ATTACHMENT 7. TECHNICAL JUSTIFICATION OF PROJECT

This attachment presents technical justification for the Project's physical benefits and provides studies, documents, and other reference materials to support the Project. The Project eliminates risk of dam failure due to excessive seepage to the Big Dry Creek Dam and adds flood storage along Dry Creek, or tributary thereto and thereby reduces the flood risk and flood damages throughout the metropolitan area. The urban area of Fresno/Clovis lacks adequate storage of flood water to prevent overtaxing channels in events exceeding the 25 year-96 hour event.

The storm and flood routing model used by FMFCD is proposed to route flood flows within the capacity of the canal system in events up to the 200-year return frequency. This event level is consistent with the event frequency used by the U.S. Army Corps of Engineers (USACE) in design of the Redbank and Fancher Creeks Flood Control Project that generally covered the Fresno County Stream Group area. It is also consistent with AB 5 establishing a 200-year urban area flood protection level and as identified in the Central Valley Flood Protection Plan. While the Fresno area is not a part of that plan, FMFCD strives to meet this urban protection goal for flood routing and to the extent it is successful in controlling such flood flows, diversion from the Fresno Metropolitan area to the San Joaquin River are lessened. Lessening such diversions help the DWR with managing flood flows on the San Joaquin River downstream.

The technical justification is explained in greater detail, along with a list of the physical benefits described in the following paragraphs. **Much of the discussion that follows is also discussed in greater detail in Attachment 8, and provided here for reference.**

Technical Justification

Each of four (4) work locations and their justification is first discussed below. Then the justification is summarized collectively in the Dry Creek Flood Control Improvement Project section that follows.

Big Dry Creek Dam

In 1995, the USACE performed a dam break analysis for Big Dry Creek Dam. The results are presented in a report entitled "Dam Breach Analysis for Big Dry Creek Dam" (see Appendix 3-2). The discussions that follow are based on the data presented in the dam break report. The dam was assumed to fail by piping, and the breach was assumed to be 80 feet wide at the dam invert. Most breaches occur after flow begins to overtop the dam, however, for the purposes of the USACE study, they simulated a dam breach occurring with the water surface at the spillway crest (from a piping failure), and after inflow to the reservoir has essentially ended.

Inundation Area

Figure 8.1 included in Attachment 8 is a map showing the potential inundation from a failure at Big Dry Creek Dam. The map is based on inundation boundaries prepared by the USACE (1995). The map shows the inundation at different time intervals over a 14 hour period. The inundation will cover 60.7 square miles and flood a large portion of the Cities of Fresno and Clovis, and unincorporated areas of Fresno County. Modeled flood depths are generally three (3) feet or less. Most areas will experience flooding of less than two (2) feet in depth. Isolated low lying areas near channels may experience flooding of up to six (6) feet in depth. It is assumed that flooding averages between one (1) and two (2) feet throughout the inundation area. Very dangerous conditions will exist within four (4) miles of the dam. Consequently, the inundation map showed two zones: High Velocity Zone (less than four (4) miles from dam) and the Low Velocity Zone (more than 4 miles from dam).

Delineated flood limits represent the best estimate of expected flooding. Additional areas of shallow sheet flooding (one (1) foot or less in depth) may occur along canals and streets outside of the delineated flood zones. Flooding outside the delineated zone (other than that within canals) is shallow flow with low velocity.

History of Seepage and Seepage Analysis

FMFCD has experienced seepage and sand boils at the toe of Big Dry Creek Dam in three (3) flood storage conditions (water surface elevation of 422.5, January 27, 1997, 419.6, April 10, 2006, and 419.02, January 3, 2011).

FMFCD began studies to improve the dam and reduce the risk of failure following the first event. However, opportunities for capturing water and gaining documentation are very infrequent. Piezometers were installed to obtain data for analysis and evaluation. FMFCD has selected a new and deeper toe drain as the most feasible and economical option for improvement that also has the least environmental impact. The toe drain improvement includes an automated electrically powered dewater pump to improve the effectiveness of its drainage and lessen the cost of a solution. In the event of a power failure, FMFCD owns and maintains 18 portable pumps that are available to temporarily replace any failed pump in its system, including this toe drain dewatering pump.

FMFCD's geotechnical consultant has presented to FMFCD several reports supporting the need to improve the seepage condition. This consultant has also assisted in assessing the risk of dam failure as greater reservoir heads develop with larger storm events.

Also noteworthy is the Department of Water Resources, Division of Dam Safety's letter dated December 19, 2012 and attached as Appendix 7-1, recommending FMFCD address the seepage issue and request DWR grant funding assistance if needed for this dam safety improvement.

The toe exit gradient at the sand boils was estimated to be 0.50, and is documented in the geotechnical consultant's report. This occurs at a reservoir elevation at 419.0 feet. Elevation

419.0 feet is a storage pool of 8,437 acre-feet, but a full reservoir is 13.7 feet higher at elevation 432.7 and a storage pool of 30,300 acre-feet. USACE standards are exit gradients of 0.50 or less. Not only does this technically justify seepage control improvement, when considering the dam is immediately upstream of a major metropolitan area, severe damages and public safety warrant action.

Further technical justification details are contained in geotechnical reports in Appendix 3-6 through 3-13.

FMFCD's geotechnical consultant performed several years of seepage and groundwater analysis and prepared conceptual designs for mitigating seepage and sand boils. Please see Appendix 3-15 for reference to the January 22, 2013 report. In this report, the consultant addressed the seepage and sand boil observations in 2006 and presented seepage mitigation alternatives. It states on Page 5, under 4.0 Seepage Mitigation Alternatives, "Seepage conditions in the area of Stations 62+00 to 85+00… A maximum pool elevation of 419.0 feet produces a toe exit gradient (i_o) of approximately 0.50." As mentioned in the same report on page 5, toe exit gradients in excess of 0.50" exceed USACE standards and warrant construction improvements. From the consultant's recommendations, FMFCD selected a deep toe drain with dewatering pumps. Please see Appendix 7-2: BSK Seepage Mitigation – Toe Drain.

The toe drain design has been developed by the licensed consulting Geotechnical Engineer who has similar design experience and is familiar with location and the Project. The preliminary design is consistent with applicable engineering standards and requirements, and the performance estimated is based on that of similar already completed projects.

Recharge

FMFCD staff anticipated the toe drain improvement would allow some water retention at the dam near the end of the rain season. This water and the toe drain discharge will be distributed downstream for groundwater recharge purposes. FMFCD staff estimates the reservoir capture to be about 1,000 acre-feet every four years or an average of about 250 acre-feet per year. This recharge would benefit the downstream metropolitan area that is experiencing a depleting groundwater table. Management of water resources is important to FMFCD, but we have not monetized this 250 acre-feet of recharge benefit as it is small in comparison to the flood damage reduction.

Water Quality

With the toe drain improvements, FMFCD anticipates that an additional 250 acre-feet of water will be held behind the dam on an average annual basis. This would remove 37.5 tons of sediment on the same average annual basis.

Pup Creek-Enterprise Detention Basin

No water is proposed to enter the Enterprise Canal at the Pup Creek Main Channel in FMFCD flood routing model. However, FMFCD staff estimates water will enter the Enterprise Canal in

approximately a 15-year, 96-hour flood event unless a detention basin is constructed. With the Project in place creating 50 acre-feet of storage, the approximate flood event before water enters the canal is a 40 year-96 hour event. FMFCD will continue to enlarge the storage at the Pup Creek-Enterprise Basin following completion of the Grant Project until the capacity is 200 acre-feet at which point the approximate flood event before water enters the canal is a 200 year-96 hour event. Figure 7-1 demonstrates the excess flow reaching the Enterprise Canal and the majority of flow entering the canal from the 200-year, 96-hour storm event (Storage Benefit Analysis calculations are included Appendix 7-3). FMFCD has identified two flood risks associated with water flowing in the Pup Creek Channel:

1) Peak flood flows exceed the capacity of the culvert beneath the Enterprise Canal. Therefore, water will overflow into the canal and disrupt the flood routing model. This will cause overflow and flood damages in downstream channels within the urban area or require urban pumps to be turned off to avoid canal overtopping. Either canal overtopping or turning pumps off will result in urban flood damages.
2) If such flows were prevented from entering the Enterprise Canal and therefore forced downstream in the main channel, damages would occur within a mile immediately downstream of the Enterprise Canal. This downstream channel is only a poorly defined topographic swale without a bed or bank.

The FMFCD Board of Directors determined that the development of the Pup Creek-Enterprise Detention Basin (See Appendix 7-4: Board Approval to develop Pup Creek-Enterprise Detention Basin Memorandum and Minutes) was warranted because of the opportunity to acquire the detention basin property at a very reasonable expense, the potential flood reduction benefit, the benefit of a groundwater recharge facility upland of the City of Clovis' municipal well system, and the wildlife enhancement and trail enhancement opportunity.

The basin will be developed in three (3) phases, with only the first two phases included in the grant Project. The latter phase of 150 acre-feet of excavation will be delayed beyond the Project period in order to contain costs. The final and non-grant phase will be completed by FMFCD over time so that the larger portion of the excavation cost will be avoided. For this third phase the FMFCD proposes to allow local contractors in need of fill for their own projects to excavate and export the material from the basin without public expense. The FMFCD has a successful on-going program that has been in place for decades.

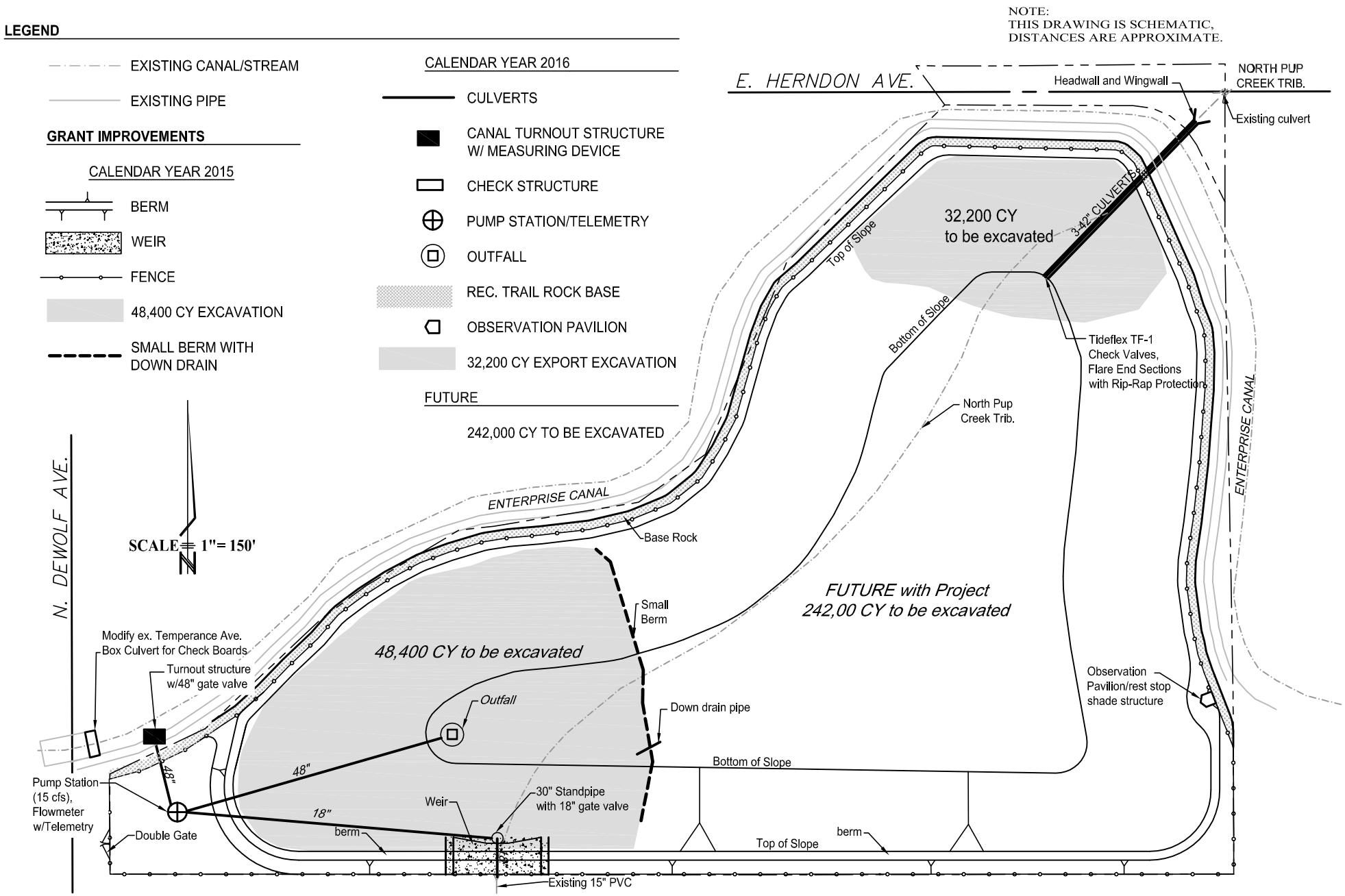
Grant Project includes two phases as listed below and shown on Figure 7-2:

Calendar Year 2015

a) Earthwork to create downstream control berm and upstream embankment against canal for trail and perimeter control of water storage (48,400 cubic yards of storage created).

PUP CREEK - ENTERPRISE CANAL ROUTING DIAGRAM

Figure 7-1



PUP CREEK-ENTERPRISE DETENTION BASIN IMPROVEMENT

FIGURE 7-2

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

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b) Outlet overflow weir with a small outlet pipeline for release of water downstream, but with a control valve for use during non-rain season groundwater recharge activity.
c) Basin security with complete perimeter of 6-foot high chain link fence.

Calendar Year 2016

a) Installing all the pipeline culverts beneath the Enterprise Canal and restore canal with concrete lining to FID standards.
b) Restrictions and valves on culverts to maintain flow limitations beneath the Enterprise Canal to match control capacity in the detention basin.
c) Turnout from the Enterprise Canal with flow meter/measuring device for groundwater recharge water deliveries.
d) Base rock recreational trail on the northerly perimeter of basin.
e) Recreation trail rest stop/shade shelter/wildlife viewing pavilion.
f) Excavation and export of 32,200 cubic yards of material.
g) Construct dewatering pump station for discharge control and long-term maintenance purposes.
h) Internal pipelines.

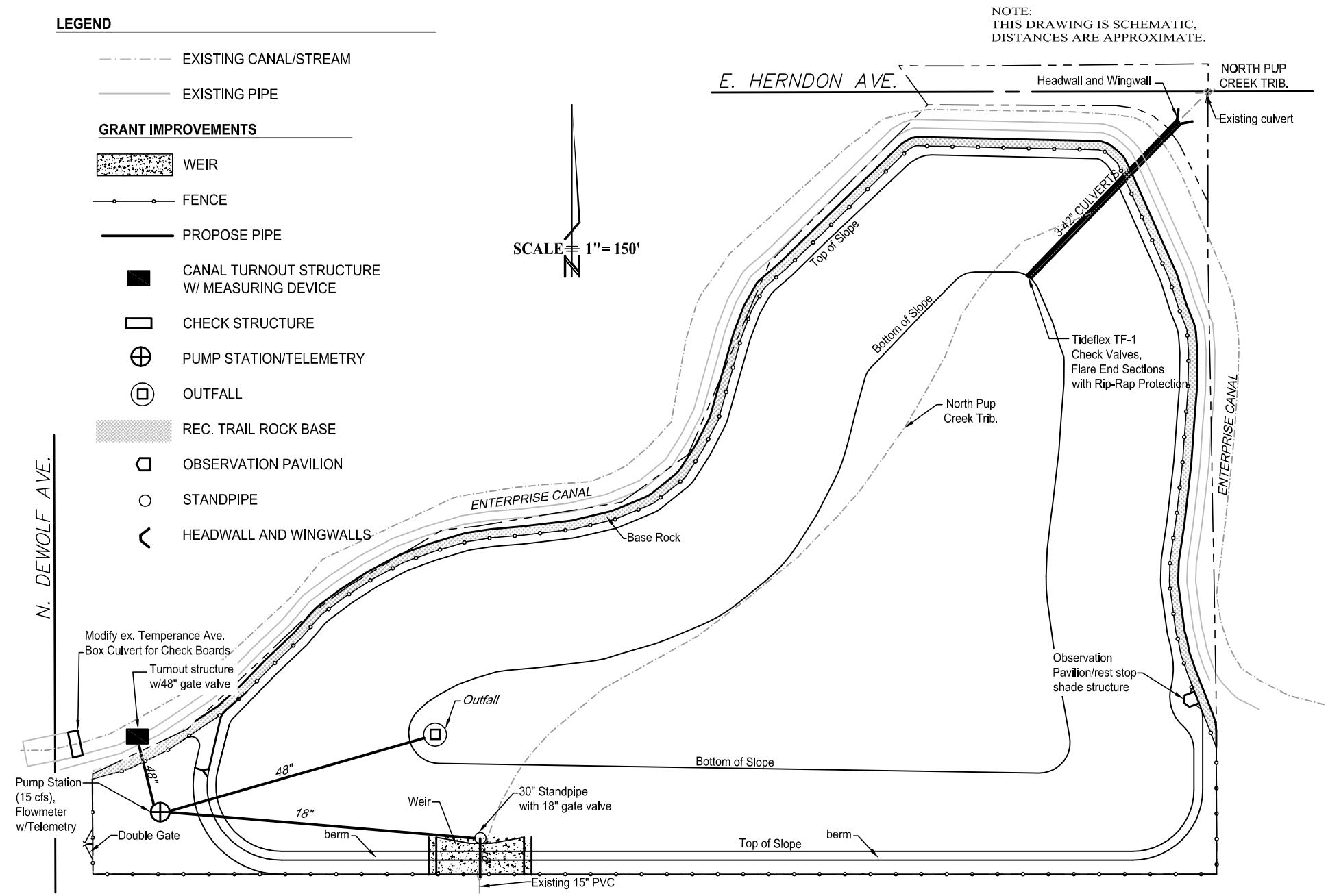
Future work (not a part of grant) (See Figure 7-3)

a) Deepen excavation of the basin to a floor depth of 26.8 feet (150 acre-foot).
b) Lessen culvert restrictions to match storage/excavation progress.

Recharge

The basin will percolate stormwater detained in the basin. The water will be percolated in Fresno-Clovis metropolitan where there is significant groundwater overdraft. The basin will also capture and recharge water that is normally lost to the region. The basin can also receive a portion of the City of Clovis' water entitlement during the irrigation delivery season from the Enterprise Canal. FMFCD will measure the percolation rate at this basin site to obtain an accurate percolation rate. To determine the percolation value prior to use of the site, FMFCD estimated the percolation rate from other sites it operates with similar soils. FMFCD acknowledges the rate will vary between the initial and subsequently evolving construction period and needs to be reassessed as the basin excavation is enlarged and deepened in the future.

For the purpose of the grant, FMFCD has estimated the percolation rate of 0.05 feet per day. This is a relatively low percolation rate, but similar to that at other basins in the vicinity that have observed percolation rates of between 0.1 and 0.2 feet per day. With the estimated percolation rates, FMFCD can compute the estimated annual groundwater recharge by estimating the number of days per year that either floodwater or City of Clovis surface water entitlement will be spread into the basin. FMFCD estimates 11.8 acres at 0.05 feet/day for 197 days at the Pup Creek-Enterprise Basins to recharge about 120 acre-feet/year.



PUP CREEK-ENTERPRISE DETENTION BASIN IMPROVEMENT POST PROJECT

FIGURE 7-3

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

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Water Quality

FMFCD has an extensive water quality improvement program that captures pollutant laden storm flows and allows pollutants to settle out with sediments in the detention basins. Basins are maintained in conformance with the FMFCD's Sediment Management Program (Appendix 7-5). Water quality will also be improved as water is filtered in the soil during recharge. The Pup Creek-Enterprise Detention Basin will improve the quality of water detained in the basin.

To provide an example, included is the Fresno-Clovis Storm Water Quality Monitoring Program Technical Memorandum for Basin "C" Monitoring (Appendix 7-6).

Approximately 7.5 tons of sediment is estimated to be removed annually from the additional 50 acre-feet of stormwater captured annually. Staff estimates the 50 acre-feet volume of the basin to fill from stream flows at least once annually.

Recreational Trail with Rest Stop/Shade Structure/Wildlife Observation

The City of Clovis and County of Fresno General Plans include a Recreational Trail Master Plan, in which the Enterprise Trail along the Enterprise Canal is identified (Appendix 7-7). The Project includes construction of a section of the trail along the Enterprise Canal, along with flood routing and stormwater storage improvements.

The canal bank is currently used by residents as a trail, but FID needs the canal bank for its operations and maintenance and desires room for trail users to be shifted to an adjoining 20 foot-wide FID access area, as shown below. This new basin will have the recreational trail along its northerly perimeter. Please see Figure 7-4 for the improvement and geometry of the trail between the Enterprise Canal and the basin.

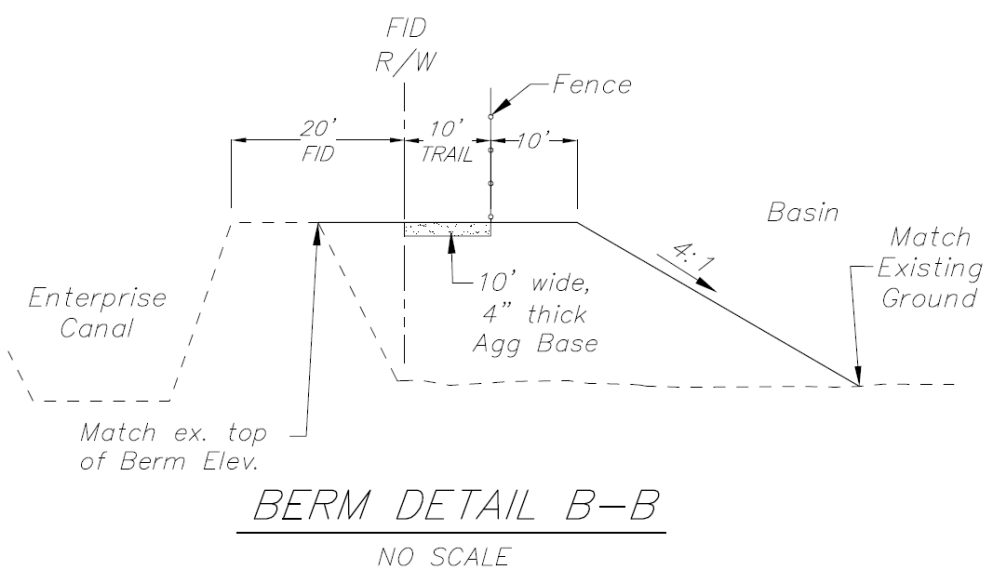


Figure 7-4: Cross Section of Enterprise Trail and Pup Creek-Enterprise Detention Basin

A rest stop/shade structure/wildlife observation pavilion is proposed near the southeast corner of the basin along the new section of the Enterprise Trail. From the pavilion, trail users can observe basin wildlife and read educational signage regarding wildlife. The basin will provide water habitat for wildlife that will be protected with a perimeter security fence. When other properties develop along the planned trail, they will connect to the portion of the trail constructed with the grant funds.

Big Dry Creek Detention Basin

This basin is located along Big Dry Creek just below the point of confluence with the Gould Canal. Flood flows are routed in both channels, so a detention basin at this location is very effective as a control point in a flood event.

Caltrans proposed a drainage basin on a portion of the site for drainage at Freeway 168. FMFCD desired to obtain the Caltrans basin and expand the basin area and capacity to meet the needs of FMFCD. FMFCD and CalTrans are nearing final approvals of the land acquisition and only one step remains. Information regarding the Federal Aviation Administration's processing of the land sale transaction is included as Appendix 7-8. Much of the basin was allowed to be excavated and serves Freeway 168. When the land transaction is completed, FMFCD will implement its uses of the basin. Those FMFCD benefits or needs for the basin are:

1) Gain capacity for Local Drainage Area "C", so that urban drainage system's storage capacity would meet current FMFCD storage standards, and
2) Add additional capacity as a detention basin to control flood flow in Big Dry Creek and through the downstream metropolitan area.

Please note that the portion of the land and excavation costs to serve Caltrans for the consolidated basin are not included in the grant, but have been complete as part of the Freeway project funding. Only remaining excavation to be completed by FMFCD is included in the grant work. Preliminary drawings of the basin have been prepared to establish the physical improvements and capacity of the basin.

The capacity of the basin is approximately 260 acre-feet. The capacity allocation is as follows:

- Freeway 168 drainage - 48.3 acre-feet
- Drainage Area "C" - 18.0 acre-feet
- Detention of flood flows - 193.7 acre-feet

The project will construct the following improvements in phases shown on Figure 7-5:

Calendar Year 2014

a) Complete excavation and grading of the basin.
b) Construct and/or relocate fence to final perimeter.

NOTE:
THIS DRAWING IS SCHEMATIC,
DISTANCES ARE APPROXIMATE.

LEGEND

EXISTING PIPE

EXISTING FENCE

GRANT IMPROVEMENTS

AREA TO BE EXCAVATED, 2014 - 2016

CALENDAR YEAR 2014

AGGREGATE BASE

EXCAVATE, FILL, GRADE AND PLACE FENCE

CALENDAR YEAR 2015

PROPOSED PIPE

PUMP STATION/TELEMETRY SYSTEM

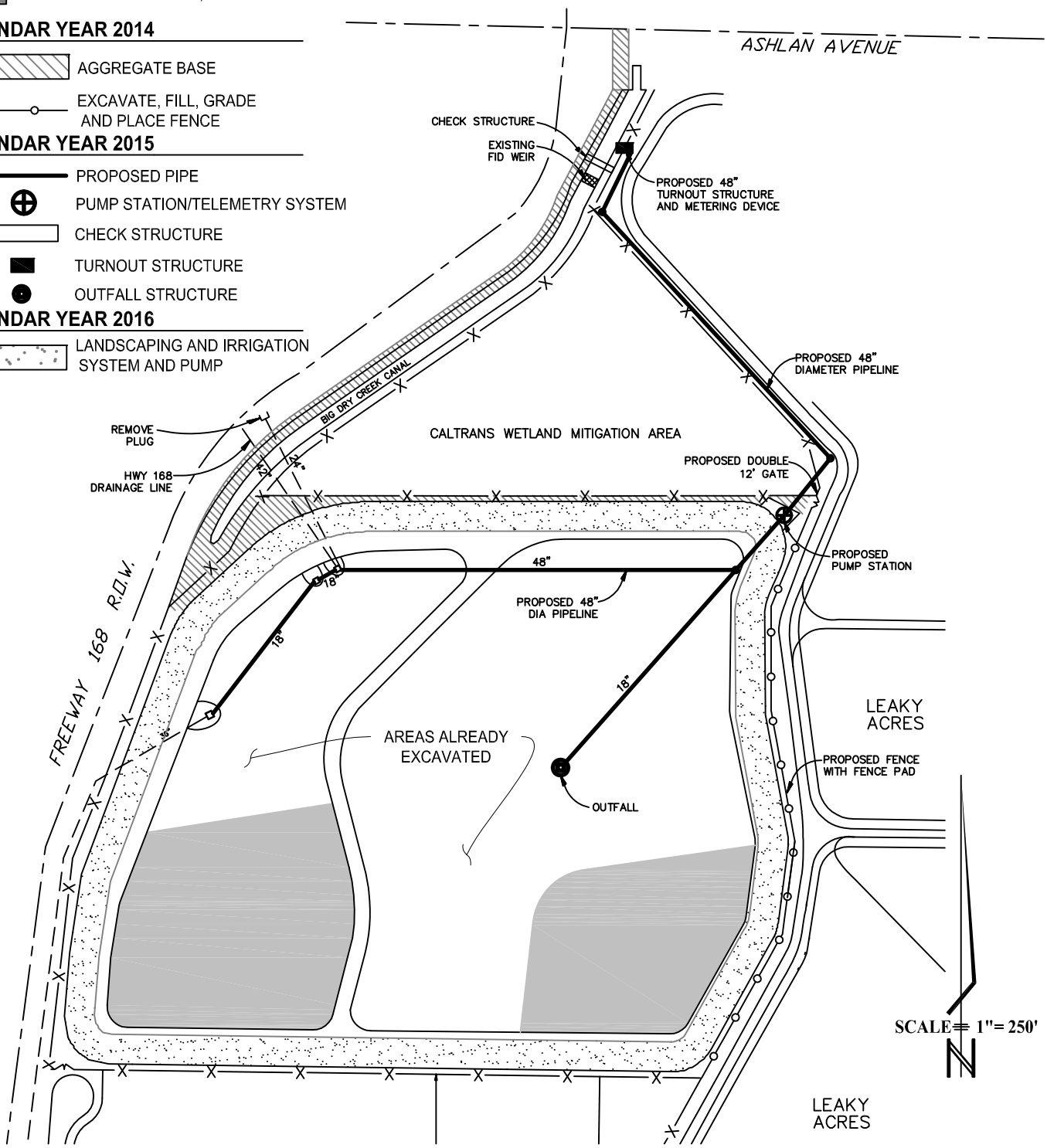
CHECK STRUCTURE

TURNOUT STRUCTURE

OUTFALL STRUCTURE

CALENDAR YEAR 2016

LANDSCAPING AND IRRIGATION SYSTEM AND PUMP



BIG DRY CREEK DETENTION BASIN IMPROVEMENT

FIGURE 7-5

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Calendar Year 2015

a) Construct 48-inch diameter pipeline connection to Big Dry Creek to divert flows into the basin or discharge water from the basin.
b) Permanent pump station with telemetry system.
c) Metering device to measure delivery of recharge water during irrigation season.
d) Turnout structure for diversion into basin.
e) Check structure for diversion into basin.
f) Internal basin pipelines.

Calendar Year 2016

a) Basin irrigation and water re-use system with pump and filter; and
b) Landscaping of upper perimeter with trees and grass.

During flood events, a flow of 32.5 cfs can be diverted into the basin from Big Dry Creek. The ability to direct 32.5 cfs into the basin allows other urban basins to use this channel capacity in lieu of being required to be shut off. Demands to shut off pumps are otherwise required by FID when canals are nearing capacity, as overtopping a canal will cause flood damage and partial or full loss of the use of the canal. The dewatering pump can evacuate water quickly when capacity exists in Big Dry Creek and the downstream flood routing system.

The improved capacity allocated for Drainage Area "C" in this detention basin also results in lessening the need for pumping water from this drainage area into Dry Creek at critical times and thereby contributes to reduction in downstream flood damages.

