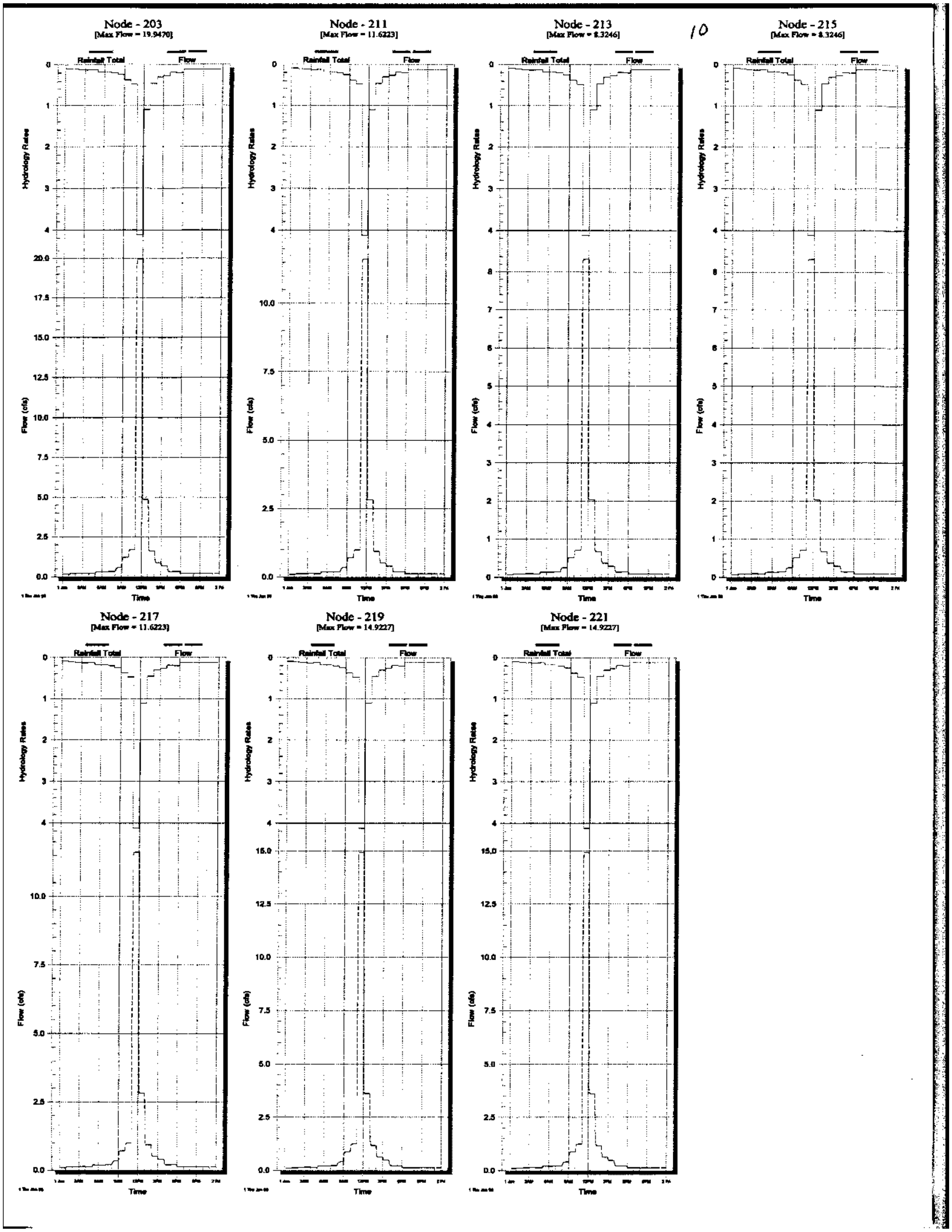

Node - 203
[Max Flow = 17.3963]
Node - 211
[Max Flow = 10.1361]
Node - 213
[Max Flow = 7.2601]
5
Node - 215
[Max Flow = 7.2601]
Node - 217
[Max Flow = 10.1361]
Node - 219
[Max Flow = 13.0097]
Node - 221
[Max Flow = 13.0097]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time



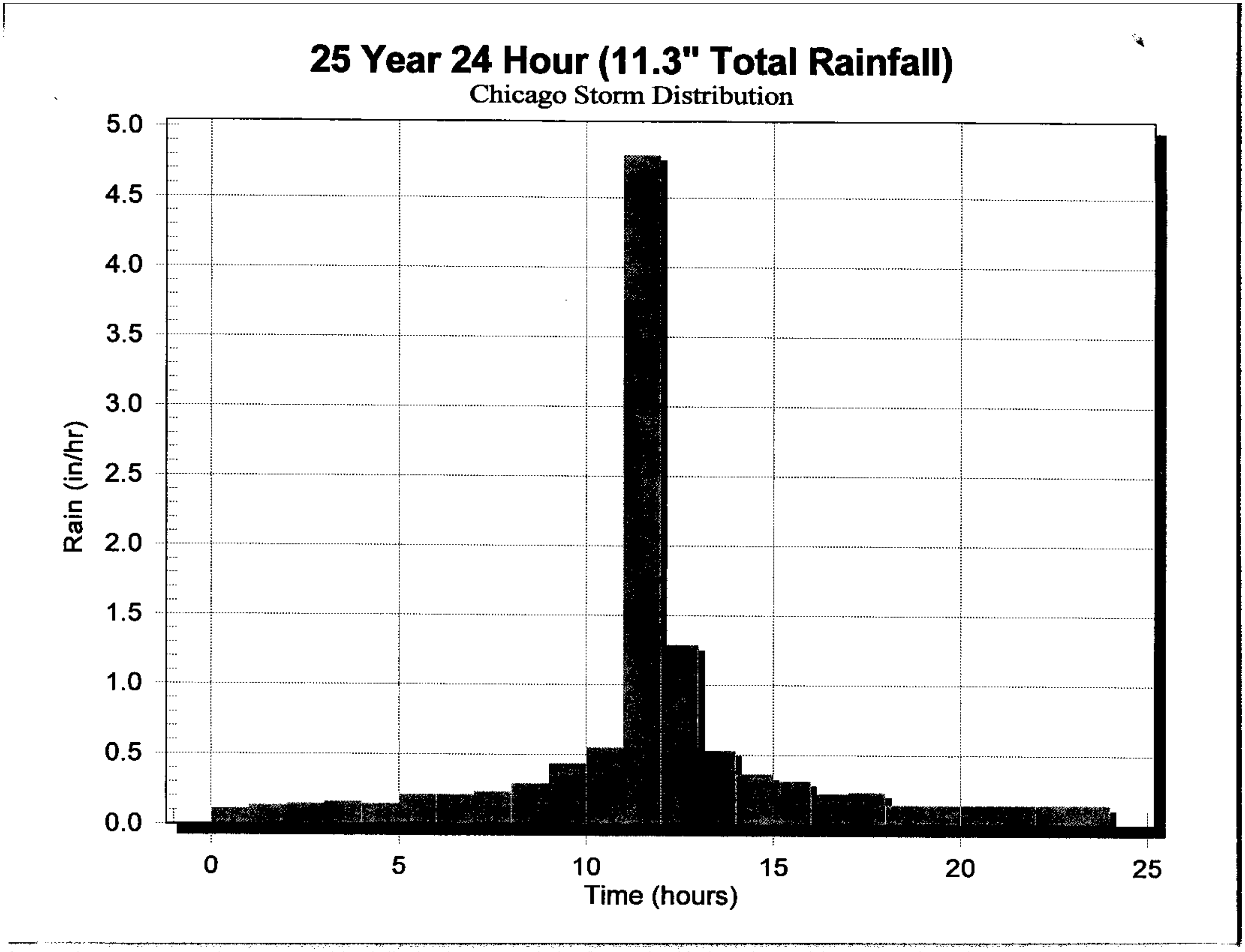
10 Year 24 Hour (9.7" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
5
10
15
20
25
Time (hours)



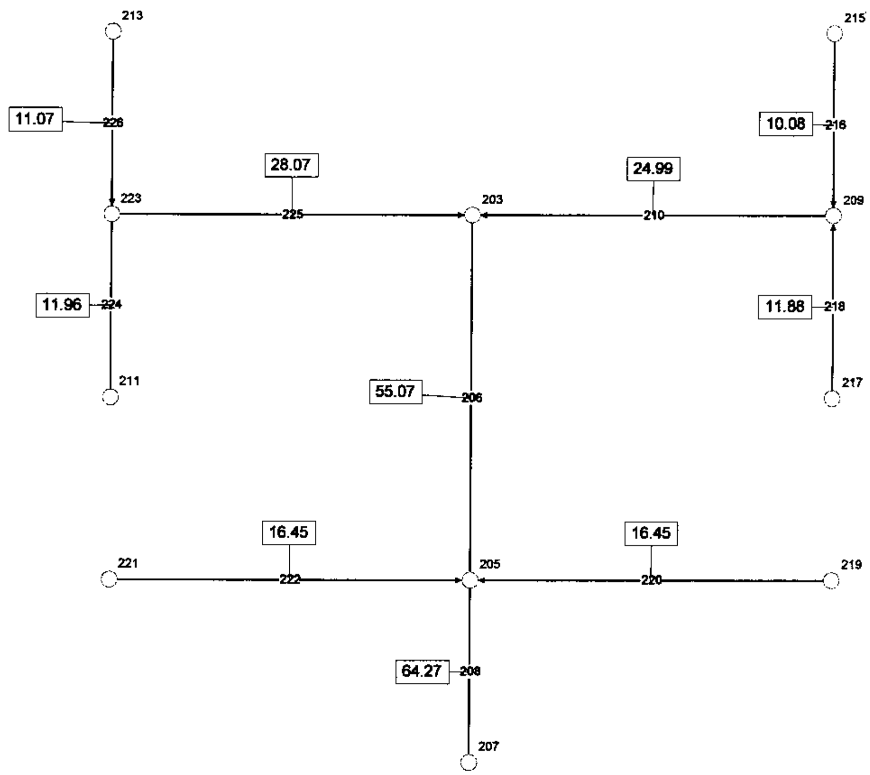
SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - ~~100~~ 10 Year 24 Hour (~~13.7"~~ 9.7" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1



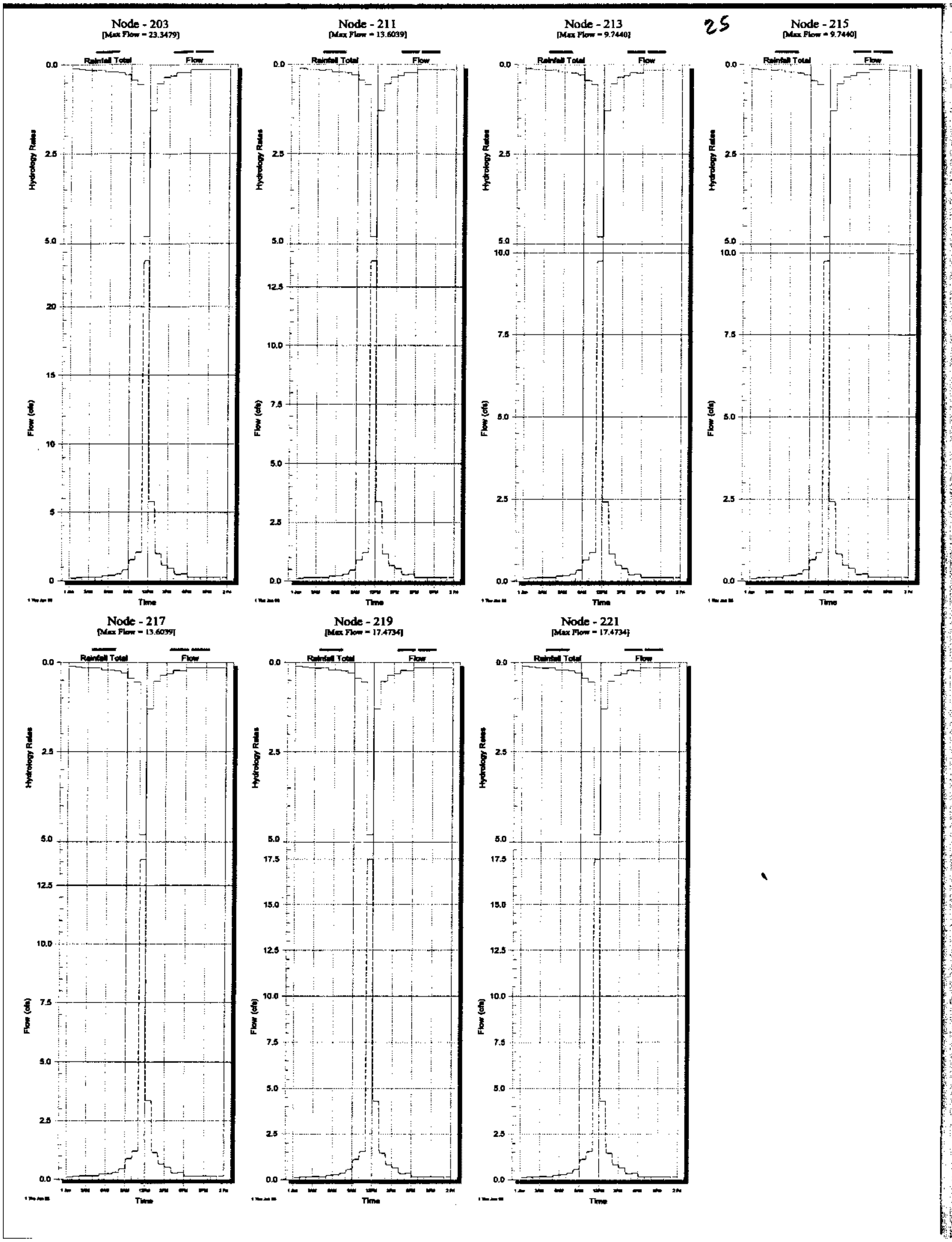
Node - 203
[Max Flow = 19.9470]
Node - 211
[Max Flow = 11.6223]
Node - 213
[Max Flow = 8.3246]
10
Node - 215
[Max Flow = 8.3246]
Node - 217
[Max Flow = 11.6223]
Node - 219
[Max Flow = 14.9227]
Node - 221
[Max Flow = 14.9227]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time

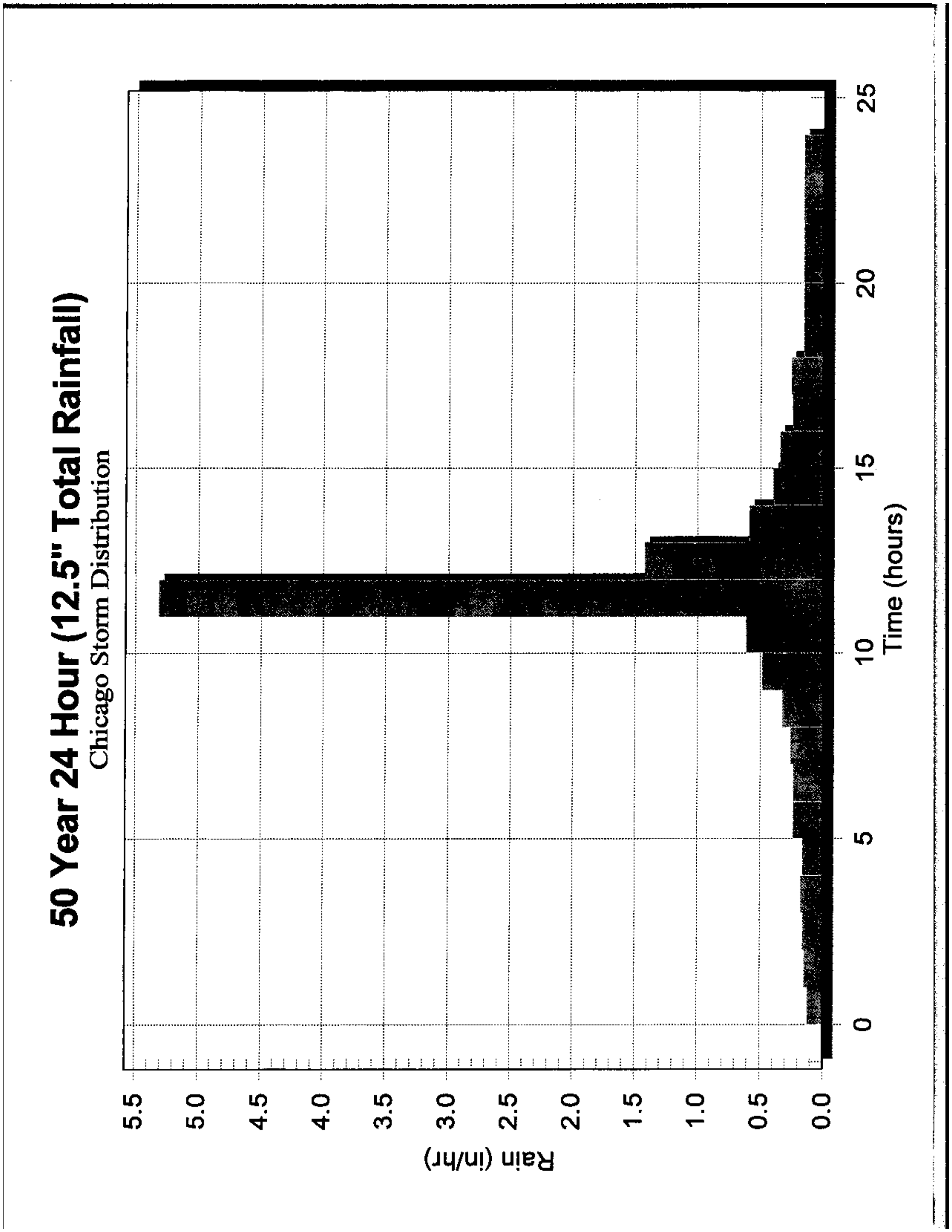


25 Year 24 Hour (11.3" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

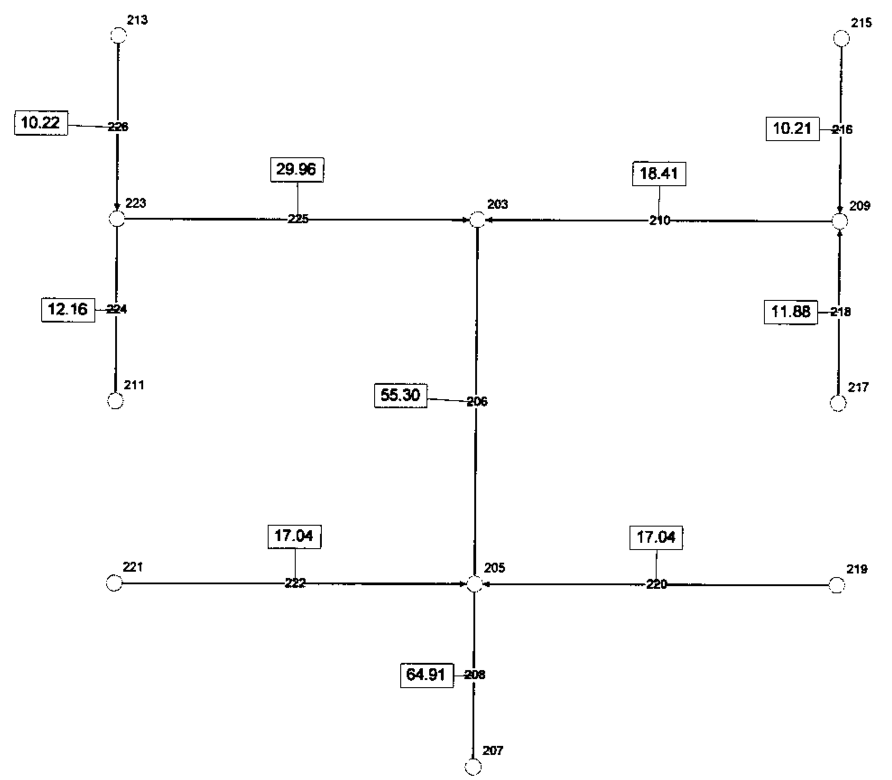


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 25 Year 24 Hour (11.3" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1

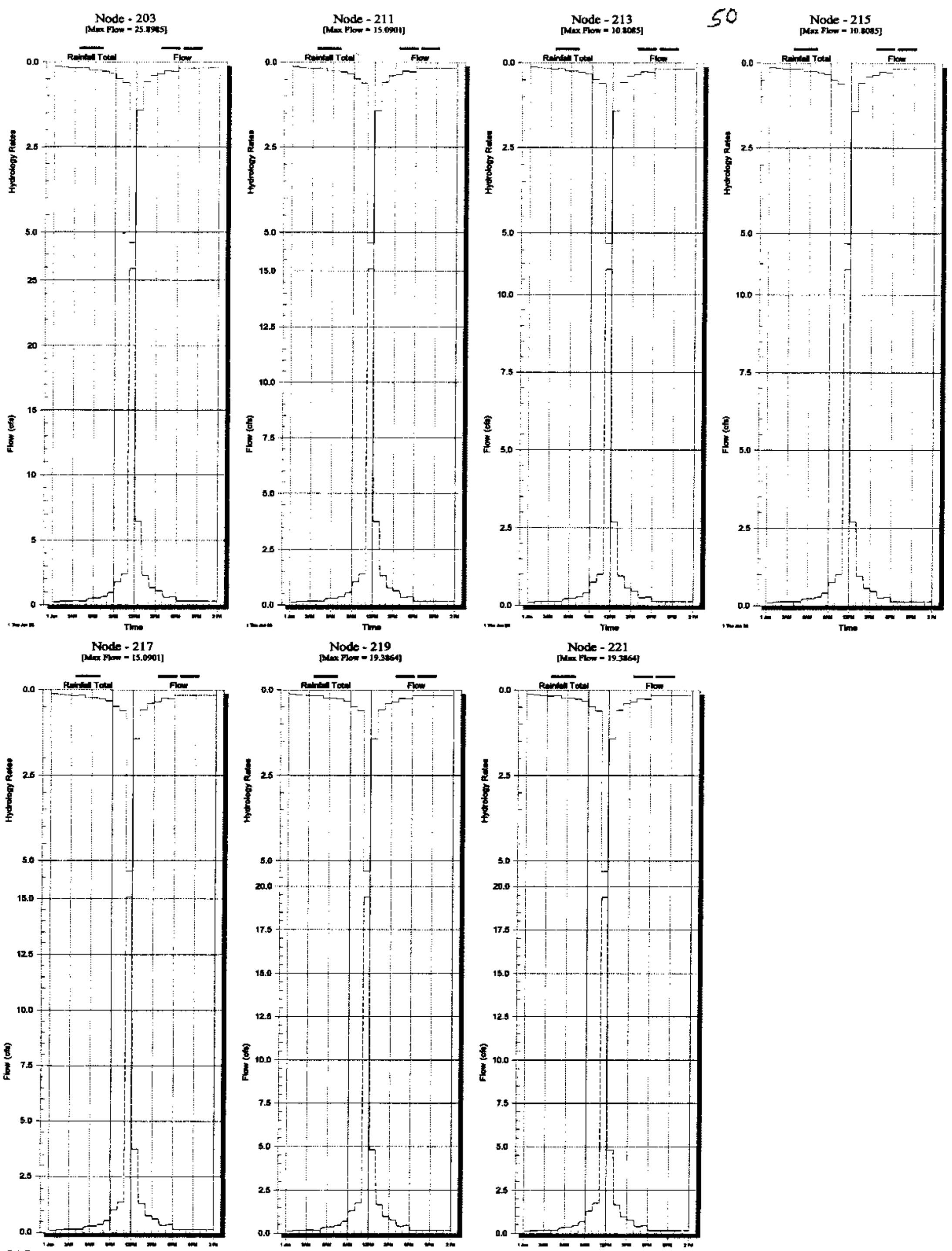

Node - 203
[Max Flow = 23.3479]
Node - 211
[Max Flow = 13.6039]
Node - 213
[Max Flow = 9.7440]
25
Node - 215
[Max Flow = 9.7440]
Node - 217
[Max Flow = 13.6039]
Node - 219
[Max Flow = 17.4734]
Node - 221
[Max Flow = 17.4734]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time

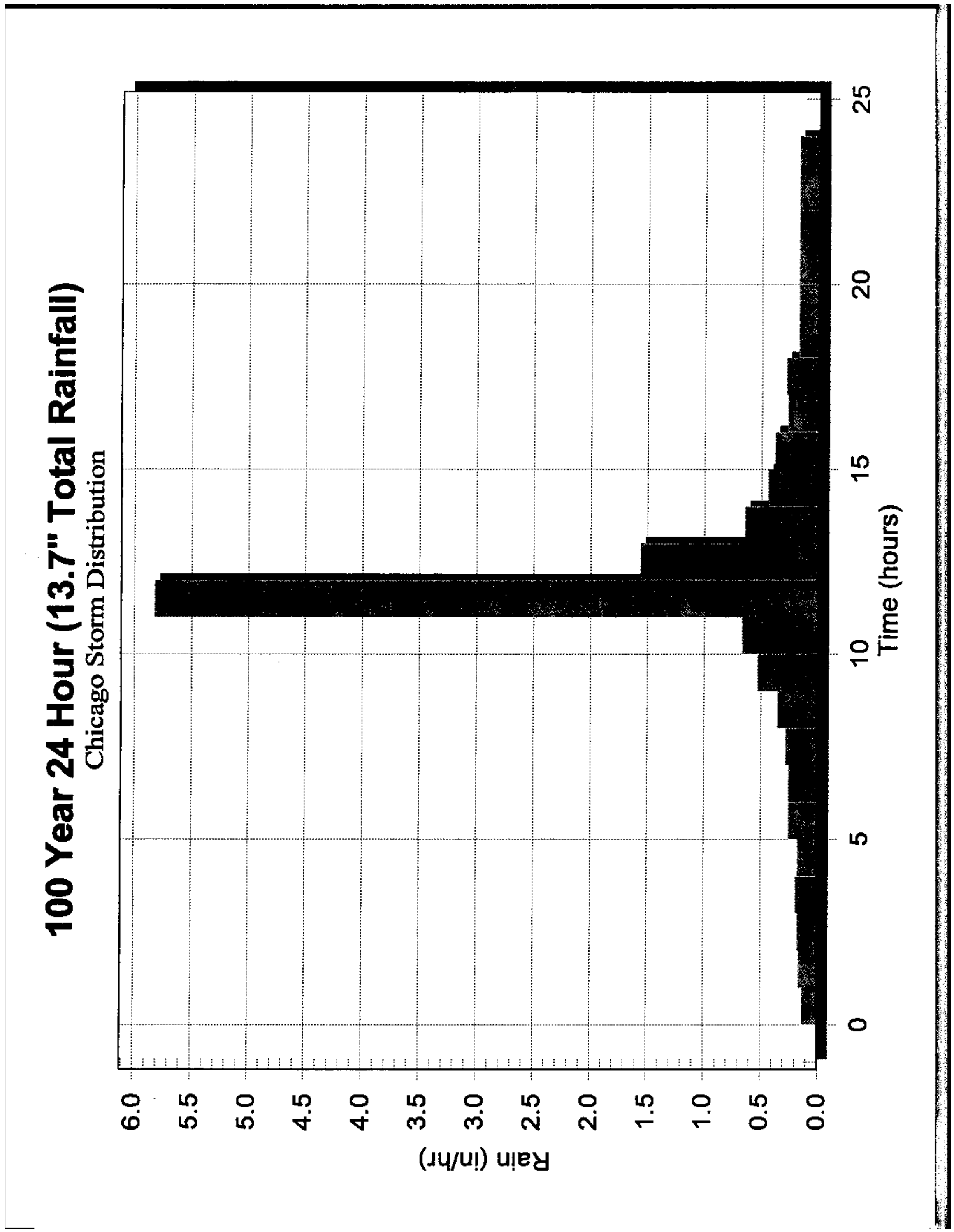


50 Year 24 Hour (12.5" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

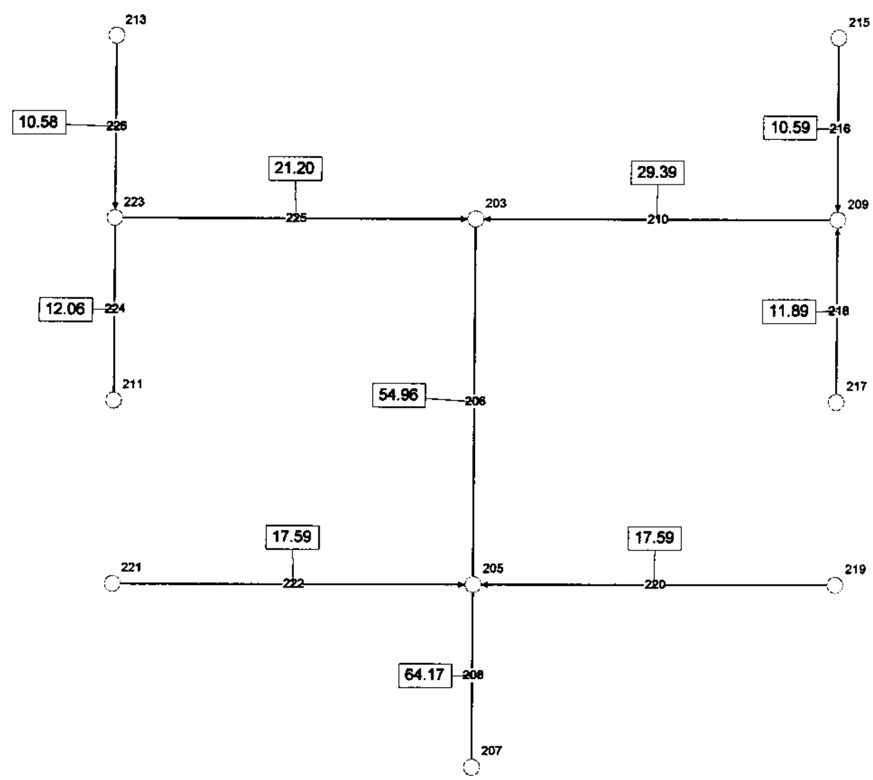


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 50 Year 24 Hour (12.5" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1