Storm and Flood Damage Reduction

The basin will be capable of accepting an inflow of 32.5 cfs for the critical 96-hour peak storm event. With this inflow capability, upstream basins that would otherwise be required to turn off pumps for lack of canal flow capacity can continue to dewater. The result is the lessening of flood waters in the streets and structures in the urban area of the allotted storage volume for flood flows to the Big Dry Creek Detention Basin which is a capacity of 193.7 acre-feet.

Water Quality

The detention basin directly receives a portion of the urban runoff from the Drainage Area "C". Such water is treated as pollutants settle out with sediments.

FMFCD's water quality improvement program and its benefits were discussed in the Water Quality section for the Pup Creek-Enterprise Basin above in this same Technical Justification section and such benefits are also applicable to the Big Dry Creek Detention Basin.

Approximately 1.8 tons of sediment will be removed from the additional 12 acre-feet of stormwater runoff stored annually.

Groundwater Recharge

As stormwater is detained in this basin, the water will percolate as groundwater recharge. Also water can be delivered to the basin either when flows are routed in Big Dry Creek or the Gould Canal. As the Gould Canal is operated nearly year-round to deliver water to the City of Fresno's large "Leaky Acres" facility immediately easterly of the basin, availability of the City's water supply to recharge in the Big Dry Creek Detention Basin is very good.

As with numerous other FMFCD basins, the percolation rate will be measured and then the volume of water recharged can be calculated based upon the amount of time water resides in the basin. For the purpose of the grant, FMFCD has estimated a percolation rate of 0.15 feet per day. This 0.15 feet per day rate is based upon comparison to FMFCD's Basin "U" data, a basin that is only approximately one-half a mile away and in which FMFCD has percolation data.

FMFCD usually has the cities' entitlement water delivered from April 1st to mid-October (197 days for recharge use). FMFCD estimated 21 acres at 0.15 feet/day for 197 days/year for an annual amount of 620 acre-feet/year (rounded) at this basin.

Water Re-Use

This basin is very visible from Freeway 168 and aesthetically pleasing stormwater facilities provide greater support of the local drainage and flood control program. Also, the addition of trees and turf adds another variation to local wildlife habitat. Therefore, it is proposed to landscape the upper perimeter with trees and grass. FMFCD has other basins that are operated for stormwater management in the rainy season and used for additional groundwater recharge during the irrigation season with similar landscaping. A few photos of such sites are included in Appendix 7-9. FMFCD will draw surface water from the basin to irrigate this landscaping, in lieu of using the municipal water supply. A connection to the municipal supply is proposed as a backup supply for use in those infrequent occasions of basin dewatering and maintenance and that connection cost is included in the grant work. Only about 19.2 acre-feet/year of water will be required to irrigate 4.6 acres of landscaping.

Dry Creek Extension Basin

FMFCD is currently developing a 20-acre basin as the Dry Creek Extension Basin in order to have a location to route and store flood water whenever channels are nearing capacity. When channels are near capacity, only additional storage will improve the flood protection of the community. The portion of Dry Creek channel between the urbanized area and this detention basin has greater capacity than the channel downstream of the detention basin, so during the flood events there is capacity to move water to the detention basin. Further, FMFCD will be able to move water to this basin earlier in a sequence of storm events because FID will have a location to store it. The benefit is that water stored at the Dry Creek Extension Basin would have otherwise caused flood damages in the urban area when the urban basins are over taxed.

The soil at the basin is sandy with a very high percolation rate and has historically percolated water at a rapid rate. As the basin was excavated, the soil was observed and the deeper exploratory tests pointed to high permeability at the site.

The site is located near both Dry Creek and the Fanning Ditch, providing two opportunities to route water to the site. Dry Creek is much larger and needed in critical flood events, but the Fanning Ditch can also contribute to flood routings. The capacity of Dry Creek is estimated to be 250 cfs and the Fanning Ditch at 10 cfs.

As a result of these aforementioned benefits, FMFCD desires to acquire an additional 23 acres from the adjoining landowner to expand the capacity of the site. The landowner has provided FMFCD a letter indicating his interest in selling the property for an expanded detention basin (Appendix 7-10). Expanding the basin to the adjoining property as one facility has the advantage of no additional water delivery connection costs or dewatering facility costs.

Preliminary drawings of the basin have been prepared to establish the physical improvements and capacity of the basin. This element of the Project includes the following improvements (See Figure 7-6):

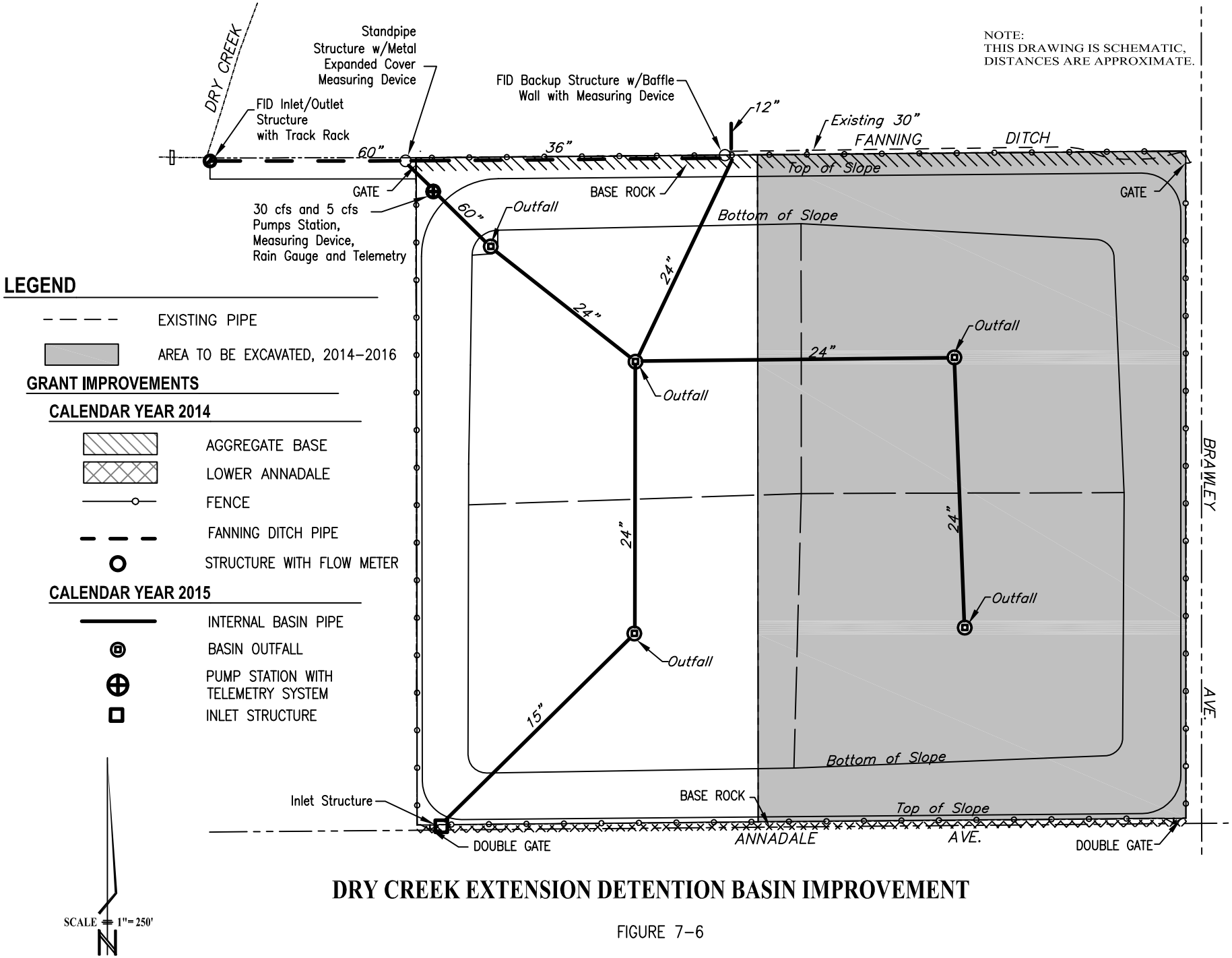
1) Acquisition credit for the value of the initial 20-acre parcel.
2) Remove 261,000 cubic yard of material each calendar year 2014, 2015, and 2016 (completed without grant cost). A contractor is currently already excavating at this rate. The material (sand) is in demand for backfill by local utility contractors. Further, acceleration in demand is also likely with the California High Speed Rail Project scheduled to begin in the Fresno area. Because of the demand for sand, FMFCD can achieve excavation without public expense.

Calendar Year 2014

1) Acquisition cost of the additional 23 acre parcel.
2) Perimeter fence of all 43 acres parcel.
3) Cost of lowering profile of roadway along the southerly edge of all 43 acres to improve basin capacity and match adjoining ground (Annadale Avenue alignment).
4) Large 60-inch diameter pipeline of 100 cfs capacity along Fanning Ditch alignment for connection to Big Dry Creek.
5) 36-inch diameter pipeline to replace Fanning Ditch adjoining the westerly 20 acres.
6) Structures on Fanning Ditch to control water backup and turnout.

Calendar Year 2015

1) Pipeline connection to the floor of basin.
2) Internal basin pipelines to distribute and collect water.
3) Dewatering pump station and telemetry system.
4) Metering device to measure delivery of recharge water during irrigation season.



DRY CREEK EXTENSION DETENTION BASIN IMPROVEMENT

FIGURE 7–6

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5) Hydroseeding side slopes for erosion control and stabilization.

Storm and Flood Damage Reduction

The basin will be capable of accepting an inflow of 100 cfs for the critical 96-hour peak storm event. With this inflow capability, other basins that would otherwise be required to turn off pumps for lack of canal flow capacity can continue to dewater. The result is the lessening of flood waters in the streets and structures in the urban area of the same amount as the storage volume of the Dry Creek Extension Basin or 795 acre-feet.

In addition, FMFCD can move water out of the urban area earlier in a storm sequence and gain some additional storage as the water moved to the Dry Creek Extension Basin will percolate rapidly. The amount percolated will add to the total volume of floodwater favorably displaced to basins.

The capacity of this basin is 795 acre-feet. Estimating early transfer of 20 acre-feet by virtue of the availability of this basin increases the total to 815 acre-feet. However, FMFCD anticipates moving water out of the urban area in advance of the critical flood routing period. Their early transfer of water will result in residence time at the Dry Creek Extension Basin to percolate at least 20 acre-feet, as the basin can recharge 20 acre-feet in less than a day. It is likely FMFCD will transfer and gain much more than 20 acre-feet. However, for the purpose of the grant benefit analysis, FMFCD has very conservatively used this low amount.

Groundwater Recharge

The sandy soils and percolation history (property owner testimony) indicates a very high percolation rate for this basin. Comparing this to the percolation rates at other FMFCD basins with similar soil indicates a percolation rate of 1.0 feet per day for short periods of recharge. But this high rate will likely lessen with silt accumulation during larger continuous periods of recharge to about 0.8 feet per day. Using the lesser rate for a 197-day irrigation season and the 34.4 acre water surface area results in 5,420 acre-feet per year capability. However, FMFCD does not have a firm supply and will only use the basin intermittently in conjunction with FID operations and flood routing. Thus to remain conservative, FMFCD is only estimating recharge of 1,000 acre-feet per year.

Water Quality

As with the two other basin features of the Dry Creek Flood Control Improvement Project, storm and flood waters diverted to the basin will provide for settling out pollutants. The same performance success is expected of this basin as in the urban basins and some sediments management program will be employed. This basin is significant as a result of its size and volume to treat such waters.

FMFCD's water quality improvement program and its benefits were discussed in the Water Quality section for the Pup Creek-Enterprise Basin above in this same Technical Justification section and such benefits are also applicable to the Dry Creek Extension Basin.

Approximately 5.4 tons of sediment will be removed from the anticipated 36 acre-feet of water runoff stored on an average annual basis.

The top perimeter of the basin will be hydroseeded with natural grasses to stabilize and reduce erosion. This will help sustain the recharge rate in the lower portion of the basin.

Dry Creek Flood Control Improvement Project

All three (3) proposed detention basins have a common benefit of providing flood water storage that would otherwise cause flood damages. As FMFCD's flood routing plans are derived from earlier work of the USACE, the FMFCD continues to use a 30-day series of 96-hour storm waves in its flood routing model. Consistent with the Benefits and Cost Analysis (Attachment 8), currently local flood control channels can withstand a 25 year-96 hour storm event. With the additional 1,077 acre-feet of storage (20 acre-feet is actually percolation) of the Dry Creek Flood Control Improvement Project, the flood control system will improve to withstand a 50 year-96 hour storm event and reduce damages in a 100 year-96 hour and 200 year-96 hour storm event.

FMFCD has an integrated flood control system including numerous reservoirs, stormwater basins and conveyance channels. These facilities are interconnected, and when a large storm occurs FMFCD can't prevent damages from the floodwater if the storm is in excess of a 25-year 96 hour storm. In storms greater than this, FMFCD will run out of storage capacity and channel flood routing capacity. Then FMFCD must store, divert and convey floodwater around the system as best it can to minimize damages throughout the entire district.

The three stormwater basins proposed with this grant application will provide up to 1,057 acre-feet of additional storage capacity. Only 18 acre-feet is needed for storing local runoff in the area draining directly to the basins. The basins are also able to accommodate floodwater diverted directly from floodwater channels. The new stormwater basins will therefore allow FMFCD greater flexibility in managing floodwaters, and would be used to reduce flood damage in other areas of FMFCD considered the most susceptible to flooding.

A specific 22-square mile area located north of Herndon Canal will receive direct benefits from the new stormwater basins. The new basins will divert floodwater and free up capacity in the Herndon Canal so stormwater in the 22-square mile area can be diverted into the Herndon Canal.

Details of this area and how it specifically benefits from the new stormwater basins is provided in Attachment 8.

Groundwater Recharge

With the addition of the toe drain and late season capture of water at Big Dry Creek Dam and the three (3) detention basin sites, groundwater recharge is estimated to increase by ,990 acre-feet annually. This amount is attributed to each feature as follows:

Big Dry Creek Dam	250 acre-feet
Pup Creek-Enterprise Basin	120 acre-feet
Big Dry Creek Detention Basin	620 acre-feet
Dry Creek Extension Basin	1,000 acre-feet
Total	1,990 acre-feet

This proposal intends to use the Kings River Conservation District's and FID's annual reports of groundwater elevations to identify any changes in the groundwater elevations. Attached is an example of an annual groundwater report (See Appendix 7-11) from the Draft 2010 Fresno Area Regional Groundwater Management Group that includes groundwater contours (depth and elevation). This report shows a considerable decline in local groundwater levels and the need for additional groundwater recharge. The City of Fresno and City of Clovis have created a cone of depression and this Project will help to alleviate the overdraft and cone of depression. FMFCD will maintain records of the volume of recharge achieved with the Dry Creek Flood Control Improvement Project.

Water Quality

FMFCD's water quality improvement program and its benefits were discussed in the Water Quality section for the Pup Creek-Enterprise Basin above in this same Technical Justification section and such benefits are also applicable to the overall Dry Creek Flood Control Improvement Project.

FMFCD anticipates late season capture of 250 acre-feet of water on an average bases at Big Dry Creek Dam and the release to the downstream basins system-wide, thereby filtering and improving water quality of this water in the recharge effort.

Also, water quality improvements will be accomplished by collecting stormwater runoff at Pup Creek-Enterprise Detention Basin, Big Dry Creek Detention Basin, and Dry Creek Extension Basin. System-wide water quality improvements would increase because of the additional system-wide storage capacity created by the three (3) detention basins. The three (3) detention basins will remove additional pollutants from stormwater runoff and flood flows captured and also increase the recharge opportunity within the three (3) basins. The water treatment identified by Dry Creek Flood Control Improvement Project is as follows:

Location	Water Treated Annually in Acre-feet	Annual Pollutant/ Sediment - in Tons[1]
Big Dry Creek Dam	250	37.5
Pup Creek-Enterprise Detention Basin	50	7.5
Big Dry Creek Detention Basin	12	1.8
Dry Creek Extension Basin	36	5.4
Total	348	52.2

[1]Based upon the average discharge of sediment calculated from pollutant removal studies conducted by the FMFCD.

Physical Benefits Being Claimed

The grant Project will increase the capacity of the regional stormwater basin system and thus increase the FMFCD's operational options to store, treat, and recharge more stormwater runoff, realizing additional flood control and water quality benefits.

The physical benefits being claimed are listed below followed with narrative description of expected physical benefits, background for benefits to be claimed, and tables that describe the methods used to estimate physical benefits.

- Reduced risk of flooding and flood damages;
  - Increased public health and safety protection;
  - Improved stormwater management and flood routing flexibility;
  - Improved system reliability;
- Increased groundwater recharge efforts;
  - Reuse of surface water for landscape irrigation
- Improved water quality;
- Habitat and wildlife improvements;
- Public education and outreach opportunities and recreational trail;
  - Rest stop/shade structure/observation pavilion benefit;
- Greenhouse emissions saved; and
  - Efficiency and Operational Cost Savings.

Flood Risk and Damages Reduction

In addition to the flood damage reduction benefits (physical damage to property and structures), the project will provide flood safety and public access benefits that relate to safe travel in streets without flooding (traffic safety), especially by emergency vehicles (travel response time is critical). Only flood damage reduction is monetized in Attachment 8. Also, not directly accounted for is the disruption of people's lives to relocate and salvage belongings when flooded. Our experience is that these issues are extremely annoying to the occupant of properties that are flooded.

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Reduction in Flood Risk and Damages			
Measure of Benefit Claimed (Name of Units): Dollars			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
2015-2065	$4,206,000	0	$4,206,000

Table 7-1: Annual Project Physical Benefits for Reduction in Flood Risk and Damages

Increased Groundwater Recharge Efforts

The collective result of the Dry Creek Flood Control Improvement Project is an average annual increase in groundwater recharge of 1,990 acre-feet. Pup Creek-Enterprise Basin will provide 50 acre-feet of storage of stormwater (long-term 200 acre-feet) and potentially recharge 120 acre-feet of groundwater annually. Big Dry Creek Detention Basin will provide recharge of approximately 620 acre-feet of water annually. Dry Creek Extension Basin will provide recharge 1,000 acre-feet of groundwater annually. Big Dry Creek Dam will provide an additional storage of 250 acre-feet of stormwater that can be rerouted to other recharge facilities to provide an extra 250 acre-feet of groundwater recharge

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Increased Groundwater Recharge			
Measure of Benefit Claimed (Name of Units): Acre-feet			
Additional Information About this Measure: Big Dry Creek Dam will provide additional recharge efforts the following year after project completion or after pump stations are installed and complete.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2014	0	0	0
2015	0	250	250
2016	0	800	800
2017	0	1930	1930
2018	0	1940	1940
2019	0	1950	1950
2020	0	1960	1960
2021	0	1970	1970
2022	0	1980	1980
2023	0	1990	1990
2024	0	1990	1990
Comments: Big Dry Creek Dam is used at the 250 acre-feet average in 2015 and thereafter. Pup Creek-Enterprise Basin begins at 60 acre-feet in 2017 and increases 10 acre-feet per year until reaching 120 acre-feet in 2023 and thereafter. Big Dry Detention Basin begins at 50 acre-feet in 2016 and is 620 acre-feet thereafter. Dry Creek Extension Basin is 500 acre-feet in 2016 and 1,000 acre-feet thereafter.			

Table 7-2: Annual Project Physical Benefits for Groundwater Recharge

Water Quality Improvements

The District's regional stormwater basin system exceeds statewide standards by capturing over 92 percent of urban stormwater runoff in retention basins and removing up to 50-80 percent of typical stormwater pollutants before it discharges to Waters of the U.S. or Waters of the State. On average, the regional basin system recharges between 70-85 percent of the annual

rainwater that falls within the permit boundary. The grant Project will increase the capacity of the regional system and thus increase the District's operational options to store and treat more stormwater runoff realizing additional flood control and water quality benefits.

According to water quality analysis that was conducted for FMFCD Basin "C" in the mid-1990s, the results indicated by collecting stormwater at a basin, "appears to be highly effective in reducing PAH concentrations, as several PAHs were consistently detected in the influent but not detected in the effluent" (see page 7 of Appendix 7-6). Also, this method is "highly effective in reducing the concentration of several metals; total recoverable Barium, Copper, Lead, Magnesium, Zinc, as well as Total Dissolved Solids, and Total Suspended Solids."

Stormwater management basins are sized on the basis of six (6) inches of rainfall. The Fresno area receives an average of 11.25 inches of rainfall annually. With this said, on average, most of FMFCD's basins capture and treat at least one full basin volume per year. To remain conservative and because of the less direct usage of the Dry Creek Extension Basin, only half of its capacity is assumed for treatment benefit purposes. With the other detention facilities, it is conservative to only assume each proposed site reaches full storage capacity once a year. With these conservative assumptions, the Project will capture storm water runoff in the proposed facilities and improve water quality for approximately 348 acre-feet a year by removing 52.2 tons of pollutant laden sediment. Initially the Pup Creek-Enterprise Basin will treat approximately 50 acre-feet per year and remove 7.5 tons of sediment. As the capacity of the Pup Creek-Enterprise Basin will increase with future excavation, in the future it will potentially improve 200 acre-feet of storm water each year when fully excavated and remove 30 tons of sediment. Big Dry Creek Detention Basin will treat about 12 acre-feet or more of storm water annually and remove 1.8 tons of sediment, and Dry Creek Extension Basin will improve water quality of about 36 acre-feet of stormwater yearly and remove 5.4 tons of sediment.

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Improved Water Quality			
Measure of Benefit Claimed (Name of Units): Tons of pollutant laden sediment removed			
Additional Information About this Measure: Storage for the first year at Pup creek-Enterprise Detention Basin will be 30 acre-feet. FMFCD anticipates it will take about 10 years to have Pup Creek-Enterprise Basin fully excavated. We are assuming the basin will gain 20 acre-feet of storage each year for 10 years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2014	0	0	0
2015	0	44.7	44.7
2016	0	49.2	49.2
2017	0	50.7	50.7

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Improved Water Quality			
Measure of Benefit Claimed (Name of Units): Tons of pollutant laden sediment removed			
Additional Information About this Measure: Storage for the first year at Pup creek-Enterprise Detention Basin will be 30 acre-feet. FMFCD anticipates it will take about 10 years to have Pup Creek-Enterprise Basin fully excavated. We are assuming the basin will gain 20 acre-feet of storage each year for 10 years.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project
2018	0	52.2	52.2
2019	0	54.5	54.5
2020	0	56.7	56.7
2021	0	59.0	59.0
2022	0	61.2	61.2
2023	0	63.5	63.5
2024	0	65.7	65.7
2025	0	68.0	68.0
2026	0	70.2	70.2
2027	0	72.5	72.5
2028	0	74.7	74.7
2028-2068	0	74.7	74.7
Comments: Big Dry Creek Dam improvements will be complete in 2014. Big Dry Creek Detention Basin will be excavated by mid-October 2014. Pup Creek-Enterprise Detention Basin will be operational in 2015 but will not be fully excavated. Storage for the first year at Pup Creek-Enterprise Detention Basin will be 30 acre-feet and increase 10 acre-feet per year for the following two years. Thereafter 15 acre-feet of material per year will be removed until complete. Dry Creek Extension Basin will be fully excavated by the end of 2014.			

Table 7-3: Annual Project Physical Benefits for Water Quality

Habitat and Wildlife Improvements

Two wildlife enhancements metrics were used to illustrate wildlife benefits, pooled surface water area and additional shoreline length. The FMFCD Project basins will increase wildlife habitat by increasing the amount of open space, pooled surface water and shoreline habitat. In addition, late rain season operational adjustments and summer recharge will increase the use of these areas by wildlife.

Birds, mammals, frogs, fish and turtles spend some or all of their life cycle in or around the water. Many species depend on this habitat for breeding, foraging, hunting, fishing, and other essential uses. Trees and vegetation along the shoreline are important feeding, nesting, and perching areas for songbirds.

FMFCD basins provide habitat for a variety of song birds, raptors and water fowl like red tail hawks, redwing blackbirds, grackles, northern flicker, american coot, great white egret, great

blue heron and the american avocet. Other species include grey foxes, bullfrogs and western pond turtles.

The four components of the Project will increase pooled surface water area by 216.8 acres and shoreline habitat by 4.5 miles which will further establish and enhance existing wildlife ecosystems.

Grant Project Area	Additional Pooled Surface Water Area (acres)	Additional Shoreline Length (miles)
Big Dry Creek Reservoir	164.0	2.7
Pup Creek Enterprise Detention Basin	11.8	0.6
Big Dry Creek Detention Basin	21.0	0.7
Dry Creek Extension Basin	20.0	0.5

Table 7-4: Habitat and Wildlife Improvements

In normal and wet years the Big Dry Creek Reservoir provides extensive seasonal wetland habitats attractive to migratory waterfowl, riparian species, and raptors. The reservoir has been in existence since 1948 and contains riparian, wetland, and upland habitats suitable for seasonal waterfowl, riparian species, and raptors. In a normal to wet year, at minimum a small pool is formed near the dam and provides habitat suitable for waterfowl breeding. Pre-Project the pool is drawn down to elevation 405.0 with a surface area of 78 acres. Post- Project FMFCD will seek to hold water at elevation 407.0 for a period of time late in the season. The total area of habitat behind the dam is approximately 242 acres when the surface water elevation is at 407.0 feet and additional 164 acres of pooled surface water area. The selection of the toe drain improvement avoids disruption of this habitat and adds to the ability to retain some water for habitat longer than would be the case without the Project improvement. As for the three basins, each adds a secured fenced in area with a water body and surrounding grass areas as follows:

-Pup Creek-Enterprise Detention - an additional 17 acres
-Big Dry Creek Detention Basin - 25 acres
-Dry Creek Extension Basin - 43 acres The District coordinates with the local mosquito abatement districts for vector control. FMFCD stocks each basin with mosquito fish and these fish along, with some fish that manage to move with irrigation water in the canals, create a feed source for wildlife.

Annual Project Physical Benefits Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Acreage of Habitat Improved and Protected (not monetized in Attachment 8)			
Measure of Benefit Claimed (Name of Units): Acre			
Additional Information About this Measure: Habitat improvement is a product of the District's ability to increase pooled surface water area within the reservoir and basins. As improvements are made that enable a larger pooled surface water area the District will observe a direct habitat improvement benefit.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2014	0	0	0
2015	0	164	164
2016	0	205	205
2017	0	216.8	216.8
2018	0	216.8	216.8
Comments:			

Table 7-5: Annual Project Physical Benefits for Habitat Area

Public Education and Outreach and Recreational Trail

As explained in the County of Fresno General Plan's Open Space and Conservation section, the purpose of the county-wide Recreation Trail Master Plan is to "…develop a system of hiking, riding, and bicycling trails and paths suitable for active recreation and transportation circulation" and further states that, "The recreational trails system shall be oriented to providing safe, off-street access from urban areas to regional recreation facilities…" (County of Fresno 2000 General Plan, page 2-145). The County Fresno General Plan refers to the City of Clovis' Trails of Clovis map (Appendix 7-6), which identifies the route of the Enterprise Trail. At the Pup Creek-Enterprise Detention Basin, FMFCD proposes to construct a section of the planned trail, and rest stop/shaded wildlife viewing pavilion complete with mounted binoculars, an interpretive sign with information about wildlife common to stormwater basins, and a bench. Together, the trail and wildlife pavilion will provide an opportunity for public education and outreach. Teaching the public about the relationship between flood and storm water, wildlife, and human behavior helps build environmental stewardship. The wildlife pavilion and the signage will be modeled after those constructed at FMFCD's Alluvial Drain Basin, also known as Basin "BX", shown here, with the addition of a bench. Basin "BX" is also located along the Enterprise Trail.

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Public Education and Outreach and Recreational Trail (not monetized in Attachment 8)			
Measure of Benefit Claimed (Name of Units): People			
Additional Information About this Measure: The City of Clovis Parks Department estimates that 18,000 people use its trail system annually. Future usage is projected at a two percent annual increase.			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project (Potential Usage per year)	With Project (Potential Usage per year)	Change Resulting from Project (c) – (b)
2016	0	0	0
2017	0	18,000	18,000
2018	0	18,360	18,360
2019	0	18,727	18,727
2020	0	19,102	19,102
2021	0	19,484	19,484
Comments:			

Table 7-6: Annual Project Physical Benefits for Public Education and Outreach

Greenhouse Emissions Saved

Two options are available for on-site pumps: electrical and diesel. FMFCD has chosen the cleaner electrical pumps that have lower overall emissions than diesel powered portable pumps. FMFCD estimates the average annual reduction in emissions to be 19.4 metric tons CO2 Equivalent (CO2e).

The use of electrical pumps requires the supply of electrical power to each location. Once power is available, telemetry equipment will be installed to obtain site data and reduce staff

trips to the sites. Also, data is collected more frequently and improves efficiency of responding to changing site conditions. The Project would also include a rain gauge at the Dry Creek Extension Basin and that data will improve operational efficiency with instant rainfall data in the southwest area of FMFCD's boundaries. FMFCD already has adequate rain gauge data in the remainder of the Project area. Rainfall data provides early assessment of anticipated runoff and early operational responses.

The use of telemetry to monitor the project features is estimated to save 60 vehicle trips from the office to the sites on an average annual basis, for an estimated annual reduction of .53 metric tons of vehicle-generated greenhouse gases.

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Reduction in Greenhouse Gas Emissions			
Measure of Benefit Claimed (Name of Units): Metric Tons of Greenhouse Gases (CO2e) Avoided Per Year			
Additional Information About this Measure: The completion of the project will reduce FMFCD's use of portable diesel pumps and reduce the number of vehicle trips required to monitor conditions at three basin sites and Dry Creek Dam. These reductions in use of internal combustion engines will reduce FMFCD's emissions of greenhouse gasses (GHGs) GHGs are reported in CO2Equivalent (CO2e).			
(a)	**(b)**	**(c)**	**(d)**
	Physical Benefits		
Year	**Without Project**	**With Project**	**Change Resulting from Project (c) – (b)**
2012-2016	0	19.9 tons/year	19.9 tons/year
2017-2020	0	11.5 tons/year	11.5 tons/year
2021-2062	0	0.79 tons/year	0.79 tons/year
Comments: Greenhouse gas benefit levels change over the life of the project as a function of progressively tightening State Air Resources Control Board limits on diesel pump emissions. The long-term change in annual project benefit is a by-product of FMFCD acquiring lower-emitting engine-pump units in response to State requirements.			