Node - 203
[Max Flow = 25.8985]
Node - 211
[Max Flow = 15.0901]
Node - 213
[Max Flow = 10.8085]
50
Node - 215
[Max Flow = 10.8085]
Node - 217
[Max Flow = 15.0901]
Node - 219
[Max Flow = 19.3864]
Node - 221
[Max Flow = 19.3864]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time



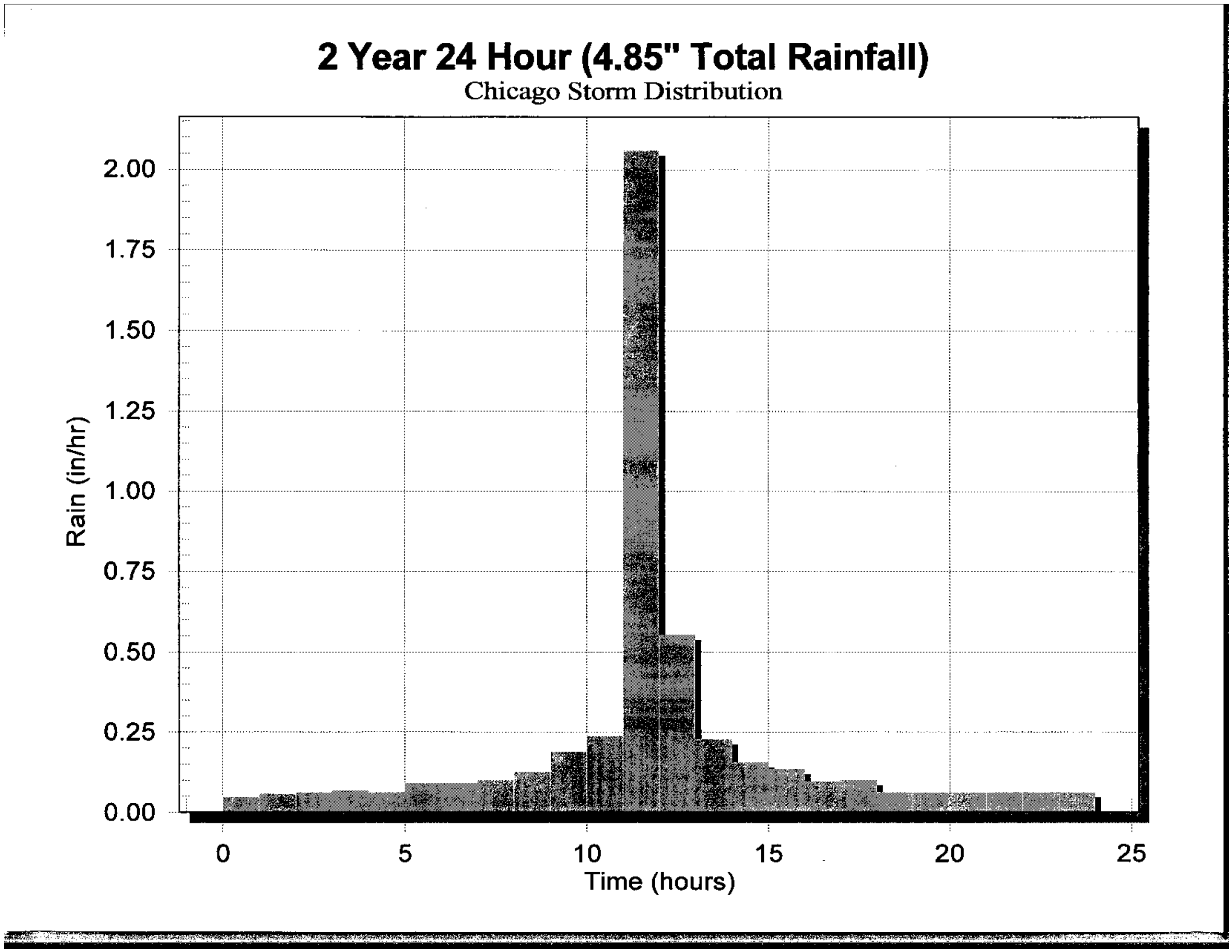
100 Year 24 Hour (13.7" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

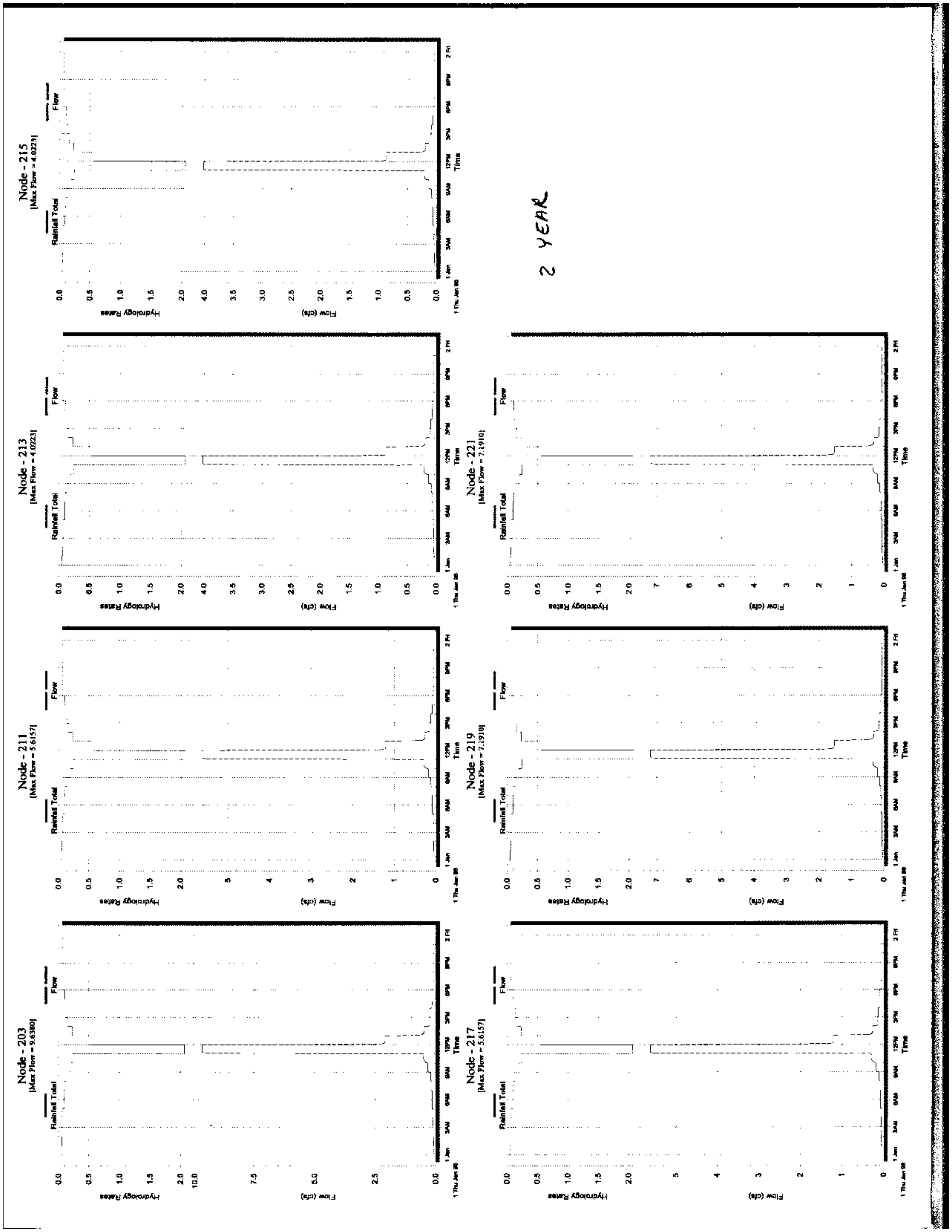


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 100 Year 24 Hour (13.7" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	11/17/07 Page 1/1

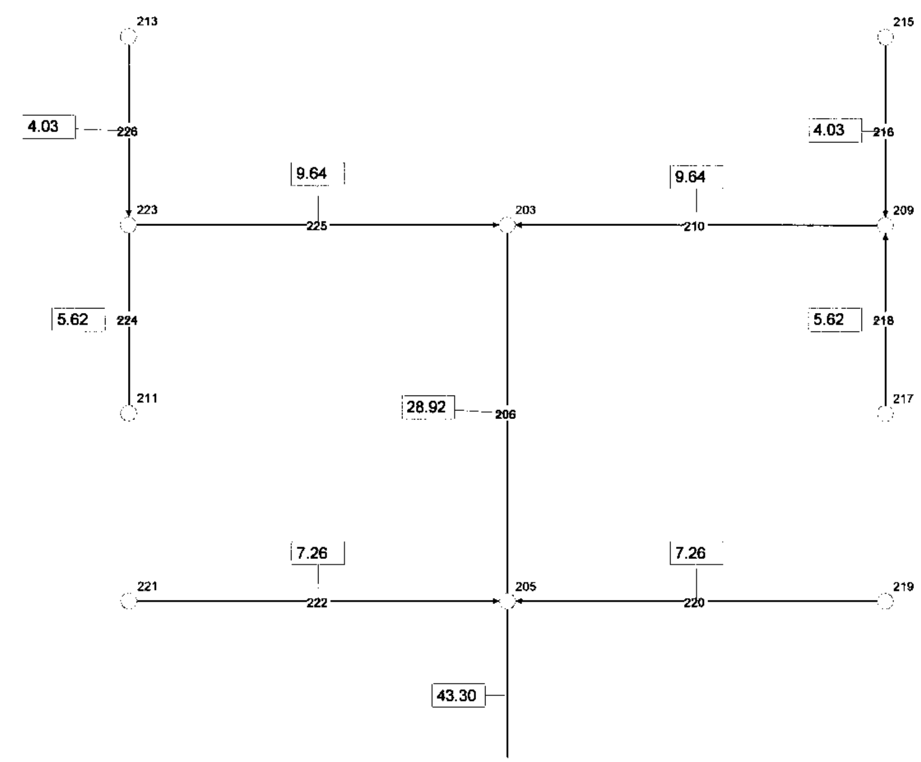
Appendix D

RAINFALL INTENSITIES USING
CHICAGO STROM DISTIBUTION
FOR NEW ORLEANS INTERNATIONAL
AIRPORT
RAIN GAUGE

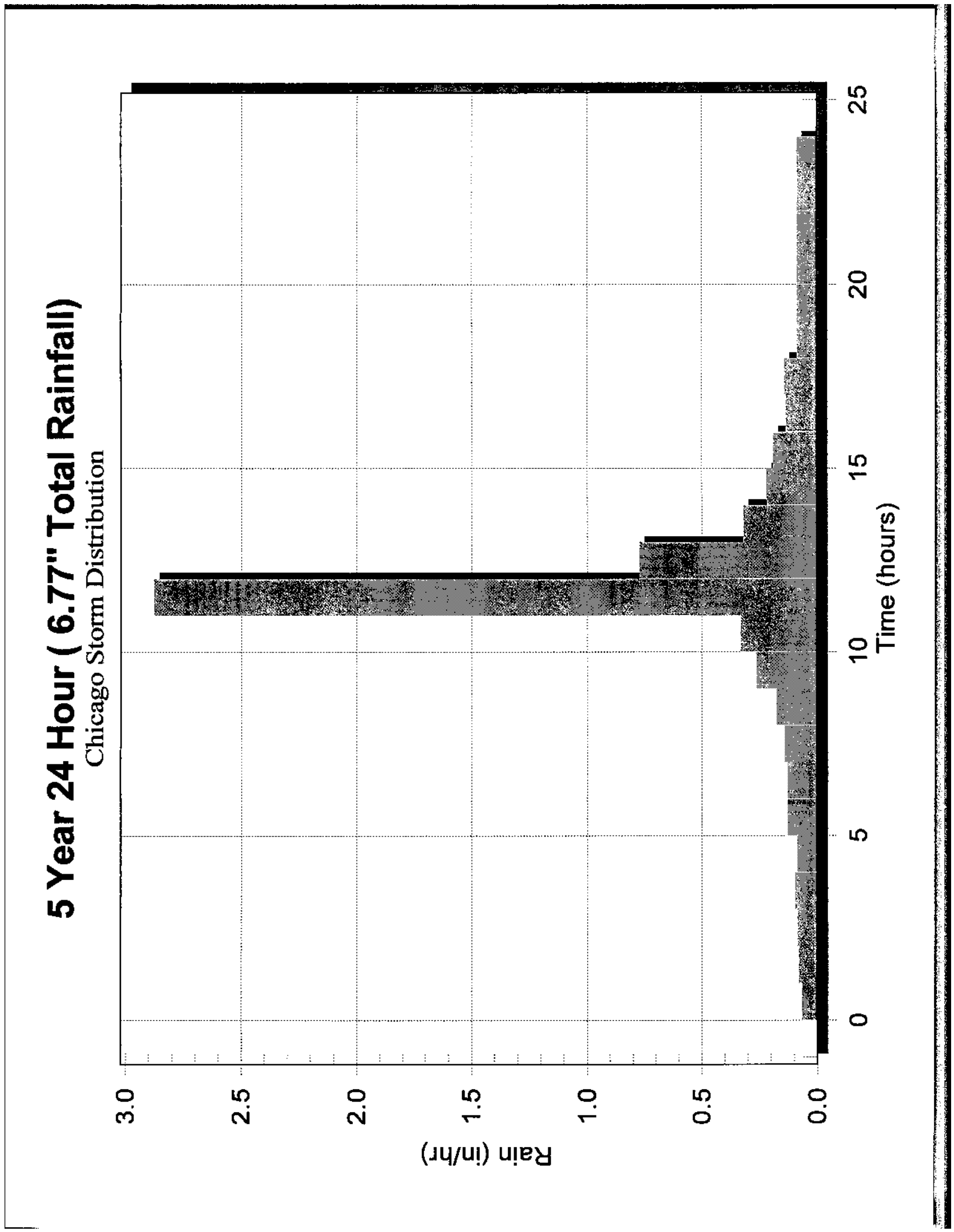

2 Year 24 Hour (4.85" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
25
Time (hours)

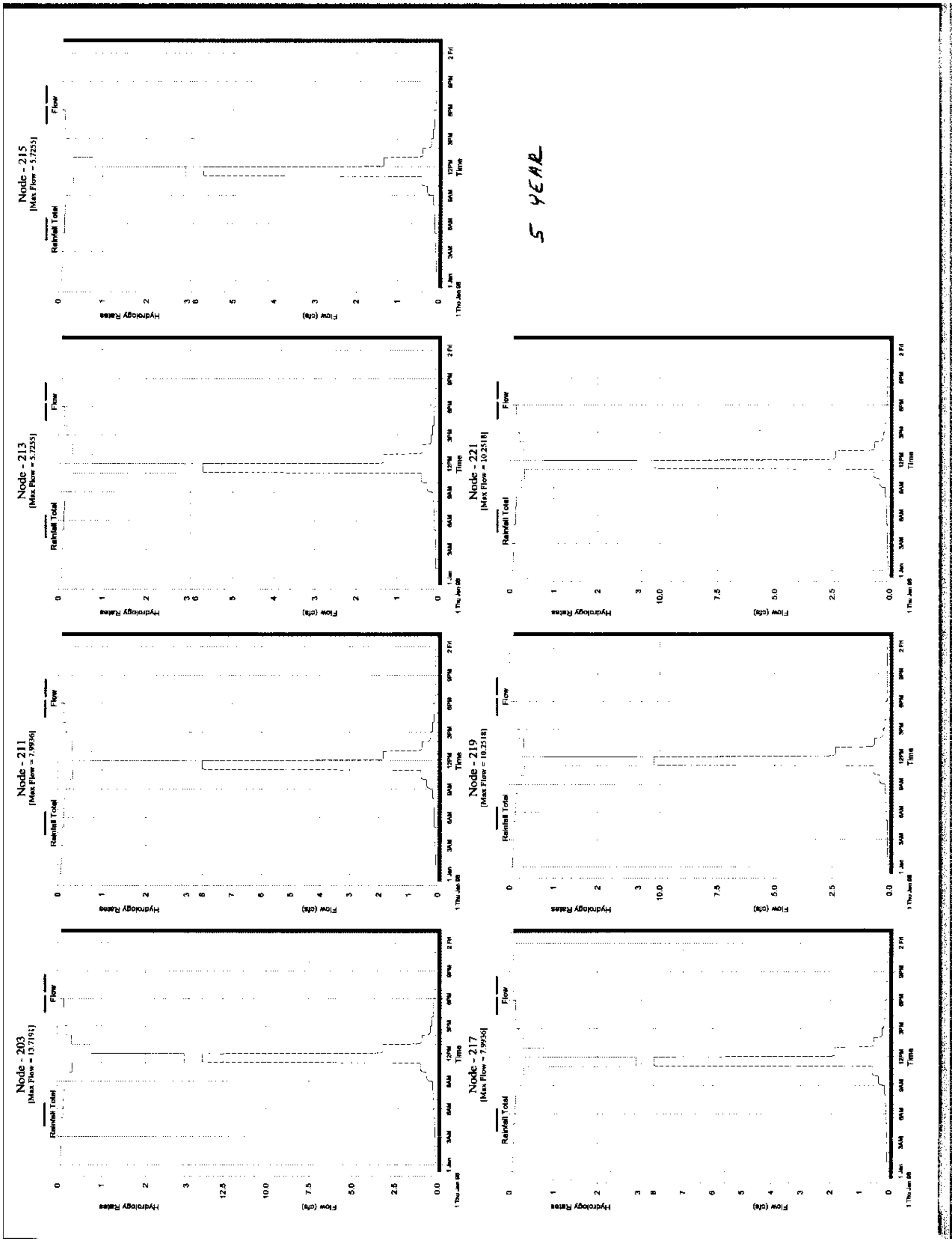


Node - 215
[Max Flow = 4.0223]
Node - 213
[Max Flow = 4.0223]
Node - 211
[Max Flow = 5.6157]
Node - 203
[Max Flow = 9.6380]
Node - 221
[Max Flow = 7.1910]
Node - 219
[Max Flow = 7.1910]
Node - 217
[Max Flow = 5.6157]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
2 YEAR

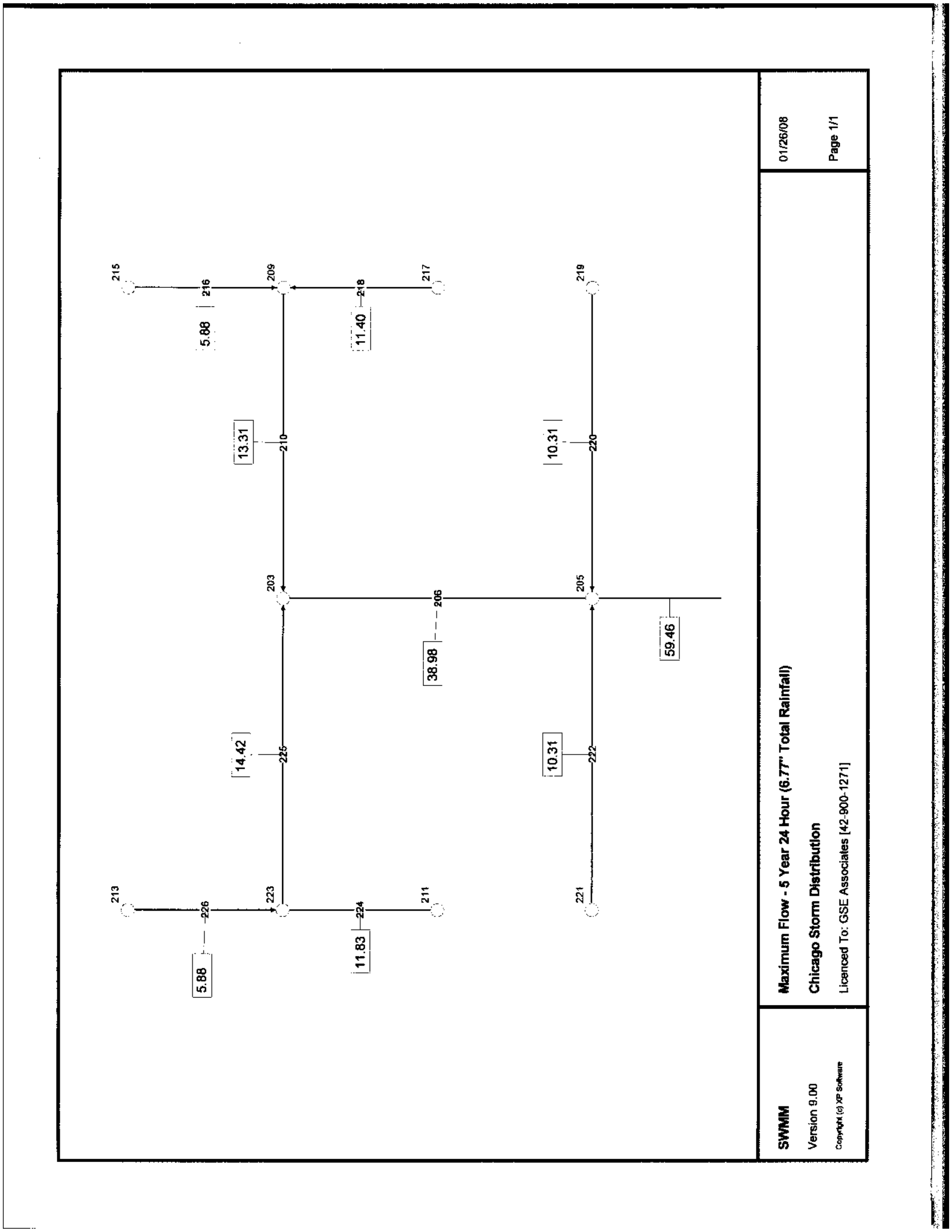


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 2 Year 24 Hour (4.85" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	01/26/08 Page 1/1


5 Year 24 Hour (6.77" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)



Node - 203
[Max Flow = 13.7191]
Node - 211
[Max Flow = 7.9936]
Node - 213
[Max Flow = 5.7255]
Node - 215
[Max Flow = 5.7255]
Node - 217
[Max Flow = 7.9936]
Node - 219
[Max Flow = 10.2518]
Node - 221
[Max Flow = 10.2518]
Rainfall Total
Flow
Time
Hydrology Rates
Flow (cfs)
5 YEAR