Table 7-7: Annual Project Physical Benefits for Greenhouse Emissions

Efficiency and Operational Cost Savings

The installation of a permanent electric pump station at each basin site, when compared to the only other viable option of using of a portable pump, is more efficient and affordable. The portable pump takes several hours of labor to set up and break down the pump, and to daily check on the fuel and oil. The electric pump will provide a potential saving of 45% of the typical costs to use a diesel powered portable pump. With the assumption of pumping 100 acre-feet, $4 per gallon of diesel, and $0.25 per kilowatt-hour for electricity, it costs FMFCD $3,300 to use

a portable pump, compared to $1,500 to use a 100 HP electric pump station. This equates to a savings of about $14,400 to divert 800 acre-feet, the estimated average annual pumping.

Further, the ability to react to flood events is much quicker and therefore more efficient from the perspective of moving water during events. Most portable pumps are of much smaller discharges than the permanent electrical pumps. Also, staffing resources are at a premium during storm events and it is important to avoid tying limited resources to placement of portable pumps.

Annual Project Physical Benefits			
Project Name: Dry Creek Flood Control Improvement Project			
Type of Benefit Claimed: Efficiency and Operational Cost Savings			
Measure of Benefit Claimed (Name of Units): Dollars			
Additional Information About this Measure: Portable Pump vs. Pump Station = Cost Savings			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	With a Portable Pump	With a Pump Station	Change Resulting from Project (b) – (c)
2013	0	0	0
2014	$5,940	$2,700	$3240
2015	$23,430	$10,650	$12,780
2016	$26,400	$12,000	$14,400
2017	$26,400	$12,000	$14,400
Comments: The pump station at Big Dry Creek Detention Basin is anticipated to be complete mid-October 2015 and the pump station at Dry Creek Extension Basin will be complete mid-October 2016. The benefits start the next year after the pump stations are complete.			

Table 7-8: Annual Project Physical Benefits for Efficiency and Operational Cost Savings

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY

EDMUND G. BROWN JR., *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

December 19, 2012

RECEIVED
DEC 24 2012
FRESNO METROPOLITAN
FLOOD CONTROL DISTRICT

Mr. Peter Sanchez
Operations Manager
Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, California 93727

SUBJECT: PROPOSITION 1E, DISASTER PREPAREDNESS & FLOOD PREVENTION BOND ACT OF 2006

This letter is to inform you of a grant program opportunity available under Proposition 1E, the Disaster Preparedness and Flood Prevention Bond Act of 2006. Projects which are designed to manage stormwater runoff to reduce damage caused by flooding may be eligible for grant assistance. The Department of Water Resources (DWR) is administering the disbursement of a portion of these grant funds.

It is our understanding that you may currently be considering a dam safety related project or are being directed to address dam safety related issues. As such, you may be eligible to receive grant assistance funding for your project. Approximately $92 million in funding will be available for Stormwater Flood Management (SWFM) projects through this round of solicitation, with a maximum grant amount of $30 million per project.

Prospective applicants should read and become familiar with the *2012 IRWM Grant Program Guidelines - Propositions 84 and 1E*, and the *IRWM Grant Program - Proposal Solicitation Package for Round 2, Stormwater Management Grants*. Close attention should be paid to the eligibility requirements, application instructions, and the review and scoring criteria. Both of these documents can be found on the Integrated Regional Water Management (IRWM) Grants webpage: www.water.ca.gov/irwm/grants

The solicitation for the SWFM grant is a one-step application process, with a due date of February 1, 2013. Information regarding applicant workshops is available on-line at the webpage referenced above.

Although our Division is not directly involved with these grant awards, we encourage you to review the details related to the grant program outlined in the guidance documents and to work with DWR's Integrated Regional Water Management staff to answer questions you may have.

If you need assistance, please contact Laura McLean at (916) 651-9212 or by email at: lmclean@water.ca.gov.

Sincerely,

Sharon K. Tapia

for

David A. Gutierrez, Chief
Division of Safety of Dams

Enclosure

cc: Mr. Zaffar Eusuff, Program Manager
Financial Assistance Branch
Division of Integrated Regional Water Management
901 P Street, 2nd Floor
Sacramento, California 95814

Ms. Laura McLean, Project Manager
Financial Assistance Branch
Division of Integrated Regional Water Management
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January 9, 2013

BSK G08-119-11F

Mr. Jerry Lakeman, P.E., District Engineer
Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, California 93727

SUBJECT: Seepage Mitigation - Toe Drain
Big Dry Creek Dam
Fresno Metropolitan Flood Control District

Dear Jerry:

This report provides an analysis of the probability of flood management structural protection failure "with" and "without" the construction of toe drain modifications at Big Creek Dam, for purposes of seepage mitigation and control of sand boils. Design parameters used in our analysis include the following:

Flood Event: 230-year exceedance intervals

Reservoir Stage/Frequency Curve: USCOE Plate 15, hydraulic data, February 1986

Standard Project Flood Routing Results: USCOE Plate 12

From the references presented above, the following design criteria were derived for our analysis:

Peak Flood Storage (Jan. 1999): 30,300 AF at elevation 432.7 for 1 day

Prevailing Stage Storage (Steady State) (Jan. 1999): 27,500 AF at elevation 431.5 for 10 days

Seepage and development of sand boils at and beyond the embankment toe is a function of seepage exit gradient (E). The occurrence of small diameter (1/4 to 1-inch) sand boils was observed during the April 2006 storm event a maximum pool elevation of 419.6 to 420.1-feet over a 6 day period. Small diameter sand soils were also observed during the flood events of December 2010-February 2011 at a maximum pool elevation of 420.0-feet. A maximum exit gradient of 0.49 was estimated at station 84+89 (Range: 0-0.49). For our analysis, the following exit gradients (E) were used for the flood stages listed above:

(1) "E" at 50-feet away from toe,
<u>no</u> toe drain modification: 0.60-0.80

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(2) "E" at 50-feet away from toe,
with toe drain medication[1]: 0.25-0.30

Recommendations

Based on the design parameters described above, the following subjective assessment of the probability of flood management projection failure is recommended for the cases of "no toe drain modification" versus "toe drain design modification" as described[2].

PROBABILITY OF FAILURE

Toe Drain Modification	1 Day Peak Flood Storage Duration (EL. 432.7)	10 Days Flood Storage Duration (EL. 431.5)
None	0.75	0.65
Toe Drain Modification	near zero	near zero

These recommendations retain a level of subjectivity resulting from the complexity of factors influencing the probability of flood management failure and the absence of actual flood data for the higher intensity flooding events. Flood storage level monitoring is recommended.

This report is submitted for your review and evaluation. Please call 559-497-2880 ext. 130, if you have questions or wish to discuss our recommendations.

Respectfully submitted,
BSK ASSOCIATES

Hugo Kevorkian
Principal Geotechnical Engineer
CE16350, GE462, REAII 20080

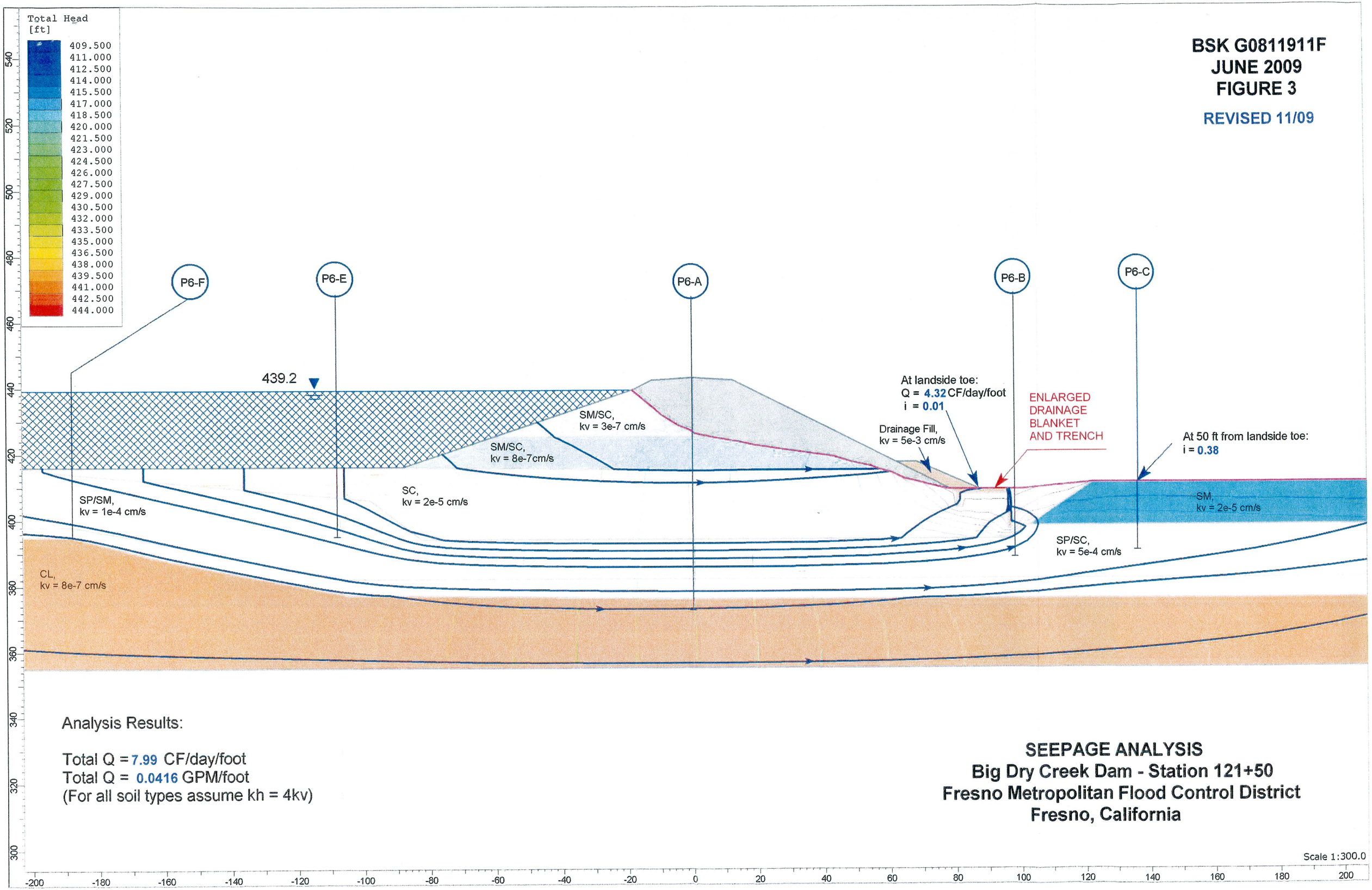
Enclosure: Figure 3 - Seepage Analysis, Big Dry Creek Dam – Station 121+50 FMFCD

Distribution: Mr. Jerry Lakeman, P.E., FMFCD (3 originals + jerryl@fresnofloodcontrol.org)
Mr. John Santos, FMFCD (johns@fresnofloodcontrol.org)
BSK (1 original + eCopy)

[1] Big Creek Dam toe drain modification "Seepage Control Alternatives, Big Dry Creek Dam. Fresno Metropolitan Flood Control District. Contract BDR-18" BSK Associated November 10, 2010, Job No. G08-119-11F
[2] Toe drain modification: 1) 12-15-feet toe drain and pumping system or 2) 12-15-feet toe drain with 300-feet-wide upgradient blanket.

BSK G0811911F
JUNE 2009
FIGURE 3

REVISED 11/09



Analysis Results:

Total Q = 7.99 CF/day/foot
Total Q = 0.0416 GPM/foot
(For all soil types assume kh = 4kv)

SEEPAGE ANALYSIS
Big Dry Creek Dam - Station 121+50
Fresno Metropolitan Flood Control District
Fresno, California

APPENDIX 7-3: Pup/Enterprise Storage Benefits Analysis

January 29, 2013 kh

Upstream Storage Benefits and the Interim Pup/Enterprise 50 ac ft Benefit Study

This study is to determine what event it would take for storm water to enter the Enterprise Canal considering the upstream storage. Also, what event could be managed with the additional 50 acre feet of storage in the interim basin.

The data used for the analysis is the routing study produced by Blair, Church, and Flynn for the **100 year-96 hour, 30 day** event that identified the issues related to the routing discrepancy in the COE model. It was decided to ratio the results of that study using the COE ratios for each wave and return frequency as identified in the Feb. 1988 COE Hydrology Report, Page 9. The table shown below is the results of that analysis. Due to the voluminous nature of the spreadsheet is has not been included, but it is available upon request.

The District's 200 scale topo revealed that there is approximately 71 acre feet of storage upstream of the Enterprise Canal using a top of bank elevation of 397' and an average depth of 1.5 feet.

The results show that a 15 year storm event will produce flows that will enter the Canal. With the additional 50 acre feet of interim basin storage gives a total of 120 acre feet of storage. As there is not a ratio that produces a result of 120 acre feet of storage, therefore a straight line proportion was used between the 25 and 50 year results indicating that a 40 year event could be managed.

The Ratio Factors and result are shown in the tables below.

Wave No.	COE RATIOS	COE RATIOS		COE RATIOS		COE RATIOS		COE RATIOS		COE RATIOS		COE RATIOS	
	100 yr	200 yr	Factor	50 yr	Factor	25 yr	Factor	20 yr	Factor	15 yr	Factor	10 yr	Factor
1	0.116	0.143	1.23	0.105	0.09	0.076	0.89	0.067	0.08	0.063	0.84	0.053	0.06
2	0.173	0.221	1.28	0.127	0.10	0.095	0.96	0.088	0.09	0.074	0.80	0.063	0.08
3	0.363	0.513	1.41	0.273	0.19	0.21	1.09	0.186	0.17	0.174	1.02	0.134	0.13
4	0.826	1	1.21	0.626	0.52	0.46	0.89	0.41	0.46	0.351	0.76	0.28	0.37
5	0.19	0.239	1.26	0.159	0.13	0.123	0.97	0.106	0.11	0.092	0.84	0.076	0.09
6	0.141	0.148	1.05	0.109	0.10	0.085	0.82	0.078	0.10	0.067	0.70	0.056	0.08

Results

Total AF Vol for the water entering the Enterprise Canal; full 30 day event							
10 yr	15 yr	20 yr	25 yr	40 yr	50 yr	100 yr	200 yr
61.8	78	89	101	122	136	180	224

MEMORANDUM

File 630.2071
630.2072

BOARD MEETING: May 23, 2012
AGENDA ITEM NO: 9

FROM: Jerry Lakeman
District Engineer

SUBJECT: Adoption of Resolution Amending Storm Drainage and Flood Control Master Plan, Pup Creek Enterprise Detention Basin (s/o Herndon, e/o DeWolf Avenues)

Summary
At the January 11, 2012 meeting, the Board of Directors authorized staff to negotiate for the purchase of a basin site on Pup Creek at the Enterprise Canal. The basin is located south of Herndon Avenue and east of DeWolf Avenue as shown on Exhibit No. 1. A detention basin at this location will correct a routing issue in the 200 year runoff model developed by the U.S. Army Corps of Engineers and increase the overall storage capacity in the Pup Creek system. Subsequently, at the April 11, 2012 meeting, the Board further adopted a mitigated negative declaration for the project and on May 9, 2012 authorized issuance of a check to proceed with the purchase of the property.

An escrow has been established for the purchase of the basin site from the Roman Catholic Bishop of Fresno. Therefore, it is appropriate and necessary to incorporate this facility into the Storm Drainage and Flood Control Master Plan.

A noticed Public Hearing was unnecessary as the amendment to the Master Plan has no new fees or assessment implications. The cost of the facilities will be borne by the General Fund from its existing revenue sources.

Recommendation
It is recommended the Board of Directors adopt the attached resolution amending the Storm Drainage and Flood Control Master Plan to include the Pup Creek Enterprise Detention Basin.

Discussion
The prior Board actions have referenced this site as Pup Creek Detention Basin No. 2. This reference does not clearly identify the location of the basin nor is it easily included in the nomenclature used for designation within the District's financial records. Therefore, the designation has been updated as the Pup Creek Enterprise Detention Basin (PEB).

The opportunity to acquire the basin site at this location has created an ability to develop a new element of the District's Master Plan that becomes an essential component of the Pup Creek flood routing system.

board\memo\perm\2012-05-23-09

BOARD MEETING: **May 23, 2012**
AGENDA ITEM NO: **9**

This project not only has the potential to rectify and improve the routing in the U.S. Army Corps of Engineers model for the Pup Creek system, but also brings these additional benefits:

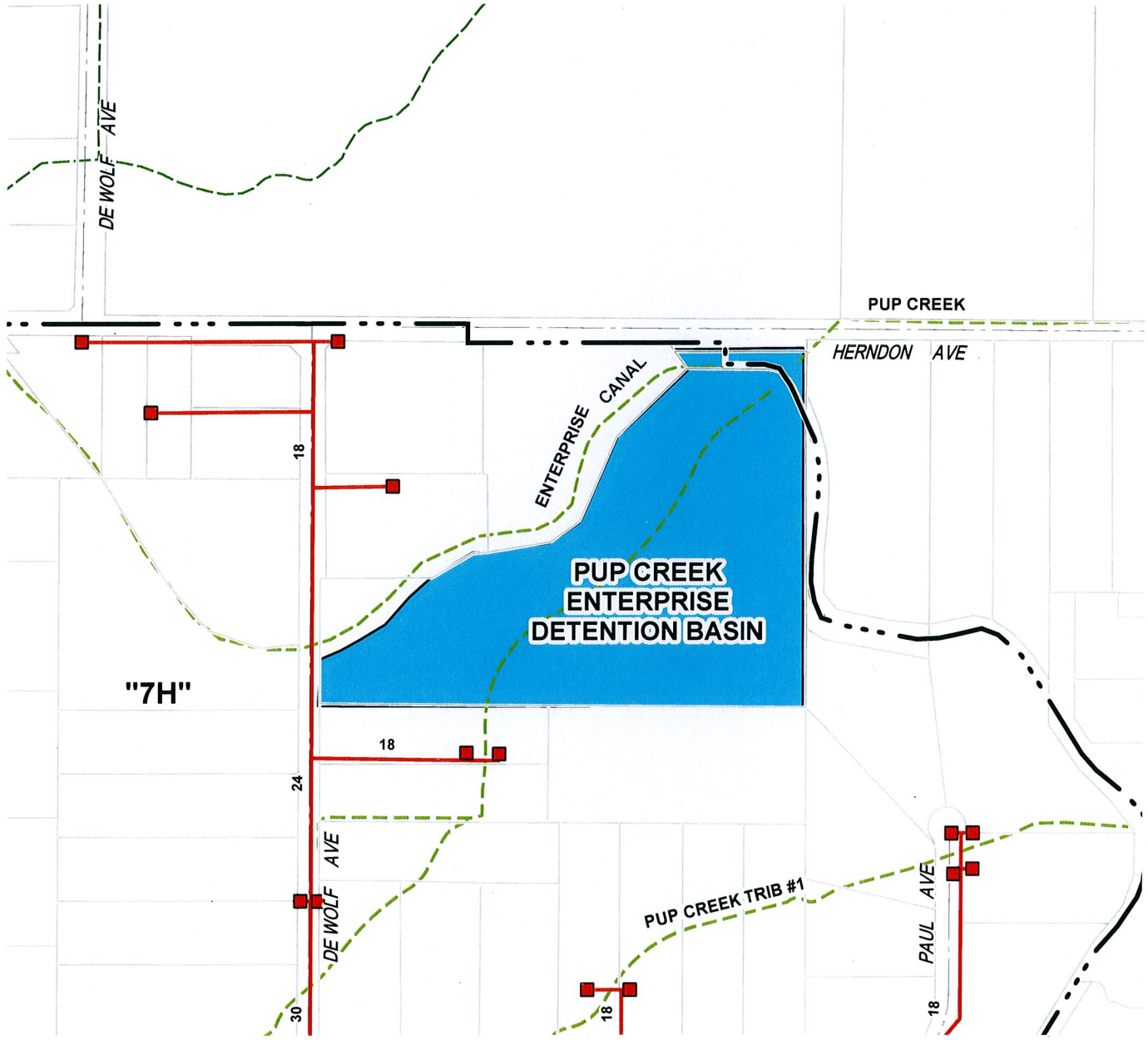
- The ability to develop interim basin storage without extensive excavation
- Development of the ultimate basin configuration over time through use of the District's dirt permit program
- Attenuation of channel flows in the Pup Creek North tributary
- Improvements to prevent flood flows from overtopping the bank of the Enterprise Canal and, therefore, reducing the flooding potential in the urban area
- Increase the overall storage capacity on the channel so it will accommodate increased runoff from future development in the Pup Creek watershed

Conceptual designs for both the interim and the ultimate basins were considered in the CEQA analysis. The two conceptual designs are attached as Exhibits No. 2 and 3. Unless otherwise directed by the Board, staff intends to proceed with development of the detention basin utilizing these designs.

Dan Gilbert
Senior Engineering Technician

DG/tls

NOTE:
THIS MAP IS SCHEMATIC
DISTANCES ARE APPROXIMATE.



LEGEND

- Future Master Plan Facilities
- Drainage Area Boundary
- Streams And Canals
- Pup Creek Enterprise Detention Basin

N

1 " = 400 '

PUP CREEK ENTERPRISE DETENTION BASIN

PUP CREEK WATERSHED

EXHIBIT NO. 1

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

Prepared by: wadet
Date: 5/17/2012
Path: K:\Autocad\DWGS\0EXHIBIT\BASINS\PUP CREEK\Pup Creek Enterprise Basin.mxd

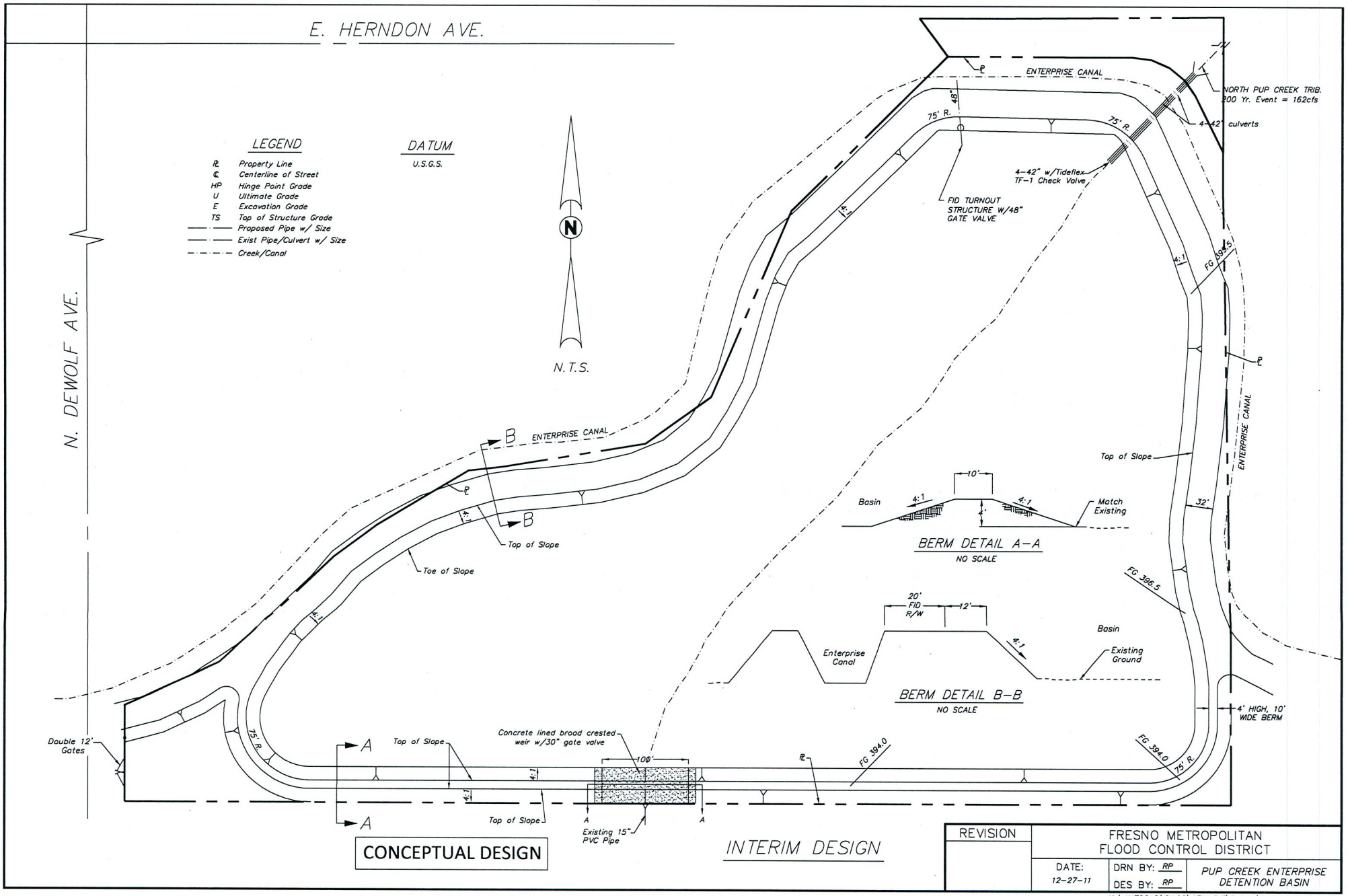
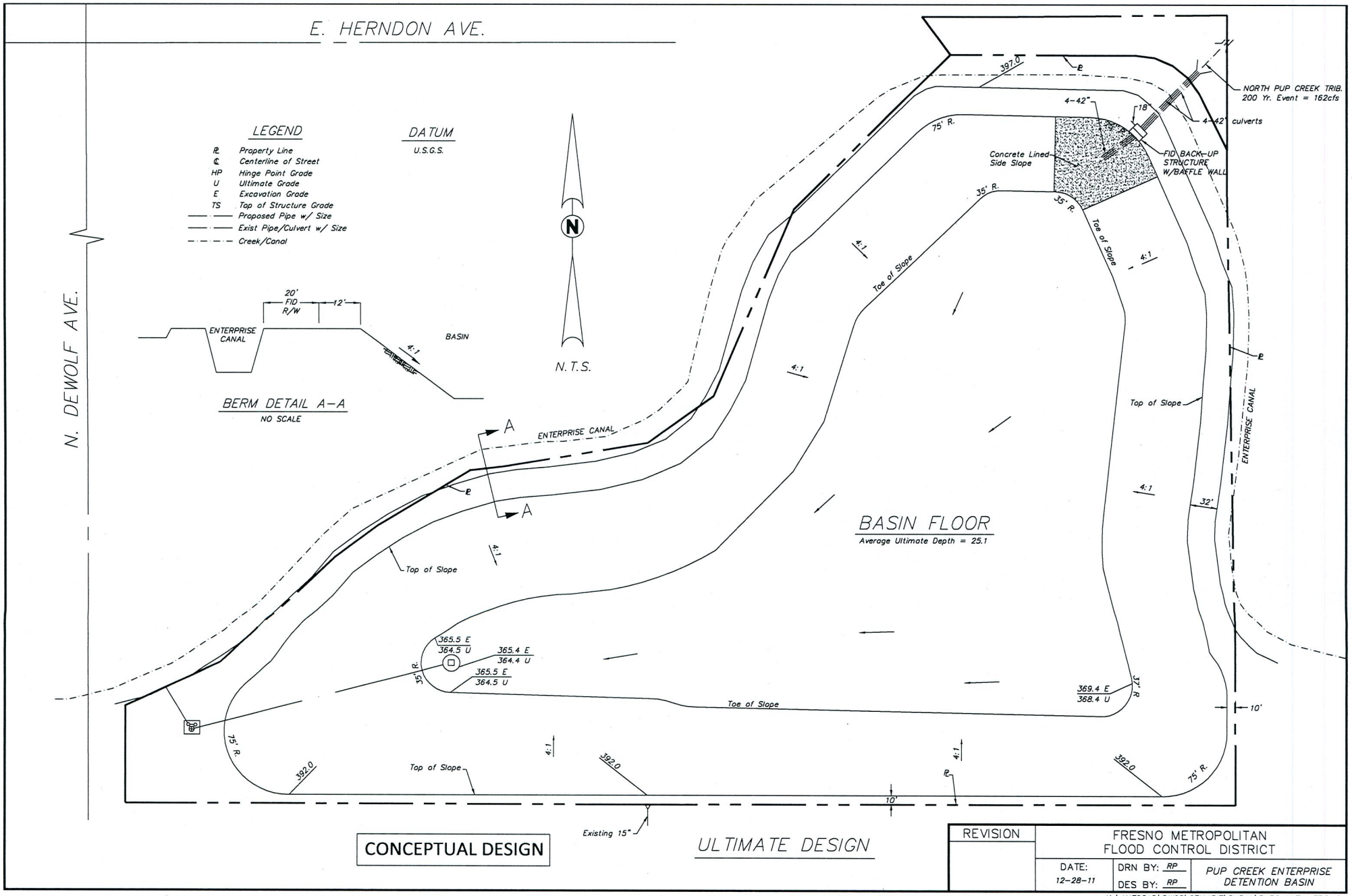

E. HERNDON AVE.
N. DEWOLF AVE.
LEGEND
Property Line
Centerline of Street
HP Hinge Point Grade
U Ultimate Grade
E Excavation Grade
TS Top of Structure Grade
Proposed Pipe w/ Size
Exist Pipe/Culvert w/ Size
Creek/Canal
DATUM
U.S.G.S.
N
N.T.S.
ENTERPRISE CANAL
NORTH PUP CREEK TRIB.
200 Yr. Event = 162cfs
4-42" culverts
4-42" w/Tideflex TF-1 Check Valve
FID TURNOUT STRUCTURE W/48" GATE VALVE
48"
75' R.
4:1
FG 395.5
FG 396.5
FG 394.0
Top of Slope
Toe of Slope
32'
BERM DETAIL A-A
NO SCALE
10'
Basin
Match Existing
BERM DETAIL B-B
NO SCALE
20' FID R/W
12'
Enterprise Canal
Existing Ground
4' HIGH, 10' WIDE BERM
Double 12' Gates
Concrete lined broad crested weir w/30" gate valve
100'
Existing 15" PVC Pipe
CONCEPTUAL DESIGN
INTERIM DESIGN
REVISION
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
DATE: 12-27-11
DRN BY: RP
DES BY: RP
PUP CREEK ENTERPRISE DETENTION BASIN
K:\AUTOCAD\DWGS\DEXHIBIT\RURAL\PUP2_INTERIM.DWG

EXHIBIT No. 2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N. DEWOLF AVE.
LEGEND
PL Property Line
℄ Centerline of Street
HP Hinge Point Grade
U Ultimate Grade
E Excavation Grade
TS Top of Structure Grade
Proposed Pipe w/ Size
Exist Pipe/Culvert w/ Size
Creek/Canal
DATUM
U.S.G.S.
N
N.T.S.
20' FID R/W
12'
ENTERPRISE CANAL
BASIN
4:1
BERM DETAIL A-A
NO SCALE
A
A
ENTERPRISE CANAL
Top of Slope
392.0
75' R.
35' R.
365.5 E
364.5 U
365.4 E
364.4 U
365.5 E
364.5 U
Toe of Slope
369.4 E
368.4 U
37' R
10'
Existing 15"
BASIN FLOOR
Average Ultimate Depth = 25.1
4-42"
18"
Concrete Lined Side Slope
FID BACK-UP STRUCTURE W/BAFFLE WALL
NORTH PUP CREEK TRIB.
200 Yr. Event = 162cfs
4-42" culverts
32'
ENTERPRISE CANAL
CONCEPTUAL DESIGN
ULTIMATE DESIGN
REVISION
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
DATE: 12-28-11
DRN BY: RP
DES BY: RP
PUP CREEK ENTERPRISE DETENTION BASIN
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EXHIBIT No. 3

RESOLUTION NO. 2012-743

BEFORE THE BOARD OF DIRECTORS OF THE FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

RESOLUTION AMENDING THE STORM DRAINAGE AND FLOOD CONTROL MASTER PLAN, ADDITION OF STORMWATER BASIN, PUP CREEK ENTERPRISE DETENTION BASIN

WHEREAS, the Fresno Metropolitan Flood Control District (District) has adopted and bears responsibility for implementation of the Storm Drainage and Flood Control Master Plan (Master Plan) for the Fresno-Clovis Metropolitan area; and

WHEREAS, the U.S. Army Corps of Engineers routing model for the Pup Creek system has been found to be insufficient to convey flood flows as proposed; and

WHEREAS, on April 11, 2012, the District adopted a Mitigated Negative Declaration for Construction of a Stormwater Retention Basin near Herndon and DeWolf Avenues (Pup Creek Enterprise Detention Basin) to rectify the routing of flood flows and accommodate increased runoff from future development in the Pup Creek watershed; and

WHEREAS, the Board of Directors of the District desires to establish by resolution the amendment of the Master Plan to include the Pup Creek Enterprise Detention Basin to resolve inherent capacity deficiencies in the Pup Creek system; and

WHEREAS, it is proposed to amend the Storm Drainage and Flood Control Master Plan to include the Pup Creek Enterprise Detention Basin.