Maximum Flow - 5 Year 24 Hour (6.77" Total Rainfall)
Chicago Storm Distribution
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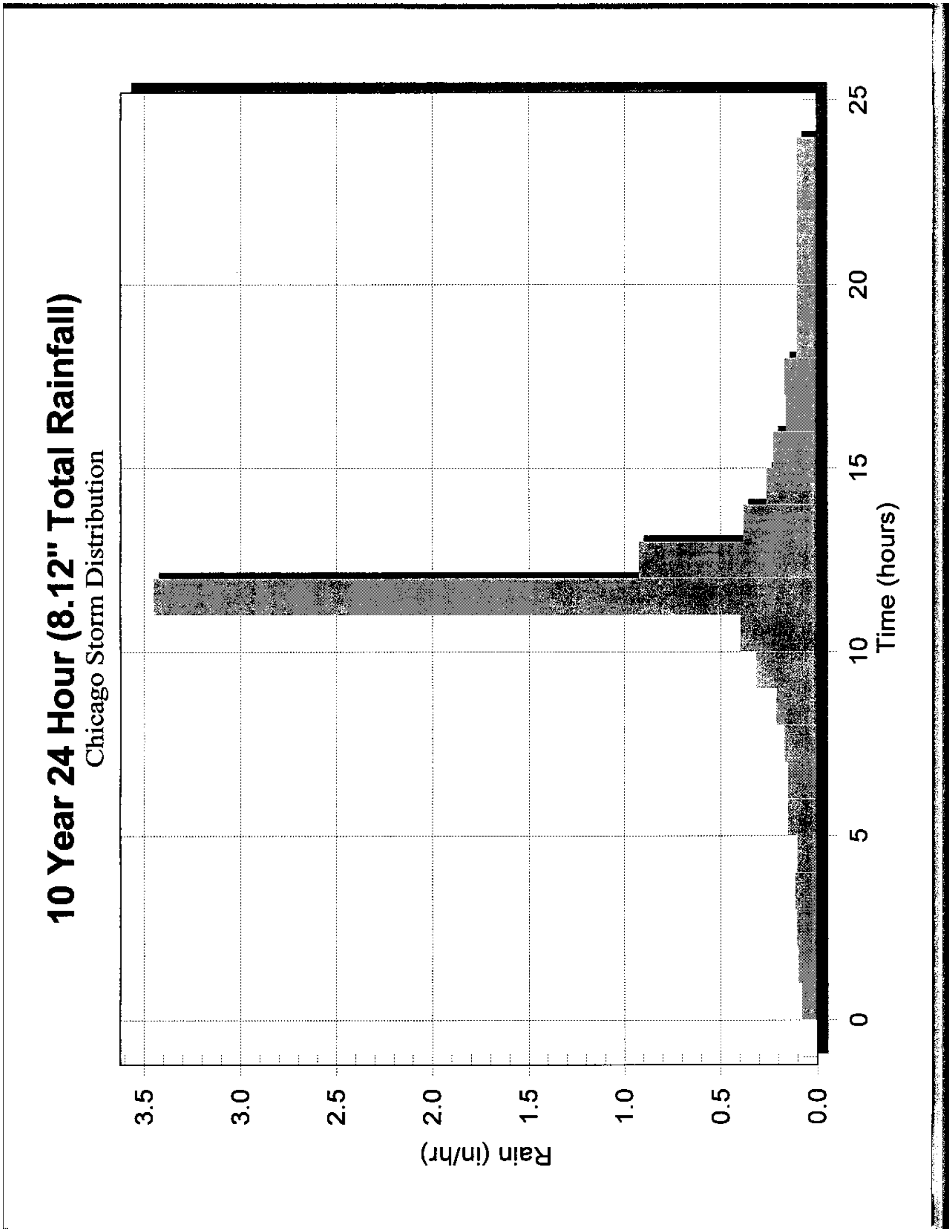
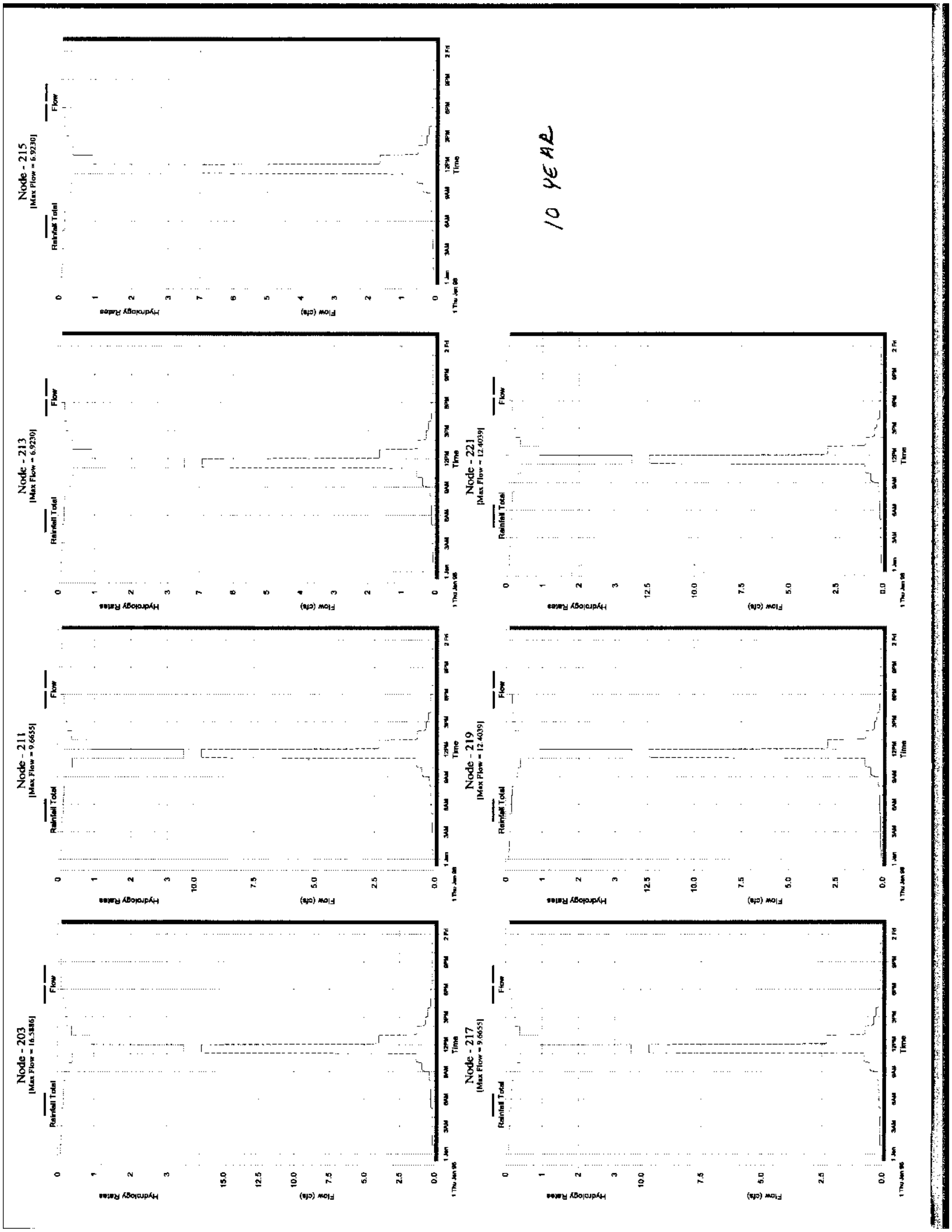
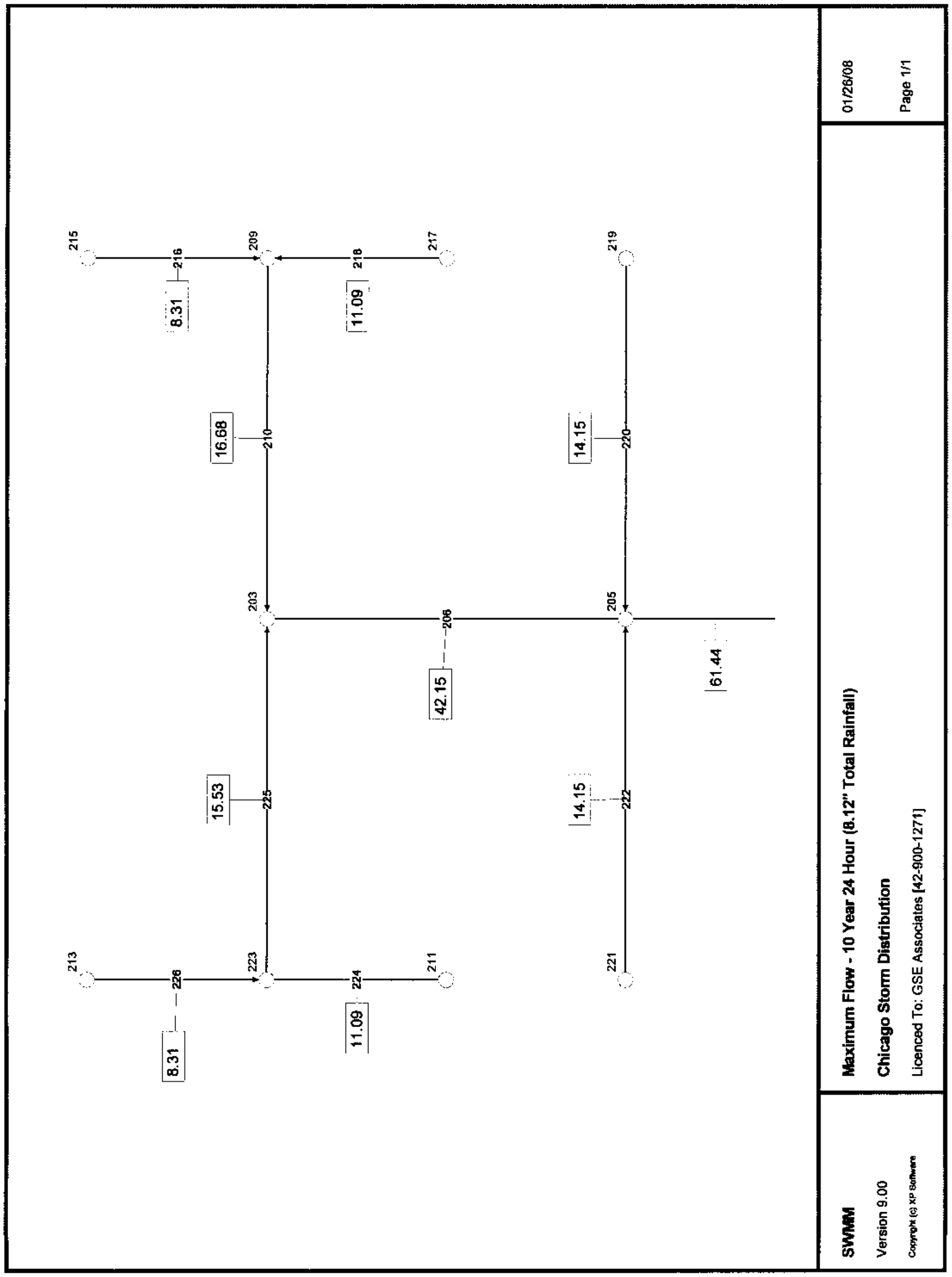
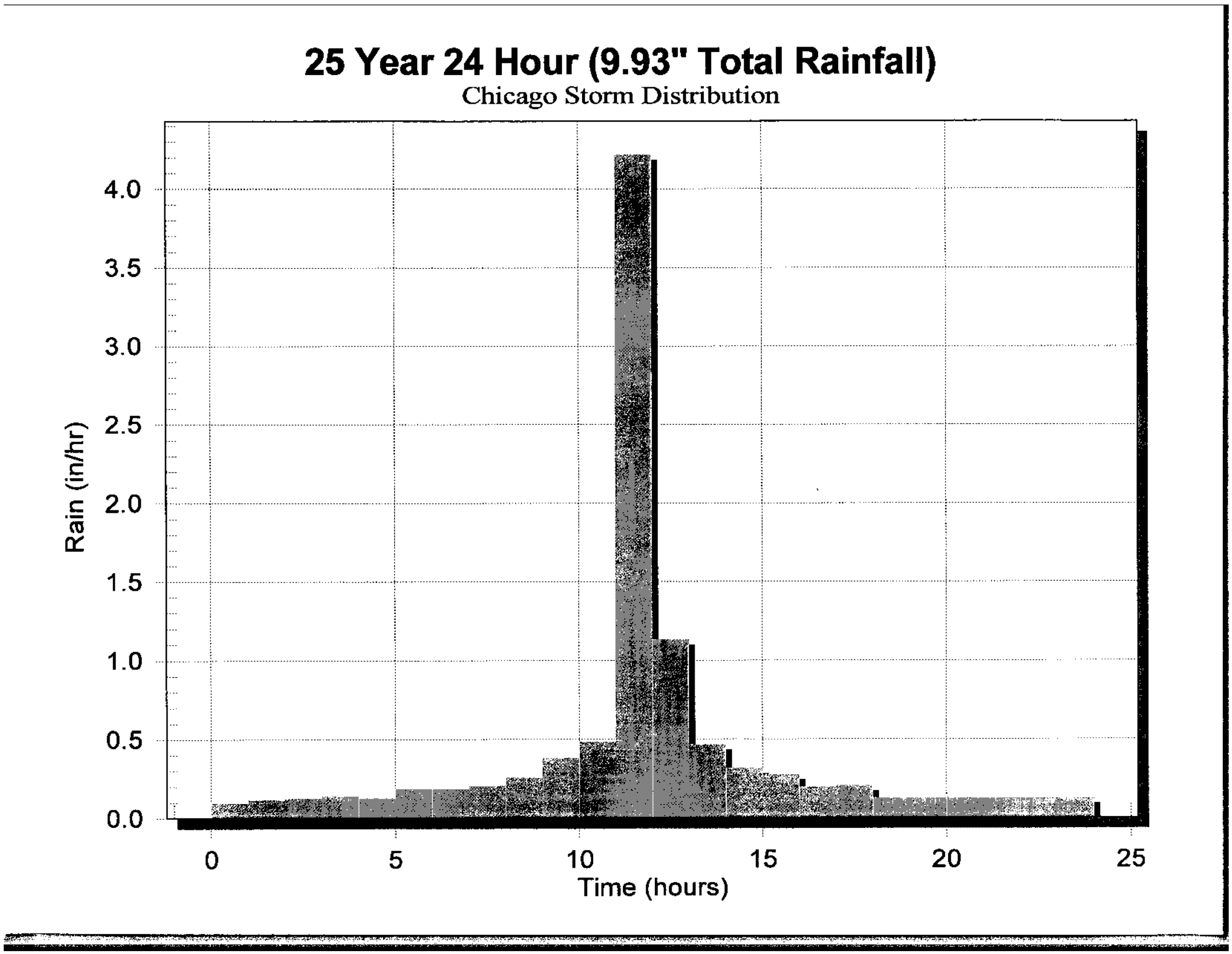
SWMM
Version 9.00
Copyright (c) XP Software
01/26/08
Page 1/1
215
216
5.88
209
218
11.40
217
210
13.31
219
220
10.31
203
206
38.98
205
59.46
225
14.42
222
10.31
213
226
5.88
223
224
11.83
211
221

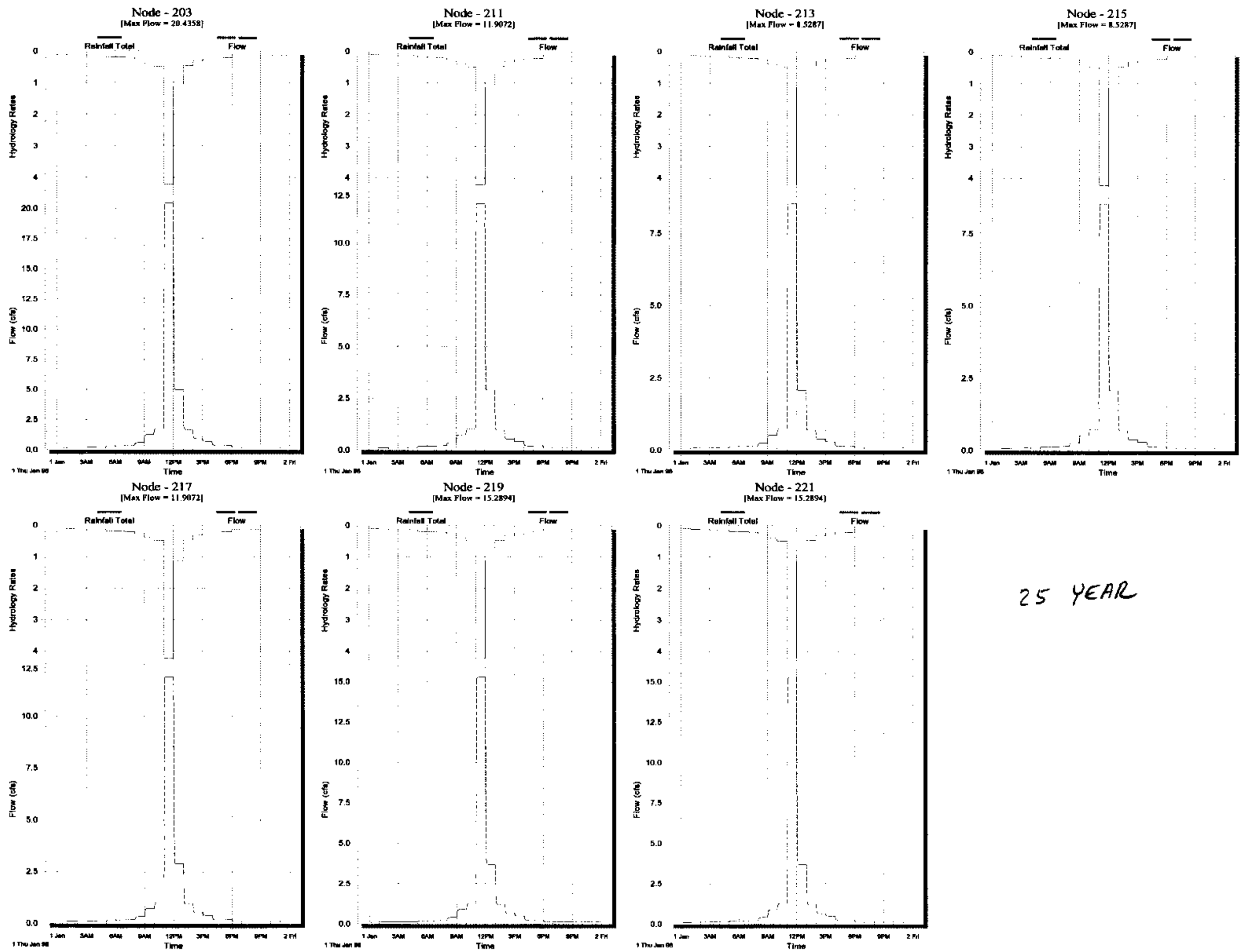


10 Year 24 Hour (8.12" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)


Node - 215
[Max Flow = 6.9230]
Node - 213
[Max Flow = 6.9230]
Node - 211
[Max Flow = 9.6655]
Node - 203
[Max Flow = 16.5886]
Node - 221
[Max Flow = 12.4039]
Node - 219
[Max Flow = 12.4039]
Node - 217
[Max Flow = 9.6655]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
10 YEAR

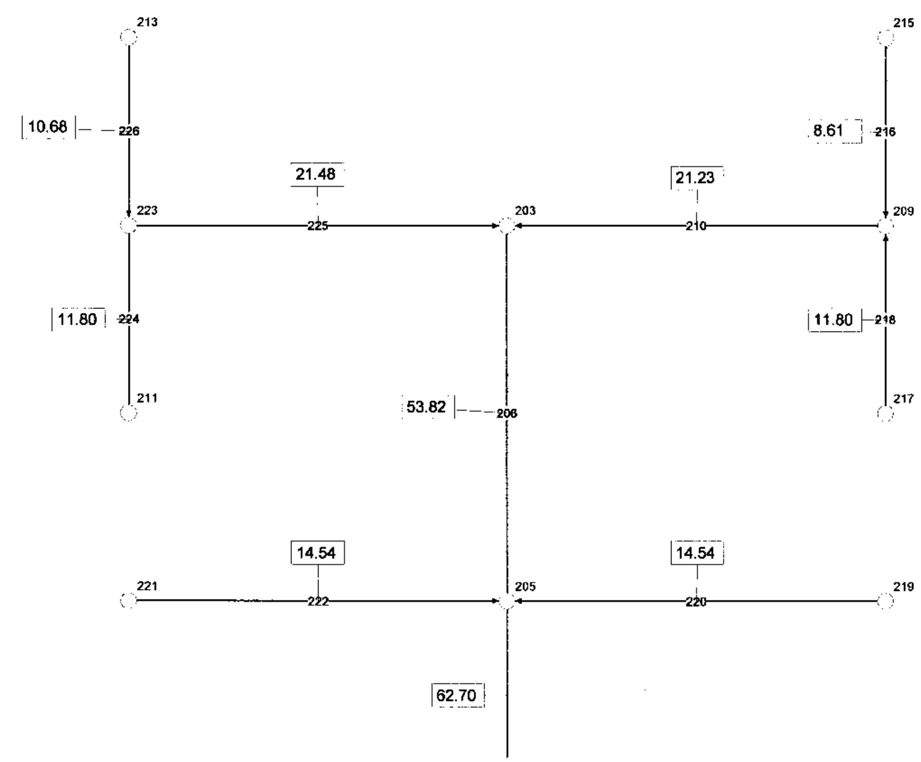

SWMM
Version 9.00
Copyright (c) XP Software
Maximum Flow - 10 Year 24 Hour (8.12" Total Rainfall)
Chicago Storm Distribution
Licenced To: GSE Associates [42-900-1271]
01/26/08
Page 1/1
215
216
209
218
217
219
8.31
11.09
16.68
210
14.15
220
203
206
205
42.15
61.44
15.53
225
14.15
222
213
226
223
224
211
221
8.31
11.09


25 Year 24 Hour (9.93" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

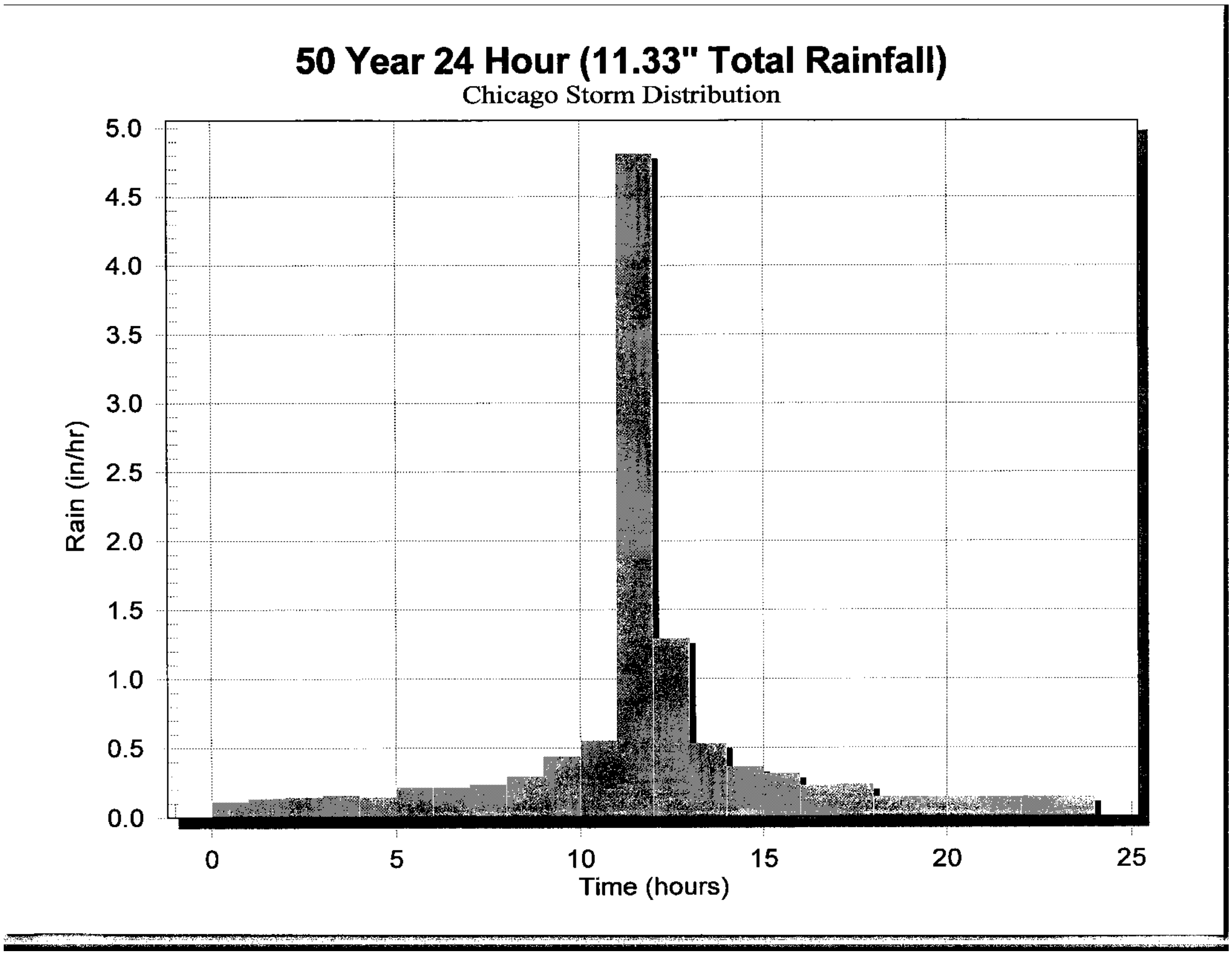


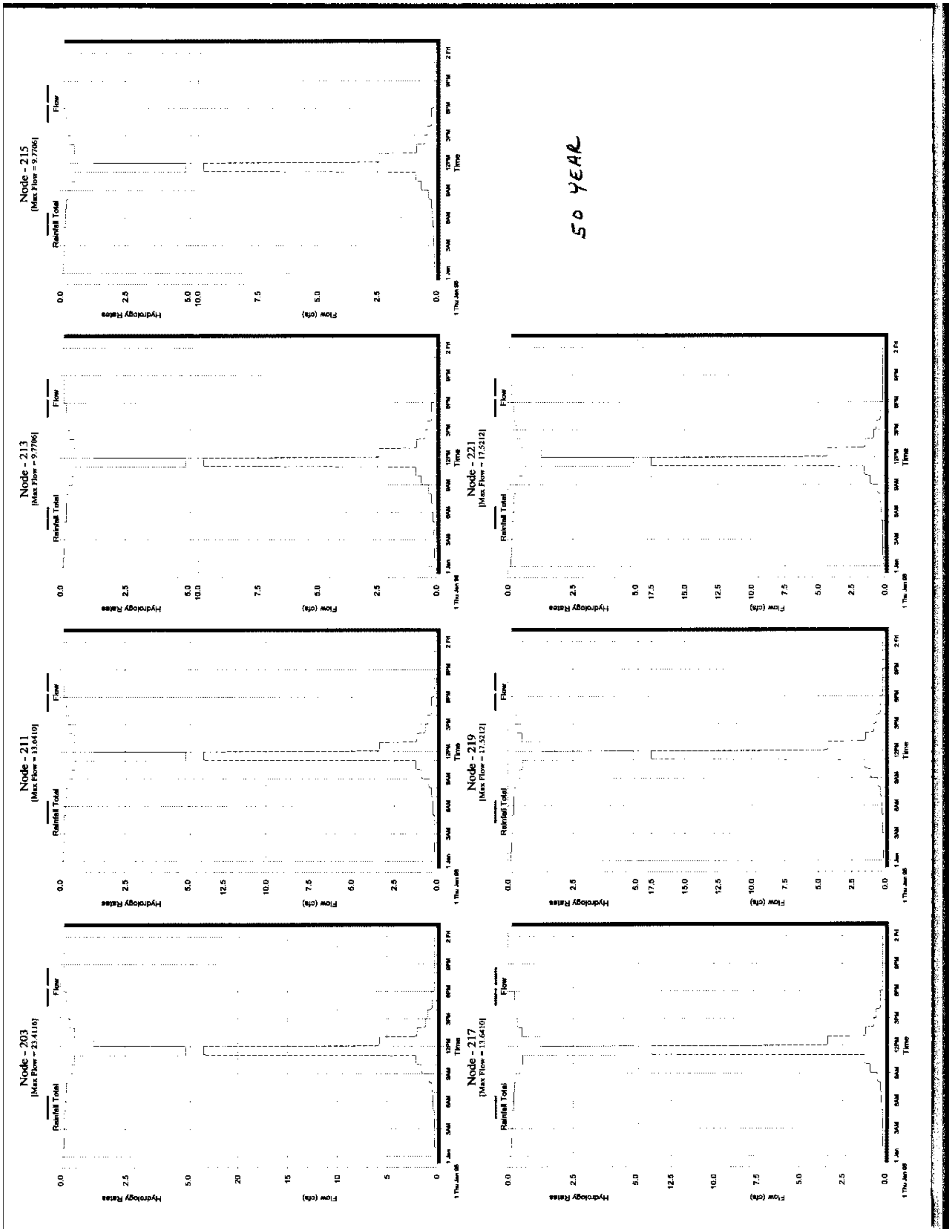
Node - 203
[Max Flow = 20.4358]
Node - 211
[Max Flow = 11.9072]
Node - 213
[Max Flow = 8.5287]
Node - 215
[Max Flow = 8.5287]
Node - 217
[Max Flow = 11.9072]
Node - 219
[Max Flow = 15.2894]
Node - 221
[Max Flow = 15.2894]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time

25 YEAR

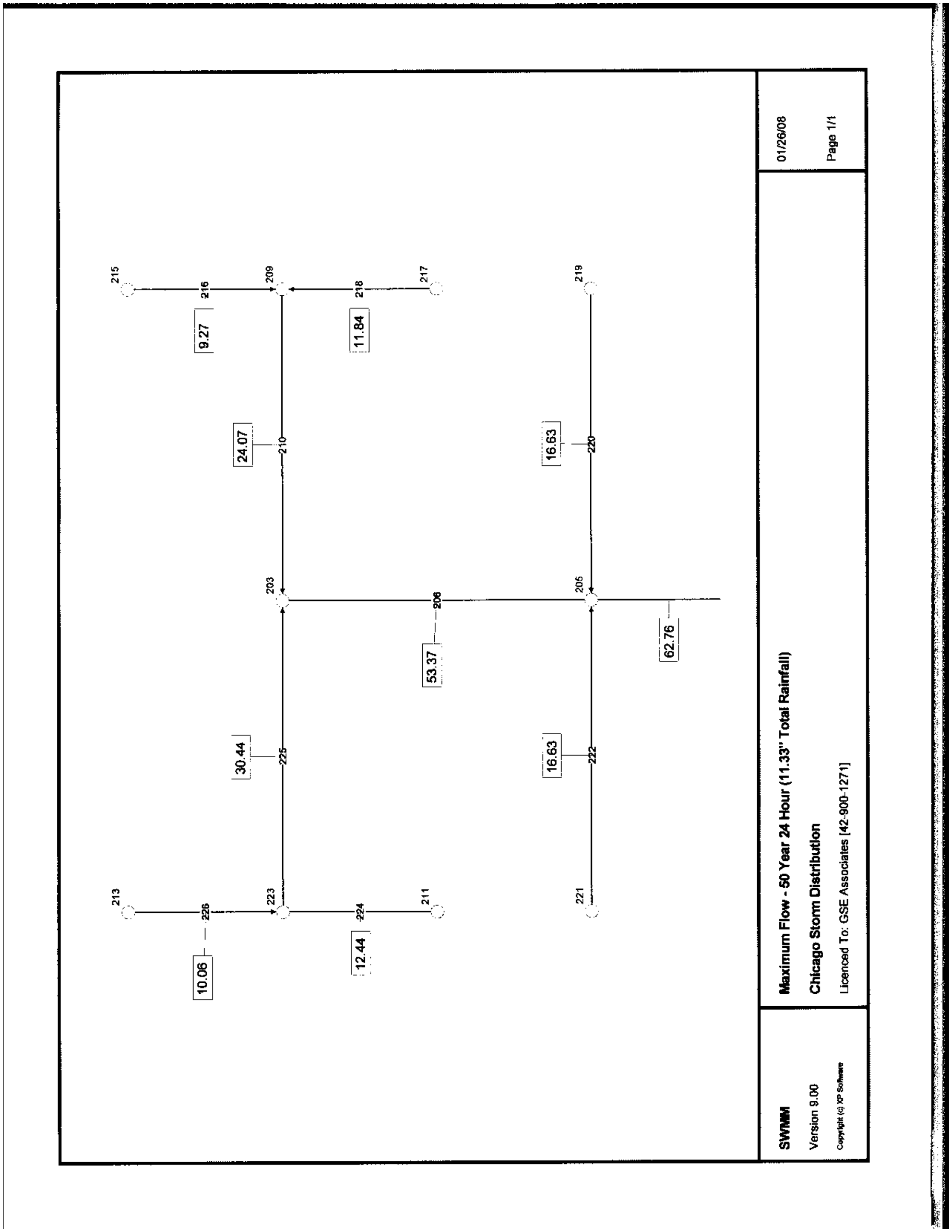


SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 25 Year 24 Hour (9.93" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	01/26/08 Page 1/1


50 Year 24 Hour (11.33" Total Rainfall)
Chicago Storm Distribution
Rain (in/hr)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)



Node - 215
[Max Flow = 9.7706]
Node - 213
[Max Flow = 9.7706]
Node - 211
[Max Flow = 13.6410]
Node - 203
[Max Flow = 23.4116]
Node - 221
[Max Flow = 17.5212]
Node - 219
[Max Flow = 17.5212]
Node - 217
[Max Flow = 13.6410]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
50 YEAR



215
216
209
218
217
9.27
11.84
24.07
210
219
16.63
220
203
206
205
53.37
62.76
30.44
225
16.63
222
213
226
223
224
211
221
10.06
12.44
SWMM
Version 9.00
Copyright (c) XP Software
Maximum Flow - 50 Year 24 Hour (11.33" Total Rainfall)
Chicago Storm Distribution
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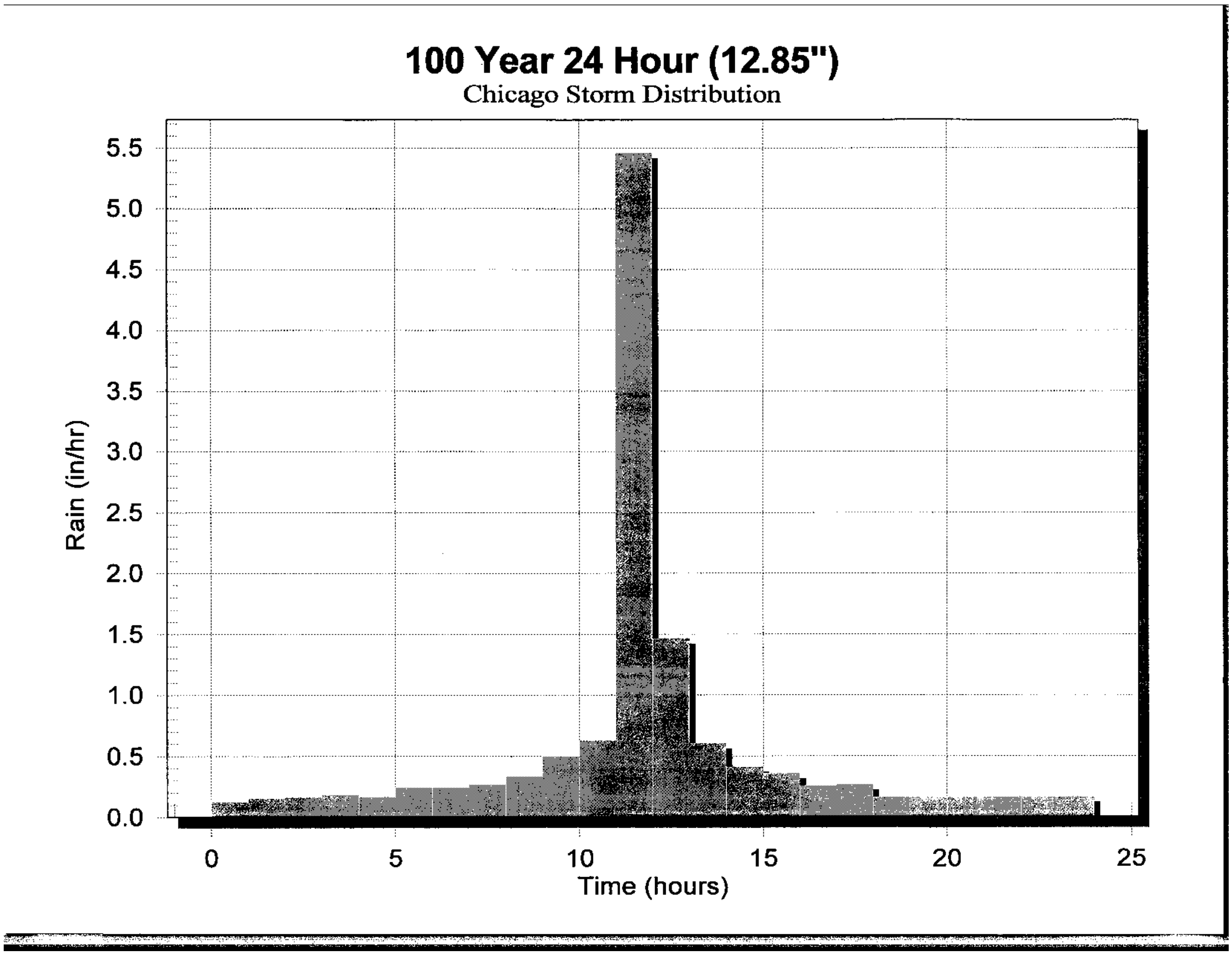
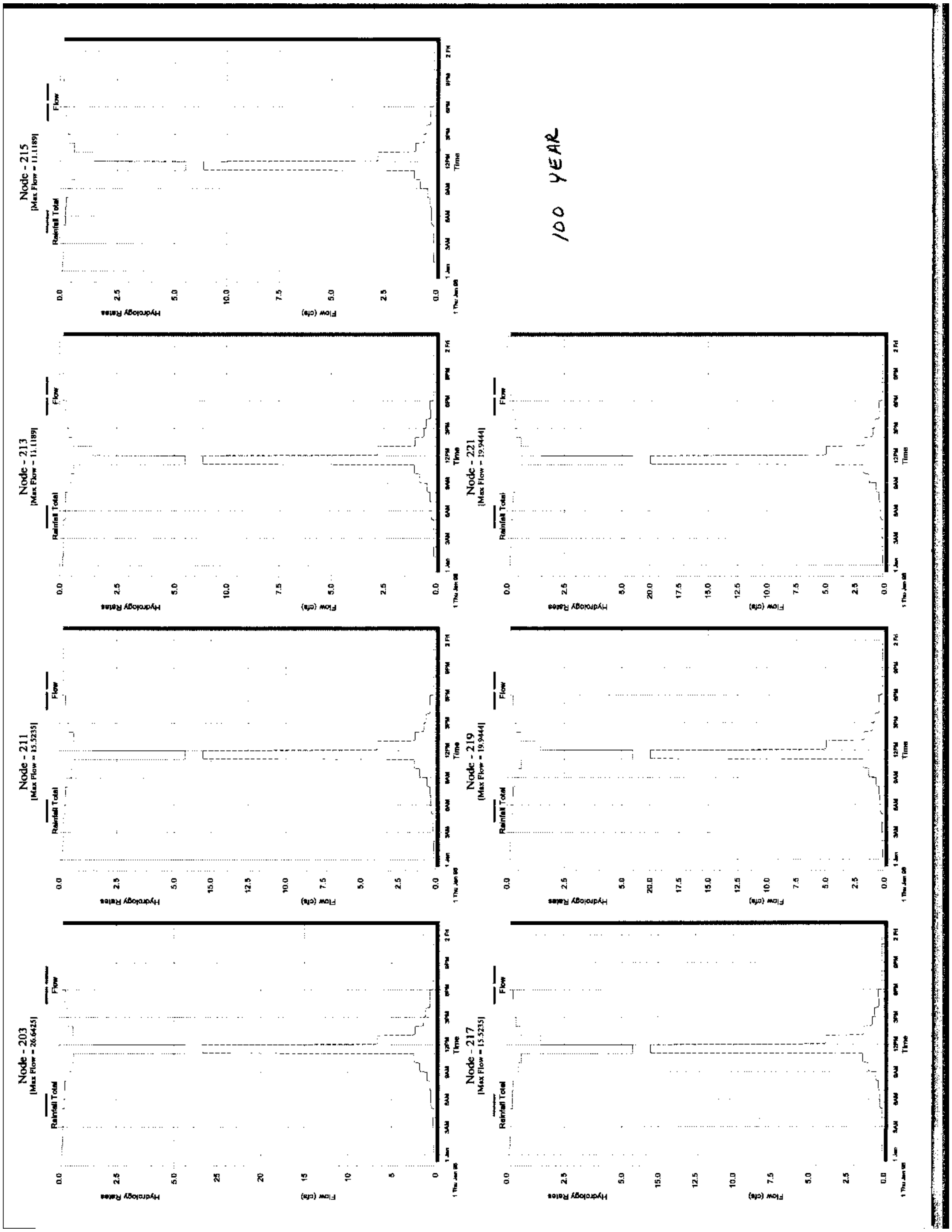
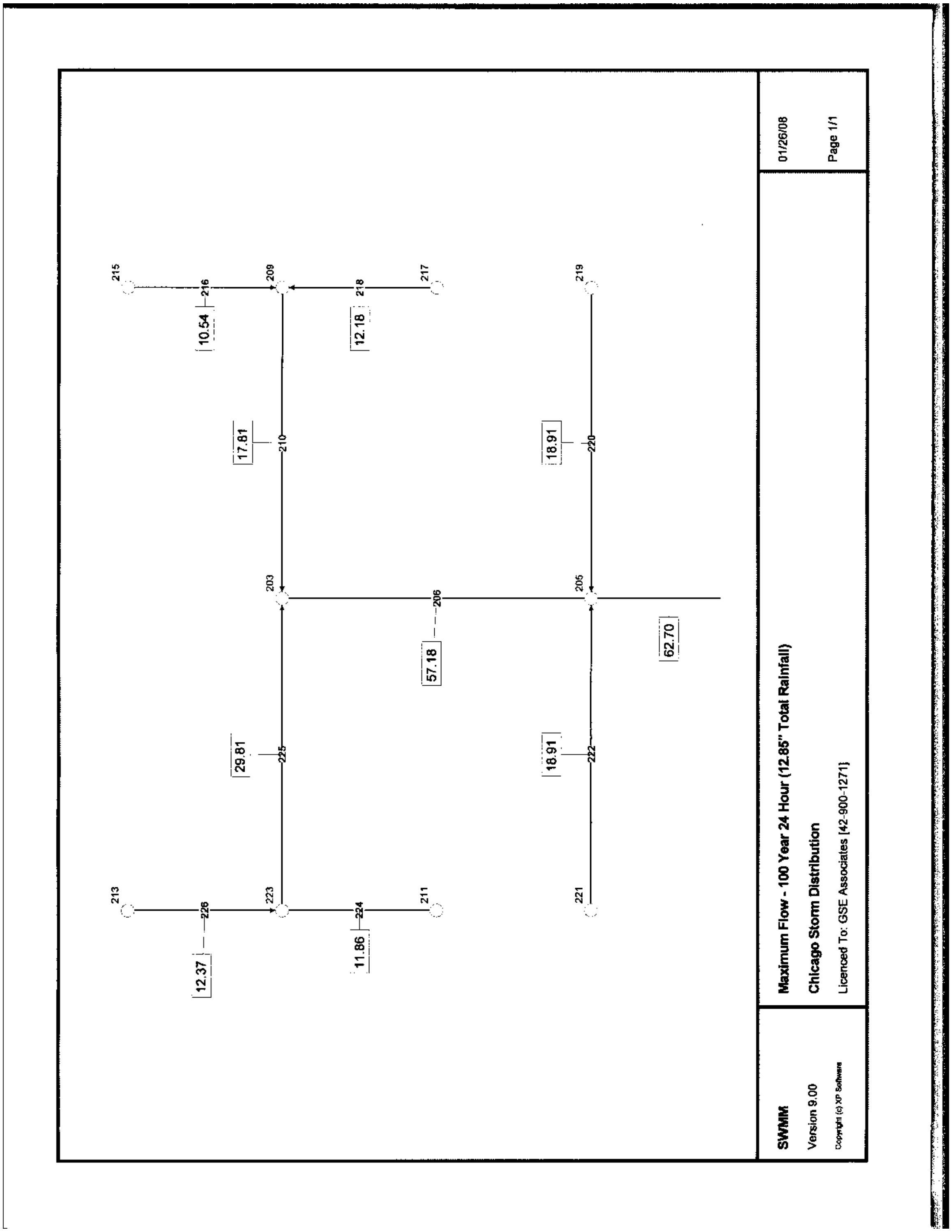
01/26/08
Page 1/1


100 Year 24 Hour (12.85")
Chicago Storm Distribution
Rain (in/hr)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

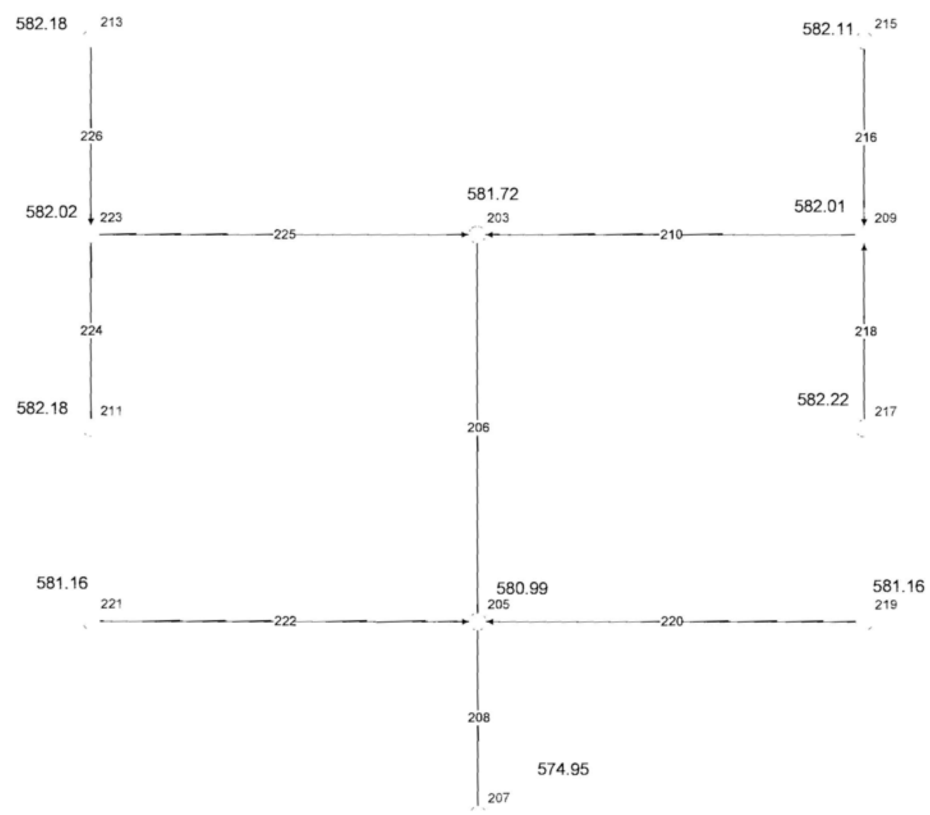


Node - 215
[Max Flow = 11.1189]
Node - 213
[Max Flow = 11.1189]
Node - 211
[Max Flow = 15.5235]
Node - 203
[Max Flow = 26.6425]
Node - 221
[Max Flow = 19.9444]
Node - 219
[Max Flow = 19.9444]
Node - 217
[Max Flow = 15.5235]
Rainfall Total
Flow
Hydrology Rates
Flow (cfs)
Time
100 YEAR

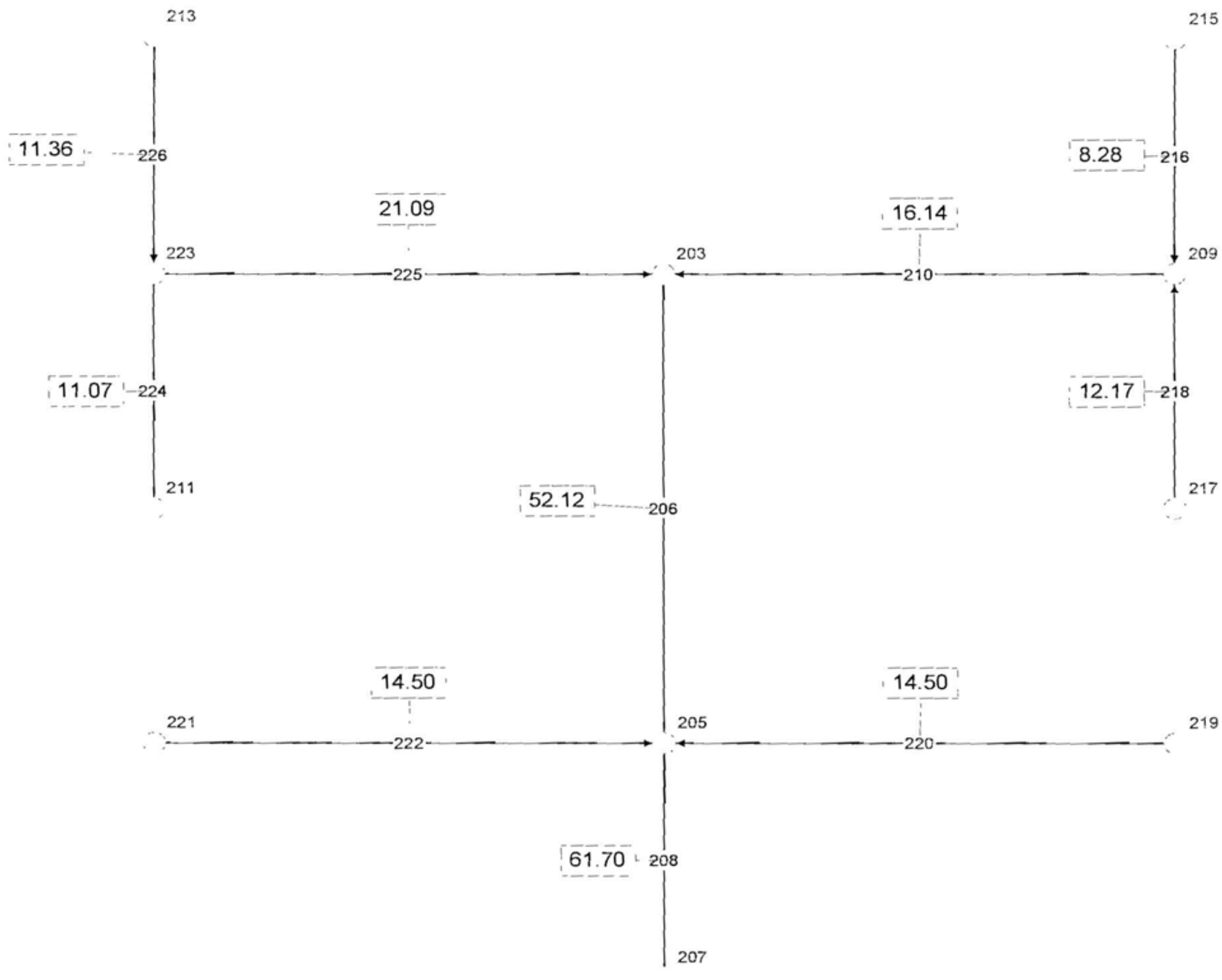


215
216
209
218
217
219
10.54
12.18
17.81
210
18.91
220
203
206
205
57.18
62.70
29.81
225
18.91
222
213
226
223
224
211
221
12.37
11.86
SWMM
Version 9.00
Copyright (c) XP Software
Maximum Flow - 100 Year 24 Hour (12.85" Total Rainfall)
Chicago Storm Distribution
Licenced To: GSE Associates [42-900-1271]
01/26/08
Page 1/1

Appendix D



SWMM Version 9.00 Copyright (c) XP Software	**Maximum Stages - 10 Year 24 Hour (9.2" Total Rainfall)** **Chicago Storm Distribution** Licenced To: GSE Associates [42-900-1271]	10/20/08 Page 1/1



SWMM	**Maximum Flow - 10 Year 24 Hour (9.2" Total Rainfall)**	10/20/08
Version 9.00	**Chicago Storm Distribution**	
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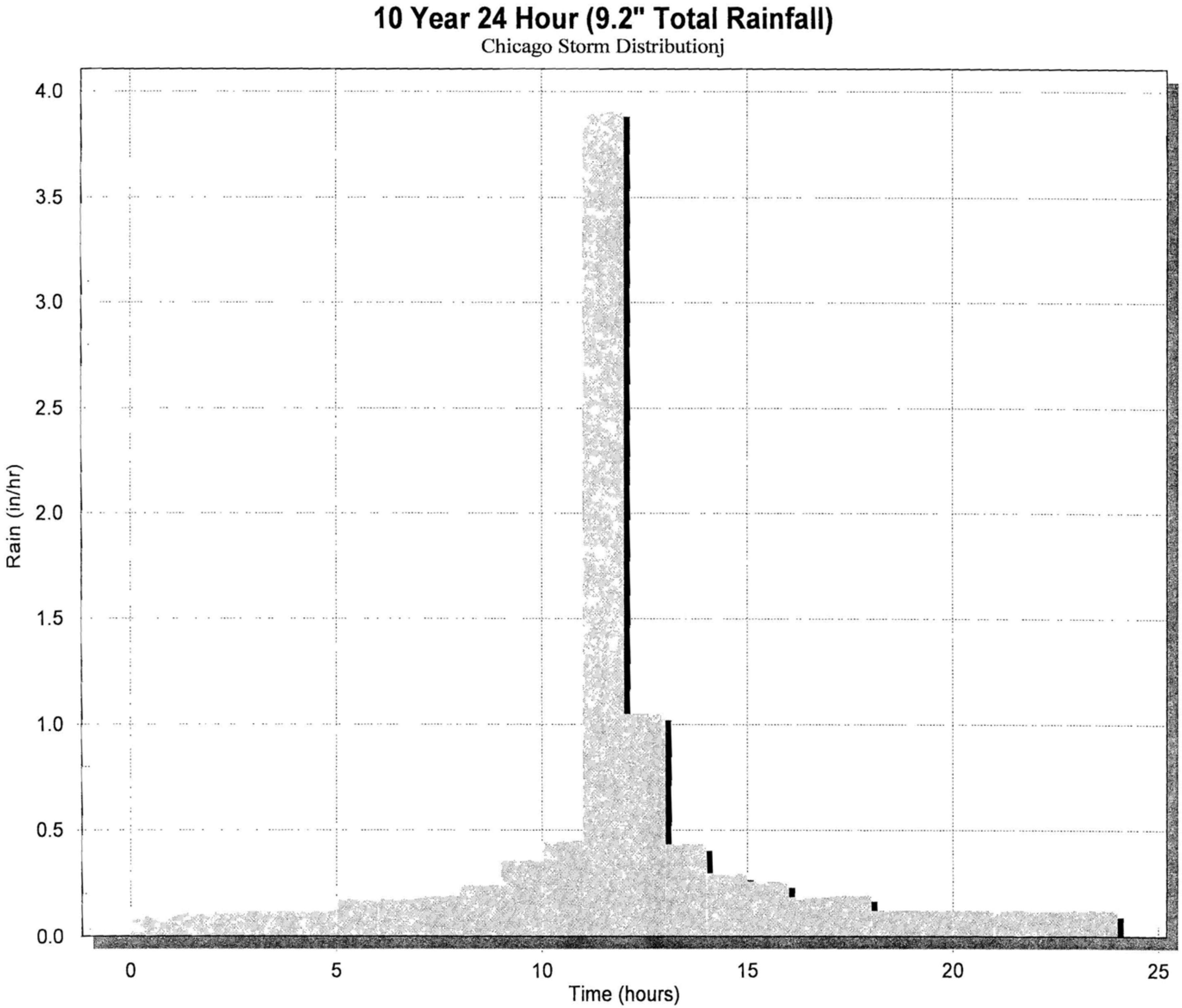

10 Year 24 Hour (9.2" Total Rainfall)
Chicago Storm Distributionj
Rain (in/hr)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Time (hours)

```
Input File : C:\XPSWMM Data\WORK\MACTEST\mac10.XP
Current Directory:   C:\XPS\XP-SWMM
Engine Name: C:\XPS\XP-SWMM\swmmengw.exe
Read      0 line(s) and found    0 items(s) from your cfg file.
          *=============================================*
          |                    XP-SWMM                  |
          |     Storm and Wastewater Management Model   |
          |                 Version 8.87                |
          |=============================================|
          |                 Developed by                |
          |=============================================|
          |                                             |
          |                 XP Software                 |
          |                                             |
          |              Based on the U.S. EPA          |
          |   Storm Water Management Model Version 4.30 |
          |                                             |
          |             Originally Developed by         |
          |              Metcalf & Eddy, Inc.           |
          |             University of Florida           |
          |            Camp Dresser & McKee Inc.        |
          |               September 1970                |
          |                                             |
          |             EPA-SWMM is maintained by       |
          |             Oregon State University         |
          |             Camp Dresser & McKee Inc.       |
          |=============================================|
          |     XP Software      October, 2003          |
          |       Data File Version --->    11.2        |
          *=============================================*


*=========================================================*
|       Input and Output file names by SWMM Layer         |
*=========================================================*

 Input File  to Layer #     1 C:\XPSWMM Data\WORK\MACTEST\mac10.INT

 Output File to Layer #     1 JOT.US


*===========================================================*
|   Special command line arguments in XP-SWMM2000. This     |
|   now includes program defaults. $Keywords are the program|
|   defaults.  Other Keywords are from the SWMMCOM.CFG file.|
|   or the command line or any cfg file on the command line.|
|   Examples include these in the file xpswm.bat under the  |
|   section :solve or in the windows version XPSWMM32 in the|
|   file solve.bat                                          |
|                                                           |
|   Note: the cfg file should be in the subdirectory swmxp  |
|         or defined by the set variable in the xpswm.bat   |
|         file.  Some examples of the command lines possible|
|         are shown below:                                  |
|                                                           |
|   swmmd swmmcom.cfg                                       |
|   swmmd my.cfg                                            |
|   swmmd nokeys nconv5 perv extranwq                       |
*===========================================================*

    $powerstation       0.0000         1         2
    $perv               0.0000         0         4
    $oldegg             0.0000         0         7
    $as                 0.0000         0        11
    $noflat             0.0000         0        21
    $oldomega           0.0000         0        24
    $oldvol             0.0000         1        28
```

```
   $implicit              0.0000         1        29
   $oldhot                0.0000         1        31
   $oldscs                0.0000         0        33
   $flood                 0.0000         1        40
   $nokeys                0.0000         0        42
   $pzero                 0.0000         0        55
   $oldvol2               0.0000         2        59
   $storage2              0.0000         3        62
   $oldhot1               0.0000         1        63
   $pumpwt                0.0000         1        70
   $ecloss                0.0000         1        77
   $exout                 0.0000         0        97
   $djref = -0.1         -0.1000         3       143
   $weirlen = 50         50.0000         1       153
   $oldbnd                0.0000         1       154
   $nogrelev              0.0000         1       161
   $ncmid                 0.0000         0       164
   $new_nl_97             0.0000         2       290
   $best97                0.0000         1       294
   $newbound              0.0000         1       295
   $q_tol = 0.1           0.0010         1       316
   $new_storage           0.0000         1       322
   $old_iteration         0.0000         1       333
   $minlen=30.0          30.0000         1       346
   $review_elevatio       0.0000         1       383
   $use_half_volume       0.0000         1       385
   $min_ts = 0.5          0.5000         1       407

*=========================================================*
| Parameter Values on the Tapes Common Block.These are the |
| values read from the data file and dynamically allocated |
| by the model for this simulation.                        |
*=========================================================*

 Number of Subcatchments in the Runoff Block (NW)....      0
 Number of Channel/Pipes in the Runoff Block (NG)....      0
 Runoff Water quality constituents (NRQ).............      0
 Runoff Land Uses per Subcatchment (NLU).............      0
 Number of Elements in the Transport Block (NET).....      0
 Number of Storage Junctions in Transport (NTSE).....      0
 Number of Input Hydrographs in Transport (NTH)......      0
 Number of Elements in the Extran Block (NEE)........     11
 Number of Groundwater Subcatchments in Runoff (NGW).      0
 Number of Interface locations for all Blocks (NIE)..     11
 Number of Pumps in Extran (NEP).....................      0
 Number of Orifices in Extran (NEO)..................      0
 Number of Tide Gates/Free Outfalls in Extran (NTG)..      1
 Number of Extran Weirs (NEW)........................      0
 Number of scs hydrograph points.....................      1
 Number of Extran printout locations (NPO)...........      3
 Number of Tide elements in Extran (NTE).............      1
 Number of Natural channels (NNC)....................      0
 Number of Storage junctions in Extran (NVSE)........      0
 Number of Time history data points in Extran(NTVAL).      0
 Number of Variable storage elements in Extran (NVST)      0
 Number of Input Hydrographs in Extran (NEH).........      0
 Number of Particle sizes in Transport Block (NPS)...      0
 Number of User defined conduits (NHW)...............     11
 Number of Connecting conduits in Extran (NECC)......     20
 Number of Upstream elements in Transport (NTCC).....     10
 Number of Storage/treatment plants (NSTU)...........      0
 Number of Values for R1 lines in Transport (NR1)....      0
 Number of Nodes to be allowed for (NNOD)............     11
 Number of Plugs in a Storage Treatment Unit.........      1


#####################################################
```

```
#    Entry made to the HYDRAULIC Layer(Block) of SWMM #
#    Last Updated October,2000 by XP Software         #

   Maximum Flow - 10 Year 24 Hour (9.2" Total Rainfall)
   Chicago Storm Distribution


*=========================================================*
|       HYDRAULICS TABLES IN THE OUTPUT FILE              |
|  These are the more important tables in the output file.|
|  You can use your editor to find the table numbers,     |
|  for example: search for Table E20 to check continuity. |
|  This output file can be imported into a Word Processor |
|  and printed on US letter or A4 paper using portrait    |
|  mode, courier font, a size of 8 pt. and margins of 0.75|
|                                                         |
| Table E1   - Basic Conduit Data                         |
| Table E2   - Conduit Factor Data                        |
| Table E3a  - Junction Data                              |
| Table E3b  - Junction Data                              |
| Table E4   - Conduit Connectivity Data                  |
| Table E4a  - Dry Weather Flow Data                      |
| Table E4b  - Real Time Control Data                     |
| Table E5   - Junction Time Step Limitation Summary      |
| Table E5a  - Conduit Explicit Condition Summary         |
| Table E6   - Final Model Condition                      |
| Table E7   - Iteration Summary                          |
| Table E8   - Junction Time Step Limitation Summary      |
| Table E9   - Junction  Summary  Statistics              |
| Table E10  - Conduit   Summary  Statistics              |
| Table E11  - Area assumptions used in the analysis      |
| Table E12  - Mean conduit information                   |
| Table E13  - Channel losses(H) and culvert info         |
| Table E13a - Culvert Analysis Classification            |
| Table E14  - Natural Channel Overbank Flow Information  |
| Table E14a - Natural Channel Encroachment Information   |
| Table E14b - Floodplain Mapping                         |
| Table E15  - Spreadsheet Info List                      |
| Table E15a - Spreadsheet Reach List                     |
| Table E16  - New Conduit Output Section                 |
| Table E17  - Pump Operation                             |
| Table E18  - Junction Continuity Error                  |
| Table E19  - Junction Inflow Sources                    |
| Table E20  - Junction Flooding and Volume List          |
| Table E21  - Continuity balance at simulation end       |
| Table E22  - Model Judgement Section                    |
*=========================================================*

Time Control from Hydraulics Job Control
Year.........    1998 Month.......       1
Day..........       1 Hour........       0
Minute.......       0 Second......       0


Control information for simulation
----------------------------------

Integration cycles.................      1440
Length of integration step is......     60.00 seconds
Simulation length..................     24.00 hours
Do not create equiv. pipes(NEQUAL).         0
Use U.S. customary units for I/O...         0
Printing starts in cycle...........         1
Intermediate printout intervals of.       500 cycles
Intermediate printout intervals of.    500.00 minutes
Summary printout intervals of......       500 cycles
Summary printout time interval of..    500.00 minutes
```

```
Hot start file parameter (REDO)....        0
Initial time......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00001
                     Head Tolerance.   0.00001
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.65000
    Time weighting parameter........   0.65000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         1
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     13.00 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............  50000.00
Ponding Area Exponent...............    5.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....     0
     or user defined hydrographs....

Water surface elevations will be plotted for the following   3 Junctions

    203        213        223
```

```
*=================================================*
|          Table E1 - Conduit Data                |
*=================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes
1	206	500.0000	Circular	12.5664	0.0150	4.0000	4.0000	
2	208	180.0000	Circular	4.9087	0.0150	2.5000	2.5000	
3	210	360.0000	Circular	7.0686	0.0150	3.0000	3.0000	
4	216	250.0000	Circular	1.7671	0.0150	1.5000	1.5000	
5	218	350.0000	Circular	1.7671	0.0150	1.5000	1.5000	
6	220	500.0000	Circular	3.1416	0.0150	2.0000	2.0000	
7	222	500.0000	Circular	3.1416	0.0150	2.0000	2.0000	
8	224	350.0000	Circular	1.7671	0.0150	1.5000	1.5000	
9	225	360.0000	Circular	7.0686	0.0150	3.0000	3.0000	
10	226	250.0000	Circular	1.7671	0.0150	1.5000	1.5000	