NOW, THEREFORE, BE IT RESOLVED BY the Board of Directors of the Fresno Metropolitan District as follows:

1. The above recitals are true and correct and this Board so finds and determines.

2. The boundary of land for the Pup Creek Enterprise Detention Basin, located near Herndon and DeWolf Avenues and identified on the attached Exhibit "A", is hereby incorporated into the Storm Drainage and Flood Control Master Plan.
3. PASSED AND ADOPTED this 23rd day of May 2012 by the following vote, to wit:

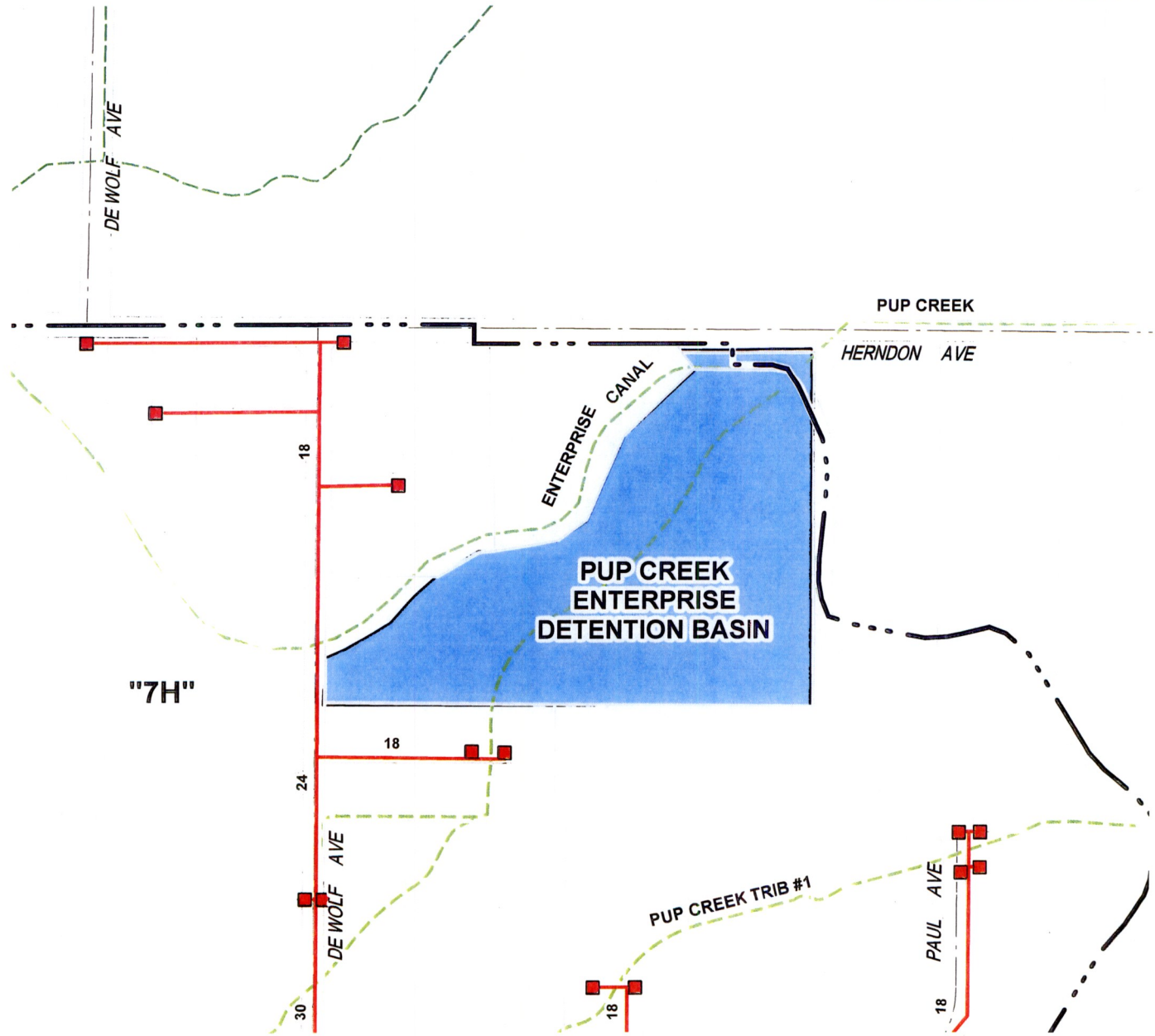
AYES: Directors Spina, Williams, Rastegar, Fowler, and Burleson

NOES: None

ABSENT: Directors Groom and Goodwin

ABSTAIN: None

NOTE:
THIS MAP IS SCHEMATIC
DISTANCES ARE APPROXIMATE.



LEGEND

- Future Master Plan Facilities
- Drainage Area Boundary
- Streams And Canals
- Pup Creek Enterprise Detention Basin

N

1 " = 400 '

PUP CREEK ENTERPRISE DETENTION BASIN

PUP CREEK WATERSHED

EXHIBIT "A"

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

Prepared by: wadet
Date: 5/17/2012
Path: K:\Autocad\DWGS\0EXHIBIT\BASINS\PUP CREEK\Pup Creek Enterprise Basin.mxd

ACTION SUMMARY MINUTES
MINUTES OF THE REGULAR MEETING OF THE BOARD OF DIRECTORS OF THE FRESNO METROPOLITAN FLOOD CONTROL DISTRICT HELD WEDNESDAY, MAY 23, 2012

Pursuant to notice, the Regular Meeting of the Board of Directors of the Fresno Metropolitan Flood Control District was held Wednesday, May 23, 2012 at 6:00 p.m. in the Board Chambers of the Fresno Metropolitan Flood Control District at 5469 East Olive Avenue; Fresno, California.

DIRECTORS PRESENT: Roy Spina, Chairman
Jennette Williams, Vice-Chairman
Mike Rastegar
Frank Fowler
Buzz Burleson

DIRECTORS ABSENT: Kendall Groom
Barbara Goodwin

STAFF, CONSULTANTS, OTHERS PRESENT: Bob Van Wyk, General Manager-Secretary
Jerry Lakeman, District Engineer
Alan Hofmann, Assistant District Engineer/Design
Paul Merrill, Finance Manager
Karyn Kruser, Staff Analyst
Daniel Rouke, Staff Analyst
Kristine Johnson, Staff Analyst
Robert McIntyre, Computer Network Technician
John Santos, Engineer
Kurt Hupp, Rural Program Manager
Frances Lopez, Office Manager; Serving as Clerk to the Board

Ken Price, Assistant General Counsel;
Baker, Manock & Jensen
Lauren Layne, Assistant General Counsel;
Baker, Manock & Jensen

Doug Harrison, Past District General Manager

PRESIDING: Director Spina, presiding as Chairman called the meeting to order at 6:00 p.m. and Mr. Price led the Pledge of Allegiance.

2. REPORT OF THE GENERAL MANAGER:

Mr. Van Wyk reported on the following: (1) acknowledged the presence of Mr. Doug Harrison; (2) complaints from Property Owners regarding Basin "V" (Sierra Vista, n/o McKinley); apparently there are soccer games going on by people/organizations who do not have an agreement with the District; he stated in order to control the site, the District staff closed the site and installed special locks; he stated staff has now opened the site and will continue to monitor the activity; (3) the draft Budget would be distributed to the Board next Friday, June 1, 2012; with the Budget Workshop being held on Wednesday, June 6, 2012; (4) the State of the City of Luncheon will be held on Wednesday, May 30th and the Clerk to the Board would be contacting the Board Members who have indicated they will be attending; (5) advancements have been made with the "Abandonment of Annadale Avenue" and he requested Mr. Lakeman update the Board as to the status; Mr. Lakeman stated the County had approved the abandonment and he will be bringing a report to the Board at the next Regularly Scheduled Board Meeting; and (6) he distributed a letter from a property owner acknowledging the District and in particular Brent Sunamoto.

3. APPROVAL OF MINUTES: Minutes of May 9, 2012

Approved as Recommended

Motion by: **Burleson** **Second by:** **Williams**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

4. BUSINESS AND PRESENTATIONS FROM THE FLOOR:

There was no Business or Presentations from the Floor

5. ADDITIONS TO THE AGENDA:

There were no Additions to the Agenda.

6. POTENTIAL CONFLICTS OF INTEREST:

There were no Conflicts of Interest.

7. PUBLIC HEARING:

There were no Public Hearings scheduled.

8. CONSENT CALENDAR:

a. Authorize the General Manager to Enter into Contracts with Environmental Consulting Firms to Provide "As-Needed" Services for Environmental Planning and Regulatory Compliance

b. Award of Contract "G-11", Pump Station, Carozza Park, Basin "G" (Olive & Winery)

c. Report of Pollutant Discharge Incidents, April 2012

f. Submittal of Third Quarter Budget Report, Fiscal Year 2011-2012

g. Acceptance of Report of External Auditor, Fiscal Year 2011 Public Agencies Post-Retirement Health Care Plan Trust

Director Burleson requested Agenda Item 8d be pulled; Director Rastegar requested Agenda Item 8e be pulled.

Approved as Recommended, Pulling Agenda items 8d and 8e

Motion by: **Burleson** **Second by:** **Williams**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

d. Report of Status of Fancher Creek Floodway (Fowler s/o Belmont) Maintenance, JPJ Incorporated (John Bonadelle, Jr.)

Report submitted for informational purposes only, no action is required by the Board unless specific direction is to be given to staff.

Responding to Director Burleson's question regarding whether the property owner, as stated in the Board Memorandum, had mowed fire breaks on the property for fire safety on May 16th, Mr. Lakeman stated the property owner had indeed done that.

As the report was submitted for informational purposes only, no further action was taken.

e. Report on Other Post-Employment Benefit (OPEB) Investment Returns for Period Ending March 31, 2012

Report submitted for informational purposes only, no action is required by the Board unless specific direction is to be given to staff.

Director Rastegar requested staff do a comparison between PARS and PERS and bring that back to the Board at a subsequent meeting. Mr. Van Wyk stated staff will complete that comparison.

As the report was submitted for informational purposes only, no further action was taken.

9. Adoption of Resolution Amending Storm Drainage and Flood Control Master Plan, Pup Creek Enterprise Detention Basin (s/o Herndon, e/o DeWolf Avenues)

Recommend the Board of Directors adopt the Resolution attached to the Board Memorandum amending the Storm Drainage and Flood Control Master Plan to include the Pup Creek Enterprise Detention Basin.

Approved as Recommended, Adopting Resolution No. 2012-743

Motion by: **Rastegar** **Second by:** **Fowler**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

10. Adoption of Resolution Authorizing Application for Local Groundwater Assistance Program Grant, California Department of Water Resources (DWR)

Recommend the Board of Directors adopt the Resolution attached to the Board Memorandum authorizing staff to submit a Grant Application to the California Department of Water Resources for recharge improvements and basin soil sampling.

Approved as Recommended, Adopting Resolution No. 2012-744

Motion by: **Rastegar** **Second by:** **Williams**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

11. Adoption of Resolution Authorizing Membership in the Southern Sierra Regional Water Management Group, Execution of Memorandum of Understanding as a Planning Committee Member, and Designation of Primary and Alternative District Representatives

Recommend the Board of Directors: (1) Adopt the Resolution attached to the Board Memorandum as Attachment No. 7 to join as a Planning Committee Member of the Southern Sierra Regional Water Management Group; (2) Authorize the District's General Manager to sign the MOU on behalf of the District; and (3) Appoint the District Engineer (Jerry Lakeman) as the Primary Representative and one staff member (Kurt Hupp, Rural Program Manager) as the alternate representative on the Planning Committee of the SSRWMG to act on behalf of the District in absence of the primary member.

Approved as Recommended, Adopting Resolution No. 2012-745

Motion by: **Burleson** **Second by:** **Williams**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

12. Adoption of Resolution of Appreciation, John L.B. Smith

Recommend the Board of Directors adopt the Resolution attached to the Board Memorandum, Resolution of Appreciation for John L.B. Smith.

Mr. Doug Harrison addressed the Board acknowledging Mr. Smith's remarkable record with the District, in particular noting he could not recall the District ever losing a liability lawsuit. He also acknowledged Mr. Smith's passion for the District and the public the District served.

Approved as Recommended, Adopting Resolution No. 2012-742

Motion by: **Burleson** **Second by:** **Williams**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

13. Authorization to Execute Development Agreement for Initial Projects for the Fancher Creek Flood Control Improvement Project, Drainage Area "BO" (Sunnyside & McKenzie), Fancher Creek Town Center, Tom Richards and Ed Kashian

Recommend the Board of Directors authorize the agreement outlined in the Board Memorandum with the developers of the Fancher Creek Town Center for the initial work on the Fancher Creek Flood Control Improvement Project.

Approved as Recommended

Motion by: **Rastegar** **Second by:** **Fowler**
Ayes: **Spina, Williams, Rastegar, Fowler, Burleson**
Noes: **None**
Abstentions: **None**
Absentees: **Groom, Goodwin**

14. Board Reports, Workshops, Correspondence and Requests for Future Agenda Items:

a. Report on Board of Directors Attendance at Various Meetings:

(1) Association of California Water Agencies (ACWA)/Joint Powers Insurance Authority (JPIA) 2012 Spring Conference, Monterey, California, Director Groom

(2) San Joaquin River Conservancy (SJRC), Director Spina

Recommend (1) Director Groom give a verbal report of the ACWA/JPIA 2012 Spring Conference held on May 7 – 9, 2012; and (2) Director Spina give a verbal report of the SJRC meeting held on May 9, 2012.

As Director Groom was not in attendance, no verbal report of the ACWA/JPIA 2012 Spring Conference was given.

Director Spina gave a verbal report of the SJRC meeting held on May 9, 2012.

As the report was submitted for informational purposes only, no further action was taken.

REPORT OF GENERAL COUNSEL

No items were reported.

CLOSED SESSION

A Closed Session was not convened.

ADJOURNMENT

Adjourned Board Meeting at 6:55 pm

Motion by:	**Williams Second by:**
Ayes:	**Spina, Williams, Rastegar, Fowler, Burleson**
Noes:	**None**
Abstentions:	**None**
Absentees:	**Groom, Goodwin**

Bob Van Wyk
BOB VAN WYK
GENERAL MANAGER/SECRETARY

6/21/12
DATE

board\minutes\perm\2012-05-23

STANDARD OPERATING PROCEDURES FOR MONITORING, MAINTENANCE, AND DISPOSAL OF STORM WATER BASIN SEDIMENTS

Fresno Metropolitan Flood Control District

September 26, 2001

Prepared by:
Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, California 93727
(559-456-3292)

STANDARD OPERATING PROCEDURES FOR MONITORING, MAINTENANCE, AND DISPOSAL OF STORM WATER BASIN SEDIMENTS

TABLE OF CONTENTS

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VIII. DATA ANALYSIS, INTERPRETATION AND MANAGEMENT 12

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I. INTRODUCTION

The Fresno Metropolitan Flood Control District (District) has revised and updated its 1990 Basin Soil Monitoring and Maintenance Plan by developing Standard Operating Procedures (SOP) for Monitoring, Maintenance, and Disposal of District Storm Water Basin Sediments.

The purpose of the SOP is to ensure the District's current basin sediment monitoring, maintenance, and disposal practices: (1) comply with applicable governmental mandates and regulations; (2) protect public health, safety, groundwater quality and the environment; (3) are properly documented; and, (4) ensure optimum basin percolation rates for groundwater recharge.

The District routinely samples and analyzes storm water basin sediments in accordance with approved Environmental Protection Agency (EPA) test methods for total lead. In August 1999, the District adopted in revised form its Basin Sediment Monitoring and Management Policy that established a goal of maintaining its basins so that mean total lead concentrations in basin sediments to be removed do not exceed 50% of current waste disposal standards. By adhering to this policy, the District can ensure that accumulated basin sediments are disposed of properly, and will not approach or exceed the lead waste disposal or hazardous waste standard.

The objectives of the SOP are to establish standard practices for basin sediment monitoring, maintenance, and disposal activities[1]. The District's basin sediment monitoring program addresses: sampling frequency, location, collection and handling practices, chemical analyses, quality assurance and quality control, and documentation. The basin sediment maintenance program addresses sediment removal, removal frequency and method, disposal of removed sediments as non-hazardous material, and documentation.

This SOP shall be reviewed and updated as necessary to ensure that the most efficient and effective monitoring, maintenance, and disposal procedures are in place, and to ensure compliance with state and federal standards, laws and regulations. Appropriate District staff shall receive periodic training on the SOP.

[1] This SOP does not address the management of accumulated basin sediments if they were to exceed the lead waste disposal standard or the state hazardous waste classification standard. Situation-specific procedures would be developed and used to ensure employee and public safety and regulatory compliance.

II. BACKGROUND

In the early 1980's the District participated in the Nationwide Urban Runoff Program (NURP) initiated by the U.S. Environmental Protection Agency in 1978. Extensive studies were conducted between 1981 and 1983 to characterize urban storm water runoff quality, groundwater quality beneath storm water basins, and sediment accumulation within basin sites to determine the fate and transport of pollutants found in urban runoff. The NURP study also evaluated and made recommendations on the District's basin maintenance practices.

It was concluded from NURP that storm water-borne pollutants accumulate and become bonded to sediments in the uppermost layer of basin soils. Of the pollutants evaluated by NURP, lead was determined to be the constituent most likely to first accumulate to hazardous concentrations, over an extended (several years) period of time.[2] For pollutant concentrations generally found in urban runoff, it was also concluded by NURP and other subsequent studies that storm water basins were protective of groundwater quality. Nonetheless, the study provided limited evidence that under certain circumstances bonded storm water-borne pollutants could be leached from upper soil strata (0.0-0.3 m) to deeper strata (0.3-1.6 m). The study recommended periodic removal of surface sediments to reduce the potential for such pollutant leaching.

Based on these findings, the District determined it was appropriate to conduct regular basin monitoring and maintenance activities designed to prevent the accumulation of lead and other pollutants so as to protect public health and safety, groundwater quality, and the environment in an economically viable manner.

III. REGULATORY CONTEXT

The District's basin sediment management program is designed to comply with the following sections of the California Health and Safety Code and the California Code of Regulations:

<u>California Health and Safety Code, Chapter 6.5, Article 2, Section 25124</u>
Sediments removed from basins are classified as a waste pursuant to the definition in this code section.

<u>California Code of Regulations, Title 22, Division 22, Section 66261.24(a)(2)(A)</u>
Title 22 establishes hazardous waste criteria for lead and other substances. Materials that meet hazardous waste criteria, unless granted a variance, must be disposed of in a Class I hazardous

[2]Other storm water-borne pollutants also accumulate in the uppermost layer of basin soils; however, because it has been determined that lead is the pollutant most likely to first exceed a hazardous waste disposal standard, it is used as an indicator constituent so that other pollutants are removed from ponding basins before their concentrations reach levels of concern.

waste disposal facility and handled and transported by a licensed hazardous waste transporter. A lead-contaminated waste is considered hazardous waste when its lead concentration is equal to or greater than 1000 mg/kg for total lead, or 5 mg/l for soluble lead.[3]

California Health and Safety Code, Chapter 6.5, Article 5, Section 25157.8 This section establishes disposal standards for wastes containing lead which must be disposed of in a Class I hazardous waste disposal facility. These wastes, so long as they do not meet or exceed hazardous waste criteria, are not required to be handled or transported by a licensed hazardous waste transporter. A lead-contaminated waste must be handled in accordance with this code section when its total lead concentration is equal to or greater than 350 parts per million. This section of the code will remain in effect until July 1, 2003, unless it is repealed or extended by the State Legislature.

IV. BASIN TYPES AND DISCRIPTIONS

The District currently owns and operates more than 140 storm water basins. Many of these basins are fully constructed to the Master Plan design, others are partially constructed, and some are yet to have construction begin. Storm water basins are monitored and maintained in accordance with their designated use and stage of construction.

A complete inventory of District basins, including information regarding their type and stage of completion, shall be maintained by the Operations Department and used as the basis for implementing this SOP.

The District's basins are divided into the three following categories:

A. Recreational Basins (Developed Basins)
Recreational basins are used by the public for open space and active recreational purposes during the dry weather season, typically mid-April through mid-October. During the wet weather season, typically mid-October through mid-April, these basins are closed to the public and are used to collect and retain urban storm water runoff. Recreational basins are normally developed with an upper floor and a deeper low-flow area. They are generally landscaped with turf and trees, and are irrigated with a sprinkler system.

B. Recharge Basins
Recharge basins store and percolate imported surface water entitlements during the irrigation delivery season. During the wet weather season, recharge basins are used to collect and retain urban storm water runoff. Recharge basins may have an upper floor and low-flow area, or may have a single floor. Recharge basins are generally closed to the public year-round.

[3] This SOP-addresses only total lead analyses.

C. Other Basins

Basins that do not fit into the recreational or recharge basin categories include basins that are not yet landscaped, or not yet fully excavated or constructed. This category also includes all San Joaquin River discharge detention basins and basins that are fully constructed but are not used for recreation or dry season groundwater recharge.

Depending on design, designated use, and stage of construction completion, these basins may be used to collect urban storm water runoff during the wet weather season, or receive surface water entitlements for dry season groundwater recharge. These basins are closed to the public.

V. BASIN SEDIMENT MONITORING AND MAINTENANCE

In general, basin monitoring and maintenance activities are conducted during the dry weather season. Monitoring activities include:

1) sampling and analyzing accumulated basin sediments;
2) documenting sample locations, site conditions, and analytical results; and
3) evaluating analytical results for compliance with applicable policies, standards, and regulations.

Sediment maintenance activities include removing and disposing of accumulated sediments, and where necessary, restoring the sediment removal areas to the proper design grade with clean soil, turf, and landscaping. Private contractors using earthmoving equipment such as a scraper, motor-grader, loader, and dump truck typically remove sediments.

A. District Organization/Responsibilities

The Facilities Manager, under the direction of the Operations District Engineer, shall be responsible for scheduling basin monitoring and maintenance activities and modifying the frequency of such activities based on the analyzed results of the sampling program and operational needs. Facilities Technicians shall be responsible for collecting and transporting the sediment samples to an analytical laboratory and overseeing the sediment removal activities. The Environmental Resources Manager shall be responsible evaluating sample results and advising the District Engineer and General Manager regarding compliance with policies, standards, and regulations.

B. Recreational Basin Monitoring and Maintenance

Basin sediments shall be sampled, analyzed, and removed from recreational basin low flow areas, and around recreational floor outfall structures as necessary to maintain lead concentrations below the District's policy goal.[4] Initially, sediments from all recreational

[4]The original Basin Soil Monitoring and Management Plan and the Draft 1999 District Services Plan identify an annual sediment monitoring frequency for recreational basin low flow areas with the objective of monitoring lead accumulation rates; however, based on review of monitoring results, sampling every three to four years appears adequate to meet management objectives. Special studies could be implemented in the future specifically to determine accumulation rates, if desired.

basins completed prior to 1990 shall be sampled and removed as described in the following sections, B.1 and B.2., no later than December 2003. Subsequent removal, and removal from more recently completed recreational sites, shall be determined in review of sampling results and be performed as described in section B.2. Samples shall be taken no less often than once every four years from the last sampling or significant excavation. Monitoring and maintenance procedures shall be as follows:

1. Sediment Monitoring

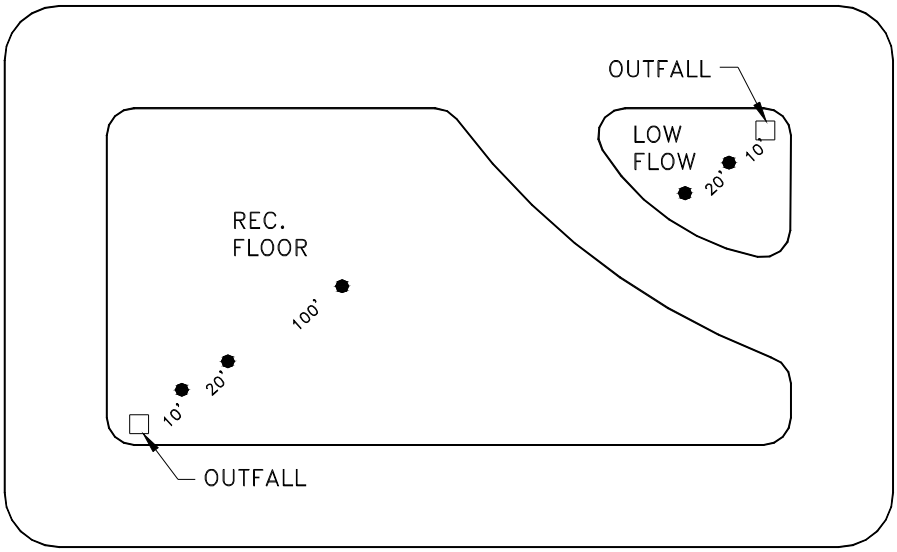
Sediment sampling shall be conducted no less often than once every four years, including periods between sediment removal, and will be conducted more frequently based on sediment accumulation rates. Facilities Technicians shall collect samples before accumulated sediments are removed from areas around turfed recreational floor outfalls and basin low-flow areas, and immediately after sediment removal and/or after clean soil is backfilled into the areas where sediments were removed. The post-cleaning samples will be used to establish the baseline mean lead concentrations.

Prior to collecting samples, the basin shall be dewatered. Using a tape measure or measuring wheel, three samples shall be collected at each upper basin floor outfall: one at approximately 10 feet, one at 20 feet, and one at 100 feet along a radius which extends outward from the outfall structure toward the center of the basin. Two samples shall be taken within the low-flow area: one at 10 feet and one at 20 feet along a radius extending outward from the outfall structure toward the farthest side slope of the low-flow area (See Figure 1). Samples shall be collected in accord with the methods presented in Section VI, B. Sample Collection. Upon completion of sample collection at each basin, sampling personnel shall document the sampling using the procedures presented in Section VI, C, and Field Documentation.

2. Sediment Maintenance

Sediments shall be physically removed from the Basins when indicated by the sediment sampling plan results and the District's Basin Sediment Monitoring and Management Policy as required to meet other Basin use objectives, such as recharge. Depending on space for maintenance equipment, accumulated sediments and associated turf shall be removed to a depth of 12 inches within a 40-foot radius around the outfall structures located on the recreational floor. Within the low-flow areas, sediments will be removed to a depth of 12 inches within a 40-foot radius around the outfall structures to the extent permitted by available working space, with the removal tapering to two inches across the balance of the bottom and extending up the slope as necessary to meet the sediment quality objectives and this policy.

Figure 1 – Sediment Monitoring Locations – Recreation Basins



Upon completion of sediment removal, clean soil will be backfilled to restore the design grade of the recreation floor and low flow area, and turf will be reestablished where necessary.

3. Sampling and Sediment Removal for Remaining Turfed Area

As determined by the NURP study, the majority of sediment accumulation in basins occurs in low-flow areas and immediately around upper floor outfall structures. This is the basis for the sediment removal procedure listed above. However, over time sediments and lead concentrations on the other portions of the recreation floor may accumulate to levels where similar maintenance will be necessary. Sediment removal for this larger area of the recreation floor will be managed on a site specific basis, and will be determined based on analysis of results obtained from samples collected from the 100 foot transects; the potential need for basin improvements; the period of time since the recreation basin was completed; land use of the drainage area; and documentation that risks to water quality and public health and safety warrant the work. Prior to determining the extent of sediment of to be removed, supplemental sampling across the recreational floor and extending up the side slopes will be performed.

C. Recharge Basin Monitoring and Maintenance

Accumulated basin sediments shall be sampled, analyzed, and removed from recharge basins as described in section C.2. and as necessary to maintain the lead concentrations below the District's policy goal. Sediment is more commonly required to be removed from

recharge basins to maintain percolation than necessary to meet the policy goal.

In order to monitor and confirm that the District's policy goals are being maintained, sample collection shall be performed as follows:

1. Sediment Monitoring

Sampling shall be conducted no less often than once every four years including periods between sediment removal and will be conducted more frequently based upon sediment accumulation rates. The sampling interval shall be from the last sampling removal or significant excavation. Facilities Technicians shall collect sediment samples before and immediately after accumulated sediments are removed from recharge basins. Prior to the sample collection, basin floors, including low-flow areas, shall be dewatered.