```
Total length of all conduits ....      3600.0000 feet

*=================================================*
| If there are messages about (sqrt(g*d)*dt/dx), or |
| the sqrt(wave celerity)*time step/conduit length  |
| in the output file all it means is that the       |
| program will lower the internal time step to      |
| satisfy this condition (explicit condition).      |
```

```
| You control the actual internal time step by       |
| using the minimum courant time step factor in the  |
| HYDRAULICS job control.  The message put in words  |
| states that the smallest conduit with the fastest  |
| velocity will control the time step selection.     |
| You have further control by using the modify       |
| conduit option in the HYDRAULICS Job Control.      |
*====================================================*
```

Conduit Name	Courant Ratio	
206	1.36	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
208	2.99	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
210	1.64	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
216	1.67	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
218	1.19	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
220	0.96	
222	0.96	
224	1.19	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
225	1.64	===> Warning ! (sqrt(wave celerity)*time step/conduit length)
226	1.67	===> Warning ! (sqrt(wave celerity)*time step/conduit length)

```
*==================*
|  Conduit Volume  |
*==================*
```

Full pipe or full open conduit volume
Input full depth volume............ 1.7518E+04 cubic feet

```
*====================================================*
|           Table E3a - Junction Data                |
*====================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	203	581.7000	581.7000	573.7000	0.0000	0.0000	100.0000
2	205	581.0000	581.0000	573.0000	0.0000	0.0000	100.0000
3	207	580.5000	580.5000	572.5000	0.0000	0.0000	100.0000
4	209	582.0000	582.0000	574.0000	0.0000	0.0000	100.0000
5	211	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
6	213	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
7	215	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
8	217	582.0000	582.0000	574.7000	0.0000	0.0000	100.0000
9	219	581.0000	581.0000	574.0000	0.0000	0.0000	100.0000
10	221	581.0000	581.0000	574.0000	0.0000	0.0000	100.0000

11	223	582.0000	582.0000	574.0000	0.0000	0.0000	100.0000

```
*==================================================*
|          Table E3b - Junction Data                |
*==================================================*
```

Inp Num	Pavement Shape	Slope	Junction Name	X Coord.	Y Coord.	Type of Manhole	Type of Inlet	Maximum Capacity
1	0	0.0000	203	55.0000	480.0000	Flooded	Normal	
2	0	0.0000	205	55.0000	470.0000	Flooded	Normal	
3	0	0.0000	207	55.0000	465.0000	Flooded	Normal	
4	0	0.0000	209	65.0000	480.0000	Flooded	Normal	
5	0	0.0000	211	45.0000	475.0000	Flooded	Normal	
6	0	0.0000	213	45.0000	485.0000	Flooded	Normal	
7	0	0.0000	215	65.0000	485.0000	Flooded	Normal	
8	0	0.0000	217	65.0000	475.0000	Flooded	Normal	
9	0	0.0000	219	65.0000	470.0000	Flooded	Normal	
10	0	0.0000	221	45.0000	470.0000	Flooded	Normal	
11	0	0.0000	223	45.0000	480.0000	Flooded	Normal	

```
*==================================================*
|          Table E4 - Conduit Connectivity          |
*==================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	206	203	205	573.7000	573.0000	No Design
2	208	205	207	573.0000	572.5000	No Design
3	210	209	203	574.0000	573.7000	No Design
4	216	215	209	574.5000	574.0000	No Design
5	218	217	209	574.7000	574.0000	No Design
6	220	219	205	574.0000	573.0000	No Design
7	222	221	205	574.0000	573.0000	No Design
8	224	211	223	574.7000	574.0000	No Design
9	225	223	203	574.0000	573.7000	No Design
10	226	213	223	574.5000	574.0000	No Design

```
*===============================================*
|    TIDE GATE OUTFALL DATA (DATA GROUP I2)    |
|      BOUNDARY CONDITION ON DATA GROUP J1     |
*===============================================*

Outfall at junction... 207        has boundary condition number...          1


*==================================================*
|        INTERNAL CONNECTIVITY INFORMATION         |
*==================================================*

        CONDUIT          JUNCTION         JUNCTION
---------------- ---------------- ----------------
       GATE # 1              207        BOUNDARY

*=====================================================*
|         Boundary Condition Information              |
|                Data Groups J1-J4                    |
*=====================================================*


BC NUMBER..         1 Control water surface elevation is..    572.00 feet.


###########################################
# Header information from interface file: #
###########################################

Title from first computational layer:
Maximum Flow - 10 Year 24 Hour (9.2" Total Rainfall)


Title from immediately preceding computational layer
Maximum Flow - 10 Year 24 Hour (9.2" Total Rainfall)


Name of preceding layer:................        Runoff Layer
Initial Julian date (IDATEZ).....................  1998001
Initial time of day in seconds (TZERO)...........      0.0
No. Transfered input locations...................        7
No. Transfered pollutants........................        0
Size of total catchment area (acres).............    22.32

#################################################
# Element numbers of interface inlet locations: #
#################################################

 215             217              211              213              203
219             221

Conversion factor to cfs for flow units on interface file.  Multiply by:     1.00000

######## Important Information ########
Start date/time of interface file was.. 1998001    0.0000 hours
Start date/time of the simulation was.. 1998001    0.0000 hours
Same date/time found in interface file and model

*=====================================================*
|             XP Note Field Summary                   |
*=====================================================*



*================================*
|   Conduit Convergence Criteria  |
```

================================

Conduit Name	Full Flow	Conduit Slope
206	46.5802	0.0014
208	18.7355	0.0028
210	16.6869	0.0008
216	4.0713	0.0020
218	4.0713	0.0020
220	8.7681	0.0020
222	8.7681	0.0020
224	4.0713	0.0020
225	16.6869	0.0008
226	4.0713	0.0020

```
*================================*
|    Initial Model Condition     |
| Initial Time =      0.02 hours |
*================================*

      Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
           203/   0.00 /   573.70                205/   0.00 /   573.00
207/   0.00 /   572.50
           209/   0.00 /   574.00                211/   0.00 /   574.50
213/   0.00 /   574.50
           215/   0.00 /   574.50                217/   0.00 /   574.70
219/   0.00 /   574.00
           221/   0.00 /   574.00                223/   0.00 /   574.00

         Conduit/       FLOW    ===> "*" Conduit uses the normal flow option.
             206/       0.00                208/        0.00                210/        0.00
             216/       0.00                218/        0.00                220/        0.00
             222/       0.00                224/        0.00                225/        0.00
             226/       0.00            GATE # 1/       0.00

         Conduit/   Velocity
             206/       0.00                208/        0.00                210/        0.00
             216/       0.00                218/        0.00                220/        0.00
             222/       0.00                224/        0.00                225/        0.00
             226/       0.00

         Conduit/ Cross Sectional Area
             206/       0.00                208/        0.00                210/        0.00
             216/       0.00                218/        0.00                220/        0.00
             222/       0.00                224/        0.00                225/        0.00
             226/       0.00

         Conduit/ Hydraulic Radius
             206/       0.00                208/        0.00                210/        0.00
             216/       0.00                218/        0.00                220/        0.00
             222/       0.00                224/        0.00                225/        0.00
             226/       0.00

         Conduit/ Upstream/ Downstream Elevation
             206/   573.00/   573.00             208/   572.50/   572.50
210/   573.70/   573.70
```

```
            216/   574.00/   574.00              218/   574.00/   574.00
220/   573.00/   573.00
            222/   573.00/   573.00              224/   574.00/   574.00
225/   573.70/   573.70
            226/   574.00/   574.00

 ===> System inflows (file) at     8.33 hours (  Junction / Inflow, cfs)

 215       / 2.18E-01 217       / 3.01E-01 211       / 3.01E-01 213       / 2.18E-01
203       / 5.05E-01 219       / 3.41E-01
 221       / 3.41E-01

 Cycle        500      Time          8 Hrs - 20.00 Min

      Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
            203/   0.47 /   574.17               205/   0.57 /   573.57
207/   0.45 /   572.95
            209/   0.35 /   574.35               211/   0.47 /   574.97
213/   0.23 /   574.73
            215/   0.23 /   574.73               217/   0.27 /   574.97
219/   0.26 /   574.26
            221/   0.26 /   574.26               223/   0.35 /   574.35

        Conduit/       FLOW   ===> "*" Conduit uses the normal flow option.
            206/       1.39*            208/      1.89              210/
0.48*           216/       0.22*
            218/       0.30*            220/      0.33*             222/
0.33*           224/       0.30*
            225/       0.49*            226/      0.22*        GATE # 1/       1.89

 ===> System inflows (file) at    16.67 hours (  Junction / Inflow, cfs)

 215       / 1.31E-01 217       / 1.83E-01 211       / 1.83E-01 213       / 1.31E-01
203       / 3.15E-01 219       / 2.02E-01
 221       / 2.02E-01

 Cycle       1000      Time         16 Hrs - 40.00 Min

      Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
            203/   0.39 /   574.09               205/   0.49 /   573.49
207/   0.38 /   572.88
            209/   0.29 /   574.29               211/   0.42 /   574.92
213/   0.18 /   574.68
            215/   0.18 /   574.68               217/   0.22 /   574.92
219/   0.21 /   574.21
            221/   0.21 /   574.21               223/   0.28 /   574.28

        Conduit/       FLOW   ===> "*" Conduit uses the normal flow option.
            206/       0.96*            208/      1.39              210/
0.32*           216/       0.13*
            218/       0.18*            220/      0.20*             222/
0.20*           224/       0.18*
            225/       0.32*            226/      0.13*        GATE # 1/       1.39


 *==================================================*
 | Table E5 - Junction Time Limitation Summary       |
 |            (0.10 or 0.25)* Depth * Area           |
 | Time step = -----------------------------         |
 |                   Sum of Flow                     |
 *==================================================*
 |  The time this junction was the limiting junction |
 |             is listed in the third column.        |
 *==================================================*

        Junction      Time(.10)  Time(.25)  Time(sec)
 ----------------     ---------  ---------  ---------
```

203	1.8460	4.6149	1080.0000
205	1.2348	3.0870	1680.0000
207	600.0000	600.0000	0.0000
209	0.5193	1.2982	1680.0000
211	0.1628	0.4070	39660.0000
213	0.7408	1.8520	120.0000
215	3.4458	8.6145	180.0000
217	0.3162	0.7905	240.0000
219	0.3102	0.7754	1440.0000
221	0.3102	0.7754	0.0000
223	1.1068	2.7669	40320.0000

The junction requiring the smallest time step was...223

```
*==========================================================*
|       Table E5a - Conduit Explicit Condition Summary      |
|       Courant   =         Conduit Length                  |
|       Time step = --------------------------------        |
|                      Velocity + sqrt(g*depth)             |
|                                                           |
|                  Conduit Implicit Condition Summary       |
|       Courant   =         Conduit Length                  |
|       Time step = --------------------------------        |
|                          Velocity                         |
*==========================================================*
|  The 3rd column is the Explicit time step times the      |
|      minimum courant time step factor                     |
|                                                           |
|  Minimum Conduit Time Step in seconds in the 4th column  |
|  in the list. Maximum possible is 10 * maximum time step |
|                                                           |
|  The 5th column is the maximum change at any time step   |
|  during the simulation. The 6th column is the wobble     |
|  value which is an indicator of the flow stability.      |
|                                                           |
|  You should use this section to find those conduits that |
|  are slowing your model down.  Use modify conduits to    |
|  alter the length of the slow conduits to make your      |
|  simulation faster, or change the conduit name to        |
|  "CHME?????" where ????? are any characters, this will   |
|  lengthen the conduit based on the model time step,      |
|  not the value listed in modify conduits.                |
*==========================================================*
```

Conduit / Type of Soln	Time(exp)	Expl*Cmin	Time(imp)	Time(min)	Max Qchange	Wobble
206 Normal Soln	24.7712	24.7712	121.2746	20.0000	-1.2737	5.2780
208 Normal Soln	6.3098	6.3098	14.3622	1420.0000	4.5001	16.7677
210 Normal Soln	19.9495	19.9495	127.8291	0.0000	-7.3091	11.2147
216 Normal Soln	12.3706	12.3706	54.6191	0.0000	2.4334	15.7307

```
               218     15.8191     15.8191     51.5606      0.0000        -3.9640  14.6833
Normal Soln
               220     26.3274     26.3274    109.0781      0.0000         1.3795   9.7742
Normal Soln
               222     26.3274     26.3274    109.0781      0.0000         1.3795   9.7742
Normal Soln
               224     16.2777     16.2777     56.7935      0.0000         1.5013  15.0619
Normal Soln
               225     19.5865     19.5865    120.9845      0.0000        -1.0342  11.4204
Normal Soln
               226     11.4240     11.4240     39.6643      0.0000         1.5978  16.2878
Normal Soln
The conduit with the smallest time step limitation was..208
The conduit with the largest wobble was.................208
The conduit with the largest flow change in any
consecutive time step...................................210

 *=================================================*
 |  Table E6. Final Model Condition                 |
 |            This table is used for steady state   |
 |            flow comparison and is the information|
 |            saved to the hot-restart file.        |
 |            Final Time =     24.017 hours         |
 *=================================================*

 Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
              203/   0.32 /   574.02/            205/   0.40 /   573.40/
207/   0.30 /   572.80/
              209/   0.23 /   574.23/            211/   0.38 /   574.88/
213/   0.15 /   574.65/
              215/   0.15 /   574.65/            217/   0.18 /   574.88/
219/   0.17 /   574.17/
              221/   0.17 /   574.17/            223/   0.23 /   574.23/

   Conduit/        Flow    ===> "*" Conduit uses the normal flow option.
              206/        0.61*/             208/        0.87 /             210/
0.20*/
              216/        0.08*/             218/        0.12*/             220/
0.13*/
              222/        0.13*/             224/        0.12*/             225/
0.20*/
              226/        0.08*/        GATE # 1/        0.87 /

         Conduit/   Velocity
              206/        1.09 /             208/        2.03 /             210/
0.63 /
              216/        0.66 /             218/        0.83 /             220/
0.48 /
              222/        0.48 /             224/        0.83 /             225/
0.63 /
              226/        0.66 /

         Conduit/      Width
              206/        2.26 /             208/        1.74 /             210/
1.71 /
              216/        0.98 /             218/        1.02 /             220/
1.33 /
              222/        1.33 /             224/        1.02 /             225/
1.71 /
              226/        0.98 /

        Junction/        EGL
              203/        0.33 /             205/        0.42 /             207/
0.36 /
              209/        0.24 /             211/        0.38 /             213/
0.15 /
              215/        0.15 /             217/        0.18 /             219/
```

```
0.17 /
            221/       0.17 /            223/       0.24 /

        Junction/  Freeboard
            203/       7.68 /            205/       7.60 /            207/
7.70 /
            209/       7.77 /            211/       7.12 /            213/
7.35 /
            215/       7.35 /            217/       7.12 /            219/
6.83 /
            221/       6.83 /            223/       7.77 /

        Junction/ Max Volume
            203/    1538.23 /            205/    1829.60 /            207/
32.38 /
            209/     642.10 /            211/   14297.00 /            213/
16207.38 /
            215/    7517.24 /            217/   19115.44 /            219/
12627.19 /
            221/   12627.19 /            223/    3420.61 /

        Junction/Total Fldng
            203/      43.19 /            205/       2.09 /            207/
0.00 /
            209/       6.60 /            211/   18116.96 /            213/
4329.41 /
            215/    4900.40 /            217/   17604.36 /            219/
16998.81 /
            221/   16998.81 /            223/      46.32 /

         Conduit/ Cross Sectional Area
            206/       0.55 /            208/       0.43 /            210/
0.32 /
            216/       0.13 /            218/       0.14 /            220/
0.27 /
            222/       0.27 /            224/       0.14 /            225/
0.32 /
            226/       0.13 /

         Conduit/  Final Volume
            206/     276.90 /            208/      76.96 /            210/
116.10 /
            216/      32.16 /            218/      49.59 /            220/
135.18 /
            222/     135.18 /            224/      49.59 /            225/
116.10 /
            226/      32.16 /

         Conduit/ Hydraulic Radius
            206/       0.23 /            208/       0.22 /            210/
0.17 /
            216/       0.12 /            218/       0.12 /            220/
0.17 /
            222/       0.17 /            224/       0.12 /            225/
0.17 /
            226/       0.12 /

         Conduit/ Upstream/ Downstream Elevation
            206/   574.02/   573.40          208/   573.40/   572.80
210/   574.23/   574.02/
            216/   574.65/   574.23          218/   574.88/   574.23
220/   574.17/   573.40/
            222/   574.17/   573.40          224/   574.88/   574.23
225/   574.23/   574.02/
            226/   574.65/   574.23
```

```
*=======================================================*
|          Table E7 -  Iteration Summary                |
*=======================================================*
```

```
Total number of time steps simulated...........       1440
Total number of passes in the simulation........      8938
Total number of time steps during simulation....      5241
Ratio of actual # of time steps / NTCYC.........     3.640
Average number of iterations per time step......     1.705
Average  time step size(seconds)................    16.485
Smallest time step size(seconds)................     0.500
Largest  time step size(seconds)................    60.000
Average minimum Conduit Courant time step (sec).    27.049
Average minimum implicit time step (sec)........    19.127
Average minimum junction time step (sec)........    19.127
Average Courant Factor Tf.......................    19.127
Number of times omega reduced...................       951
```

```
*=======================================================*
|      Table E8 - Junction Time Step Limitation Summary  |
*=======================================================*
|   Not Convr = Number of times this junction did not    |
|               converge during the simulation.          |
|   Avg Convr = Average junction iterations.             |
|   Conv err  = Mean convergence error.                  |
|   Omega Cng = Change of omega during iterations        |
|   Max Itern = Maximum number of iterations             |
*=======================================================*
```

Junction	Not Convr	Avg Convr	Total Itt	Omega Cng	Max Itern	Ittrn >10	Ittrn >25	Ittrn >40
203	0	2.04	10691	49	44	17	3	1
205	0	1.91	10032	64	29	15	3	0
207	0	1.63	8519	25	45	7	5	2
209	0	1.94	10150	123	50	29	4	1
211	0	1.44	7569	93	17	10	0	0
213	0	1.51	7888	131	43	11	1	1
215	0	1.55	8134	103	28	11	1	0
217	1	1.38	7245	79	51	9	1	1
219	0	1.55	8106	89	15	9	0	0
221	0	1.55	8106	89	15	9	0	0
223	2	1.91	10032	106	51	31	8	2

```
Total number of iterations for all junctions..     96472
Minimum number of possible iterations.........     57651
Efficiency of the simulation..................      1.67
                                                Excellent Efficiency
```

```
*=======================================================*
| Extran Efficiency is an indicator of the efficiency of  |
| the simulation.  Ideal efficiency is one iteration per  |
| time step.  Altering the underrelaxation parameter,     |
| lowering the time step, increasing the flow and head    |
| tolerance are good ways of improving the efficiency,    |
| another is lowering the internal time step. The lower the|
```

```
| efficiency generally the faster your model will run.    |
| If your efficiency is less than 1.5 then you may try    |
| increasing your time step so that your overall simulation|
| is faster.  Ideal efficiency would be around 2.0        |
|                                                         |
| Good Efficiency      < 1.5          mean iterations     |
| Excellent Efficiency < 2.5 and > 1.5 mean iterations    |
| Good      Efficiency < 4.0 and > 2.5 mean iterations    |
| Fair      Efficiency < 7.5 and > 4.0 mean iterations    |
| Poor Efficiency      > 7.5          mean iterations     |
*=========================================================*
```

```
*=====================================================*
|        Table E9 - JUNCTION SUMMARY STATISTICS       |
| The Maximum area is only the area of the node, it   |
| does not include the area of the surrounding conduits|
*=====================================================*
```

Junction Name	Ground Elevation feet	Uppermost PipeCrown Elevation feet	Maximum Junction Elevation feet	Time of Occurence Hr.	Min.	Feet of Surcharge at Max Elevation	Freeboard of node feet	Maximum Junction Area ft^2	Maximum Gutter Depth feet	Maximum Gutter Width feet	Maximum Gutter Velocity ft/s
203	581.7000	577.7000	581.7228	11	9	4.0228	0.0000	57171.145	0.0000	0.0000	0.0000
205	581.0000	577.0000	580.9950	11	9	3.9950	0.0050	58628.024	0.0000	0.0000	0.0000
207	580.5000	575.0000	574.9910	11	12	0.0000	5.5090	13.0000	0.0000	0.0000	0.0000
209	582.0000	577.0000	582.0073	11	8	5.0073	0.0000	52690.502	0.0000	0.0000	0.0000
211	582.0000	576.2000	582.1767	12	3	5.9767	0.0000	120997.51	0.0000	0.0000	0.0000
213	582.0000	576.0000	582.1731	12	1	6.1731	0.0000	130549.42	0.0000	0.0000	0.0000
215	582.0000	576.0000	582.1030	12	1	6.1030	0.0000	87098.683	0.0000	0.0000	0.0000
217	582.0000	576.2000	582.2131	12	3	6.0131	0.0000	145102.70	0.0000	0.0000	0.0000
219	581.0000	576.0000	581.1625	12	2	5.1625	0.0000	112680.95	0.0000	0.0000	0.0000
221	581.0000	576.0000	581.1625	12	2	5.1625	0.0000	112680.95	0.0000	0.0000	0.0000
223	582.0000	577.0000	582.0285	11	8	5.0285	0.0000	66583.075	0.0000	0.0000	0.0000

```
*=====================================================*
|        Table E10 - CONDUIT SUMMARY STATISTICS       |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the  |
| downstream boundary conditions.                     |
|                                                     |
| * denotes an open conduit that has been overtopped  |
|   this is a potential source of severe errors       |
*=====================================================*
```

Conduit	Design Flow	Design Velocity	Conduit Vertical Depth	Maximum Computed Flow	Time of Occurence	Maximum Computed Velocity	Time of Occurence	Ratio of Max. to Design Flow	Maximum Depth at Pipe Ends	Ratio d/D

Name	(cfs)	(ft/s)	(in)	(cfs)	Hr.	Min.	(ft/s)	Hr.	Min.	Design Flow	Upstream (ft)	Dwnstrm (ft)	US	DS
206	46.5802	3.7067	48.0000	52.8393	11	11	4.1798	11	11	1.1344	581.7228	580.9950	2.005	1.998
208	18.7355	3.8168	30.0000	62.2310	11	12	12.5995	11	12	3.3216	581.0318	574.9910	3.212	.9964
210	16.6869	2.3607	36.0000	18.5913	11	11	2.8389	13	14	1.1141	582.0073	581.7228	2.669	2.674
216	4.0713	2.3039	18.0000	8.2857	12	11	4.5830	12	11	2.0351	582.1030	582.0105	5.068	5.340
218	4.0713	2.3039	18.0000	12.1752	13	14	6.7925	13	14	2.9905	582.2131	582.0105	5.008	5.340
220	8.7681	2.7910	24.0000	14.4933	11	7	4.5839	11	7	1.6530	581.1625	581.0318	3.581	4.015
222	8.7681	2.7910	24.0000	14.4933	11	7	4.5839	11	7	1.6530	581.1625	581.0318	3.581	4.015
224	4.0713	2.3039	18.0000	11.0683	13	3	6.1627	13	3	2.7186	582.1767	582.0285	4.984	5.352
225	16.6869	2.3607	36.0000	21.2642	12	45	3.0009	12	45	1.2743	582.0285	581.7228	2.676	2.674
226	4.0713	2.3039	18.0000	11.3902	12	45	6.3234	12	45	2.7977	582.1919	582.0285	5.128	5.352
GATE # 1	Undefnd	Undefnd	Undefn	62.2364	11	12								

Table E11. Area assumptions used in the analysis
Subcritical and Critical flow assumptions from
Subroutine Head. See Figure 17-1 in the
manual for further information.

Conduit Name	Duration of Dry Flow(min)	Duration of Sub-Critical Flow(min)	Durat. of Upstream Critical Flow(min)	Durat. of Downstream Critical Flow(min)	Maximum Hydraulic Radius-m	Maximum X-Sect Area(ft^2)	Maximum Vel*D (ft^2/s)
206	2.0000	1438.0000	0.0000	0.0000	1.2090	13.1722	32.8626
208	2.0000	1438.0000	0.0000	0.0000	0.7403	4.9604	65.1299
210	4.0000	1436.0000	0.0000	0.0000	0.9126	7.4087	15.9279
216	3.0000	1437.0000	0.0000	0.0000	0.4548	1.8235	31.3571
218	3.0000	1437.0000	0.0000	0.0000	0.4405	1.8343	32.4088
220	3.0000	1437.0000	0.0000	0.0000	0.6084	3.2854	25.7485
222	3.0000	1437.0000	0.0000	0.0000	0.6084	3.2854	25.7485
224	5.5000	1434.5000	0.0000	0.0000	0.4434	1.8186	31.9931
225	5.5000	1434.5000	0.0000	0.0000	0.9126	7.3921	18.5631
226	2.0000	1438.0000	0.0000	0.0000	0.4525	1.8271	37.2567

Table E12. Mean Conduit Flow Information

===

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
206	4.5828	395950.61	0.0060	0.9989	0.3202	0.5756	4.7952	0.0162
208	6.6097	571074.55	0.0086	0.9987	0.8670	0.4387	2.2016	0.0152
210	1.5829	136761.00	0.0058	0.9989	0.2090	0.4333	2.8157	0.0162
216	0.6383	55152.190	0.0026	0.9989	0.2727	0.2413	0.7979	0.0162
218	0.9352	80802.907	0.0033	0.9989	0.3668	0.2482	0.8119	0.0162
220	1.0161	87789.601	0.0022	0.9989	0.2096	0.3302	1.4341	0.0162
222	1.0161	87789.601	0.0022	0.9989	0.2096	0.3302	1.4341	0.0162
224	0.8330	71969.082	0.0020	0.9983	0.3423	0.2489	0.8041	0.0150
225	1.6014	138362.12	0.0036	0.9989	0.2050	0.4335	2.7982	0.0162
226	0.7475	64585.284	0.0018	0.9989	0.2942	0.2415	0.7936	0.0162
GATE # 1	6.6106	571152.82						

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                          =
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 Junction      |                          #   #
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Water Surf     |                          #   #
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 Elev(ft)      |                          #    #
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       576.000 =                          #    #
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====|=========|
            0.0       4.0       8.0       12.0      16.0      20.0      24.0
28.0      32.0      36.0      40.0

                LOCATION NO. : 203          Clock time in hours.


                 Plot of Junction Elevation

                   Invert Elev -  573.70 feet
                    Crown Elev -  577.70 feet
                   Ground Elev -  581.70 feet

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       584.000
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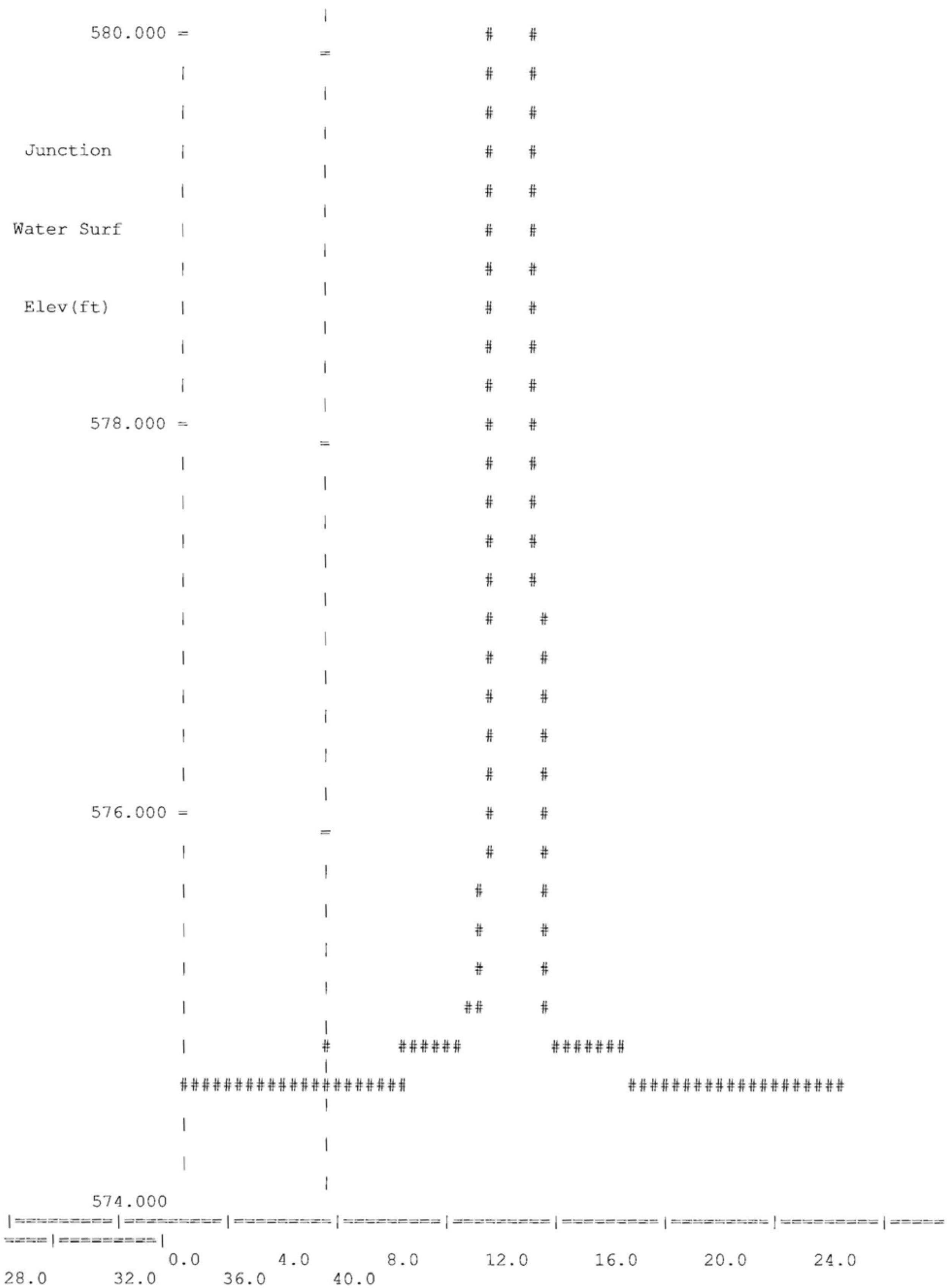
```


580.000
Junction
Water Surf
Elev(ft)
578.000
576.000
574.000
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
36.0
40.0

```
                 LOCATION NO. : 213          Clock time in hours.

                  Plot of Junction Elevation

                    Invert Elev -  574.50 feet
                     Crown Elev -  576.00 feet
                    Ground Elev -  582.00 feet

1
        584.000
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  Junction      |                           #   #
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 Water Surf     |                           #   #
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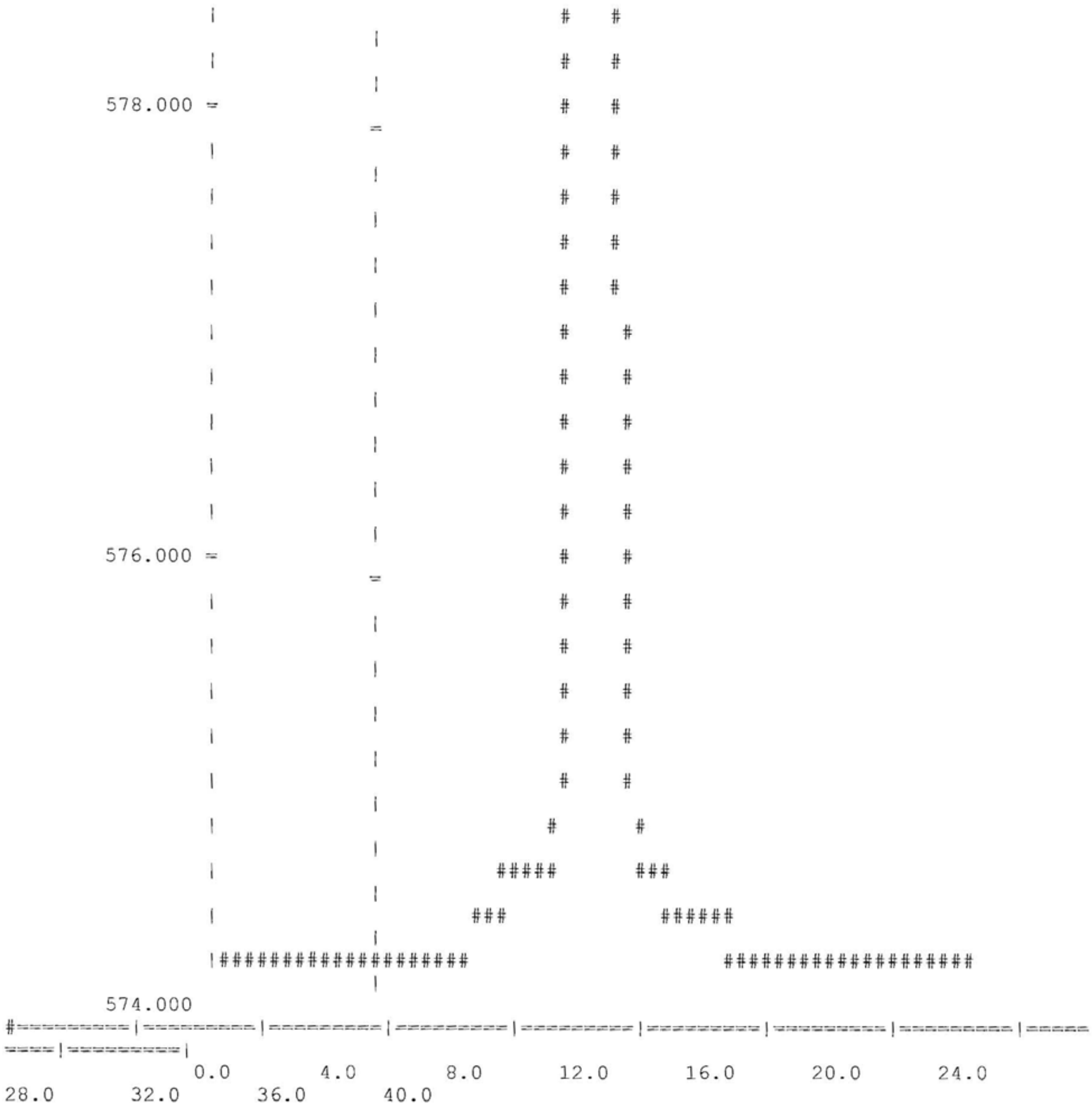
                |                           #   #
                             |
  Elev(ft)      |                           #   #
                             |
```



LOCATION NO. : 223   Clock time in hours.

Plot of Junction Elevation

Invert Elev - 574.00 feet
Crown Elev - 577.00 feet
Ground Elev - 582.00 feet

==
| Table E13. Channel losses(H), headwater depth (HW), tailwater |
| depth (TW), critical and normal depth (Yc and Yn). |
| Use this section for culvert comparisons |
==

Conduit Name	Maximum Flow	Head Loss	Friction Loss	Critical Depth	Normal Depth	HW Elevat	TW Elevat

206	52.1179	0.0000	0.8653	2.1663	4.0000	581.7119	580.9296	Max Flow
208	61.7029	0.0000	5.1712	2.4483	2.5000	580.1188	574.9476	Max Flow
210	16.1415	0.0000	0.2690	1.2819	2.3762	576.4577	576.3239	Max Flow
216	8.2738	0.0000	1.9731	1.1135	1.5000	582.0889	580.1127	Max Flow
218	12.1685	0.0000	6.0778	1.3207	1.5000	582.0052	575.9065	Max Flow
220	14.4933	0.0000	2.6968	1.3713	2.0000	578.8990	576.0265	Max Flow
222	14.4933	0.0000	2.6968	1.3713	2.0000	578.8990	576.0265	Max Flow
224	11.0683	0.0000	5.0086	1.2722	1.5000	581.9983	576.9673	Max Flow
225	21.0864	0.0000	0.4766	1.4744	3.0000	578.2789	577.7897	Max Flow
226	11.3554	0.0000	3.7429	1.2849	1.5000	582.0393	578.2789	Max Flow

Table E13a. CULVERT ANALYSIS CLASSIFICATION, and the time the culvert was in a particular classification during the simulation. The time is in minutes. The Dynamic Wave Equation is used for all conduit analysis but the culvert flow classification condition is based on the HW and TW depths.

Conduit Name	Mild Slope Critical D Outlet Control	Mild Slope TW Control Outlet Control	Steep Slope TW Insignf Entrance Control	Slug Flow Outlet/ Entrance Control	Mild Slope TW > D Outlet Control	Mild Slope TW <= D Outlet Control	Outlet Control	Inlet Control	Inlet Configuration
206	9.0000	1327.0000	2.0000	0.0000	102.0000	0.0000	0.0000	0.0000	None
208	693.0000	639.0000	3.0000	0.0000	0.0000	0.0000	105.0000	0.0000	None
210	0.0000	1322.0000	2.0000	0.0000	116.0000	0.0000	0.0000	0.0000	None
216	12.0000	1295.0000	3.0000	0.0000	130.0000	0.0000	0.0000	0.0000	None
218	13.0000	1293.0000	3.0000	0.0000	130.0000	0.0000	1.0000	0.0000	None
220	15.0000	1291.0000	3.0000	0.0000	131.0000	0.0000	0.0000	0.0000	None
222	15.0000	1291.0000	3.0000	0.0000	131.0000	0.0000	0.0000	0.0000	None
224	11.0000	1293.0000	5.0000	0.0000	130.0000	0.0000	1.0000	0.0000	None
225	0.0000	1322.0000	2.0000	0.0000	116.0000	0.0000	0.0000	0.0000	None
226	13.0000	1295.0000	2.0000	0.0000	130.0000	0.0000	0.0000	0.0000	None

Kinematic Wave Approximations
Time in Minutes for Each Condition

Conduit Name	Duration of Normal Flow	Slope Criteria	Super-Critical	Roll Waves
206	1271.0000	1313.0850	3.0000	0.0000
208	0.0000	0.0000	6.0000	0.0000
210	1023.0520	1315.5473	0.0000	0.0000
216	1277.7500	1289.5750	2.5000	0.0000
218	1282.0083	1287.2750	3.5000	0.0000
220	1276.7500	1295.9778	4.5000	0.0000
222	1276.7500	1295.9778	4.5000	0.0000
224	1282.0000	1293.2500	3.0000	0.0000
225	1023.0000	1320.6445	0.0000	0.0000
226	1278.2500	1295.2500	4.0000	0.0000

```
*=======================================================*
|     Table E15 - SPREADSHEET INFO LIST                 |
| Conduit Flow and Junction Depth Information for use in |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the       |
| maximum of a subset of all the time steps in the run.  |
| Note: These flows are only the flows in a single barrel.|
*=======================================================*
```

Conduit Name	Maximum Flow	Total Flow	Maximum Velocity	Maximum Volume	##	Junction Name	Invert Elevation	Maximum Elevation
206	52.8393	395950.6075	4.1798	6554.7252	##	203	573.7000	581.7228
208	62.2310	571074.5492	12.5995	886.8742	##	205	573.0000	580.9950
210	18.5913	136761.0011	2.8389	2666.7351	##	207	572.5000	574.9910
216	8.2857	55152.1896	4.5830	453.9840	##	209	574.0000	582.0073
218	12.1752	80802.9067	6.7925	635.5775	##	211	574.5000	582.1767
220	14.4933	87789.6009	4.5839	1600.7641	##	213	574.5000	582.1731
222	14.4933	87789.6009	4.5839	1600.7641	##	215	574.5000	582.1030
224	11.0683	71969.0821	6.1627	635.6334	##	217	574.7000	582.2131
225	21.2642	138362.1192	3.0009	2666.7351	##	219	574.0000	581.1625
226	11.3902	64585.2844	6.3234	454.0239	##	221	574.0000	581.1625
GATE # 1	62.2364	571152.8152	0.0000	0.0000	##	223	574.0000	582.0285

```
*==================================================*
|     Table E15a - SPREADSHEET REACH LIST          |
| Peak flow and Total Flow listed by Reach or those |
```

| conduits or diversions having the same |
| upstream and downstream nodes. |
==

Upstream Node	Downstream Node	Maximum Flow	Total Flow
203	205	52.8393	395950.607
205	207	62.2310	571074.549
209	203	18.5913	136761.001
215	209	8.2857	55152.1896
217	209	12.1752	80802.9067
219	205	14.4933	87789.6009
221	205	14.4933	87789.6009
211	223	11.0683	71969.0821
223	203	21.2642	138362.119
213	223	11.3902	64585.2844

\##
\# Table E16. New Conduit Information Section #
\# Conduit Invert (IE) Elevation and Conduit #
\# Maximum Water Surface (WS) Elevations #
\##

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
206	203	205	573.7000	573.0000	581.7228	580.9950	Circular
208	205	207	573.0000	572.5000	581.0318	574.9910	Circular
210	209	203	574.0000	573.7000	582.0073	581.7228	Circular
216	215	209	574.5000	574.0000	582.1030	582.0105	Circular
218	217	209	574.7000	574.0000	582.2131	582.0105	Circular
220	219	205	574.0000	573.0000	581.1625	581.0318	Circular
222	221	205	574.0000	573.0000	581.1625		

						581.0318	Circular
224	211	223	574.7000	574.0000	582.1767	582.0285	Circular
225	223	203	574.0000	573.7000	582.0285	581.7228	Circular
226	213	223	574.5000	574.0000	582.1919	582.0285	Circular

```
*============================================================================*
|   Table E18 - Junction Continuity Error.   Division by Volume added 11/96  |
|                                                                            |
|  Continuity Error = Net Flow + Beginning Volume - Ending Volume            |
|                     ----------------------------------------------         |
|                     Total Flow + (Beginning Volume + Ending Volume)/2      |
|                                                                            |
|  Net Flow   = Node Inflow - Node Outflow                                   |
|  Total Flow = absolute (Inflow + Outflow                                   |
|  Intermediate column is a judgement on the node continuity error.         |
|                                                                            |
|  Excellent  < 1 percent    Great  1 to  2 percent  Good  2 to  5 percent   |
|  Fair  5 to 10  percent    Poor  10 to 25 percent  Bad  25 to 50 percent   |
|  Terrible > 50  percent                                                    |
*============================================================================*
```

Junction Name	<------Continuity Error -------> Volume	% of Node	% of Inflow	Remaining Volume	Beginning Volume	Net Flow Thru Node	Total Flow Thru Node	Failed to Converge
203	-1294.6078	-0.1637	0.2427	262.0773	0.0061	-1032.5366	790777.6090	0
205	-493.4388	-0.0432	0.0925	317.9817	0.0084	-175.4655	1142604.358	0
207	-56.0820	-0.0049	0.0105	41.3929	0.0010	-14.6900	1142227.364	0
209	-925.0351	-0.3391	0.1734	103.3525	0.0048	-821.6874	272716.0974	0
211	-2315.1560	-1.6339	0.4340	30.0068	0.0018	-2285.1509	141678.6858	0
213	-14687.0117	-12.8256	2.7530	18.2530	0.0013	-14668.7599	114503.9512	0
215	-5231.3211	-4.9784	0.9806	18.2530	0.0013	-5213.0693	105070.8565	0
217	-11119.8467	-7.3873	2.0844	27.4068	0.0018	-11092.4416	150512.5105	1
219	-627.9917	-0.3587	0.1177	69.8081	0.0025			

```
-558.1861 175050.1405          0


            221   -627.9917     -0.3587      0.1177     69.8081      0.0025
-558.1861 175050.1405          0


            223  -1895.5049     -0.6894      0.3553    103.3525      0.0048
-1792.1572 274916.4856          2


 The total continuity error was  -39274.     cubic feet
 The remaining total volume was   1061.7     cubic feet
 Your mean node continuity error was   Excellent
 Your worst node continuity error was  Good

   *=================================================*
   |  Table E19 - Junction Inflow Sources              |
   |              Units are either ft^3 or m^3         |
   |              depending on the units in your model.|
   *=================================================*
```

Junction Name	Constant Inflow to Node	User Inflow to Node	Interface Inflow to Node	DWF Inlow to Node	Inflow through Outfall	RNF Layer Inflow to Node	Outflow from Node	Evaporation from Node
203	0.0000	0.0000	119668.3604	0.0000	0.0000	0.0000	0.0000	0.0000
207	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	571152.8152	0.0000
211	0.0000	0.0000	69688.1975	0.0000	0.0000	0.0000	0.0000	0.0000
213	0.0000	0.0000	49903.1915	0.0000	0.0000	0.0000	0.0000	0.0000
215	0.0000	0.0000	49903.1915	0.0000	0.0000	0.0000	0.0000	0.0000
217	0.0000	0.0000	69688.1975	0.0000	0.0000	0.0000	0.0000	0.0000
219	0.0000	0.0000	87233.8720	0.0000	0.0000	0.0000	0.0000	0.0000
221	0.0000	0.0000	87233.8720	0.0000	0.0000	0.0000	0.0000	0.0000

```
   *====================================================*
   | Table E20 - Junction Flooding and Volume Listing.    |
   |             The maximum volume is the total volume   |
   |             in the node including the volume in the  |
   |             flooded storage area. This is the max    |
   |             volume at any time. The volume in the    |
   |             flooded storage area is the total volume |
   |             above the ground elevation, where the    |
   |             flooded pond storage area starts.        |
   | The fourth column is instantaneous, the fifth is the |
   | sum of the flooded volume over the entire simulation |
   | Units are either ft^3 or m^3 depending on the units. |
```

```
*=====================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of System Flooded Volume	Maximum Volume	Stored in System Ponding Allowed Flood Pond Volume
203	100.4000	2.7000	0.0000	1538.2290	43.1904
205	101.9926	0.0000	0.0000	1829.6048	2.0869
207	0.0000	0.0000	0.0000	32.3834	0.0000
209	114.4229	2.3500	0.0000	642.1004	6.6018
211	121.5000	114.5214	0.0000	14297.0030	18116.9635
213	122.1667	99.3250	0.0000	16207.3832	4329.4096
215	126.1667	81.6722	0.0000	7517.2367	4900.4044
217	130.9167	126.3500	0.0000	19115.4404	17604.3578
219	119.5667	91.1667	0.0000	12627.1905	16998.8066
221	119.5667	91.1667	0.0000	12627.1905	16998.8066
223	114.1371	2.7500	0.0000	3420.6149	46.3191

```
*=================================*
| Simulation Specific Information |
*=================================*
Number of Input Conduits..........       10 Number of Simulated Conduits......
11
Number of Natural Channels........        0 Number of Junctions...............
11
Number of Storage Junctions.......        0 Number of Weirs...................
 0
Number of Orifices................        0 Number of Pumps...................
 0
Number of Free Outfalls...........        0 Number of Tide Gate Outfalls......
 1
```

```
*=======================================================*
| Average % Change in Junction or Conduit is defined as: |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull  |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull  |
*=======================================================*

The Conduit with the largest average change was..GATE # 1   with     0.010 percent
The Junction with the largest average change was.217        with     0.484 percent
The Conduit with the largest sinuosity was.......208        with    16.768
```

```
*=================================================================*
| Table E21. Continuity balance at the end of the simulation      |
|            Junction Inflow, Outflow or Street Flooding          |
| Error = Inflow  + Initial Volume - Outflow - Final   Volume     |
*=================================================================*
```

Inflow Junction	Inflow Volume,ft^3	Average Inflow, cfs
203	119703.8813	1.3855
211	69709.6038	0.8068
213	49918.6669	0.5778
215	49918.6669	0.5778
217	69709.6038	0.8068
219	87260.5395	1.0100
221	87260.5395	1.0100
207	-571152.8152	-6.6106

Outflow Junction	Outflow Volume,ft^3	Average Outflow, cfs
207	571152.8152	6.6106

```
*================================================*
| Initial system volume       =       0.0361 Cu Ft |
| Total system inflow volume  =  533318.8823 Cu Ft |
| Inflow + Initial volume     =  533318.9184 Cu Ft |
*================================================*
| Total system outflow        =  571152.8152 Cu Ft |
| Volume left in system       =    1061.6929 Cu Ft |
| Evaporation                 =       0.0000 Cu Ft |
| Outflow + Final Volume      =  572214.5080 Cu Ft |
```

```
*=====================================================*

*================================================*
| Total Model Continuity Error                   |
| Error in Continuity, Percent =         -7.2931 |
| Error in Continuity, ft^3    =      -38895.590 |
| + Error means a continuity loss, - a gain      |
*================================================*

###################################################
# Table E22. Numerical Model judgement section    #
###################################################

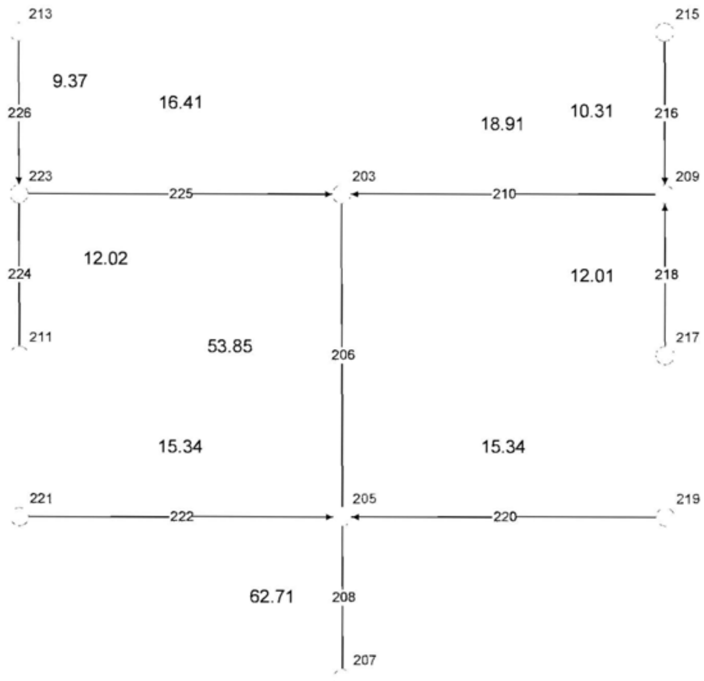
Your overall error was                                            -7.2931 percent
Worst nodal error was in node 213                with            -12.8265 percent
Of the total inflow this loss was                                  2.7539 percent
Your overall continuity error was                    Fair
                                                    Excellent Efficiency
Efficiency of the simulation                         1.67
Most Number of Non Convergences at one Node          2.
Total Number Non Convergences at all Nodes           3.
Total Number of Nodes with Non Convergences          2.

===> Hydraulic model simulation ended normally.
===> XP-SWMM Simulation ended normally.
===> Your input file was named  : C:\XPSWMM Data\WORK\MACTEST\mac10.DAT

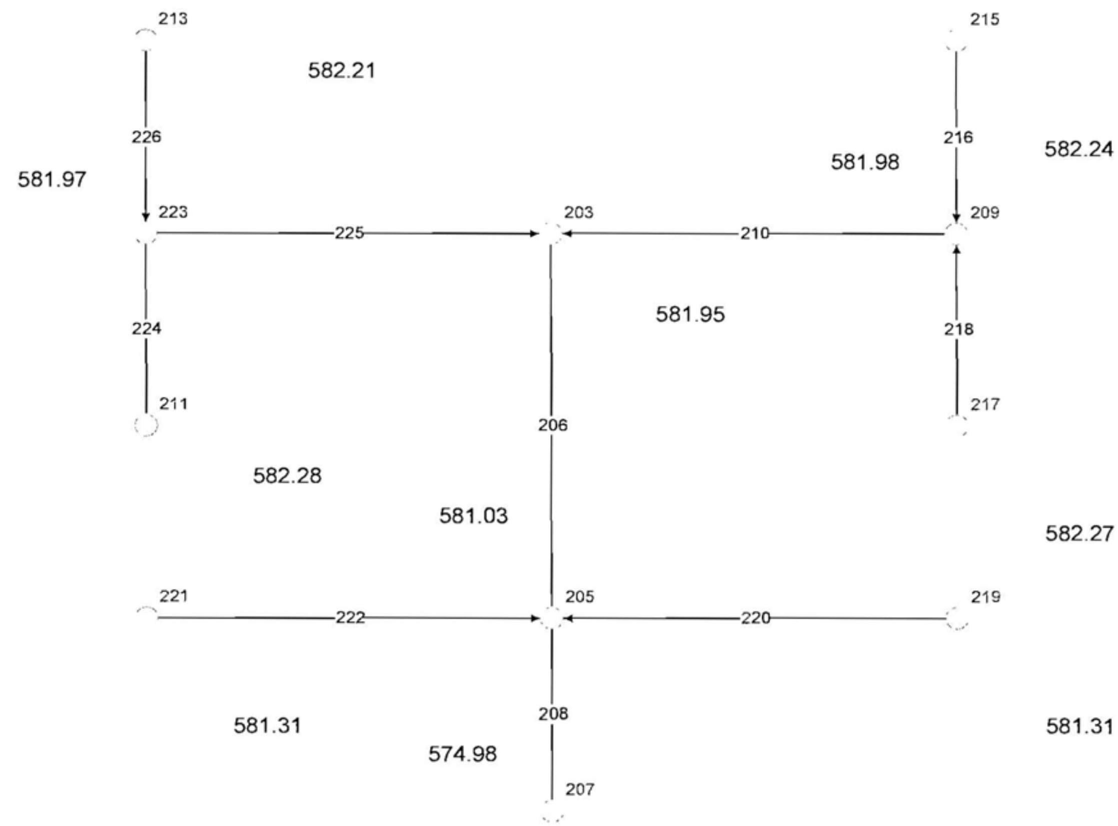
===> Your output file was named : C:\XPSWMM Data\WORK\MACTEST\mac10.out