Using a tape measure, samples shall be collected at each basin outfall at approximately 10 feet, 20 feet, and 100 feet along a radius extending outward from the outfall structure toward the center of the basin (See Figures 2 & 3). Samples shall be collected in accord with the methods presented in Section VI, B, Sample Collection. Upon completion of sample collection at each basin, sampling personnel shall document the sampling using the procedures presented in Section VI, C; Field Documentation.

2. Sediment Maintenance

The District shall remove accumulated sediments from the entire basin floor and low-flow area to the extent it is accessible. The depth of accumulated sediments being removed from the basin floor and low-flow area will range from approximately 2 inch to 12 inches. The actual depth of sediment removal will vary from site to site and outfall to outfall, and will depend upon visual observations and sampling results of sediment accumulation.

Figure 2 – Sediment Monitoring Locations – Recharge Basins

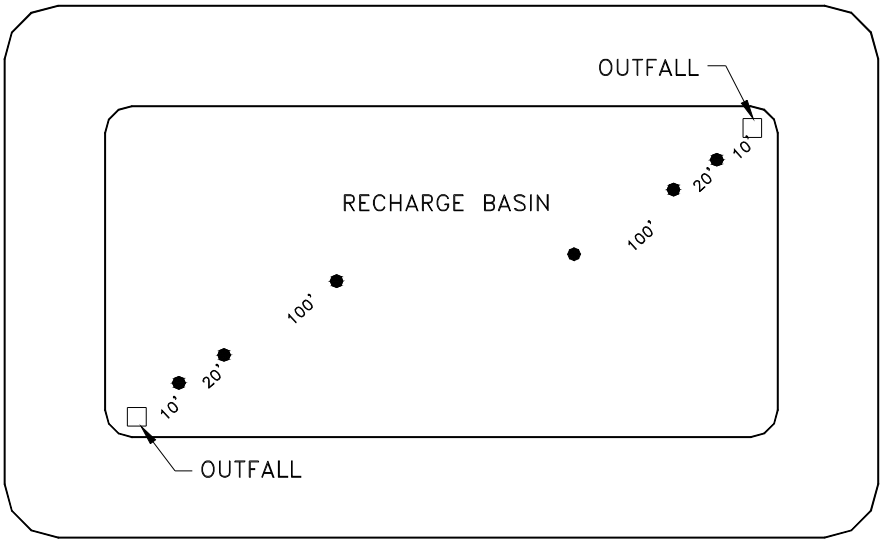
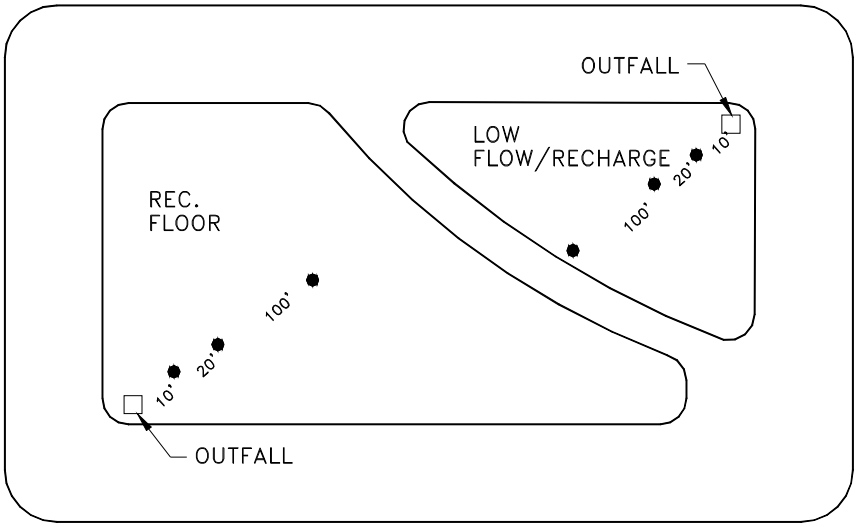


Figure 3 – Sediment Monitoring Locations – Recharge Basins with Recreation Areas



D. Monitoring and Maintenance of Other Basins

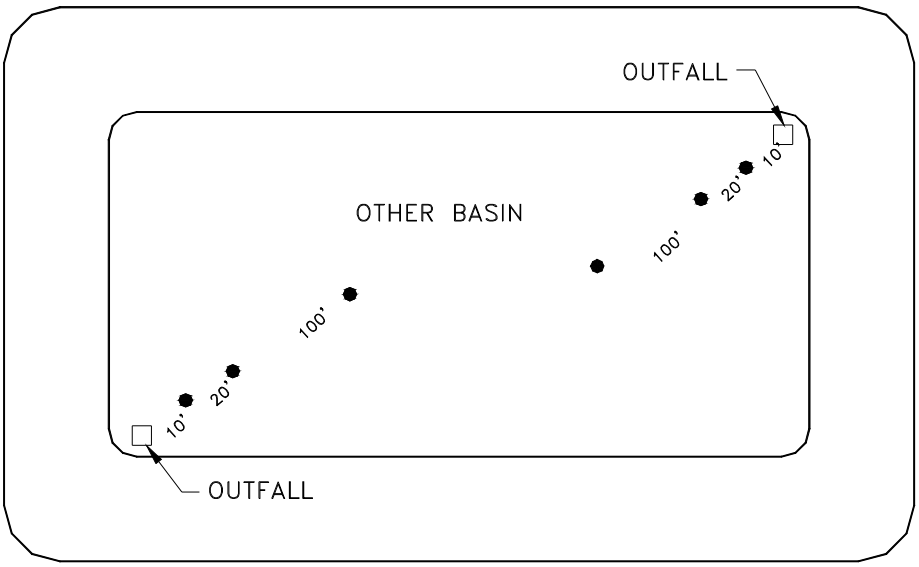
With the exception of those basins described in section D.3. accumulated basin sediments shall be sampled, analyzed, and removed from all other types of basins as described in this document, as necessary to maintain the lead concentrations below the District's policy goal. Initially sediments from all such basins completed prior to 1990 shall sampled as described in section D.1. and removed as described in section D.2. no later than December 2003. Subsequent removal, and removal from more recently completed sites, shall be determined in review of sampling results and be performed as described in section D.2. Samples shall also be taken no less often than once every four years during periods between sediment removal. Monitoring and maintenance procedures shall be as follows:

1. Sediment Monitoring

Facilities Technicians shall collect samples before and immediately after accumulated sediments are removed, and as otherwise required due to sediment accumulation date and other Basin objectives. Prior to the sample collection, basin floors and low-flow areas (as applicable) shall be dewatered. Some basins, including detention basins, may require proper vegetation removal and disposal prior to sampling.

Using a tape measure, samples shall be collected at each basin outfall at approximately 10 feet, 20 feet, and 100 feet along a radius extending outward from the outfall structure toward the center of the basin (See Figure 4). Samples shall be collected in accord with the methods presented in Section VI, B, Sample Collection. Upon completion of sample collection at each basin, sampling personnel shall document the sampling using the procedures presented in Section VI, C, Field Documentation.

Figure 4 – Sediment Monitoring Locations – Other Basins



2. Sediment Maintenance

District contractors shall remove accumulated sediments from functioning basin floors and low-flow areas, depending on the basin's stage of development. Depending on space for maintenance equipment, accumulated sediments and associated vegetation shall be removed to a depth of 12 inches within a 40-foot radius around each outfall structure.

3. Special Considerations

Any basin characterized by any of the following is exempt from the above requirements:

- Basin sites that have not yet been excavated.
- Excavated or partially excavated basin sites that do not yet receive storm water runoff.
- Basin sites that are under active excavation and for which soil has

been removed from the area receiving runoff within the past four years.[5]

(Basin sites that are under excavation, but that have not had excavation activity for a period of four years, and which receive storm water runoff, shall be monitored every four years to determine if interim sediment maintenance is necessary. For these basins, sediment maintenance shall be managed on a case-by-case basis, and will be determined by the Operations Engineer.)

E. Basins Serving Industrial Land Uses

The District shall identify those basins serving primarily industrial land uses, and may identify other basins believed to be at a higher risk for pollutant accumulation, and shall schedule those basins for sampling and maintenance no less often than once every three years. Sampling and sediment maintenance procedures shall be as described above for the particular type of basin. (Most commonly basins serving industrial land uses are in the "Other Basin" category, section D.

VI. PERSONAL PROTECTION, SAMPLE COLLECTION, HANDLING, AND SAMPLE TEST METHOD

A. Personal Protection

Sampling personnel shall wear appropriate protective clothing, such as work boots, long pants, long-sleeved shirts, and gloves when collecting sediment samples to minimize risk of injury from possible debris that may be embedded in accumulated sediments.

B. Sample Collection

All sediment samples shall be collected in a clean 1 inch x 12-inch stainless steel sampling tube. Once the sediments are analyzed, the tubes shall be cleaned by the laboratory or the District before they are reused. Sediments samples shall be collected by driving the entire length of sampling tube into the ground using a slide hammer sampling device. Once a sample is collected, clean plastic caps shall be placed on both ends of the sampling tube. The sample tube shall be immediately labeled with the date, basin designation, and appropriate sample number corresponding to the basin sampling location diagram.

C. Field Documentation

The sampling personnel shall prepare proper field documentation that shall include a basin diagram (Exhibit 1) and Chain of Custody form (Exhibit 2) for each sampling event. A "sampling event" consists of all samples collected at a basin at one time.

[5] If a basin site is under active excavation but has substantial areas completed, and those areas receive storm water runoff, then those areas must be monitored and maintained as otherwise described in the SOP.

1. Basin Sampling Location Diagram

For each sampling event, the Facilities Technician shall label and number the sample location on a basin diagram (Exhibit 1). The basin diagram must also identify the sampling personnel, date and time of the event, and if the samples were obtained before or after sediments were removed. A separate diagram shall be used for pre-cleaning samples and post-cleaning samples.

Standard basin drawings shall be used showing basin designation, configuration, and location of each outfall structure. A complete catalog of basin diagrams for all sampled basins shall be maintained by the Facilities Manager and used for sampling documentation. Diagrams for basins under active excavation shall require periodic updating.

2. Chain of Custody Forms

Chain of Custody forms (Exhibit 2) shall be completed by the Facilities Technician for each sampling event. Separate forms shall be used for the pre-cleaning and post-cleaning samples. Chain of Custody forms shall identify any unusual sampling conditions, deviations from this SOP, and reasons any sampling did not occur as planned. Exhibit 2 presents an example of a properly completed Chain of Custody form.

D. Handling of Samples

When feasible, sediment samples should be transported to the laboratory, under Chain of Custody, the day of sample collection. If it is not possible to transport the sample to the laboratory the day of sample collection, the samples shall be transported the next working day.

At the conclusion of sampling a basin, the Basin Diagram and a copy of the Chain of Custody form shall be stapled together and submitted to the Operations Engineer.

E. Sample Test Method

All sediment samples shall be analyzed for total lead in accordance with EPA analytical test method 200.7, 200.8, 6020a, or equivalent. The method detection limit shall be 0.5 mg/kg.

VII. QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance and Quality Control (QA/QC) is achieved through field documentation, the use of Chain of Custody forms, both described in Section VI, and the use of state certified laboratory.

A. State Certified Laboratory

All sediment samples shall be submitted with a completed Chain of Custody form to a District selected state certified laboratory for analysis. The laboratory shall submit the sample results to the District within 21 days of receipt of the samples. The Facilities Manager and Environmental Resources staff shall review the laboratory report to verify that the samples were analyzed as requested.

B. Out-of-Range Data

Environmental Resources Manager shall evaluate laboratory results for out-of-range data (i.e., and results that meet or exceed the Basin Sediment Monitoring and Management Policy goal of 50% of the waste disposal standard). Sample results that appear out-of-range shall be verified with the laboratory. If the laboratory verifies the result, the Operations' Engineer and the Environmental Resources Manager will be notified to determine if a second digestion and analysis of the sample shall be requested. If the result of a second analysis is generally consistent with the original, the original result shall be accepted. If the result of the second sample digestion and analysis is generally inconsistent with the original, a third confirming sample digestion and analysis shall be requested. Two consistent results shall be deemed a confirmed result. If all results are inconsistent, the District shall monitor the work of the laboratory and determine inability of future analytical assignments.

C. Sample Holding Time

All samples shall be held by the laboratory for a minimum of three months beyond the sample receipt date before they are discarded. All digested sample aliquots shall be held by the laboratory for a minimum of 30 days beyond their sample receipt date before they are discarded.

VIII. DATA ANALYSIS, INTERPRETATION, AND MANAGEMENT

A. Data Analysis

All data shall be entered by District staff into a computerized database. At the conclusion of each basin maintenance season (usually October or November) all laboratory data resulting from basin sediment sampling shall be analyzed statistically using an adaptation of the U.S. EPA's 1986 Test Methods for Evaluating Solid Waste, also known as SW-846. The SW-846 method is the California Department of Toxic Substances Control's accepted method for determining whether a solid waste is hazardous. This method may also be used to determine whether a solid waste exceeds a disposal standard.

For each basin, pre- and post-maintenance sample results shall be analyzed independently to determine the pre- and post-sample mean. Utilizing the Students *t* distribution, and using a probability of 0.20, a two-tailed confidence interval shall be established around each sample mean in order to estimate the range within which each population mean likely resides. For any given basin, so long as the value of the upper confidence interval is less than the regulatory standard against which it is being compared (e.g., waste disposal standard or hazardous waste standard), the basin sediments shall be considered in compliance. This comparison shall also be made against the Basin Sediment Monitoring and Management Policy goal of 50% of the waste disposal standard.

B. Annual Report

A summary of the data analyses shall be presented in an annual basin monitoring and maintenance report. At a minimum, the annual report shall include the following information:

$ List of Basins that were monitored and maintained;

$ Descriptive statistics, including the means and ranges of lead concentrations found in each monitored basin;

$ Confidence interval analyses;

$ Determination of compliance with applicable waste disposal standards and the District's Basin Sediment Monitoring and Management Policy goal;

$ Identification of basins which appear to have the potential to approach or exceed the District's policy goal for lead concentration within the next year;

$ Description of any unusual circumstances that occurred during the monitoring and maintenance season; and

$ Maintenance recommendations based on the data analyses, including an increase in maintenance frequency for basins with relatively elevated lead concentrations, or reduction in maintenance frequency for those with repeatedly low lead concentrations.

IX. SEDIMENT DISPOSAL

Since the basin maintenance program began in the mid 1980's, sediment sample results have never exceeded the hazardous waste or waste disposal criterion. Unless the District has reason to conclude or suspect otherwise, accumulated basin sediments maintained in accordance with this SOP shall be considered and disposed of as non-hazardous fill material. The District generally accomplishes sediment disposal by making the material available to contractors and interested citizens for construction fill through the "Removal of Borrow Material Permit" process. Sediments are generally stockpiled on site, or they are transported to and stockpiled at another District facility until such time they are disposed of through the borrow material permit process.

If the Facilities Technician overseeing the sediment removal, or if the contractor performing the sediment removal has reason to suspect basin sediments or soils are unusually contaminated (e.g., due to odor, color, wastes, or other evidence) then the Facilities Technician or contractor shall halt work and notify the Operations Engineer. The Operations Engineer shall consult with the Environmental Resources Manager to determine an appropriate supplemental investigation of the source of the concern, and determine any necessary change in the sediment disposal.

EXHIBIT 1

Basin Sampling Diagram

EXHIBIT 2

Chain of Custody Form

AUGUST 1998

Fresno-Clovis Storm Water Quality Monitoring Program Technical Memorandum:

Basin "C" Monitoring 1996-1997

Prepared for:

Fresno Metropolitan Flood Control District

INTRODUCTION

National Pollutant Discharge Elimination System (NPDES) municipal storm water permit number CA0083500 was issued by the Central Valley Regional Water Quality Control Board to the Fresno Metropolitan Flood Control District on September 16, 1994. This permit requires a detention basin monitoring program. The objectives of the detention basin monitoring program are to characterize the water quality of urban runoff and evaluate the water quality treatment performance of the storm water detention basin. During 1996-97, monitoring of Detention Basin "C" (Basin "C") was conducted in conformance with these plans and in compliance with NPDES permit monitoring requirements. Samples from Basin "C" were collected from both influent and effluent by both manual and automated means.

This report presents a comparison analysis of influent and effluent concentration data and an interpretation of the results of that analysis. Descriptive statistics were calculated for all constituents with at least three detected data points (mean, median, maximum value, minimum value, and standard deviation) in either influent or effluent data sets. All constituents with five or more detected data points were tested for normality/lognormality, and subsequently analyzed in tests comparing influent and effluent concentrations. Time series regression was used to evaluate day to day changes in effluent concentration for multi-day effluent pumping events.

Results of the analysis showed Basin "C" to be highly effective in reducing the concentrations of several important constituents in storm water runoff. These include various metals (total recoverable) as well as Total Dissolved Solids and Total Suspended Solids. Additionally, Basin "C" was also highly effective in reducing the concentration of PAH's.

Monitoring Locations and Data

Stormwater samples were collected from six storm events during the 1996-97 wet season, at the influent and effluent points of stormwater detention Basin "C" (see Figure 1). Composite and grab samples were collected to characterize basin inflow and outflow, and to determine event mean concentrations for each storm. Flow-weighted composite samples were collected using automated equipment at both the influent and effluent stations. See the *Fresno-Clovis Storm Water Quality Monitoring Program: 1996-1997 Annual Report* (Larry Walker Associates 1997) for a complete description of methods used in sample collection and analysis.

Because effluent is pumped out of the basin at a fixed rate, it can take several days of pumping to completely empty the basin. During such times, daily composite and grab samples of the effluent were continued for up to five days in order to detect any changes in effluent water quality over time. Effluent composite sample collection was halted after five days of pumping to prevent surpassing the maximum holding time for some analytical constituents. For the multi-day effluent monitoring events, storm-length composites were

analyzed for the full suite of constituents, and daily composites were analyzed for a limited subset of constituents.

Six basin monitoring events were successfully conducted during the 1996 – 97 storm season:

	Influent Sampling	Effluent Sampling
Event #1	December 5, 1996	December 5-6, 1996
Event #2	December 9, 1996	December 9-14, 1996*
Event #3	December 10, 1996	
Event #4	January 15, 1997	January 15-17, 1997
Event #5	January 20-21, 1997	January 20-22, 1997
Event #6	January 24-26, 1997	January 24-28, 1997

*Because Event #2 (December 9, 1996) and Event #3 (December 10, 1996) occurred in rapid succession, the basin was not completely emptied between these events, and runoff from the two storms commingled in the basin. Therefore, the effluent samples for these two events were combined into a single effluent event (#2/3).

METHODS

Basin "C" influent and effluent concentration data were compiled for statistical analysis. Descriptive statistics (mean, median, minimum, maximum, standard deviation) were calculated for influent and effluent monitoring stations for all constituents with at least three detected data points. All constituents with at least five detected data points were tested for normality. All constituents for which sufficient data were available to perform normality tests were compared, using *t*-tests, to determine whether influent quality was significantly different from effluent quality. Data from multi-day effluent sampling events were analyzed with time series regression to determine any trends in intra-storm effluent quality.

Probability Distributions/Testing for Normality

A normally distributed population of values produces a bell-shaped probability distribution plot. Such plots have a preponderance of data points around the mean, with progressively fewer observations toward the extreme ranges of reported values (this can be shown graphically as the "bell-shaped curve" to represent the "normal" probability distribution). Environmental data generally tend to conform better to a normal probability distribution when the data are transformed into their natural logarithms (i.e. when the data are "log-transformed"). It can therefore be said that environmental data typically are lognormally distributed.

An underlying assumption of many statistical tests is that the data in question follow a normal probability distribution. Basin "C" influent and effluent data were tested for normality/lognormality using both cumulative frequency distribution plots and linear

regression techniques to ensure that the underlying assumptions of the necessary statistical tests were met, as described below.

Graphical methods present a simple and convenient approach for checking normality. For this analysis, probability distribution plots were used to show the frequency of occurrence of each water quality constituent throughout the full range of reported concentrations. Cumulative frequency distribution plots were used to visualize the normal probability curve in such a way that a straight line indicates an exactly normal distribution (these plots are presented in Appendix A with lognormal concentration/cumulative probability axes). These graphical methods are useful for indicating the way in which a sample set may deviate from expectations (such as a non-normal distribution, or the presence of outliers, etc.). If the data are normally distributed, the cumulative probability plot of data points should approximate a straight line.

Evaluating the "goodness-of-fit" of a data set to a normal or lognormal distribution is an important step in determining the validity of subsequent statistical techniques (e.g. *t*-test comparisons) which assume a normal data distribution. Goodness-of-fit was evaluated for the cumulative probability plots using the coefficient of determination (r^2) obtained from linear regression analysis of influent and effluent data (regression equations are shown in Appendix A). Essentially, regression analysis runs the best fitting line through a set of data points, using the minimum average distance from any point to the fitted straight line as the criteria by which the "goodness-of-fit" of the line is measured. The smaller the minimum average distance to the line for a group of data points, the stronger the relationship between the two sets of variables. The coefficient of determination may be thought of as a measure of the straight line relationship between the variables. The closer an r^2 value is to 1, the stronger the linear relationship between actual and predicted values, and the closer the fit to a normal distribution.

Handling of Non-Detected Data

For several constituents (especially trace metals and organics), concentrations were frequently below the minimum detection level and were, therefore, reported as non-detected. When stormwater influent and effluent data are sufficiently numerous for a specific constituent (at least three detected data points for both influent and effluent), an advanced statistical technique known as the "robust method" developed by Hazen may be used to estimate the value of the non-detected data points.

Hazen's method uses the detected values and a combination of regression and probability analysis to determine a "fill-in" concentration for the non-detected data points. Essentially, Hazen's method determines the point along a probability distribution regression line (derived from detected data points) where the true concentrations of non-detected data points have the highest probability of residing (brief descriptions of probability distributions and regression techniques are given above). The estimated values for non-detected data points derived in this way were then used in further analysis. The Hazen method was used to estimate values for non-detects in 14 influent constituents and 9 effluent constituents.

t – Test Comparisons

t-Tests are often useful for evaluating a significant difference between two sets of data. Specifically, *t*-tests are used to calculate the probability (p) associated with the null hypothesis, which states that any observed difference between two sets of data is due to chance or random variability alone, rather than any fundamental differences in the data sets. A very low p value (e.g. $p \leq 0.05$) corresponds to a high level of confidence that the observed differences between the two data sets are not due to chance alone; i.e. that the data sets are significantly different from one another. Alternately, a higher p value ($p \geq 0.05$) indicates that there is no statistically significant difference between the data sets. This analysis utilized paired *t*-tests (i.e. compared influent and effluent data sets on an event-by-event basis, one pair of data at a time) to assess differences in concentrations between influent and effluent constituents. In this analysis, to maintain the assumptions of the paired *t*-tests technique, influent data for events 2 and 3 were combined for purposes of comparing influent and effluent constituents.

Time Series Regression Analysis

Time series regression was used to examine the relationship between constituent concentration and basin retention time. This technique establishes the form and significance of functional relationships between two variables, in this case constituent concentration and time. By regressing effluent concentration values against time, it can be determined whether basin retention time played a significant role in the reduction of constituent concentrations in basin effluent. As described above, regression analysis simply examines the strength of the relationships between two variables. In time series regression, the magnitude of one of the variables is assumed to be determined by the magnitude of the second variable, whereas the reverse is not true. In this case we tested the hypothesis that the constituent concentrations of a given volume of water are dependent upon the amount of time that the volume of water has spent in the detention basin. As above, the degree of significance of this relationship is associated with the probability (p value) calculated for the null hypothesis. In this analysis, a low p value ($p \leq 0.05$) corresponds to a high level of confidence that there is a strong relationship between the variables.

RESULTS

Results of the data analysis show that Basin "C" was highly effective in reducing the concentrations of several important storm water constituents.

Non-detected Constituents

Results for constituents that were detected on fewer than three occasions in either influent or effluent are given in Table 1. It is worth noting that seven PAH's (Acenaphthylene, Anthracene, Benzo(k)flouranthene, Dibenzo(a,h)anthracene, Flourene, Indeno(1,2,3-

cd)pyrene and Phenanthrene) and fourteen pesticides (DDT, Aldrin, Chlordane, Diazinon, Dieldrin, Endrin, Heptachlor, Heptachlor epoxide, Malathion, Methoxychlor, Methyl Parathion, Phorate, Phosdrin and Toxaphene) went non-detected or were detected on fewer than three occasions. It is important to note that few organic constituents were encountered in both influent and effluent samples.

Constituents with 3 or More Detected Data Points

Descriptive statistics for constituents with three or more detected data points are given in Table 2. For influent samples, Table 2 includes the results for all composite and grab sample analyses. For effluent samples, Table 2 includes the results of the storm-length composites, plus storm-event averages of daily effluent grab samples during multi-day effluent monitoring events.

Constituents with 5 or More Detected Data Points

All constituents with at least 5 detected data points (representing data from at least 5 storms) were examined to determine whether the data are normally/lognormally distributed. These analyses showed that data for all constituents were normally distributed after log transformation. The lognormal cumulative probability distribution plots and linear regression equations for these constituents are given in Appendix A.

Basin "C" Performance

The pollutant removal effectiveness of Basin "C" was evaluated in terms of the percent reduction between mean influent and effluent concentrations of stormwater constituents. Table 3 shows percent reductions for all constituents with detected data from 3 or more influent samples. *t*-Tests were used to determine the statistical significance (at the 0.05 level) of the percent reduction for all constituents with five or more detected influent or effluent data points (see discussion below).

Several constituents were detected in influent samples but were never detected in effluent samples. These include several polynuclear aromatics (PAHs): Benzo(a)pyrene, Benzo(b)flouranthene, Benzo(ghi)perylene, Chrysene, Flouranthene, and Pyrene; and three metals: total recoverable Arsenic, Cadmium, and Chromium. The lack of detected data points precluded the use of the Hazen method in this circumstance. When constituents were never detected in effluent samples, their percent removals were estimated by assuming their effluent concentrations were equal to one-half the method detection limit (MDL). Although the lack of detected effluent values precluded a formal statistical comparison of influent and effluent data points, the results shown in Table 3 appear to indicate that the detention basin played a substantial role in reducing the concentrations of these constituents to below detectable levels. Average percent reductions between influent and effluent values for these nine constituents was very high (>70%), using the assumed effluent concentrations of one-half the MDL.

Several constituents increased in concentration between influent and effluent. Table 4 shows the percent increases for these constituents. When a lack of detected influent values prevented use of the Hazen method, the average influent value was set at one-half the MDL in Table 4, as was done previously in Table 3 for non-detected effluent values. The most noteworthy of these constituents is Di-syston, an organophosphate pesticide which was detected in the last three effluent samples but only in the last influent sample. Using half the method detection limit for the mean influent concentration, it appears that Di-syston levels increased on average by 7160%. As the Fresno-Clovis Flood Control District does not use Di-syston in basin maintenance, a possible explanation is that the pollutant entered the basin through the 24" influent pipe (see Figure 1). Discharge through this influent line was not sampled during any of the monitored storm events. Illicit dumping of Di-syston into the basin is also a possibility, but is probably unlikely.

Dissolved Lead was detected in several effluent samples but detected in only one influent sample. This may be attributable to transformation of suspended Lead to dissolved Lead in the detention basin. This is illustrated in Tables 3 and 4, which show total Lead decreasing by 66% (a statistically significant decrease) and dissolved Lead increasing by 188% between influent and effluent concentrations (assuming a mean influent dissolved Lead concentration of one-half the MDL). The reduction in total Lead may also be accounted for by the settling of particulate lead in the basin.

Several other constituents also increased between influent and effluent sampling. These include: Chemical Oxygen Demand, Chloride, Nitrate, Potassium, and Sulfate. Increases in these constituents were moderate for the most part, and increases in these constituents are common in standing water.

Statistical Evaluation of Significance (*t*-Tests)

Results of influent-effluent comparison tests (*t*-tests) are shown in Table 5. These comparisons showed a significant difference between influent and effluent concentrations for seven measured constituents: total recoverable Barium, Copper, Lead, Magnesium, Zinc, as well as Total Dissolved Solids, and Total Suspended Solids. The percent reductions of these constituents ranged from a low of 22% (TDS) to a high of 66% (Lead). These results indicate that the detention basin played a significant role in reducing the concentrations of these constituents. These results are not surprising as detention basins are known to commonly reduce the concentration of suspended solids, and much of the influent metals loadings are in the particulate form.

It is noteworthy that although Aluminum showed a relatively high percent reduction (nearly 55%), this was not statistically significant (p-value = 0.0947). This may be attributable to the fact that on one occasion (Event #4) the effluent concentration was greater than the influent concentration. This anomaly may have prevented finding a statistically significant reduction. It does appear, however, that the detention basin generally did substantially reduce Aluminum concentrations in the effluent.

Table 5 also shows *t*-test results for several constituents which did not undergo significant reductions (*t*-test *p*-values ≥ 0.05), but nonetheless were reduced by some amount between influent and effluent. Concentrations of Boron, Calcium, dissolved Copper, Hardness and dissolved Zinc all underwent some level of reduction following basin detention.

Time Series Regression Analysis

Table 6 shows the descriptive statistics for multi-day effluent sample constituents with three or more detected data points. Results of the time series regression analysis are shown in Table 7. This analysis was performed on the daily effluent composite and grab samples for events #2/3 and #6. Time series analysis of daily effluent samples for Event #2/3 showed that effluent concentrations of some constituents (total recoverable Lead, dissolved Lead, dissolved Zinc, Total Suspended Solids, Fecal Coliform, and Fecal Streptococcus) were reduced significantly over the sampling period. However, similar analysis of Event #6 effluent data showed no significant effect of time on effluent concentrations, although the *p*-values for Fecal Coliform and Total Coliform were close to the 0.05 significance level. The lack of statistical significance may be attributable to the fact that only four data points per constituent were available for this event. Such a small data set may not yield significant results, despite the fact that clear reductions in these constituents over time were observed.

CONCLUSIONS

Detention Basin "C" appeared to be highly effective in reducing PAH concentrations, as several PAHs were consistently detected in the influent but not detected in the effluent. Basin "C" was also highly effective in reducing the concentrations of several metals; total recoverable Barium, Copper, Lead, Magnesium, Zinc, as well as Total Dissolved Solids, and Total Suspended Solids. Analysis of daily effluent samples showed that the residence time of storm water runoff in Basin "C" played a significant role in reducing concentrations of suspended solids, bacteria, total recoverable Lead, dissolved Lead and dissolved Zinc. Some common stormwater constituents (such as dissolved metals and nutrients) showed increasing concentrations following detention in Basin "C". Other constituents (nutrients, ions, oxygen demand, etc.) did not appear to be affected by detention in the basin. Although the latter constituents were not significantly reduced, these results were not unexpected as many of these constituents are generally unaffected by detention basin residence.