*==============================================================*
|               SWMM Simulation Date and Time Summary          |
*==============================================================*
| Starting Date... October    20, 2008  Time...   10: 7:10:29  |
|   Ending Date... October    20, 2008  Time...   10: 7:19: 9  |
|  Elapsed Time...    0.14667 minutes or      8.80000 seconds  |
*==============================================================*
```

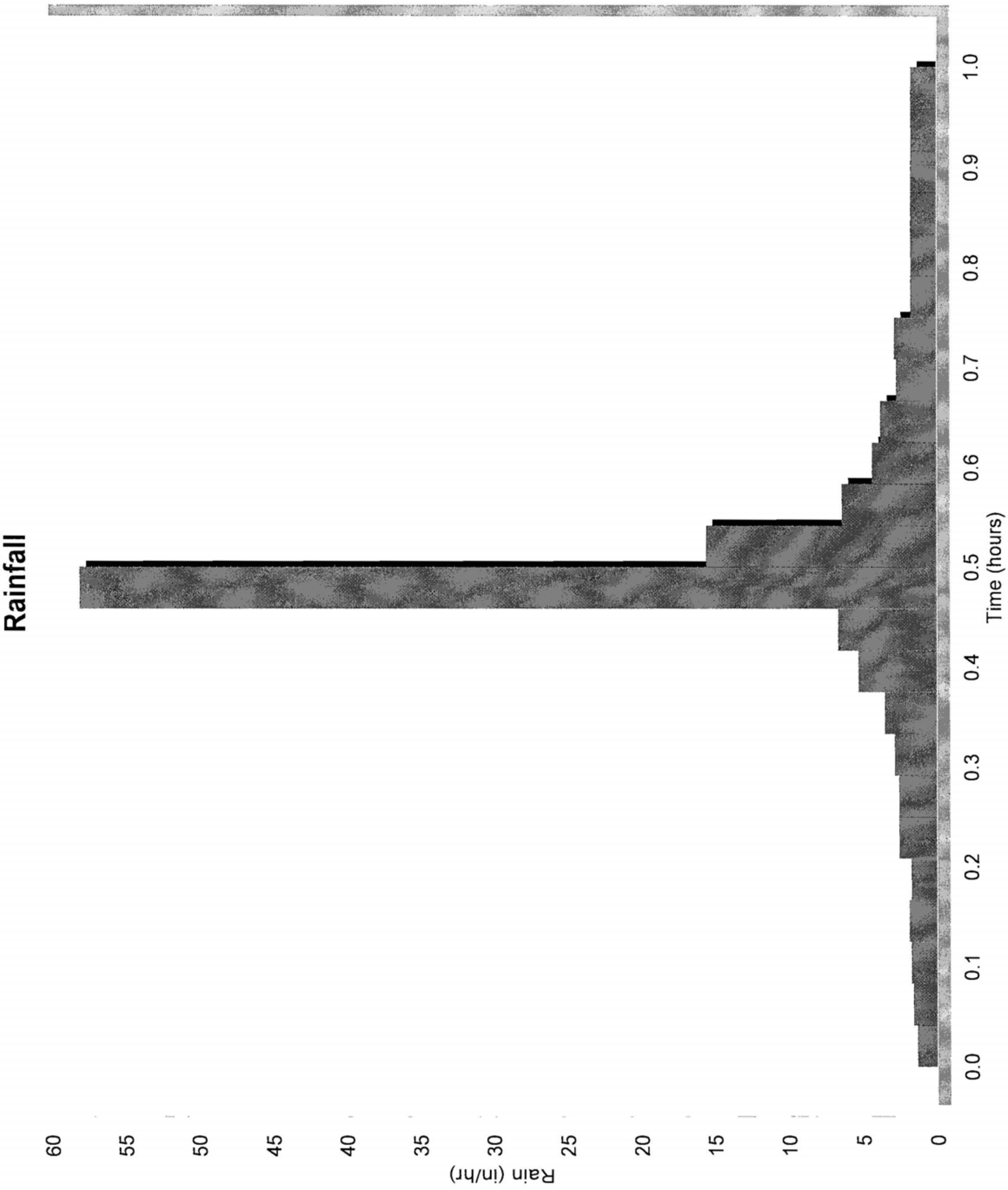
Appendix E



SWMM Version 9.00 Copyright (c) XP Software	**Maximum Flow - 2 Hour (5.8" Total Rainfall)** **Chicago Storm Distribution (Maximum Flows)** Licenced To: GSE Associates [42-900-1271]	10/16/08 Page 1/1



SWMM	**Maximum Flow - 2 Hour (5.8" Total Rainfall)**	10/16/08
Version 9.00	**Chicago Storm Distribution (Maximum Stages)**	Page 1/1
Copyright (c) XP Software	Licenced To: GSE Associates [42-900-1271]	



Rainfall
Rain (in/hr)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (hours)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

```
Input File : C:\XPSWMM Data\WORK\MACTEST\mac100.XP
Current Directory:   C:\XPS\XP-SWMM
Engine Name: C:\XPS\XP-SWMM\swmmengw.exe
Read      0 line(s) and found    0 items(s) from your cfg file.
         *===============================================*
         |                    XP-SWMM                    |
         |     Storm and Wastewater Management Model     |
         |                 Version 8.87                  |
         |===============================================|
         |                 Developed by                  |
         |===============================================|
         |                                               |
         |                  XP Software                  |
         |                                               |
         |             Based on the U.S. EPA             |
         |   Storm Water Management Model Version 4.30   |
         |                                               |
         |           Originally Developed by             |
         |            Metcalf & Eddy, Inc.               |
         |           University of Florida               |
         |         Camp Dresser & McKee Inc.             |
         |             September 1970                    |
         |                                               |
         |           EPA-SWMM is maintained by           |
         |           Oregon State University             |
         |           Camp Dresser & McKee Inc.           |
         |===============================================|
         |     XP Software      October, 2003            |
         |       Data File Version --->    11.2          |
         *===============================================*


*========================================================*
|       Input and Output file names by SWMM Layer        |
*========================================================*

 Input File  to Layer #     1 C:\XPSWMM Data\WORK\MACTEST\mac100.INT

 Output File to Layer #     1 JOT.US


*==========================================================*
|   Special command line arguments in XP-SWMM2000. This    |
|   now includes program defaults. $Keywords are the program|
|   defaults.  Other Keywords are from the SWMMCOM.CFG file.|
|   or the command line or any cfg file on the command line.|
|   Examples include these in the file xpswm.bat under the  |
|   section :solve or in the windows version XPSWMM32 in the|
|   file solve.bat                                         |
|                                                          |
|   Note: the cfg file should be in the subdirectory swmxp  |
|         or defined by the set variable in the xpswm.bat   |
|         file.  Some examples of the command lines possible|
|         are shown below:                                 |
|                                                          |
|   swmmd swmmcom.cfg                                      |
|   swmmd my.cfg                                           |
|   swmmd nokeys nconv5 perv extranwq                      |
*==========================================================*

     $powerstation        0.0000         1         2
     $perv                0.0000         0         4
     $oldegg              0.0000         0         7
     $as                  0.0000         0        11
     $noflat              0.0000         0        21
     $oldomega            0.0000         0        24
     $oldvol              0.0000         1        28
```

```
    $implicit              0.0000          1         29
    $oldhot                0.0000          1         31
    $oldscs                0.0000          0         33
    $flood                 0.0000          1         40
    $nokeys                0.0000          0         42
    $pzero                 0.0000          0         55
    $oldvol2               0.0000          2         59
    $storage2              0.0000          3         62
    $oldhot1               0.0000          1         63
    $pumpwt                0.0000          1         70
    $ecloss                0.0000          1         77
    $exout                 0.0000          0         97
    $djref = -0.1         -0.1000          3        143
    $weirlen = 50         50.0000          1        153
    $oldbnd                0.0000          1        154
    $nogrelev              0.0000          1        161
    $ncmid                 0.0000          0        164
    $new_n1_97             0.0000          2        290
    $best97                0.0000          1        294
    $newbound              0.0000          1        295
    $q_tol = 0.1           0.0010          1        316
    $new_storage           0.0000          1        322
    $old_iteration         0.0000          1        333
    $minlen=30.0          30.0000          1        346
    $review_elevatio       0.0000          1        383
    $use_half_volume       0.0000          1        385
    $min_ts = 0.5          0.5000          1        407

*===========================================================*
| Parameter Values on the Tapes Common Block.These are the |
| values read from the data file and dynamically allocated |
| by the model for this simulation.                         |
*===========================================================*

 Number of Subcatchments in the Runoff Block (NW)....      0
 Number of Channel/Pipes in the Runoff Block (NG)....      0
 Runoff Water quality constituents (NRQ).............      0
 Runoff Land Uses per Subcatchment (NLU).............      0
 Number of Elements in the Transport Block (NET).....      0
 Number of Storage Junctions in Transport (NTSE).....      0
 Number of Input Hydrographs in Transport (NTH)......      0
 Number of Elements in the Extran Block (NEE)........     11
 Number of Groundwater Subcatchments in Runoff (NGW).      0
 Number of Interface locations for all Blocks (NIE)..     11
 Number of Pumps in Extran (NEP).....................      0
 Number of Orifices in Extran (NEO)..................      0
 Number of Tide Gates/Free Outfalls in Extran (NTG)..      1
 Number of Extran Weirs (NEW)........................      0
 Number of scs hydrograph points.....................      1
 Number of Extran printout locations (NPO)...........      2
 Number of Tide elements in Extran (NTE).............      1
 Number of Natural channels (NNC)....................      0
 Number of Storage junctions in Extran (NVSE)........      0
 Number of Time history data points in Extran(NTVAL).      0
 Number of Variable storage elements in Extran (NVST)      0
 Number of Input Hydrographs in Extran (NEH).........      0
 Number of Particle sizes in Transport Block (NPS)...      0
 Number of User defined conduits (NHW)...............     11
 Number of Connecting conduits in Extran (NECC)......     20
 Number of Upstream elements in Transport (NTCC).....     10
 Number of Storage/treatment plants (NSTU)...........      0
 Number of Values for R1 lines in Transport (NR1)....      0
 Number of Nodes to be allowed for (NNOD)............     11
 Number of Plugs in a Storage Treatment Unit.........      1

#######################################################
```

```
#    Entry made to the HYDRAULIC Layer(Block) of SWMM #
#    Last Updated October,2000 by XP Software         #

    Maximum Flow - 2 Hour (5.8" Total Rainfall)
    Chicago Storm Distribution (Maximum Flows)


*===========================================================*
|        HYDRAULICS TABLES IN THE OUTPUT FILE               |
|  These are the more important tables in the output file.  |
|  You can use your editor to find the table numbers,       |
|  for example: search for Table E20 to check continuity.   |
|  This output file can be imported into a Word Processor   |
|  and printed on US letter or A4 paper using portrait      |
|  mode, courier font, a size of 8 pt. and margins of 0.75  |
|                                                           |
| Table E1   - Basic Conduit Data                           |
| Table E2   - Conduit Factor Data                          |
| Table E3a  - Junction Data                                |
| Table E3b  - Junction Data                                |
| Table E4   - Conduit Connectivity Data                    |
| Table E4a  - Dry Weather Flow Data                        |
| Table E4b  - Real Time Control Data                       |
| Table E5   - Junction Time Step Limitation Summary        |
| Table E5a  - Conduit Explicit Condition Summary           |
| Table E6   - Final Model Condition                        |
| Table E7   - Iteration Summary                            |
| Table E8   - Junction Time Step Limitation Summary        |
| Table E9   - Junction  Summary  Statistics                |
| Table E10  - Conduit   Summary  Statistics                |
| Table E11  - Area assumptions used in the analysis        |
| Table E12  - Mean conduit information                     |
| Table E13  - Channel losses(H) and culvert info           |
| Table E13a - Culvert Analysis Classification              |
| Table E14  - Natural Channel Overbank Flow Information    |
| Table E14a - Natural Channel Encroachment Information     |
| Table E14b - Floodplain Mapping                           |
| Table E15  - Spreadsheet Info List                        |
| Table E15a - Spreadsheet Reach List                       |
| Table E16  - New Conduit Output Section                   |
| Table E17  - Pump Operation                               |
| Table E18  - Junction Continuity Error                    |
| Table E19  - Junction Inflow Sources                      |
| Table E20  - Junction Flooding and Volume List            |
| Table E21  - Continuity balance at simulation end         |
| Table E22  - Model Judgement Section                      |
*===========================================================*

Time Control from Hydraulics Job Control
Year.........    1998 Month.......      1
Day..........       1 Hour........      0
Minute.......       0 Second......      0


Control information for simulation
----------------------------------

Integration cycles................     1440
Length of integration step is......   60.00 seconds
Simulation length.................    24.00 hours
Do not create equiv. pipes(NEQUAL).       0
Use U.S. customary units for I/O...       0
Printing starts in cycle..........        1
Intermediate printout intervals of.     500 cycles
Intermediate printout intervals of.  500.00 minutes
Summary printout intervals of......     500 cycles
Summary printout time interval of..  500.00 minutes
```

```
Hot start file parameter (REDO)....        0
Initial time......................      0.00 hours

Iteration variables: Flow Tolerance.   0.00010
                     Head Tolerance.   0.00010
    Minimum depth (m or ft).........   0.00001
    Underrelaxation parameter.......   0.65000
    Time weighting parameter........   0.65000
    Conduit roughness factor........   1.00000
    Flow adjustment factor..........   1.00000
    Initial Condition Smoothing.....         1
    Courant Time Step Factor........   1.00000
    Default Expansion/Contraction K.   0.00000
    Default Entrance/Exit K.........   0.00000
    Routing Method..................   Dynamic Wave
Default surface area of junctions...     13.00 square feet.
Minimum Junction/Conduit Depth......   0.00001 feet.
Ponding Area Coefficient............  50000.00
Ponding Area Exponent...............    5.0000
Minimum Orifice Length..............   1000.00 feet.
NJSW input hydrograph junctions.....      0
     or user defined hydrographs....

Water surface elevations will be plotted for the following   2 Junctions

    213       223

*===================================================*
|          Table E1 - Conduit Data                  |
*===================================================*
```

Inp Num	Conduit Name	Length (ft)	Conduit Class	Area (ft^2)	Manning Coef.	Max Width (ft)	Depth (ft)	Trapezoid Side Slopes
1	206	500.0000	Circular	12.5664	0.0150	4.0000	4.0000	
2	208	180.0000	Circular	4.9087	0.0150	2.5000	2.5000	
3	210	360.0000	Circular	7.0686	0.0150	3.0000	3.0000	
4	216	250.0000	Circular	1.7671	0.0150	1.5000	1.5000	
5	218	350.0000	Circular	1.7671	0.0150	1.5000	1.5000	
6	220	500.0000	Circular	3.1416	0.0150	2.0000	2.0000	
7	222	500.0000	Circular	3.1416	0.0150	2.0000	2.0000	
8	224	350.0000	Circular	1.7671	0.0150	1.5000	1.5000	
9	225	360.0000	Circular	7.0686	0.0150	3.0000	3.0000	
10	226	250.0000	Circular	1.7671	0.0150	1.5000	1.5000	

```
Total length of all conduits ....      3600.0000 feet

*===================================================*
| If there are messages about (sqrt(g*d)*dt/dx), or |
| the sqrt(wave celerity)*time step/conduit length  |
| in the output file all it means is that the       |
| program will lower the internal time step to      |
| satisfy this condition (explicit condition).      |
```

```
| You control the actual internal time step by       |
| using the minimum courant time step factor in the  |
| HYDRAULICS job control.  The message put in words  |
| states that the smallest conduit with the fastest  |
| velocity will control the time step selection.     |
| You have further control by using the modify       |
| conduit option in the HYDRAULICS Job Control.      |
*====================================================*


        Conduit     Courant
           Name       Ratio
 ---------------   ---------
            206        1.36  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            208        2.99  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            210        1.64  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            216        1.67  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            218        1.19  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            220        0.96
            222        0.96
            224        1.19  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            225        1.64  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)
            226        1.67  ===> Warning ! (sqrt(wave celerity)*time step/conduit
length)

 *===================*
 |  Conduit Volume   |
 *===================*

 Full pipe or full open conduit volume
 Input full depth volume............    1.7518E+04 cubic feet


 *====================================================*
 |           Table E3a - Junction Data                 |
 *====================================================*
```

Inp Num	Junction Name	Ground Elevation	Crown Elevation	Invert Elevation	Qinst cfs	Initial Depth-ft	Interface Flow (%)
1	203	581.7000	581.7000	573.7000	0.0000	0.0000	100.0000
2	205	581.0000	581.0000	573.0000	0.0000	0.0000	100.0000
3	207	580.5000	580.5000	572.5000	0.0000	0.0000	100.0000
4	209	582.0000	582.0000	574.0000	0.0000	0.0000	100.0000
5	211	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
6	213	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
7	215	582.0000	582.0000	574.5000	0.0000	0.0000	100.0000
8	217	582.0000	582.0000	574.7000	0.0000	0.0000	100.0000
9	219	581.0000	581.0000	574.0000	0.0000	0.0000	100.0000
10	221	581.0000	581.0000	574.0000	0.0000	0.0000	100.0000

11	223	582.0000	582.0000	574.0000	0.0000	0.0000	100.0000

```
*================================================*
|           Table E3b - Junction Data            |
*================================================*
```

Inp Num	Junction Name	X Coord.	Y Coord.	Type of Manhole	Type of Inlet	Maximum Capacity	Pavement Shape	Slope
1	203	55.0000	480.0000	Flooded	Normal		0	0.0000
2	205	55.0000	470.0000	Flooded	Normal		0	0.0000
3	207	55.0000	465.0000	Flooded	Normal		0	0.0000
4	209	65.0000	480.0000	Flooded	Normal		0	0.0000
5	211	45.0000	475.0000	Flooded	Normal		0	0.0000
6	213	45.0000	485.0000	Flooded	Normal		0	0.0000
7	215	65.0000	485.0000	Flooded	Normal		0	0.0000
8	217	65.0000	475.0000	Flooded	Normal		0	0.0000
9	219	65.0000	470.0000	Flooded	Normal		0	0.0000
10	221	45.0000	470.0000	Flooded	Normal		0	0.0000
11	223	45.0000	480.0000	Flooded	Normal		0	0.0000

```
*================================================*
|          Table E4 - Conduit Connectivity       |
*================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	206	203	205	573.7000	573.0000	No Design
2	208	205	207	573.0000	572.5000	No Design
3	210	209	203	574.0000	573.7000	No Design
4	216	215	209	574.5000	574.0000	No Design
5	218	217	209	574.7000	574.0000	No Design
6	220	219	205	574.0000	573.0000	No Design
7	222	221	205	574.0000	573.0000	No Design
8	224	211	223	574.7000	574.0000	No Design
9	225	223	203	574.0000	573.7000	No Design
10	226	213	223	574.5000	574.0000	No Design

```
*============================================*
|    TIDE GATE OUTFALL DATA (DATA GROUP I2)   |
|      BOUNDARY CONDITION ON DATA GROUP J1    |
*============================================*

Outfall at junction... 207       has boundary condition number...        1

*=============================================*
|         INTERNAL CONNECTIVITY INFORMATION    |
*=============================================*

         CONDUIT         JUNCTION         JUNCTION
---------------- ---------------- ----------------
        GATE # 1              207         BOUNDARY

*================================================*
|         Boundary Condition Information          |
|                  Data Groups J1-J4              |
*================================================*

BC NUMBER..         1 Control water surface elevation is..    572.00 feet.

###########################################
# Header information from interface file: #
###########################################

Title from first computational layer:
Maximum Flow - 2 Hour (5.8" Total Rainfall)


Title from immediately preceding computational layer
Maximum Flow - 2 Hour (5.8" Total Rainfall)


Name of preceding layer:................        Runoff Layer
Initial Julian date (IDATEZ).....................   1998001
Initial time of day in seconds (TZERO)...........       0.0
No. Transfered input locations...................         7
No. Transfered pollutants........................         0
Size of total catchment area (acres).............     22.32

#################################################
# Element numbers of interface inlet locations: #
#################################################

215              217              211              213              203
219              221

Conversion factor to cfs for flow units on interface file.  Multiply by:     1.00000

######## Important Information ########
Start date/time of interface file was.. 1998001    0.0000 hours
Start date/time of the simulation was.. 1998001    0.0000 hours
Same date/time found in interface file and model

*================================================*
|             XP Note Field Summary               |
*================================================*



*================================*
|   Conduit Convergence Criteria  |
```

```
*=================================*

          Conduit         Full      Conduit
             Name         Flow        Slope
-----------------  -----------  -----------
              206      46.5802       0.0014

              208      18.7355       0.0028

              210      16.6869       0.0008

              216       4.0713       0.0020

              218       4.0713       0.0020

              220       8.7681       0.0020

              222       8.7681       0.0020

              224       4.0713       0.0020

              225      16.6869       0.0008

              226       4.0713       0.0020


*=================================*
|     Initial Model Condition     |
| Initial Time =       0.02 hours |
*=================================*

       Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
             203/   0.00 /   573.70              205/   0.00 /   573.00
207/   0.00 /   572.50
             209/   0.00 /   574.00              211/   0.00 /   574.50
213/   0.00 /   574.50
             215/   0.00 /   574.50              217/   0.00 /   574.70
219/   0.00 /   574.00
             221/   0.00 /   574.00              223/   0.00 /   574.00

         Conduit/        FLOW   ===> "*" Conduit uses the normal flow option.
             206/        0.00             208/        0.00            210/        0.00
             216/        0.00             218/        0.00            220/        0.00
             222/        0.00             224/        0.00            225/        0.00
             226/        0.00        GATE # 1/        0.00

         Conduit/   Velocity
             206/        0.00             208/        0.00            210/        0.00
             216/        0.00             218/        0.00            220/        0.00
             222/        0.00             224/        0.00            225/        0.00
             226/        0.00

         Conduit/ Cross Sectional Area
             206/        0.00             208/        0.00            210/        0.00
             216/        0.00             218/        0.00            220/        0.00
             222/        0.00             224/        0.00            225/        0.00
             226/        0.00

         Conduit/ Hydraulic Radius
             206/        0.00             208/        0.00            210/        0.00
             216/        0.00             218/        0.00            220/        0.00
             222/        0.00             224/        0.00            225/        0.00
             226/        0.00

         Conduit/ Upstream/ Downstream Elevation
             206/   573.00/   573.00             208/   572.50/   572.50
210/   573.70/   573.70
```

```
            216/   574.00/   574.00             218/   574.00/   574.00
220/   573.00/   573.00
            222/   573.00/   573.00             224/   574.00/   574.00
225/   573.70/   573.70
            226/   574.00/   574.00

 ===> System inflows (file) at     8.33 hours (  Junction / Inflow, cfs)

 215        / 0.00E+00 217        / 0.00E+00 211        / 0.00E+00 213        / 0.00E+00
203        / 0.00E+00 219        / 0.00E+00
 221        / 0.00E+00

 Cycle        500      Time          8 Hrs - 20.00 Min

      Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
            203/   0.01 /   573.71             205/   0.03 /   573.03
207/   0.00 /   572.50
            209/   0.00 /   574.00             211/   0.20 /   574.70
213/   0.00 /   574.50
            215/   0.00 /   574.50             217/   0.00 /   574.70
219/   0.00 /   574.00
            221/   0.00 /   574.00             223/   0.00 /   574.00

        Conduit/        FLOW    ===> "*" Conduit uses the normal flow option.
            206/        0.00*            208/        0.00             210/
0.00*           216/        0.00*
            218/        0.00*            220/        0.00*            222/
0.00*           224/        0.00*
            225/        0.00*            226/        0.00*        GATE # 1/        0.00

 ===> System inflows (file) at    16.67 hours (  Junction / Inflow, cfs)

 215        / 0.00E+00 217        / 0.00E+00 211        / 0.00E+00 213        / 0.00E+00
203        / 0.00E+00 219        / 0.00E+00
 221        / 0.00E+00

 Cycle       1000      Time         16 Hrs - 40.00 Min

      Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
            203/   0.00 /   573.70             205/   0.00 /   573.00
207/   0.00 /   572.50
            209/   0.00 /   574.00             211/   0.20 /   574.70
213/   0.00 /   574.50
            215/   0.00 /   574.50             217/   0.00 /   574.70
219/   0.00 /   574.00
            221/   0.00 /   574.00             223/   0.00 /   574.00

        Conduit/        FLOW    ===> "*" Conduit uses the normal flow option.
            206/        0.00*            208/        0.00             210/
0.00*           216/        0.00
            218/        0.00             220/        0.00*            222/
0.00*           224/        0.00
            225/        0.00*            226/        0.00         GATE # 1/        0.00


 *=====================================================*
 | Table E5 - Junction Time Limitation Summary         |
 |             (0.10 or 0.25)* Depth * Area            |
 | Time step = ------------------------------          |
 |                 Sum of Flow                         |
 *=====================================================*
 |  The time this junction was the limiting junction  |
 |              is listed in the third column.         |
 *=====================================================*

        Junction      Time(.10)  Time(.25)  Time(sec)
 ----------------     ---------  ---------  ---------
```

203	0.6314	1.5784	780.0000
205	1.6691	4.1727	4020.0000
207	600.0000	600.0000	0.0000
209	1.5847	3.9618	1260.0000
211	0.1195	0.2987	2640.0000
213	1.2706	3.1766	420.0000
215	0.1453	0.3632	960.0000
217	0.1520	0.3801	360.0000
219	1.3279	3.3198	75300.0000
221	1.3279	3.3198	0.0000
223	0.9268	2.3169	660.0000

The junction requiring the smallest time step was...219

```
*==========================================================*
|       Table E5a - Conduit Explicit Condition Summary     |
|       Courant   =          Conduit Length                |
|       Time step = -------------------------------        |
|                      Velocity + sqrt(g*depth)            |
|                                                          |
|                  Conduit Implicit Condition Summary      |
|       Courant   =          Conduit Length                |
|       Time step = -------------------------------        |
|                             Velocity                     |
*==========================================================*
|  The 3rd column is the Explicit time step times the      |
|     minimum courant time step factor                     |
|                                                          |
|  Minimum Conduit Time Step in seconds in the 4th column  |
|  in the list. Maximum possible is 10 * maximum time step |
|                                                          |
|  The 5th column is the maximum change at any time step   |
|  during the simulation. The 6th column is the wobble     |
|  value which is an indicator of the flow stability.      |
|                                                          |
|  You should use this section to find those conduits that |
|  are slowing your model down.  Use modify conduits to    |
|  alter the length of the slow conduits to make your      |
|  simulation faster, or change the conduit name to        |
|  "CHME?????" where ????? are any characters, this will   |
|  lengthen the conduit based on the model time step,      |
|  not the value listed in modify conduits.                |
*==========================================================*
```

Conduit	Time(exp)	Expl*Cmin	Time(imp)	Time(min)	Max Qchange	Wobble	Type of Soln
206	24.3309	24.3309	117.4521	7.0000	2.9982	4.9147	Normal Soln
208	6.2534	6.2534	14.1598	1429.0000	4.2506	73.4391	Normal Soln
210	21.0221	21.0221	135.1440	0.0000	0.4124	7.6025	Normal Soln
216	11.7097	11.7097	43.7250	0.0000	0.7391	16.5835	Normal Soln

```
                218     15.8561     15.8561     52.2846      0.0000          0.6727  11.9680
Normal Soln
                220     25.1394     25.1394    103.7788      0.0000         -1.8362  10.0094
Normal Soln
                222     25.1394     25.1394    103.7788      0.0000         -1.8362  10.0094
Normal Soln
                224     15.8474     15.8474     52.2306      0.0000          0.5378  11.6164
Normal Soln
                225     21.0502     21.0502    153.9205      0.0000          0.5777   6.9620
Normal Soln
                226     11.9397     11.9397     48.1997      4.0000          1.0639  14.5389
Normal Soln
The conduit with the smallest time step limitation was..208
The conduit with the largest wobble was.................208
The conduit with the largest flow change in any
consecutive time step...................................208

 *==================================================*
 |  Table E6. Final Model Condition                 |
 |            This table is used for steady state   |
 |            flow comparison and is the information|
 |            saved to the hot-restart file.        |
 |            Final Time =    24.017 hours          |
 *==================================================*

 Junction / Depth  / Elevation    ===>  "*" Junction is Surcharged.
               203/   0.00 /   573.70/             205/   0.00 /   573.00/
207/   0.00 /   572.50/
               209/   0.00 /   574.00/             211/   0.20 /   574.70/
213/   0.00 /   574.50/
               215/   0.00 /   574.50/             217/   0.00 /   574.70/
219/   0.00 /   574.00/
               221/   0.00 /   574.00/             223/   0.00 /   574.00/

   Conduit/        Flow   ===> "*" Conduit uses the normal flow option.
               206/        0.00*/            208/        0.00 /                210/
0.00 /
               216/        0.00 /            218/        0.00 /                220/
0.00*/
               222/        0.00*/            224/        0.00 /                225/
0.00 /
               226/        0.00 /        GATE # 1/       0.00 /

          Conduit/   Velocity
               206/        0.08 /            208/        0.17 /                210/
0.00 /
               216/        0.00 /            218/        0.00 /                220/
0.10 /
               222/        0.10 /            224/        0.00 /                225/
0.00 /
               226/        0.00 /

          Conduit/      Width
               206/        1.57 /            208/        0.98 /                210/
1.18 /
               216/        0.59 /            218/        0.59 /                220/
0.78 /
               222/        0.78 /            224/        0.59 /                225/
1.18 /
               226/        0.59 /

         Junction/        EGL
               203/        0.00 /            205/        0.00 /                207/
0.00 /
               209/        0.00 /            211/        0.20 /                213/
0.00 /
               215/        0.00 /            217/        0.00 /                219/
```

```
0.00 /
            221/       0.00 /              223/       0.00 /

        Junction/  Freeboard
            203/       8.00 /              205/       8.00 /              207/
8.00 /
            209/       8.00 /              211/       7.30 /              213/
7.50 /
            215/       7.50 /              217/       7.30 /              219/
7.00 /
            221/       7.00 /              223/       8.00 /

        Junction/ Max Volume
            203/   24160.59 /              205/    3669.31 /              207/
32.45 /
            209/     103.80 /              211/   31277.09 /              213/
18198.56 /
            215/   22817.22 /              217/   29189.05 /              219/
36667.22 /
            221/   36667.22 /              223/     103.78 /

        Junction/Total Fldng
            203/   29489.89 /              205/      45.28 /              207/
0.00 /
            209/       0.00 /              211/   35572.16 /              213/
23826.92 /
            215/   23533.54 /              217/   35726.43 /              219/
44005.09 /
            221/   44005.09 /              223/       0.00 /

         Conduit/ Cross Sectional Area
            206/       0.00 /              208/       0.00 /              210/
0.00 /
            216/       0.00 /              218/       0.00 /              220/
0.00 /
            222/       0.00 /              224/       0.00 /              225/
0.00 /
            226/       0.00 /

         Conduit/  Final Volume
            206/       0.01 /              208/       0.00 /              210/
0.00 /
            216/       0.00 /              218/       0.00 /              220/
0.01 /
            222/       0.01 /              224/       0.00 /              225/
0.00 /
            226/       0.00 /

         Conduit/ Hydraulic Radius
            206/       0.01 /              208/       0.01 /              210/
0.00 /
            216/       0.00 /              218/       0.00 /              220/
0.01 /
            222/       0.01 /              224/       0.00 /              225/
0.00 /
            226/       0.00 /

         Conduit/ Upstream/ Downstream Elevation
            206/   573.70/   573.00            208/   573.00/   572.50
210/   573.70/   573.70/
            216/   574.00/   574.00            218/   574.00/   574.00
220/   574.00/   573.00/
            222/   574.00/   573.00            224/   574.00/   574.00
225/   573.70/   573.70/
            226/   574.00/   574.00
```

```
*==========================================================*
|         Table E7 -  Iteration Summary                    |
*==========================================================*
```