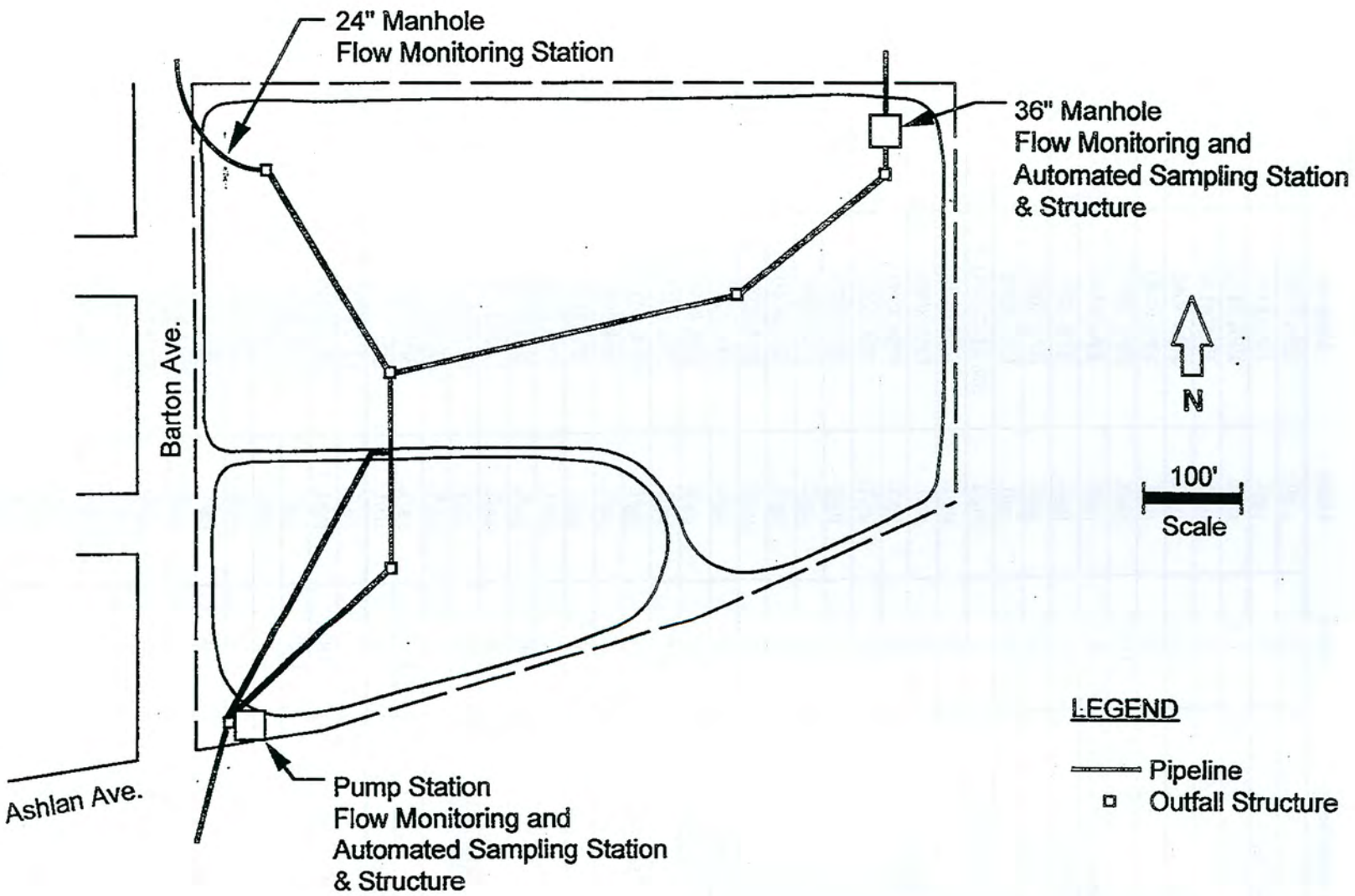


FIGURE 1
BASIN "C" MONITORING STATIONS

Table 1. Constituents Detected in Influent/Effluent Samples on Fewer than 3 Occasions.

Constituent	MDL	Units	Method	# Detected Data Points
2,4,5-T	0.8	µg/L	EPA 8150	0
2,4,5-TP (Silvex)	0.4	µg/L	EPA 8150	0
2,4-D	1.6	µg/L	EPA 8150	0
2,4-DB	2	µg/L	EPA 8150	0
4,4'-DDD	0.05	µg/L	EPA 8080	0
4,4'-DDE	0.05	µg/L	EPA 8080	0
4,4'-DDT	0.05	µg/L	EPA 8080	0
Acenaphthene	0.5	µg/L	EPA 8270	0
Acenaphthylene	0.5	µg/L	EPA 8270	0
Aldrin	0.05	µg/L	EPA 8080	0
alpha-BHC	0.05	µg/L	EPA 8080	0
Ammonia (NH3-N)	1	mg/L	SM 4500-NH3-F	2
Anthracene	0.5	µg/L	EPA 8270	0
Arochlor 1016	0.5	µg/L	EPA 8080	0
Arochlor 1221	0.5	µg/L	EPA 8080	0
Arochlor 1232	0.5	µg/L	EPA 8080	0
Arochlor 1242	0.5	µg/L	EPA 8080	0
Arochlor 1248	0.5	µg/L	EPA 8080	0
Arochlor 1254	0.5	µg/L	EPA 8080	0
Arochlor 1260	0.5	µg/L	EPA 8080	0
Benzo(a)anthracene	0.5	µg/L	EPA 8270	2
Benzo(k)fluoranthene	0.5	µg/L	EPA 8270	2
beta-BHC	0.05	µg/L	EPA 8080	0
Cadmium, Dissolved	0.2	µg/L	EPA 200.8	0
Chlordane	0.5	µg/L	EPA 8080	0
Co-Ral	0.05	µg/L	EPA 8140	0
DDVP	0.05	µg/L	EPA 8140	0
delta-BHC	0.05	µg/L	EPA 8080	0
Diazinon	0.05	µg/L	EPA 8140	2
Dibenz(a,h)anthracene	0.5	µg/L	EPA 8270	0
Dichloroprop	2	µg/L	EPA 8150	0
Dieldrin	0.05	µg/L	EPA 8080	0
Dinoseb (DNBP)	0.4	µg/L	EPA 8150	0
Endosulfan I	0.05	µg/L	EPA 8080	0
Endosulfan II	0.05	µg/L	EPA 8080	0
Endosulfan sulfate	0.05	µg/L	EPA 8080	0
Endrin	0.05	µg/L	EPA 8080	0
Endrin aldehyde	0.05	µg/L	EPA 8080	0
Ethion	0.05	µg/L	EPA 8140	2
Fluorene	0.5	µg/L	EPA 8270	0
gamma-BHC	0.05	µg/L	EPA 8080	0
Guthion	0.05	µg/L	EPA 8140	0
Heptachlor	0.05	µg/L	EPA 8080	0
Heptachlor epoxide	0.05	µg/L	EPA 8080	0
Indeno(1,2,3-cd)pyrene	0.5	µg/L	EPA 8270	2
Malathion	0.05	µg/L	EPA 8140	0
Mercury (Hg)	0.0002	mg/L	EPA 245.2	0

Constituent	MDL	Units	Method	# Detected Data Points
Methoxychlor	0.05	µg/L	EPA 8080	0
Methyl Parathion	0.05	µg/L	EPA 8140	1
Naled	0.05	µg/L	EPA 8140	0
Naphthalene	0.5	µg/L	EPA 8270	0
Nitrite (NO2-N)	0.05	mg/L	EPA 300.0	2
Phenanthrene	0.5	µg/L	EPA 8270	2
Phorate	0.05	µg/L	EPA 8140	0
Phosdrin	0.05	µg/L	EPA 8140	1
Phosphate, Ortho	0.05	mg/L	EPA 300.0	1
Selenium (Se)	0.2	µg/L	EPA 200.8	2
Silver (Ag)	0.2	µg/L	EPA 200.8	0
Toxaphene	1	µg/L	EPA 8080	0

Table 2. Descriptive Statistics for Constituents with 3 or More Detected Data Points.

Sample Location	Constituent	# Samples	# Detects	Mean	Median	Minimum	Maximum	Standard Deviation	Units	MDL
Influent	Aluminum (Al)	6	6	860	688	190	1800	566	µg/L	20
Effluent	Aluminum (Al)	5	5	388	364	220	620	153	µg/L	20
Influent	Arsenic (As)	6	4	1.09	1.07	1	1.9	0.651	µg/L	1
Effluent	Arsenic (As)	5	2	ND	ND	ND	ND	ND	µg/L	1
Influent	Barium (Ba)	6	6	31.5	30	17	40	9.01	µg/L	5
Effluent	Barium (Ba)	5	5	21	19.5	12	37	8.97	µg/L	5
Influent	Benzo(a)pyrene	6	3	0.693	0.496	0.66	2.5	1.61	µg/L	0.5
Effluent	Benzo(a)pyrene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Benzo(b)fluoranthene	6	5	1.38	1.12	0.74	5.4	2.18	µg/L	0.5
Effluent	Benzo(b)fluoranthene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Benzo(ghi)perylene	6	3	0.733	0.538	0.7	2.6	1.66	µg/L	0.5
Effluent	Benzo(ghi)perylene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Boron (B)	6	6	55.2	44.3	22	130	39	µg/L	10
Effluent	Boron (B)	5	5	43.8	41.4	26	64	16	µg/L	10
Influent	Cadmium (Cd)	6	4	0.293	0.294	0.3	0.4	0.0621	µg/L	0.2
Effluent	Cadmium (Cd)	5	0	ND	ND	ND	ND	ND	µg/L	0.2
Influent	Calcium (Ca)	6	6	5.63	5.24	3.4	10	2.34	mg/L	0.1
Effluent	Calcium (Ca)	5	5	4.84	4.72	3.4	6	1.14	mg/L	0.1
Influent	TOC	6	6	11.5	10.4	7.3	20	5.07	mg/L	0.2
Effluent	TOC	6	6	8.98	8.17	5.6	19	4.19	mg/L	0.2
Influent	COD	6	6	32	29.3	16	57	14.5	mg/L	4
Effluent	COD	5	5	34	31.2	17	53	14.8	mg/L	4

Sample Location	Constituent	# Samples	# Detects	Mean	Median	Minimum	Maximum	Standard Deviation	Units	MDL
Influent	Chloride (Cl)	5	5	2.14	1.95	0.9	3.1	0.913	mg/L	0.1
Effluent	Chloride (Cl)	5	5	4.72	3.04	0.9	11	4.25	mg/L	0.1
Influent	Chromium (Cr)	6	5	4.16	3.44	2	9	3.75	µg/L	1
Effluent	Chromium (Cr)	5	2	ND	ND	ND	ND	ND	µg/L	1
Influent	Chrysene	6	5	0.995	0.921	0.7	2.2	0.771	µg/L	0.5
Effluent	Chrysene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Copper (Cu)	6	6	13.2	11.9	5	19	5.64	µg/L	1
Effluent	Copper (Cu)	5	5	5.72	5.25	4	9.6	1.85	µg/L	1
Influent	Copper (Cu)-Dis	6	6	4.72	4.48	2.3	7	1.59	µg/L	1
Effluent	Copper (Cu)-Dis	5	5	3.96	3.72	1.9	9	2.16	µg/L	1
Influent	Di-syston	6	1	ND	ND	ND	ND	ND	µg/L	0.05
Effluent	Di-syston	5	3	1.79	1.81	1.9	2.6	0.573	µg/L	0.05
Influent	Fecal Coliform	6	3	10200	4630	450	17000	8550	MPN/100	2
Effluent*	Fecal Coliform	5	4	6620	2810	330	35000	7940	MPN/100	2
Influent	Fecal Streptococcus	6	6	20100	13500	2500	44000	16400	MPN/100	1
Effluent*	Fecal Streptococcus	5	4	10100	4950	350	33000	9960	MPN/100	1
Influent	Fluoranthene	6	6	1.94	1.47	0.56	5.4	1.57	µg/L	0.5
Effluent	Fluoranthene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Hardness (as CaCO3)	6	6	22.3	20.7	14	43	9.66	mg/L	1
Effluent	Hardness (as CaCO3)	5	5	18	17.5	13	24	4.77	mg/L	1
Influent	Oil & Grease	6	4	1.12	1.09	1	2	0.736	mg/L	1
Effluent*	Oil & Grease	5	4	0.254	0.596	1	2	1.04	mg/L	1

Sample Location	Constituent	# Samples	# Detects	Mean	Median	Minimum	Maximum	Standard Deviation	Units	MDL
Influent	Lead (Pb)	6	6	11.7	10.7	5	16	4.4	µg/L	1
Effluent	Lead (Pb)	5	5	4	3.74	2	8	2.13	µg/L	1
Influent	Lead (Pb)-Dis	6	1	ND	ND	ND	ND	ND	µg/L	1
Effluent	Lead (Pb)-Dis	5	4	1.44	1.6	1	2	2.68	µg/L	1
Influent	Magnesium (Mg)	6	6	2.02	1.8	1.1	4.4	1.04	mg/L	0.1
Effluent	Magnesium (Mg)	5	5	1.38	1.33	1.1	2.2	0.409	mg/L	0.1
Influent	Nickel (Ni)	6	5	5.07	4.71	3	8	2.7	µg/L	2
Effluent	Nickel (Ni)	5	3	1.55	1.74	2	4.8	2.29	µg/L	2
Influent	Nitrate (NO3)	5	5	2	1.88	1.2	3.4	0.776	mg/L	0.1
Effluent	Nitrate (NO3)	5	5	2.22	2.15	1.3	2.7	0.509	mg/L	0.1
Influent	TKN	6	5	1.33	1.3	1.1	2.5	0.669	mg/L	0.5
Effluent	TKN	5	4	0.984	0.952	0.7	1.4	0.363	mg/L	0.5
Influent	Potassium (K)	6	4	2.61	2.6	2.3	4	1.01	mg/L	1
Effluent	Potassium (K)	5	5	2.88	2.8	2.1	4	0.758	mg/L	1
Influent	Pyrene	6	5	1.32	1.14	0.8	4.3	1.66	µg/L	0.5
Effluent	Pyrene	5	0	ND	ND	ND	ND	ND	µg/L	0.5
Influent	Sodium (Na)	6	6	4280	3620	1500	8500	2590	µg/L	50
Effluent	Sodium (Na)	5	4	3220	2940	1800	6100	2350	µg/L	50
Influent	TDS	5	5	41.8	38	28	87	19.5	mg/L	10
Effluent	TDS	6	6	32.4	28.5	16	58	17.6	mg/L	10
Influent	TSS	6	6	45.6	42.6	25	120	17.9	mg/L	4
Effluent	TSS	5	5	12.8	12.3	2	24	9.78	mg/L	4

Sample Location	Constituent	# Samples	# Detects	Mean	Median	Minimum	Maximum	Standard Deviation	Units	MDL
Influent	Sulfate (SO4)	6	6	3.02	2.74	1.9	6	1.47	mg/L	0.1
Effluent	Sulfate (SO4)	5	5	3.1	3.01	2.2	4.5	0.851	mg/L	0.1
Influent	Total Coliform	6	2	40300	33600	13000	54000	21200	MPN/100	2
Effluent*	Total Coliform	5	4	54200	36100	4600	160000	43400	MPN/100	2
Influent	Zinc (Zn)	6	6	85.2	82.9	53	100	18.1	µg/L	1
Effluent	Zinc (Zn)	5	5	48.4	41.5	37	78	14.1	µg/L	1
Influent	Zinc (Zn) - Dis	6	6	39.2	38.4	32	53	8.48	µg/L	1
Effluent	Zinc (Zn) - Dis	5	5	35.8	32.8	28	48	11.8	µg/L	1

ND = Indicates that majority of analyzed samples had concentrations below the minimum detection level.

*Descriptive statistics for these effluent constituents (Fecal Coliform, Fecal Streptococcus, Oil and Grease, and Total Coliform) were derived from means of several effluent grab samples.

Table 3. Percent Reductions for Constituents with 3 or More Detected Influent Data Points.

Event	Sample Location	Constituent	# Samples	# Detects	Mean	Units	Percent Reduction
All Events	Influent	Aluminum (Al)	6	6	860	µg/L	54.88
All Events	Effluent	Aluminum (Al)	5	5	388	µg/L	
All Events	Influent	Arsenic (As)	6	4	1.09	µg/L	54.13*
All Events	Effluent	Arsenic (As)	5	2	(0.5)*	µg/L	
All Events	Influent	Barium (Ba)	6	6	31.5	µg/L	33.33
All Events	Effluent	Barium (Ba)	5	5	21.0	µg/L	
All Events	Influent	Benzo(a)pyrene	6	3	0.693	µg/L	63.92*
All Events	Effluent	Benzo(a)pyrene	5	0	(0.25)*	µg/L	
All Events	Influent	Benzo(b)fluoranthene	6	5	1.38	µg/L	81.88*
All Events	Effluent	Benzo(b)fluoranthene	5	0	(0.25)*	µg/L	
All Events	Influent	Benzo(ghi)perylene	6	3	0.733	µg/L	65.89*
All Events	Effluent	Benzo(ghi)perylene	5	0	(0.25)*	µg/L	
All Events	Influent	Boron (B)	6	6	55.2	µg/L	20.65
All Events	Effluent	Boron (B)	5	5	43.8	µg/L	
All Events	Influent	Cadmium (Cd)	6	4	0.293	µg/L	65.87*
All Events	Effluent	Cadmium (Cd)	5	0	(0.1)*	µg/L	
All Events	Influent	Calcium (Ca)	6	6	5.63	mg/L	14.03
All Events	Effluent	Calcium (Ca)	5	5	4.84	mg/L	
All Events	Influent	TOC	6	6	11.5	mg/L	21.91
All Events	Effluent	TOC	6	6	8.98	mg/L	
All Events	Influent	Chromium (Cr)	6	5	4.16	µg/L	87.98*
All Events	Effluent	Chromium (Cr)	5	2	(0.5)*	µg/L	
All Events	Influent	Chrysene	6	5	0.995	µg/L	74.87*
All Events	Effluent	Chrysene	5	0	(0.25)*	µg/L	
All Events	Influent	Copper (Cu)	6	6	13.20	µg/L	56.67
All Events	Effluent	Copper (Cu)	5	5	5.72	µg/L	
All Events	Influent	Copper (Cu)-Dis	6	6	4.72	µg/L	16.10
All Events	Effluent	Copper (Cu)-Dis	5	5	3.96	µg/L	
All Events	Influent	Fluoranthene	6	6	1.94	µg/L	87.11*
All Events	Effluent	Fluoranthene	5	0	(0.25)*	µg/L	
All Events	Influent	Hardness (as CaCO3)	6	6	22.3	mg/L	19.28
All Events	Effluent	Hardness (as CaCO3)	5	5	18.0	mg/L	

Event	Sample Location	Constituent	# Samples	# Detects	Mean	Units	Percent Reduction
All Events	Influent	Oil and Grease	6	4	1.120	mg/L	77.32
All Events	Effluent	Oil and Grease	5	4	0.254	mg/L	
All Events	Influent	Lead (Pb)	6	6	11.70	µg/L	65.81
All Events	Effluent	Lead (Pb)	5	5	4.00	µg/L	
All Events	Influent	Magnesium (Mg)	6	6	2.02	mg/L	31.68
All Events	Effluent	Magnesium (Mg)	5	5	1.38	mg/L	
All Events	Influent	Nickel (Ni)	6	5	5.07	µg/L	69.43
All Events	Effluent	Nickel (Ni)	5	3	1.55	µg/L	
All Events	Influent	TKN	6	5	1.33	mg/L	26.02
All Events	Effluent	TKN	5	4	0.984	mg/L	
All Events	Influent	Pyrene	6	5	1.32	µg/L	81.06*
All Events	Effluent	Pyrene	5	0	(0.25)*	µg/L	
All Events	Influent	Sodium (Na)	6	6	4280	µg/L	24.77
All Events	Effluent	Sodium (Na)	5	4	3220	µg/L	
All Events	Influent	TDS	5	5	41.8	mg/L	22.49
All Events	Effluent	TDS	6	6	32.4	mg/L	
All Events	Influent	TSS	6	6	45.6	mg/L	71.93
All Events	Effluent	TSS	5	5	12.8	mg/L	
All Events	Influent	Zinc (Zn)	6	6	85.2	µg/L	43.19
All Events	Effluent	Zinc (Zn)	5	5	48.4	µg/L	
All Events	Influent	Zinc (Zn) - Dis	6	6	39.2	µg/L	8.67
All Events	Effluent	Zinc (Zn) - Dis	5	5	35.8	µg/L	

ND = Indicates that majority of analyzed samples had concentrations below the minimum detection level.

* Utilized 1/2 method detection limit for effluent non-detects as the basis for determining percent reduction.

Table 4. Percent Increases for Constituents with 3 or More Detected Effluent Data Points.

Event	Sample Location	Constituent	# Samples	# Detects	Mean	Units	Percent Increases
All Events	Influent	COD	6	6	32	mg/L	6.25
All Events	Effluent	COD	5	5	34	mg/L	
All Events	Influent	Chloride (Cl)	5	5	2.14	mg/L	120.56
All Events	Effluent	Chloride (Cl)	5	5	4.72	mg/L	
All Events	Influent	Di-syston	6	1	(0.025)*	µg/L	7160.00*
All Events	Effluent	Di-syston	5	3	1.790	µg/L	
All Events	Influent	Lead (Pb)-Dis	6	1	(0.5)*	µg/L	188.00*
All Events	Effluent	Lead (Pb)-Dis	5	4	1.44	µg/L	
All Events	Influent	Nitrate (NO3)	5	5	2.00	mg/L	11.00
All Events	Effluent	Nitrate (NO3)	5	5	2.22	mg/L	
All Events	Influent	Potassium (K)	6	4	2.61	mg/L	10.34
All Events	Effluent	Potassium (K)	5	5	2.88	mg/L	
All Events	Influent	Sulfate (SO4)	6	6	3.02	mg/L	2.65
All Events	Effluent	Sulfate (SO4)	5	5	3.10	mg/L	

ND = Indicates that majority of analyzed samples had concentrations below the minimum detection level.

* Utilized 1/2 method detection limit for influent non-detects as the basis for determining percent reduction.

Table 5. Results of Influent-Effluent Comparison *t*-Tests.

Sample Location	Constituent	Mean	Median	Min. Value	Max. Value	S.D.	t-Statistic	Critical t-value	*p* - value	Significant Difference
Influent	Aluminum (Al)	860	688	190	1800	566				
Effluent	Aluminum (Al)	388	364	220	620	153	2.1799	2.7765	0.0947	No
Influent	Barium (Ba)	31.5	30	17	40	9.01				
Effluent	Barium (Ba)	21	19.5	12	37	8.97	4.125	2.7765	0.0146	Yes
Influent	Boron (B)	55.2	44.3	22	130	39				
Effluent	Boron (B)	43.8	41.4	26	64	16	0.6011	2.7765	0.5801	No
Influent	Calcium (Ca)	5.63	5.24	3.4	10	2.34				
Effluent	Calcium (Ca)	4.84	4.72	3.4	6	1.14	2.058	2.7765	0.1087	No
Influent	Carbon, Total Organic	11.5	10.4	7.3	20	5.07				
Effluent	Carbon, Total Organic	8.98	8.17	5.6	19	4.19	2.1177	2.7765	0.1016	No
Influent	Chem. Oxygen Demand	32	29.3	16	57	14.5				
Effluent	Chem. Oxygen Demand	34	31.2	17	53	14.8	-0.5491	2.7765	0.6122	No
Influent	Copper (Cu)	13.2	11.9	5	19	5.64				
Effluent	Copper (Cu)	5.72	5.25	3.8	9.6	1.85	3.1087	2.7765	0.0359	Yes
Influent	Copper (Cu)-Dissolved	4.72	4.48	2.3	7	1.59				
Effluent	Copper (Cu)-Dissolved	3.96	3.72	1.9	9	2.16	0.7711	2.7765	0.4836	No
Influent	Hardness (as CaCO3)	22.3	20.7	14	43	9.66				
Effluent	Hardness (as CaCO3)	18	17.5	13	24	4.77	2.3664	2.7765	0.0771	No
Influent	Lead (Pb)	11.7	10.7	5	16	4.4				
Effluent	Lead (Pb)	4	3.74	2	9	2.13	5.1832	2.7765	0.0066	Yes
Influent	Magnesium (Mg)	2.02	1.8	1.1	4.4	1.04				
Effluent	Magnesium (Mg)	1.38	1.33	1.1	2.2	0.409	2.914	2.7765	0.0435	Yes

Sample Location	Constituent	Mean	Median	Min. Value	Max. Value	S.D.	t-Statistic	Critical t-value	*p* - value	Significant Difference
Influent	Solids, Total Dissolved (TDS)	41.8	38	28	87	19.5				
Effluent	Solids, Total Dissolved (TDS)	32.4	28.5	16	58	17.6	3.3282	2.7765	0.0292	Yes
Influent	Solids, Total Suspended (TSS)	45.6	42.6	22	71	17.9				
Effluent	Solids, Total Suspended (TSS)	12.8	12.3	5	40	9.78	3.6695	2.7765	0.0214	Yes
Influent	Zinc (Zn)	85.2	82.9	53	100	18.1				
Effluent	Zinc (Zn)	48.4	41.5	31	78	14.1	3.612	2.7765	0.0225	Yes
Influent	Zinc (Zn) - Dissolved	39.2	38.4	31	53	8.48				
Effluent	Zinc (Zn) - Dissolved	35.8	32.8	21	60	11.8	0.7264	2.7765	0.5078	No

Bold boxes indicate a significant result.

Table 6. Descriptive Statistics for all Daily Effluent Sample Constituents with 3 or More Detected Data Points.

Event	Constituent	# Samples	# Detects	Mean	Median	Minimum	Maximum	Standard Deviation	Units	MDL
2/3	Copper (Cu)	6	6	5.72	5.44	4.4	8	1.28	µg/L	1
6	Copper (Cu)	4	4	5.25	4.89	4	7	1.14	µg/L	1
2/3	Copper (Cu)-Dis	6	6	5.35	4.96	4	8.8	1.51	µg/L	1
6	Copper (Cu)-Dis	4	4	2.5	2.55	2	3	0.471	µg/L	1
2/3	Fecal Coliform	6	4	1700	946	330	4900	330	MPN/100 mL	2
6	Fecal Coliform	4	4	7250	5320	1700	13000	5420	MPN/100 mL	2
2/3	Fecal	6	6	14100	4730	350	33000	14300	MPN/100 mL	1
6	Fecal	4	4	5150	3590	680	10000	3800	MPN/100 mL	1
2/3	Lead (Pb)	6	6	4.76	4.46	3.2	9	1.86	µg/L	1
6	Lead (Pb)	4	4	3.4	3.29	2	4	0.805	µg/L	1
2/3	Lead (Pb)-Dis	6	6	3.11	2.85	2	5.9	1.39	µg/L	1
2/3	TSS	6	6	12.7	11.8	8	26	6.14	mg/L	4
6	TSS	4	4	11.3	10.3	8	33	13.9	mg/L	4
2,3	Total Coliform	5	4	69600	39000	9200	160000	69300	MPN/100 mL	2
6	Total Coliform	4	4	46400	29900	4600	92000	37400	MPN/100 mL	2
2/3	Zinc (Zn)	6	6	39.6	38.2	31	67	10.8	µg/L	1
6	Zinc (Zn)	4	4	46.6	45.5	37	67	11.3	µg/L	1
2/3	Zinc (Zn) - Dis	6	6	38	37.1	32	59	7.96	µg/L	1
6	Zinc (Zn) - Dis	4	4	24.6	24.4	21	27	3.02	µg/L	1

Table 7. Results of Time Series Regression Analysis of Daily Effluent Samples

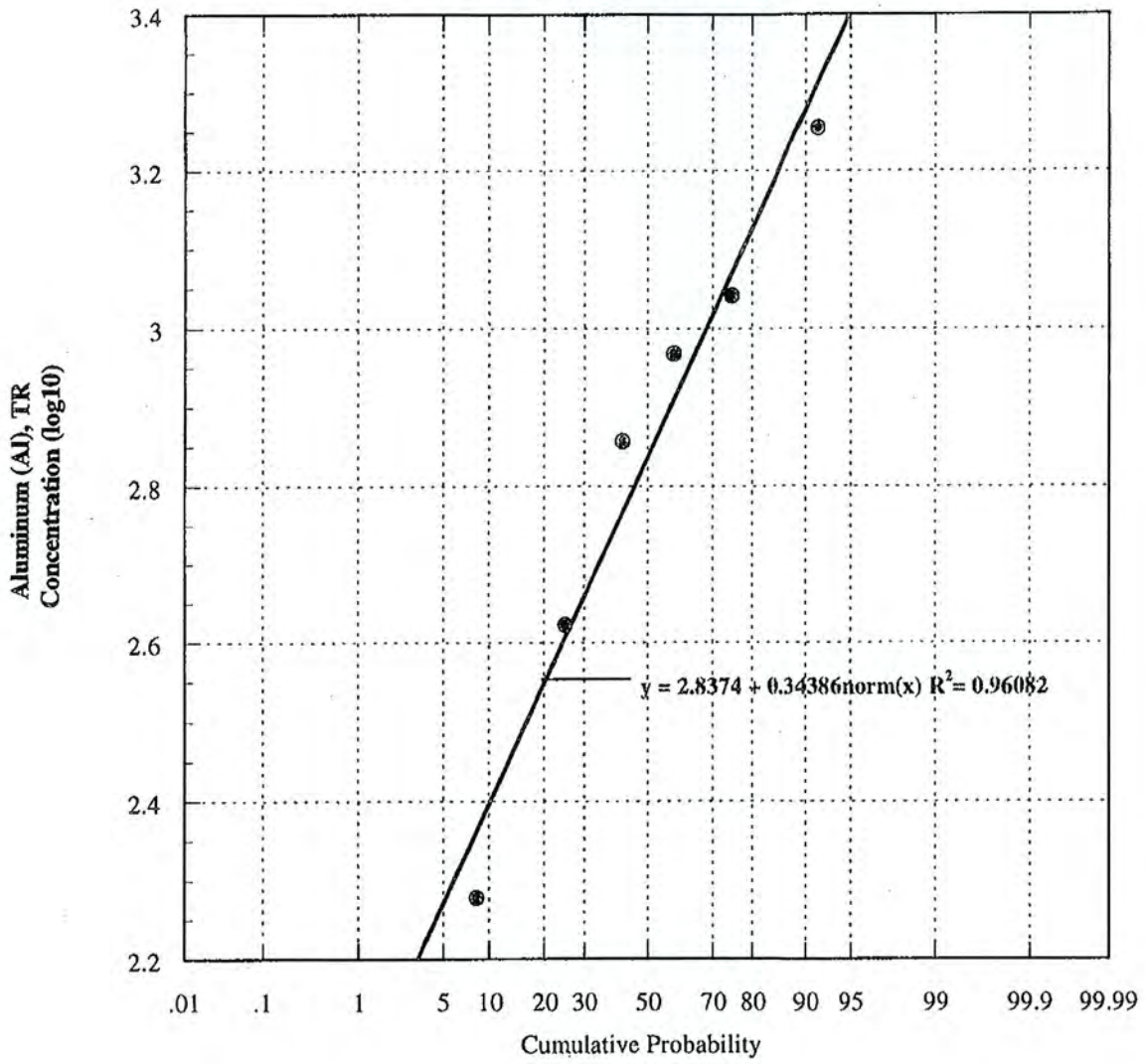
Event	Constituent	# Samples	r - squared	F-value	*p* - value	Significant ?
2/3	Fecal Coliform	4	0.922	23.742	0.0396	Yes
2/3	Fecal Streptococcus	6	0.934	56.370	0.0017	Yes
2/3	TSS	6	0.797	15.700	0.0199	Yes
2/3	Total Coliform	4	0.433	1.527	0.3420	No
2/3	Copper (Cu)	6	0.078	0.339	0.5919	No
2/3	Copper (Cu) - Dis	6	0.381	0.680	0.4561	No
2/3	Lead (Pb)	6	0.789	14.989	0.018	Yes
2/3	Lead (Pb) - Dis	6	0.940	62.395	0.0014	Yes
2/3	Zinc (Zn)	6	0.557	5.038	0.0882	No
2/3	Zinc (Zn) - Dis	6	0.677	9.393	0.0442	Yes
6	Fecal Coliform	4	0.874	13.872	0.0651	No
6	TSS	4	0.745	5.849	0.1368	No
6	Total Coliform	4	0.900	17.928	0.0515	No
6	Fecal Streptococcus	4	0.592	2.905	0.2304	No
6	Copper (Cu)	4	0.415	1.417	0.3561	No
6	Copper (Cu) - Dis	4	0.004	0.008	0.9379	No
6	Lead (Pb)	4	0.656	3.817	0.1899	No
6	Zinc (Zn)	4	0.724	5.235	0.1494	No
6	Zinc (Zn) - Dis	4	0.071	0.153	0.7338	No

Bold boxes indicate a significant result.

APPENDIX A

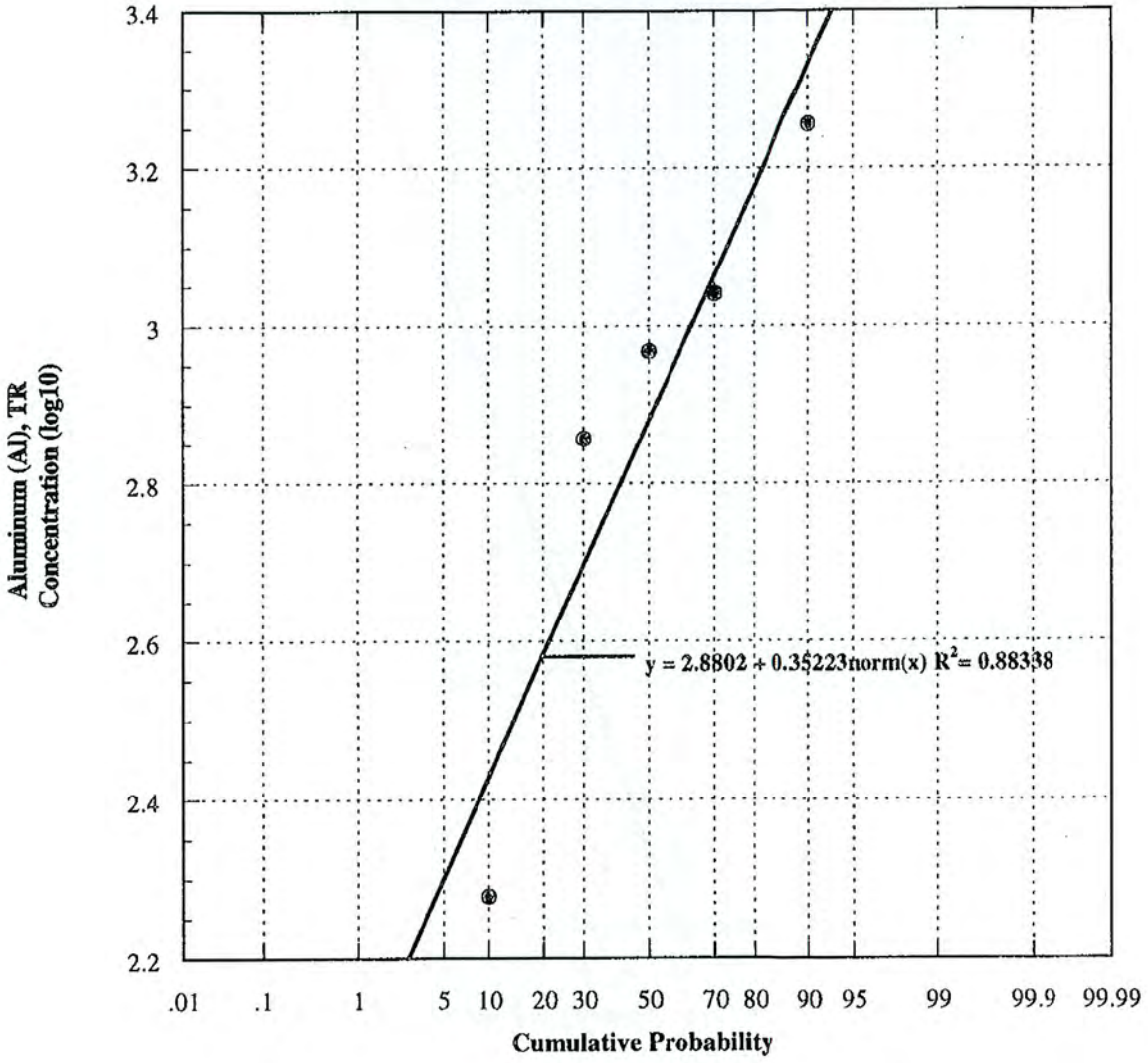
Probability Plots

GRAPH 1
Detention Basin "C" Influent Flow
Aluminum, Total Recoverable



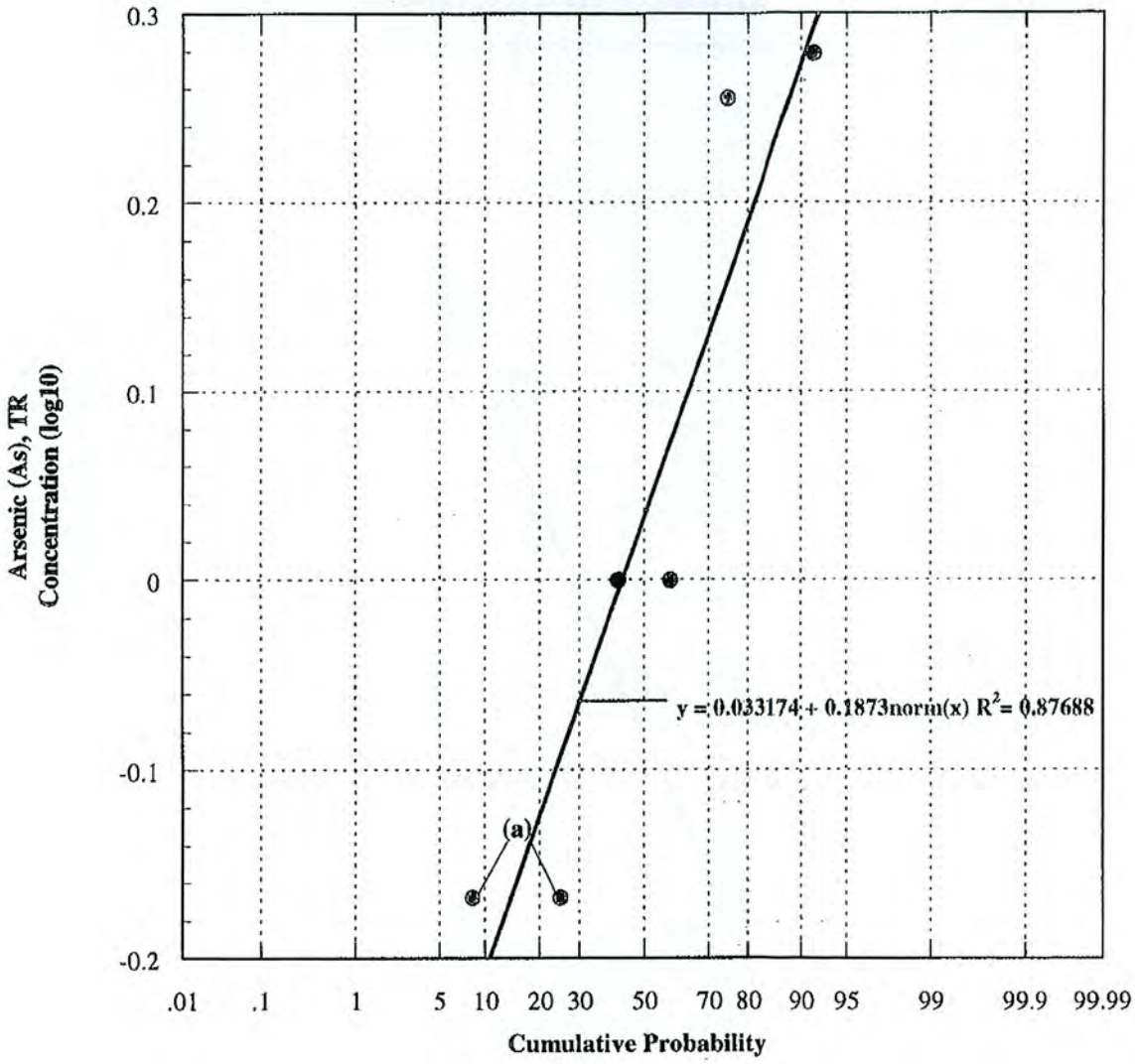
Note: There were no non-detected values in the data set.

GRAPH 2
Detention Basin "C" Effluent Flow
Aluminum, Total Recoverable



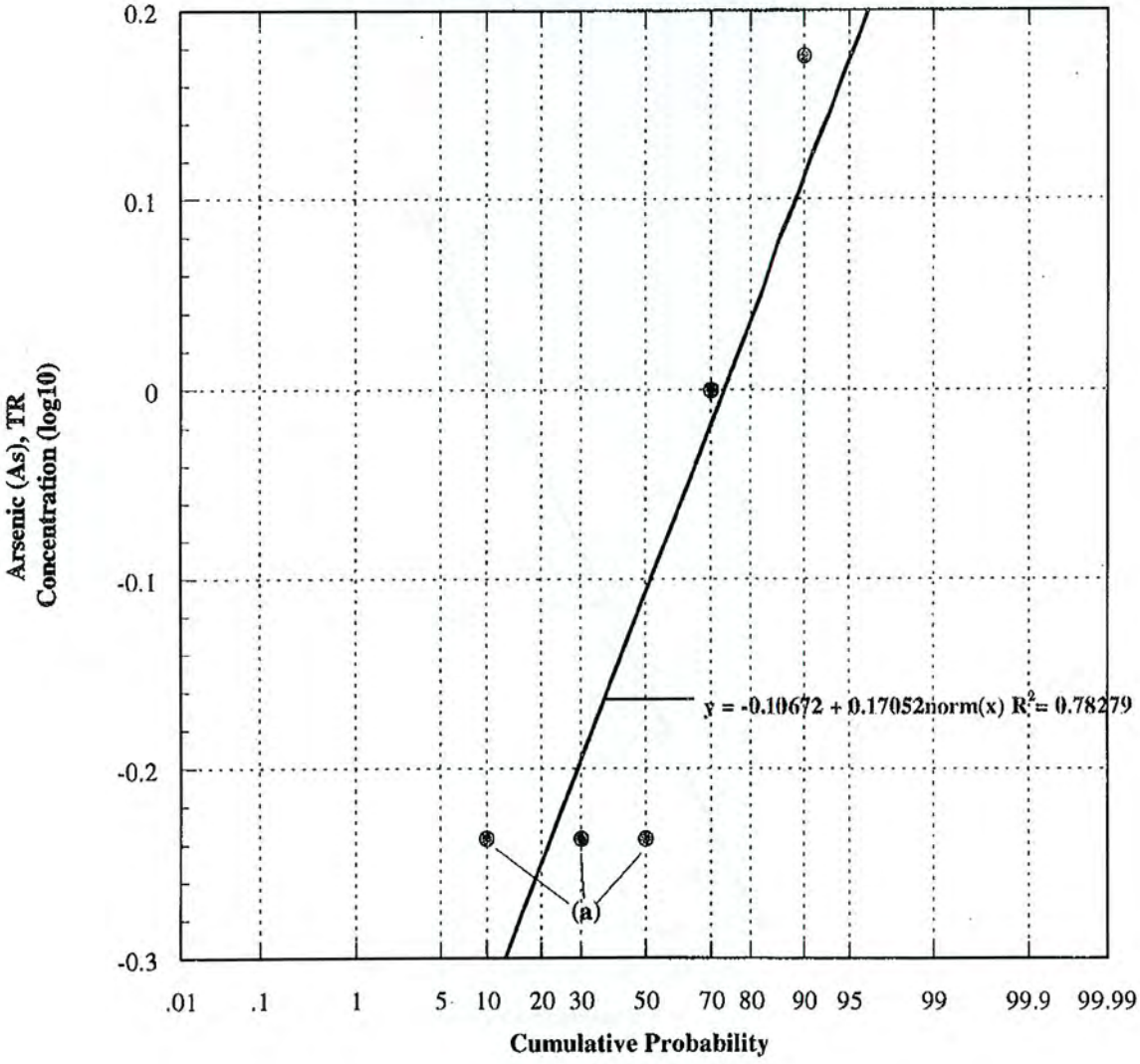
Note: There were no non-detected values in the data set.

GRAPH 3
Detention Basin "C" Influent Flow
Arsenic, Total Recoverable



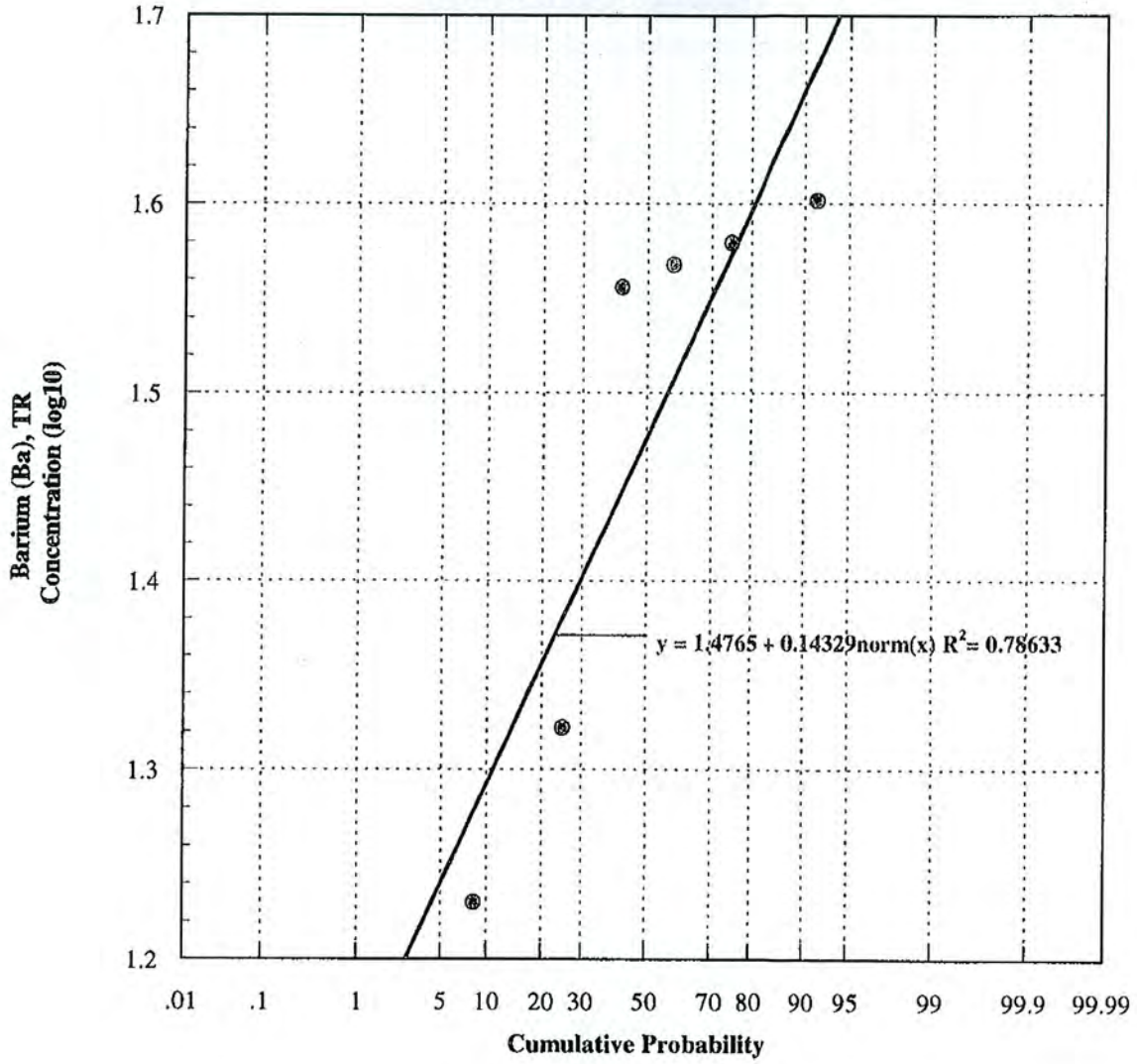
(a) Calculated non-detect values of 0.682 ug/L using Robust Method.

GRAPH 4
Detention Basin "C" Effluent Flow
Arsenic, Total Recoverable



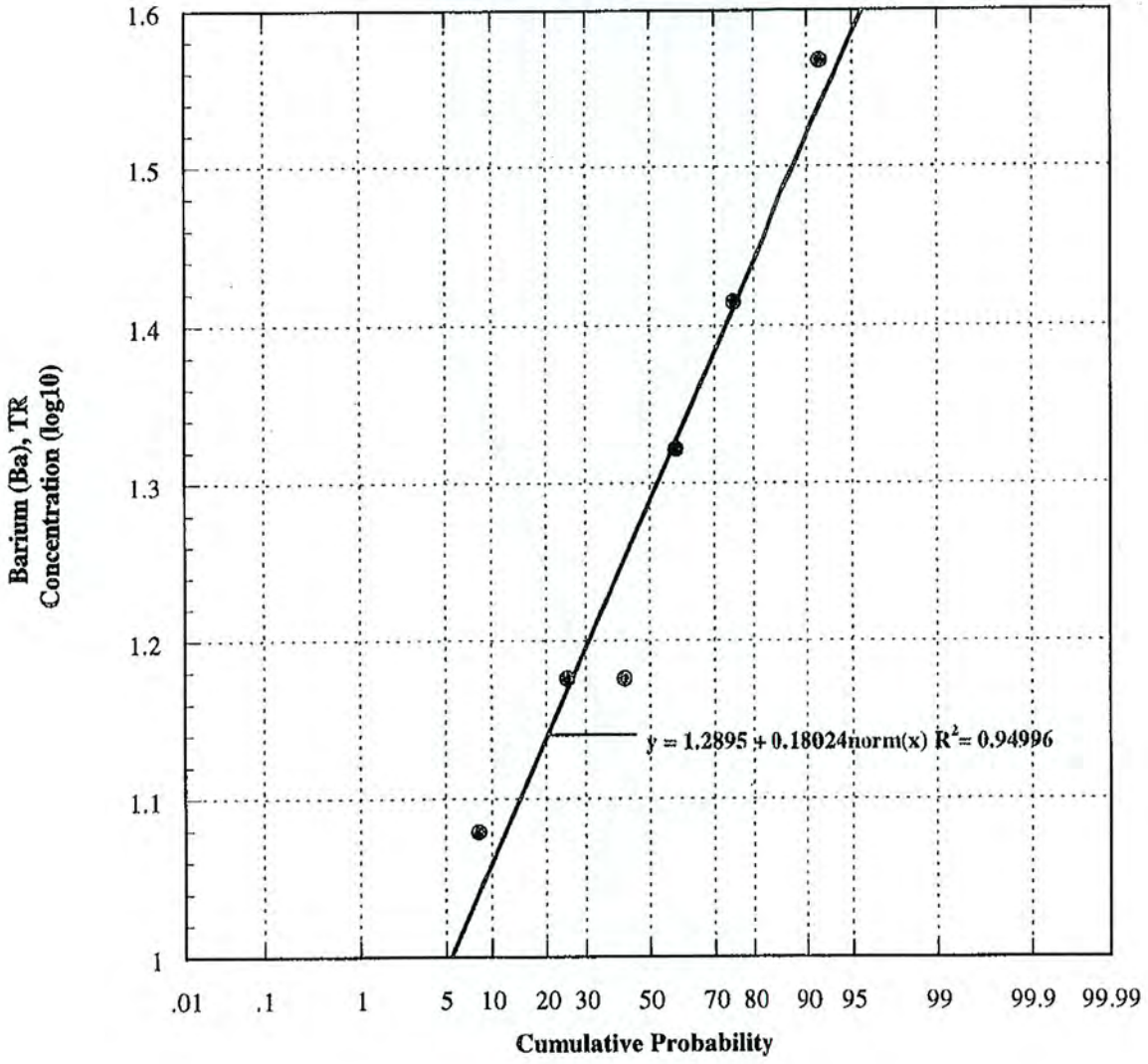
(a) Calculated non-detect values of 0.570 ug/L using Robust Method.

GRAPH 5
Detention Basin "C" Influent Flow
Barium, Total Recoverable



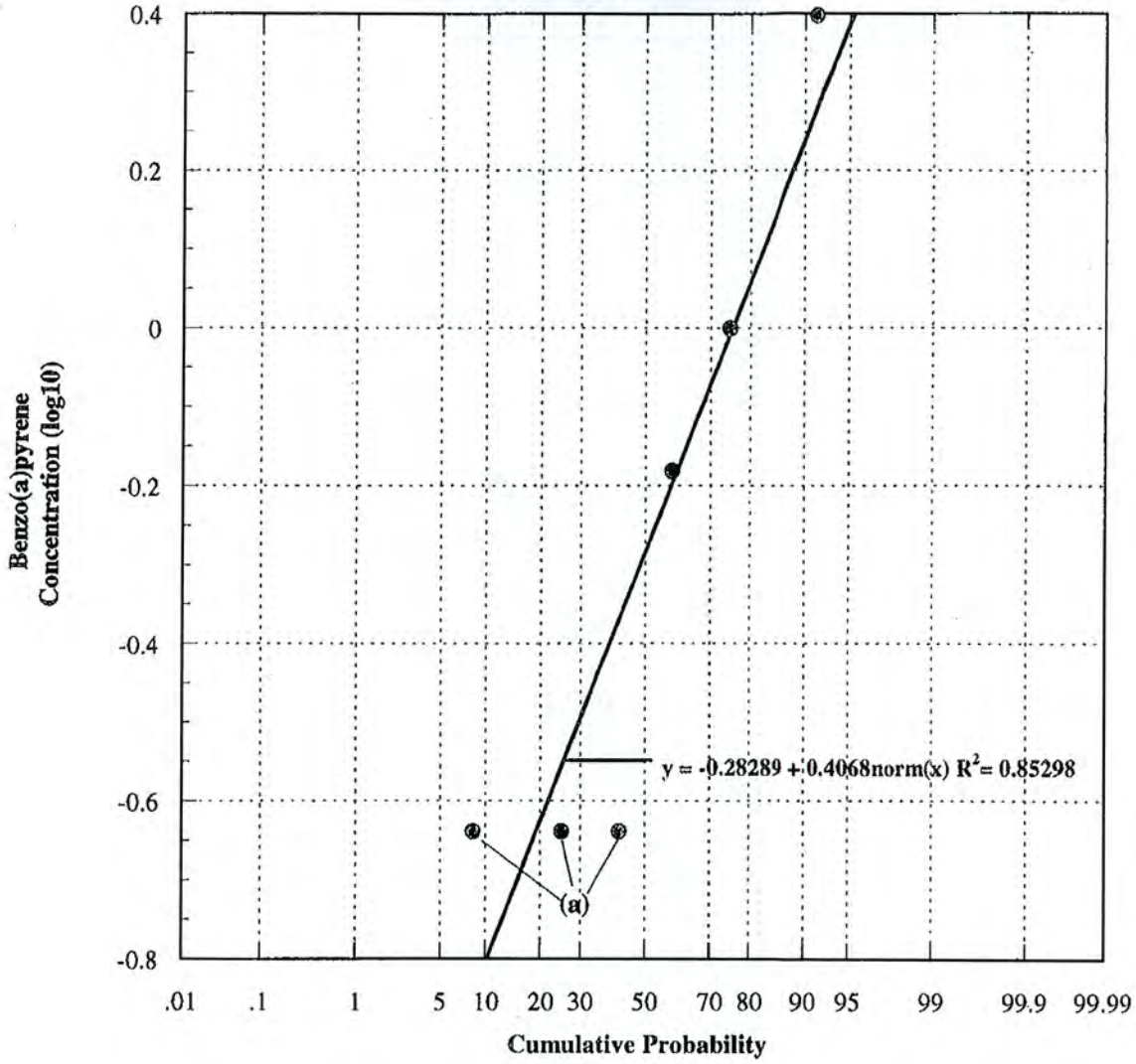
Note: There were no non-detected values in the data set.

GRAPH 6
Detention Basin "C" Effluent Flow
Barium, Total Recoverable



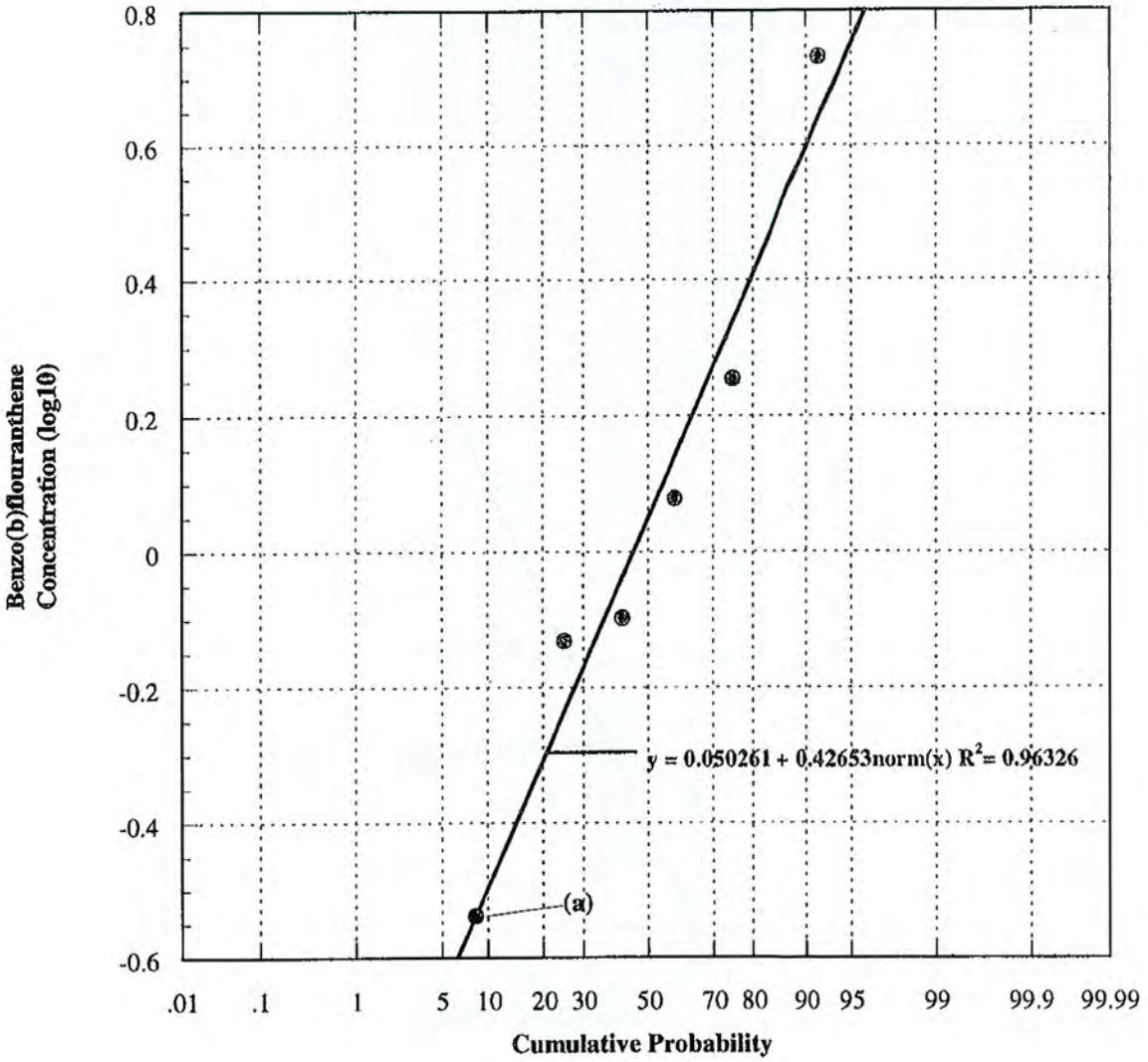
Note: There were no non-detected values in the data set.