Total number of time steps simulated...........	1440
Total number of passes in the simulation........	6937
Total number of time steps during simulation....	3351
Ratio of actual # of time steps / NTCYC.........	2.327
Average number of iterations per time step......	2.070
Average time step size(seconds)................	25.783
Smallest time step size(seconds)................	0.500
Largest time step size(seconds)................	60.000
Average minimum Conduit Courant time step (sec).	52.740
Average minimum implicit time step (sec)........	5.516
Average minimum junction time step (sec)........	5.516
Average Courant Factor Tf......................	5.516
Number of times omega reduced..................	695

```
*==========================================================*
|     Table E8 - Junction Time Step Limitation Summary     |
*==========================================================*
|   Not Convr = Number of times this junction did not      |
|               converge during the simulation.            |
|   Avg Convr = Average junction iterations.               |
|   Conv err  = Mean convergence error.                    |
|   Omega Cng = Change of omega during iterations          |
|   Max Itern = Maximum number of iterations               |
*==========================================================*
```

Junction	Not Convr	Avg Convr	Total Itt	Omega Cng	Max Itern	Ittrn >10	Ittrn >25	Ittrn >40
203	0	2.47	8293	36	36	16	1	0
205	0	2.44	8176	60	25	21	1	0
207	0	3.49	11688	149	43	138	134	5
209	0	2.51	8408	91	29	49	3	0
211	0	1.52	5096	14	16	5	0	0
213	0	2.14	7159	83	37	65	4	0
215	0	1.94	6498	78	30	41	1	0
217	0	1.59	5326	17	19	6	0	0
219	0	1.73	5790	24	47	15	3	1
221	0	1.73	5790	24	47	15	3	1
223	0	2.45	8225	119	30	59	2	0

Total number of iterations for all junctions..	80449
Minimum number of possible iterations.........	36861
Efficiency of the simulation.................	2.18
	Excellent Efficiency

```
*==========================================================*
| Extran Efficiency is an indicator of the efficiency of   |
| the simulation.  Ideal efficiency is one iteration per   |
| time step.  Altering the underrelaxation parameter,      |
| lowering the time step, increasing the flow and head     |
| tolerance are good ways of improving the efficiency,     |
| another is lowering the internal time step. The lower the|
```

```
| efficiency generally the faster your model will run.     |
| If your efficiency is less than 1.5 then you may try     |
| increasing your time step so that your overall simulation|
| is faster.  Ideal efficiency would be around 2.0         |
|                                                          |
| Good Efficiency      < 1.5            mean iterations    |
| Excellent Efficiency < 2.5 and > 1.5 mean iterations     |
| Good      Efficiency < 4.0 and > 2.5 mean iterations     |
| Fair      Efficiency < 7.5 and > 4.0 mean iterations     |
| Poor Efficiency      > 7.5            mean iterations    |
*==========================================================*


*=======================================================*
|         Table E9 - JUNCTION SUMMARY STATISTICS        |
| The Maximum area is only the area of the node, it     |
| does not include the area of the surrounding conduits|
*=======================================================*

                              Uppermost  Maximum      Time        Feet of
Maximum   Maximum   Maximum   Maximum
                      Ground PipeCrown  Junction      of        Surcharge  Freeboard
Junction    Gutter    Gutter    Gutter
       Junction   Elevation Elevation Elevation    Occurence      at Max    of node
 Area     Depth     Width  Velocity
            Name       feet      feet      feet    Hr. Min.   Elevation      feet
 ft^2      feet     feet      ft/s
 ---------------   ---------  --------  --------  ---------   ---------  --------
-------- --------- ---------- ---------
            203    581.7000  577.7000  581.9451     1    5      4.2451    0.0000
170282.95    0.0000    0.0000    0.0000
            205    581.0000  577.0000  581.0297     1    0      4.0297    0.0000
67826.571    0.0000    0.0000    0.0000
            207    580.5000  575.0000  574.9961     1    0      0.0000    5.5039
13.0000    0.0000    0.0000    0.0000
            209    582.0000  577.0000  581.9845     1    6      4.9845    0.0155
13.0000    0.0000    0.0000    0.0000
            211    582.0000  576.2000  582.2831     1   24      6.0831    0.0000
205897.96    0.0000    0.0000    0.0000
            213    582.0000  576.0000  582.2066     1   21      6.2066    0.0000
140505.31    0.0000    0.0000    0.0000
            215    582.0000  576.0000  582.2371     1   21      6.2371    0.0000
163598.58    0.0000    0.0000    0.0000
            217    582.0000  576.2000  582.2727     1   24      6.0727    0.0000
195470.73    0.0000    0.0000    0.0000
            219    581.0000  576.0000  581.3077     1   24      5.3077    0.0000
232881.11    0.0000    0.0000    0.0000
            221    581.0000  576.0000  581.3077     1   24      5.3077    0.0000
232881.11    0.0000    0.0000    0.0000
            223    582.0000  577.0000  581.9827     1    5      4.9827    0.0173
13.0000    0.0000    0.0000    0.0000

*=======================================================*
|         Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the    |
| downstream boundary conditions.                       |
|                                                       |
| * denotes an open conduit that has been overtopped    |
|   this is a potential source of severe errors         |
*=======================================================*

                              Conduit  Maximum  Maximum    Time      Maximum    Time
Ratio of   Maximum Depth        Ratio
                  Design   Design Vertical Computed     of      Computed     of
Max. to   at Pipe Ends          d/D
        Conduit      Flow Velocity     Depth     Flow  Occurence  Velocity Occurence
```

```
Design  Upstream  Dwnstrm   US   DS
            Name     (cfs)   (ft/s)      (in)      (cfs)    Hr.  Min.     (ft/s)  Hr.  Min.
 Flow     (ft)      (ft)
 ---------------  ------- -------- --------  ------- -----------  ------- ----------
------- -------- -------- ----- -----
             206  46.5802   3.7067  48.0000  53.8587      1     6   4.2579     1    6
1.1563 581.9451 581.0297 2.061 2.007
             208  18.7355   3.8168  30.0000  62.8641      1     0  12.7255     1   22
3.3553 581.0610 574.9961 3.224 .9984
             210  16.6869   2.3607  36.0000  19.2430      2    22   2.7107     2   22
1.1532 581.9845 581.9451 2.661 2.748
             216   4.0713   2.3039  18.0000  10.3687      2    23   5.7480     2   23
2.5468 582.2371 581.9844 5.158 5.322
             218   4.0713   2.3039  18.0000  12.0041      3     0   6.6946     3    2
2.9484 582.2727 581.9844 5.048 5.322
             220   8.7681   2.7910  24.0000  15.6084      2    39   4.9044     2   39
1.7801 581.3077 581.0610 3.653 4.030
             222   8.7681   2.7910  24.0000  15.6084      2    39   4.9044     2   39
1.7801 581.3077 581.0610 3.653 4.030
             224   4.0713   2.3039  18.0000  12.0475      3     3   6.7186     3    3
2.9591 582.2831 581.9827 5.055 5.321
             225  16.6869   2.3607  36.0000  16.4229      2     9   2.3879     3    4
0.9842 581.9827 581.9451 2.660 2.748
             226   4.0713   2.3039  18.0000   9.5501      1    25   5.2874     1   25
2.3457 582.2066 581.9827 5.137 5.321
        GATE # 1  Undefnd  Undefnd  Undefn   62.2997      1     0
```

```
 *=================================================*
 | Table E11.  Area assumptions used in the analysis|
 | Subcritical and Critical flow assumptions from   |
 |    Subroutine Head.  See Figure 17-1 in the      |
 |         manual for further information.          |
 *=================================================*
```

```
                 Duration    Duration   Durat. of Durat. of
                    of       of Sub-    Upstream Downstream   Maximum    Maximum
Maximum
        Conduit     Dry      Critical   Critical   Critical Hydraulic    X-Sect
Vel*D
         Name    Flow(min)  Flow(min)  Flow(min)  Flow(min)  Radius-m Area(ft^2)
(ft^2/s)
 --------------- ---------- ----------  ---------  --------- ---------  ---------
--------
            206   258.0000  1182.0000     0.0000     0.0000    1.2165    13.1384
34.6165
            208     2.0000  1438.0000     0.0000     0.0000    0.7411     4.9655
66.5580
            210   474.0000   966.0000     0.0000     0.0000    0.9121     7.4070
13.6681
            216   908.0000   532.0000     0.0000     0.0000    0.4441     1.8399
35.7051
            218   790.0000   650.0000     0.0000     0.0000    0.4485     1.8520
32.1825
            220   698.0000   742.0000     0.0000     0.0000    0.5596     3.2317
29.1092
            222   698.0000   742.0000     0.0000     0.0000    0.5596     3.2317
29.1092
            224   791.3333   648.6667     0.0000     0.0000    0.4484     1.8506
32.2229
            225   473.0000   967.0000     0.0000     0.0000    0.9121     7.4061
13.6580
            226   908.0000   532.0000     0.0000     0.0000    0.4440     1.8394
33.4593
```

```
 *==========================================*
 | Table E12. Mean Conduit Flow Information  |
```

==

Conduit Name	Mean Flow (cfs)	Total Flow (ft^3)	Mean Percent Change	Low Flow Weightng	Mean Froude Number	Mean Hydraulic Radius	Mean Cross Area	Mean Conduit Roughness
206	3.5973	310810.26	0.0123	0.9982	0.3003	0.6083	6.5072	0.0195
208	5.4317	469295.47	0.0688	0.9982	1.5944	0.4145	2.7538	0.0195
210	1.3173	113815.35	0.0051	0.9197	0.3319	0.4608	3.7735	0.0195
216	0.5852	50560.970	0.0024	0.8415	0.2696	0.2291	1.0269	0.0195
218	0.7314	63195.321	0.0025	0.8415	0.3375	0.2281	1.0111	0.0195
220	0.9186	79370.444	0.0053	0.9982	0.2315	0.3110	1.7938	0.0195
222	0.9186	79370.444	0.0053	0.9982	0.2315	0.3110	1.7938	0.0195
224	0.7459	64448.370	0.0018	0.8412	0.3642	0.2280	1.0292	0.0195
225	1.2175	105188.58	0.0050	0.9197	0.3318	0.4629	3.8025	0.0195
226	0.4705	40650.367	0.0026	0.8412	0.2384	0.2276	1.0344	0.0195
GATE # 1	5.4234	468583.24						

```
1
       584.000
|=========|=========|=========|=========|=========|=========|=========|=========|=========
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       582.000 =  # ##
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                  | #    #
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                  | #    #
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         580.000 = #    #
                                  =
                  | #    #
                                  |
                  | #    #
                                  |
 Junction         | #    #
                                  |
                  | #    #
                                  |
Water Surf        | #    #
                                  |
                  | #     #
                                  |
 Elev(ft)         | #     #
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                  | #     #
                                  |
                  | #     #
                                  |
         578.000 = #     #
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         576.000 = #      #
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        574.000
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====|=========|
               0.0       4.0       8.0      12.0      16.0      20.0      24.0
28.0      32.0      36.0      40.0

                 LOCATION NO. : 213           Clock time in hours.


                  Plot of Junction Elevation

                    Invert Elev -  574.50 feet
                     Crown Elev -  576.00 feet
                    Ground Elev -  582.00 feet

1
        584.000
|=========|=========|=========|=========|=========|=========|=========|=========|=====
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```
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         580.000 = #   #
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                 | #   ##
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                 | #    #
                                    |
  Junction       | #    #
                                    |
                 | #    #
                                    |
 Water Surf      | #    #
                                    |
                 | #    #
                                    |
  Elev(ft)       | #     #
                                    |
                 | #     #
                                    |
                 | #     #
                                    |
         578.000 = #     #
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                 | #     #
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         576.000 = #      #
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                 |#       #
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                 #         #
                                    |
         574.000
|========##################################################=========|=========|=====
====|=========|
                   0.0       4.0       8.0      12.0      16.0      20.0      24.0
28.0      32.0      36.0      40.0
```

LOCATION NO. : 223   Clock time in hours.

Plot of Junction Elevation

Invert Elev - 574.00 feet
Crown Elev - 577.00 feet
Ground Elev - 582.00 feet

Table E13. Channel losses(H), headwater depth (HW), tailwater depth (TW), critical and normal depth (Yc and Yn).
Use this section for culvert comparisons

Conduit Name	Maximum Flow	Head Loss	Friction Loss	Critical Depth	Normal Depth	HW Elevat	TW Elevat	
206	53.8483	0.0000	0.9233	2.2040	4.0000	581.9428	581.0203	Max Flow
208	62.7093	0.0000	5.3355	8.0221	2.5000	581.0221	574.9495	Max Flow
210	18.9083	0.0000	0.3822	1.3925	3.0000	578.9054	578.5022	Max Flow
216	10.3087	0.0000	3.0768	1.2342	1.5000	582.0891	578.9005	Max Flow
218	12.0036	0.0000	5.9103	1.3136	1.5000	582.0070	576.0759	Max Flow
220	15.3394	0.0000	2.9814	1.4111	2.0000	581.0540	578.0297	Max Flow
222	15.3394	0.0000	2.9814	1.4111	2.0000	581.0540	578.0297	Max Flow
224	12.0156	0.0000	5.9222	1.3142	1.5000	582.0106	576.0682	Max Flow
225	16.4095	0.0000	0.2866	1.2933	2.4160	579.9178	579.6068	Max Flow
226	9.3628	0.0000	2.5339	1.1818	1.5000	582.2055	579.1963	Max Flow

Table E13a. CULVERT ANALYSIS CLASSIFICATION, and the time the culvert was in a particular classification during the simulation. The time is in minutes. The Dynamic Wave Equation is used for all conduit analysis but the culvert flow classification condition is based on the HW and TW depths.

Conduit Name	Mild Slope Critical D Outlet Control	Mild Slope TW Control Outlet Control	Steep Slope TW Insignf Entrance Control	Slug Flow Outlet/ Entrance Control	Mild Slope TW > D Outlet Control	Mild Slope TW <= D Outlet Control	Outlet Control	Inlet Control	Inlet Configuration
206	8.0000	1317.0000	2.0000	0.0000	113.0000	0.0000	0.0000	0.0000	None
208	82.0000	1242.0000	2.0000	0.0000	0.0000	0.0000	114.0000	0.0000	None
210	0.0000	1059.0000	265.0000	0.0000	116.0000	0.0000	0.0000	0.0000	None
216	6.0000	766.0000	528.0000	0.0000	140.0000	0.0000	0.0000	0.0000	None
218	7.0000	765.0000	528.0000	0.0000	140.0000	0.0000	0.0000		

0.0000 None

220	8.0000	1287.0000	2.0000	0.0000	143.0000	0.0000	0.0000	0.0000	None
222	8.0000	1287.0000	2.0000	0.0000	143.0000	0.0000	0.0000	0.0000	None
224	6.0000	765.0000	528.0000	0.0000	141.0000	0.0000	0.0000	0.0000	None
225	0.0000	1059.0000	265.0000	0.0000	116.0000	0.0000	0.0000	0.0000	None
226	8.0000	763.0000	528.0000	0.0000	141.0000	0.0000	0.0000	0.0000	None

```
*=====================================*
|    Kinematic Wave Approximations    |
|  Time in Minutes for Each Condition |
*=====================================*
```

Conduit Name	Duration of Normal Flow	Slope Criteria	Super-Critical	Roll Waves
206	1263.7500	1311.6548	121.0000	0.0000
208	0.0000	0.0000	2.0000	0.0000
210	960.8333	1322.2500	407.0000	0.0000
216	722.5000	1289.3083	670.0000	0.0000
218	728.1583	1287.6000	670.0000	0.0000
220	1270.5000	1300.1333	136.0000	0.0000
222	1270.5000	1300.1333	136.0000	0.0000
224	727.1083	1289.3750	670.0000	0.0000
225	958.1667	1322.0833	407.0000	0.0000
226	720.7500	1289.4083	671.0000	0.0000

```
*=========================================================*
|     Table E15 - SPREADSHEET INFO LIST                   |
| Conduit Flow and Junction Depth Information for use in  |
| spreadsheets.  The maximum values in this table are the |
| true maximum values because they sample every time step.|
| The values in the review results may only be the        |
| maximum of a subset of all the time steps in the run.   |
| Note: These flows are only the flows in a single barrel.|
*=========================================================*
```

Conduit Name	Maximum Flow	Total Flow	Maximum Velocity	Maximum Volume	##	Junction Name	Invert Elevation	Maximum Elevation
206	53.8587	310810.2632	4.2579	6333.0846	##	203	573.7000	581.9451
208	62.8641	469295.4733	12.7255	888.2685	##	205	573.0000	581.0297
210	19.2430	113815.3463	2.7107	2605.8369	##	207	572.5000	574.9961
216	10.3687	50560.9704	5.7480	459.8544	##	209	574.0000	581.9845
218	12.0041	63195.3212	6.6946	642.8668	##	211	574.5000	582.2831
220	15.6084	79370.4438	4.9044	1600.9382	##	213	574.5000	582.2066
222	15.6084	79370.4438	4.9044	1600.9382	##	215	574.5000	582.2371

```
          224     12.0475  64448.3699        6.7186       642.8362    ##
217   574.7000     582.2727

          225     16.4229 105188.5845        2.3879      2604.1924    ##
219   574.0000     581.3077

          226      9.5501  40650.3670        5.2874       459.7105    ##
221   574.0000     581.3077

       GATE # 1   62.2997 468583.2426        0.0000         0.0000    ##
223   574.0000     581.9827
```

```
*=====================================================*
|     Table E15a - SPREADSHEET REACH LIST              |
| Peak flow and Total Flow listed by Reach or those   |
|      conduits or diversions having the same          |
|      upstream and downstream nodes.                  |
*=====================================================*
```

Upstream Node	Downstream Node	Maximum Flow	Total Flow
203	205	53.8587	310810.263
205	207	62.8641	469295.473
209	203	19.2430	113815.346
215	209	10.3687	50560.9704
217	209	12.0041	63195.3212
219	205	15.6084	79370.4438
221	205	15.6084	79370.4438
211	223	12.0475	64448.3699
223	203	16.4229	105188.584
213	223	9.5501	40650.3670

```
#######################################################
# Table E16. New Conduit Information Section          #
#            Conduit Invert (IE) Elevation and Conduit  #
#            Maximum Water Surface (WS) Elevations      #
#######################################################
```

Conduit Name	Upstream Node	Downstream Node	IE Up	IE Dn	WS Up	WS Dn	Conduit Type
206	203	205	573.7000	573.0000	581.9451	581.0297	Circular

```
            208              205              207  573.0000  572.5000  581.0610
574.9961 Circular

            210              209              203  574.0000  573.7000  581.9845
581.9451 Circular

            216              215              209  574.5000  574.0000  582.2371
581.9844 Circular

            218              217              209  574.7000  574.0000  582.2727
581.9844 Circular

            220              219              205  574.0000  573.0000  581.3077
581.0610 Circular

            222              221              205  574.0000  573.0000  581.3077
581.0610 Circular

            224              211              223  574.7000  574.0000  582.2831
581.9827 Circular

            225              223              203  574.0000  573.7000  581.9827
581.9451 Circular

            226              213              223  574.5000  574.0000  582.2066
581.9827 Circular
```

```
 *==============================================================================*
 |   Table E18 - Junction Continuity Error.   Division by Volume added 11/96   |
 |                                                                              |
 |  Continuity Error = Net Flow + Beginning Volume - Ending Volume              |
 |                     -------------------------------------------------        |
 |                     Total Flow + (Beginning Volume + Ending Volume)/2        |
 |                                                                              |
 |  Net Flow   = Node Inflow - Node Outflow                                     |
 |  Total Flow = absolute (Inflow + Outflow                                     |
 |  Intermediate column is a judgement on the node continuity error.           |
 |                                                                              |
 |  Excellent  < 1 percent    Great  1 to  2 percent  Good  2 to  5 percent    |
 |  Fair  5 to 10  percent    Poor  10 to 25 percent  Bad  25 to 50 percent    |
 |  Terrible > 50  percent                                                      |
 *==============================================================================*

      Junction    <------Continuity Error ------->  Remaining   Beginning    Net
Flow  Total Flow Failed to
          Name      Volume  % of Node  % of Inflow     Volume      Volume   Thru
Node   Thru Node  Converge
----------------  --------  ---------- ----------   --------  ----------
----------  ---------- ---------
            203   2011.1572      0.3225     0.4762     0.0090      0.0061
2011.1601 623595.5442          0


            205  -5301.2916     -0.5647     1.2553     0.0141      0.0084
-5301.2859 938846.6240          0


            207     23.3883      0.0025     0.0055     0.0014      0.0010
23.3887 937878.7158          0


            209    -63.0941     -0.0277     0.0149     0.0048      0.0048
-63.0941 227571.6379          0
```

```
            211  -9489.8937     -7.9523      2.2472      2.6015      0.0018
-9487.2939 119334.3079          0

            213  -1067.8512     -1.3319      0.2529      0.0013      0.0013
-1067.8512  80173.8636          0

            215 -10978.6762    -12.1871      2.5997      0.0013      0.0013
-10978.6762  90084.4670          0

            217  -8194.7423     -6.9399      1.9405      0.0018      0.0018
-8194.7423 118081.2592          0

            219  -9392.4314     -6.2943      2.2241      0.0034      0.0025
-9392.4305 149221.8088          0

            221  -9392.4314     -6.2943      2.2241      0.0034      0.0025
-9392.4305 149221.8088          0

            223    -77.2129     -0.0367      0.0183      0.0048      0.0048
-77.2129 210287.3214          0

 The total continuity error was  -51923.     cubic feet
 The remaining total volume was   2.6466     cubic feet
 Your mean node continuity error was   Excellent
 Your worst node continuity error was  Good

   *====================================================*
   | Table E19 - Junction Inflow Sources                 |
   |             Units are either ft^3 or m^3            |
   |             depending on the units in your model.|
   *====================================================*

                  Constant       User       Interface      DWF        Inflow     RNF
Layer
       Junction     Inflow      Inflow       Inflow       Inlow       through
Inflow      Outflow   Evaporation
            Name    to Node      to Node       to Node      to Node      Outfall
to Node    from Node     from Node
 ---------------  ----------  -----------  -----------  -----------  -----------
 -----------  -----------  -----------
            203     0.0000       0.0000   93791.0461       0.0000       0.0000
0.0000        0.0000       0.0000

            207     0.0000       0.0000       0.0000       0.0000       0.0000
0.0000   468583.2426       0.0000

            211     0.0000       0.0000   54891.7211       0.0000       0.0000
0.0000        0.0000       0.0000

            213     0.0000       0.0000   39527.9182       0.0000       0.0000
0.0000        0.0000       0.0000

            215     0.0000       0.0000   39527.9182       0.0000       0.0000
0.0000        0.0000       0.0000

            217     0.0000       0.0000   54891.7211       0.0000       0.0000
0.0000        0.0000       0.0000

            219     0.0000       0.0000   69861.1573       0.0000       0.0000
0.0000        0.0000       0.0000
```

```
          221       0.0000        0.0000    69861.1573        0.0000        0.0000
0.0000        0.0000        0.0000
```

```
*===================================================*
| Table E20 - Junction Flooding and Volume Listing.  |
|             The maximum volume is the total volume  |
|             in the node including the volume in the |
|             flooded storage area. This is the max   |
|             volume at any time. The volume in the   |
|             flooded storage area is the total volume|
|             above the ground elevation, where the   |
|             flooded pond storage area starts.       |
| The fourth column is instantaneous, the fifth is the|
| sum of the flooded volume over the entire simulation|
| Units are either ft^3 or m^3 depending on the units.|
*===================================================*
```

Junction Name	Surcharged Time (min)	Flooded Time(min)	Out of System Flooded Volume	Maximum Volume	Stored in System Ponding Allowed Flood Pond Volume
203	112.7857	28.1000	0.0000	24160.5893	29489.8851
205	113.3036	26.7056	0.0000	3669.3141	45.2826
207	0.0000	0.0000	0.0000	32.4493	0.0000
209	115.2083	0.0000	0.0000	103.7982	0.0000
211	139.0167	129.8128	0.0000	31277.0913	35572.1630
213	137.9500	86.1111	0.0000	18198.5612	23826.9203
215	136.9750	101.5556	0.0000	22817.2160	23533.5389
217	138.0250	128.2615	0.0000	29189.0459	35726.4278
219	120.3125	110.4904	0.0000	36667.2216	44005.0875
221	120.3125	110.4904	0.0000	36667.2216	44005.0875
223	115.1250	0.0000	0.0000	103.7756	0.0000

```
*=================================*
| Simulation Specific Information  |
*=================================*
Number of Input Conduits..........        10 Number of Simulated Conduits......
11
Number of Natural Channels........         0 Number of Junctions...............
11
Number of Storage Junctions.......         0 Number of Weirs...................
 0
```

```
Number of Orifices...............          0 Number of Pumps..................
 0
Number of Free Outfalls..........          0 Number of Tide Gate Outfalls......
 1


*=====================================================*
| Average % Change in Junction or Conduit is defined as:  |
| Conduit  % Change ==> 100.0 ( Q(n+1) - Q(n) ) / Qfull   |
| Junction % Change ==> 100.0 ( Y(n+1) - Y(n) ) / Yfull   |
*=====================================================*

The Conduit with the largest average change was..208        with     0.069 percent
The Junction with the largest average change was.205        with     0.306 percent
The Conduit with the largest sinuosity was.......208        with    73.439


*==================================================================*
| Table E21. Continuity balance at the end of the simulation       |
|            Junction Inflow, Outflow or Street Flooding           |
| Error = Inflow  + Initial Volume - Outflow - Final   Volume      |
*==================================================================*

       Inflow         Inflow      Average
       Junction    Volume,ft^3   Inflow, cfs
 ---------------  ------------  ------------
            203    93781.3503        1.0854

            211    54885.9380        0.6353

            213    39523.4966        0.4574

            215    39523.4966        0.4574

            217    54885.9380        0.6353

            219    69851.3650        0.8085

            221    69851.3650        0.8085

            207  -468583.2426       -5.4234


       Outflow      Outflow        Average
       Junction   Volume,ft^3   Outflow, cfs
 ---------------  ------------  ------------
            207   468583.2426        5.4234



*=====================================================*

| Initial system volume        =          0.0361 Cu Ft |

| Total system inflow volume   =     422352.6394 Cu Ft |
```

```
| Inflow + Initial volume       =    422352.6756 Cu Ft |

*=====================================================*

| Total system outflow          =    468583.2426 Cu Ft |

| Volume left in system         =         2.6466 Cu Ft |

| Evaporation                   =         0.0000 Cu Ft |

| Outflow + Final Volume        =    468585.8892 Cu Ft |

*=====================================================*


*================================================*
| Total Model Continuity Error                   |
| Error in Continuity, Percent =       -10.9466 |
| Error in Continuity, ft^3    =     -46233.214 |
| + Error means a continuity loss, - a gain      |
*================================================*

###################################################
# Table E22. Numerical Model judgement section    #
###################################################

Your overall error was                                          -10.9466 percent
Worst nodal error was in node 215              with             -12.1871 percent
Of the total inflow this loss was                                 2.5994 percent
Your overall continuity error was                  Poor
                                                  Excellent Efficiency
Efficiency of the simulation                       2.18
Most Number of Non Convergences at one Node        0.
Total Number Non Convergences at all Nodes         0.
Total Number of Nodes with Non Convergences        0.

===> Hydraulic model simulation ended normally.
===> XP-SWMM Simulation ended normally.
===> Your input file was named  : C:\XPSWMM Data\WORK\MACTEST\mac100.DAT

===> Your output file was named : C:\XPSWMM Data\WORK\MACTEST\mac100.out


*===============================================================*
|             SWMM Simulation Date and Time Summary             |
*===============================================================*
| Starting Date... October    20, 2008  Time...     9:58:51:37  |
|   Ending Date... October    20, 2008  Time...     9:59: 0:37  |
|  Elapsed Time...     0.15000 minutes or      9.00000 seconds  |
*===============================================================*
```

VITA

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In January of 1985, he started his graduate studies at the University of New Orleans in the Department of Civil and Environmental Engineering. He received his Master of Science in Engineering in May of 1994. He continued with his graduate work until January of 2001 when he started his post graduate work.