GRAPH 7
Detention Basin "C" Influent Flow
Benzo(a)pyrene



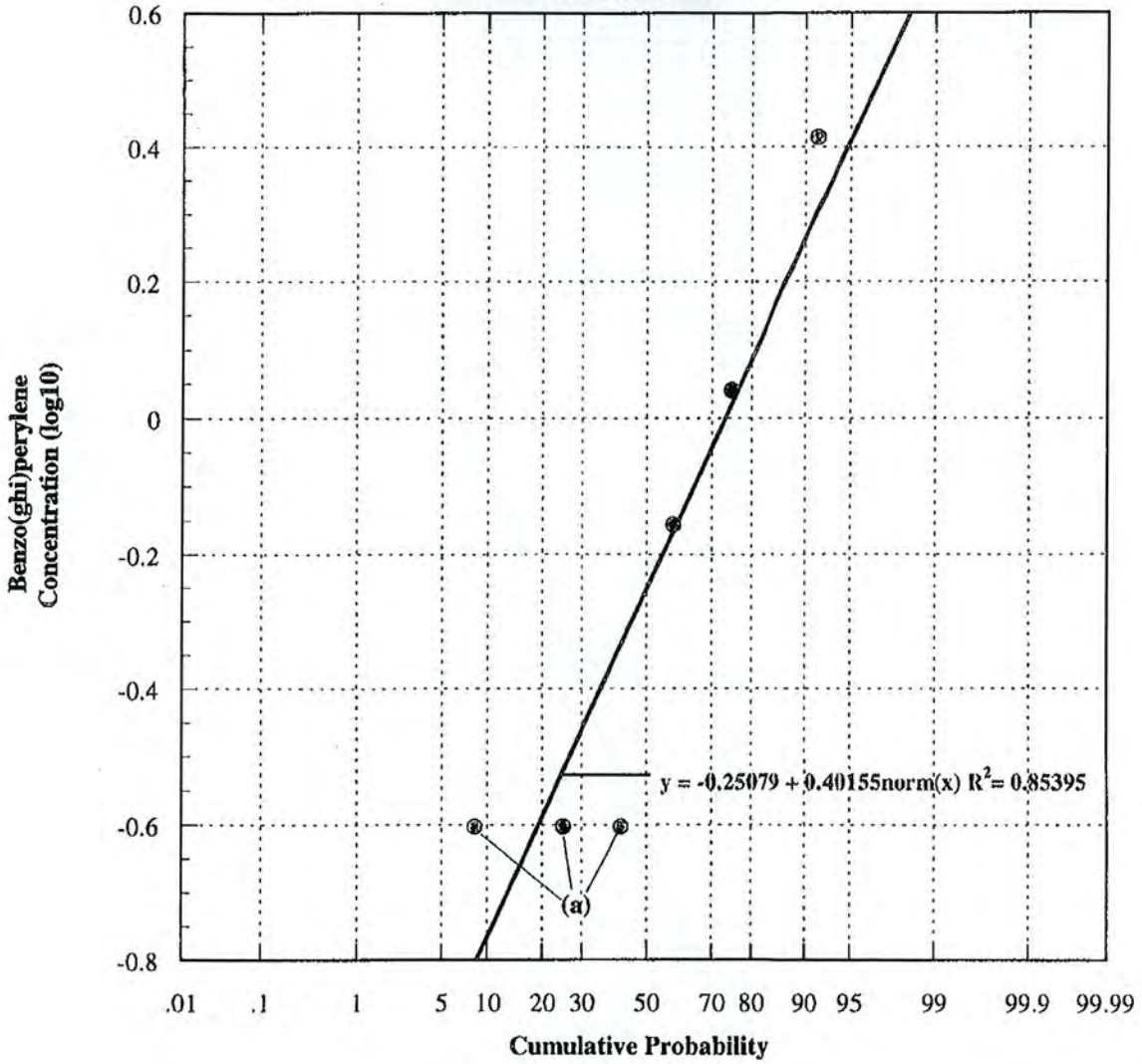
(a) Calculated non-detect values of 0.228 ug/L using Robust Method.

GRAPH 8
Detention Basin "C" Influent Flow
Benzo(b)flouranthene



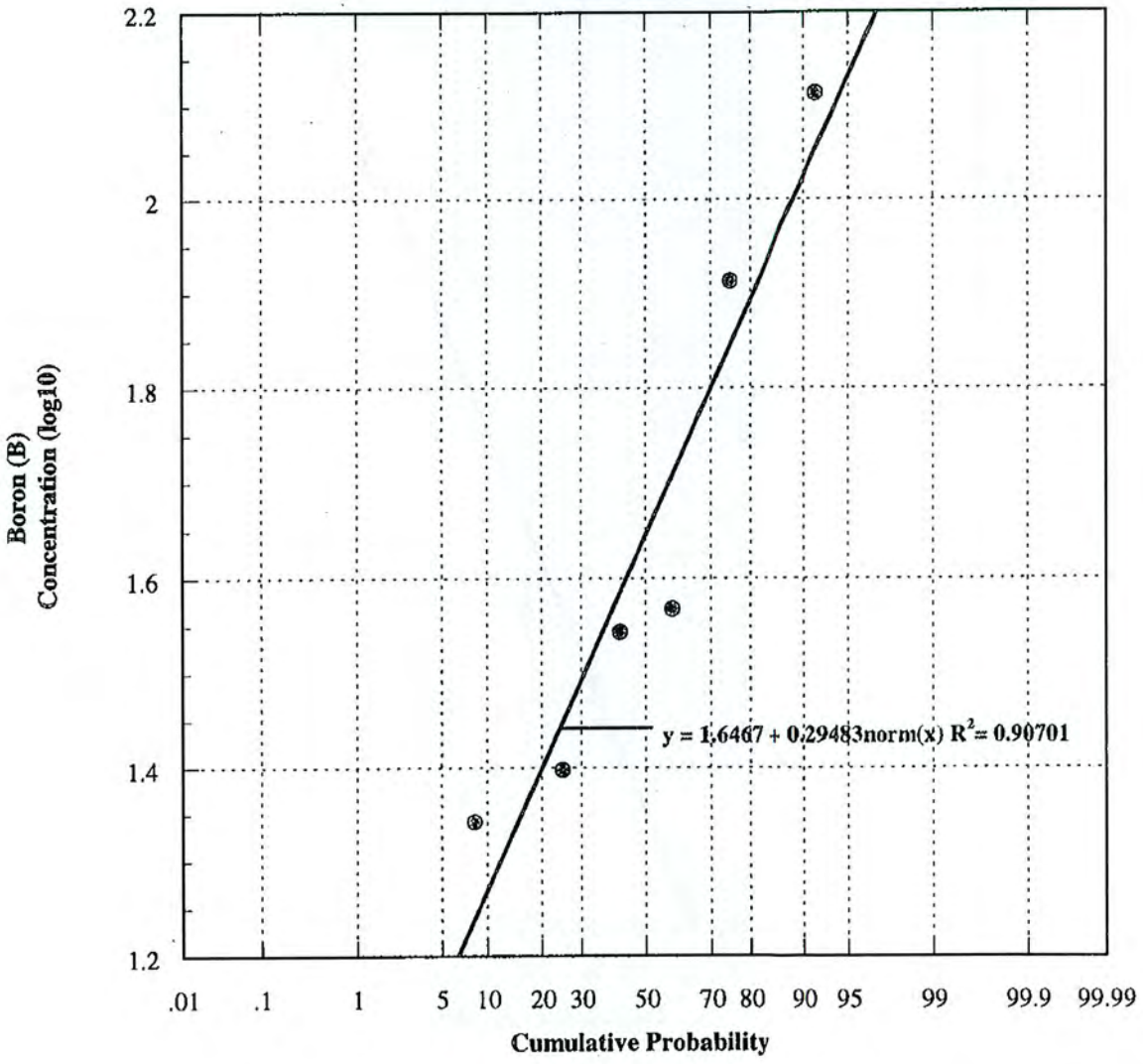
(a) Calculated non-detect values of 0.289 ug/L using Robust Method.

GRAPH 9
Detention Basin "C" Influent Flow
Benzo(ghi)perylene



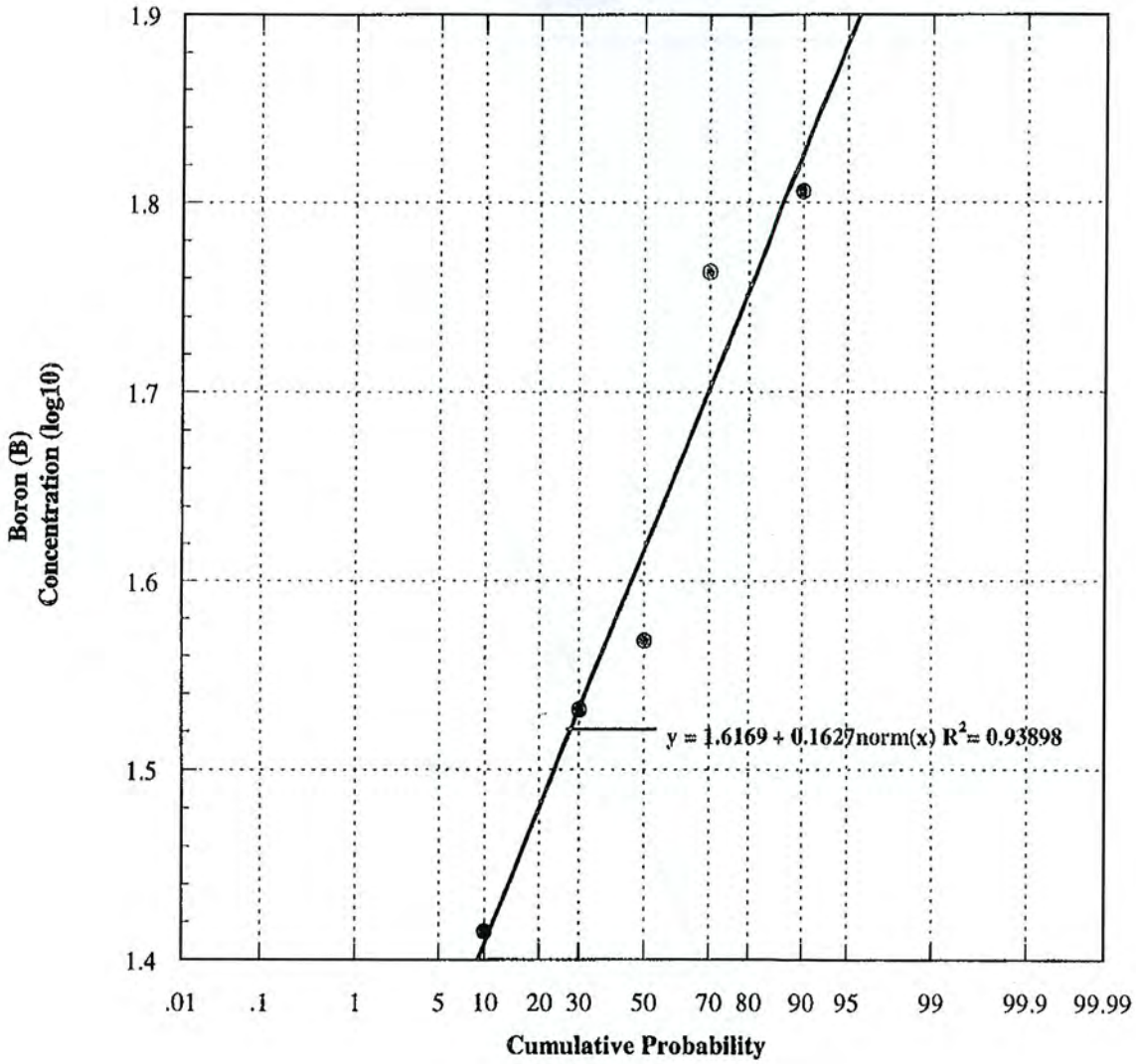
(a) Calculated non-detect values of 0.251 ug/L using Robust Method.

GRAPH 10
Detention Basin "C" Influent Flow
Boron



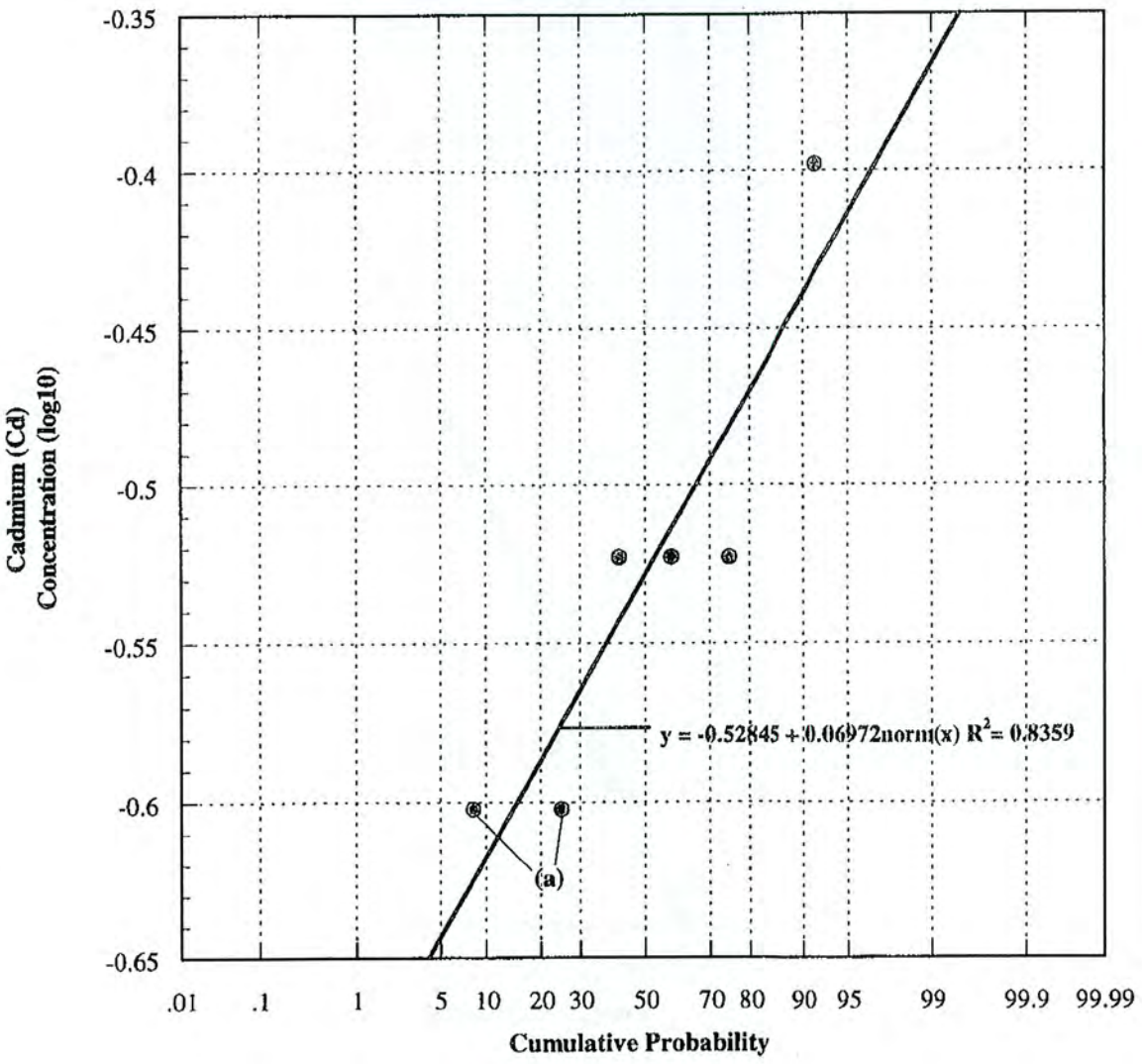
Note: There were no non-detected values in the data set.

GRAPH 11
Detention Basin "C" Effluent Flow
Boron



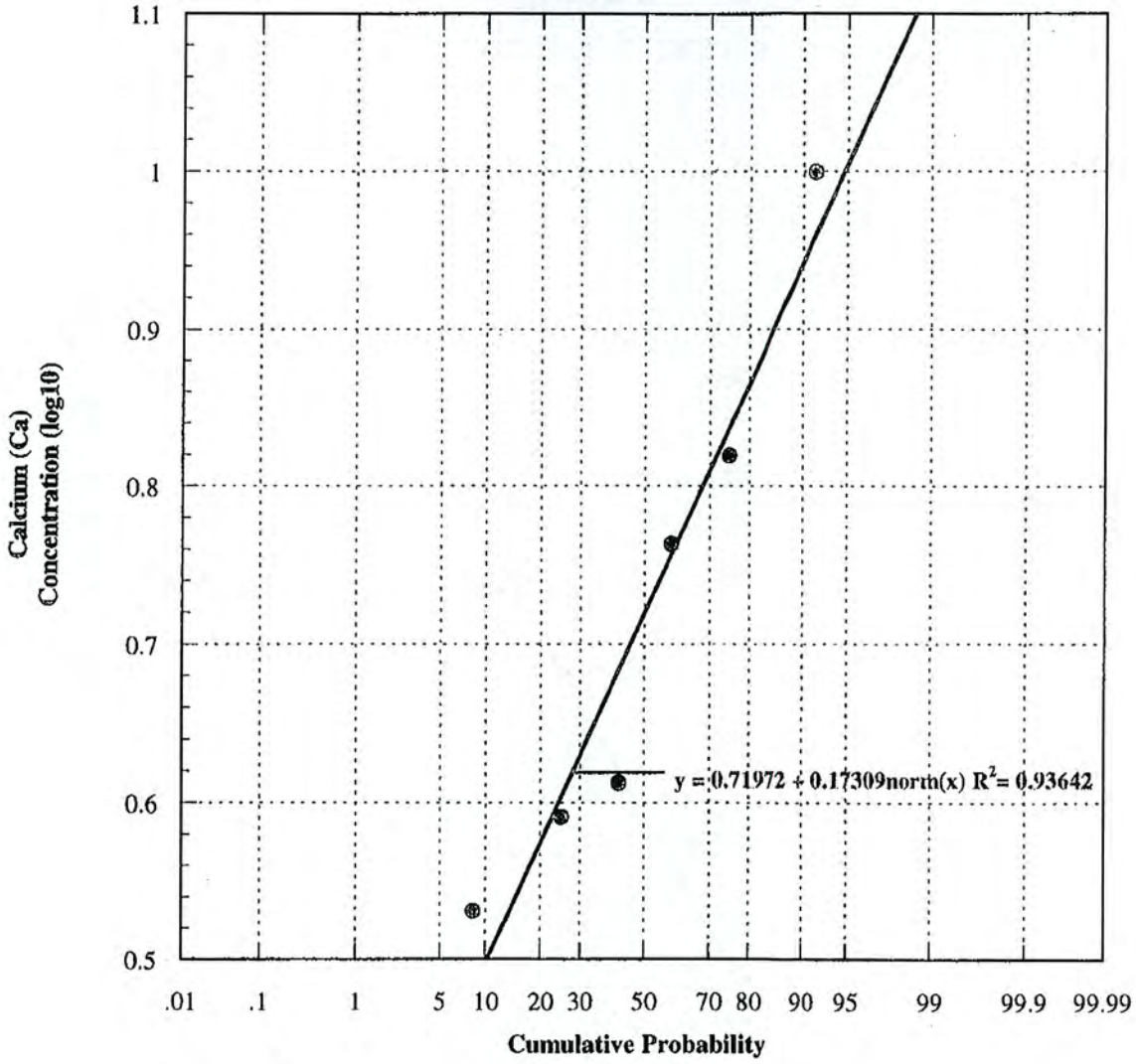
Note: There were no non-detected values in the data set.

GRAPH 12
Detention Basin "C" Influent Flow
Cadmium



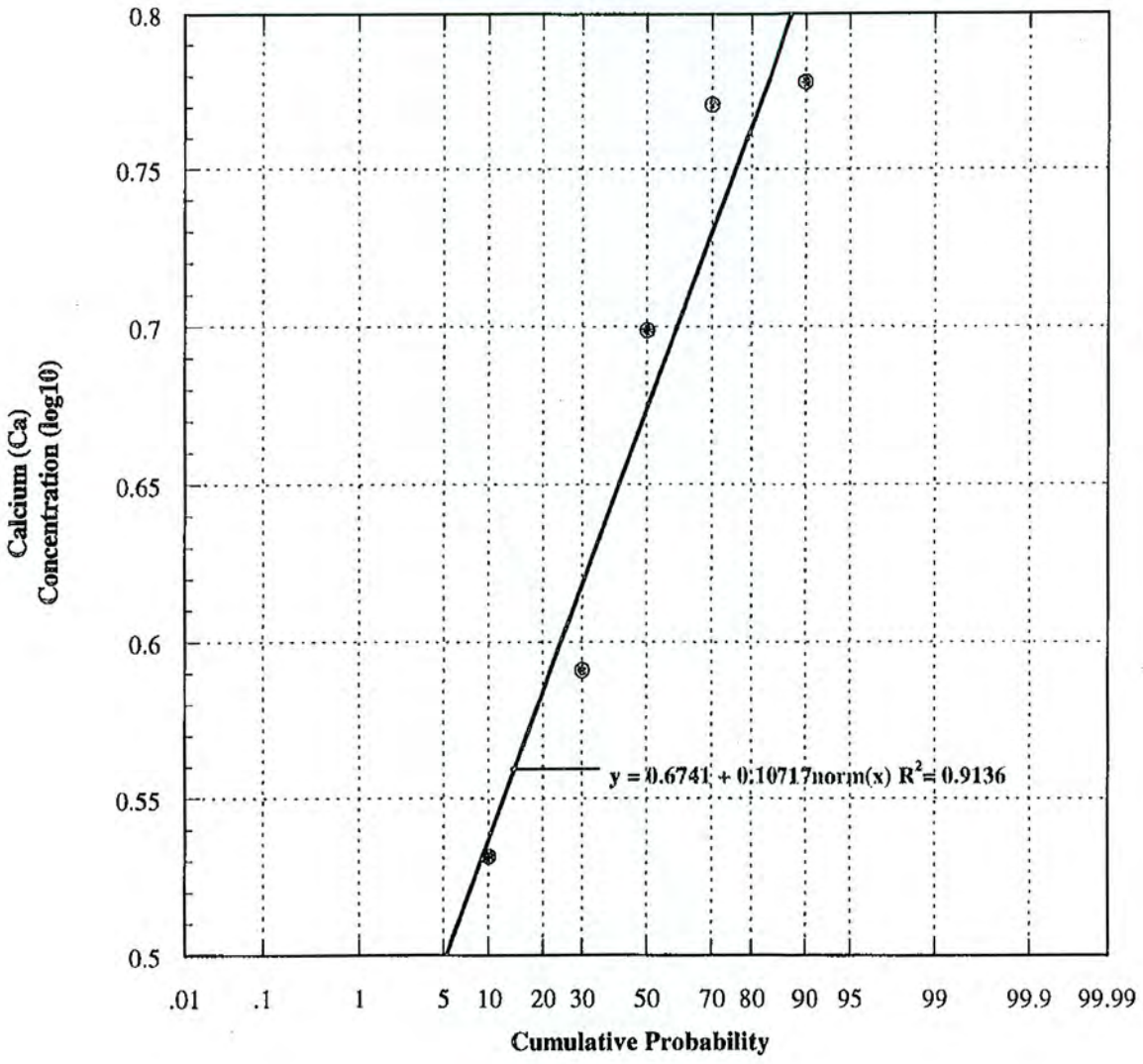
(a) Calculated non-detect values of 0.247 ug/L using Robust Method.

GRAPH 13
Detention Basin "C" Influent Flow
Calcium



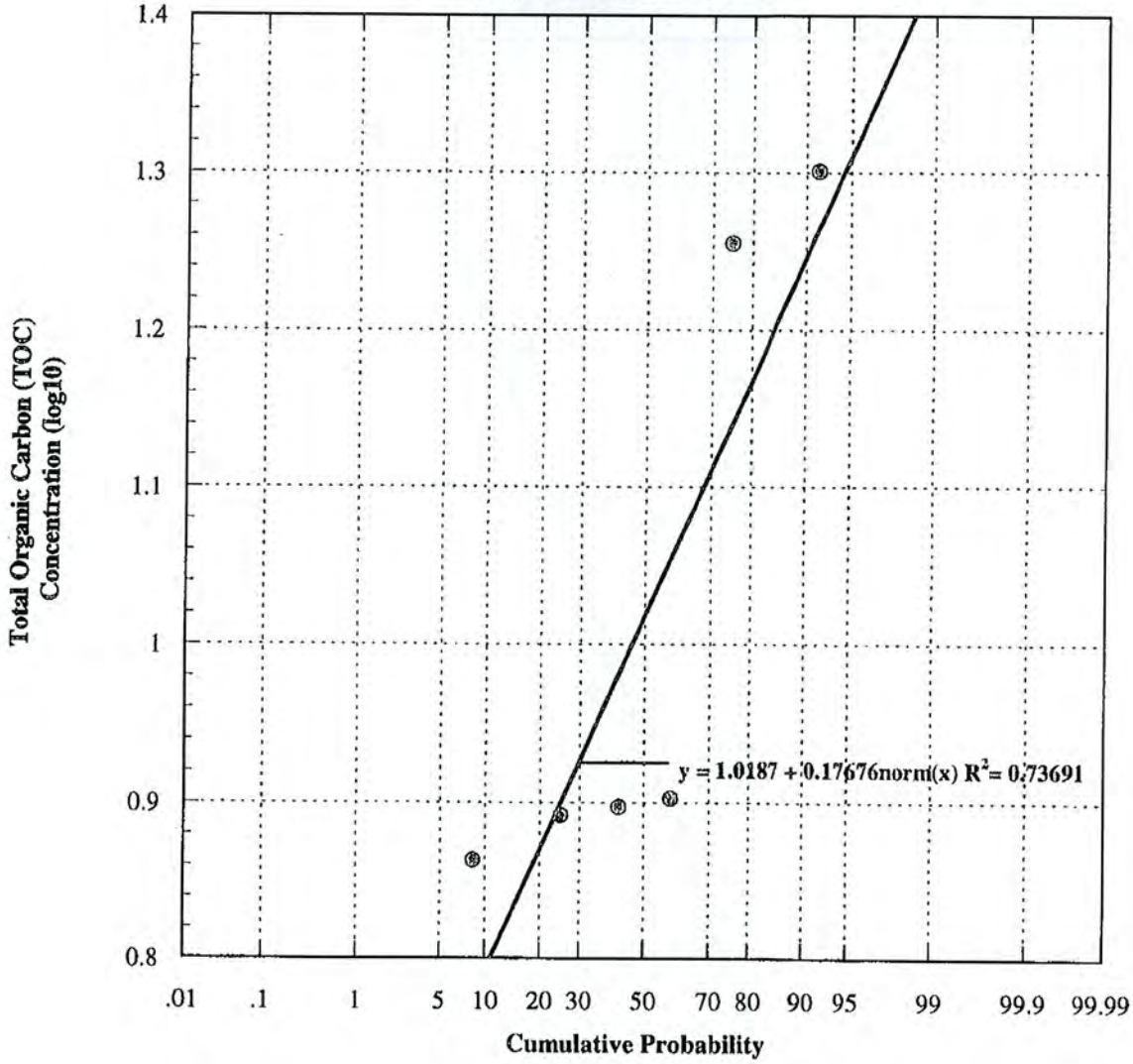
Note: There were no non-detected values in the data set.

GRAPH 14
Detention Basin "C" Effluent Flow
Calcium



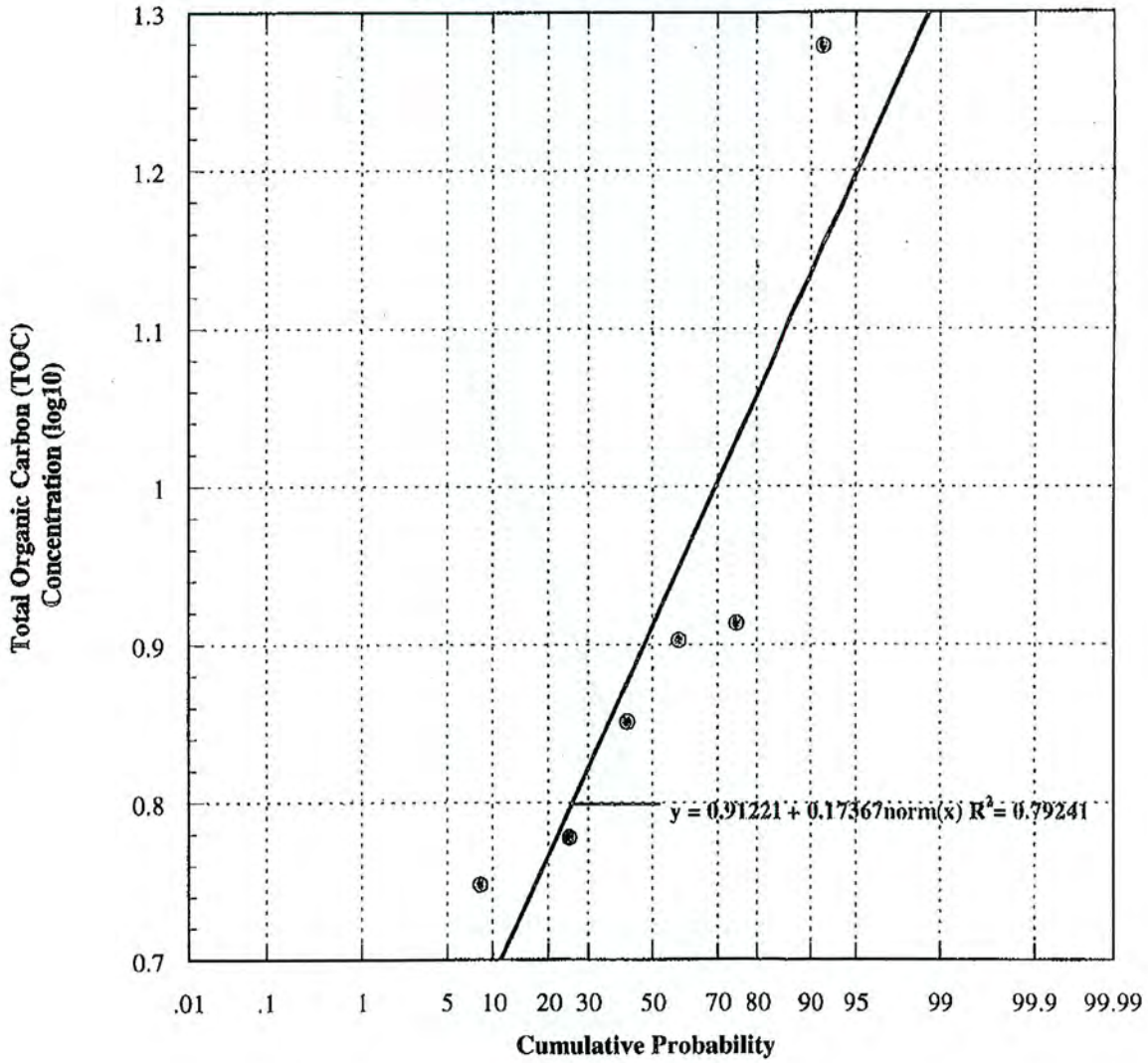
Note: There were no non-detected values in the data set.

GRAPH 15
Detention Basin "C" Influent Flow
Total Organic Carbon (TOC)



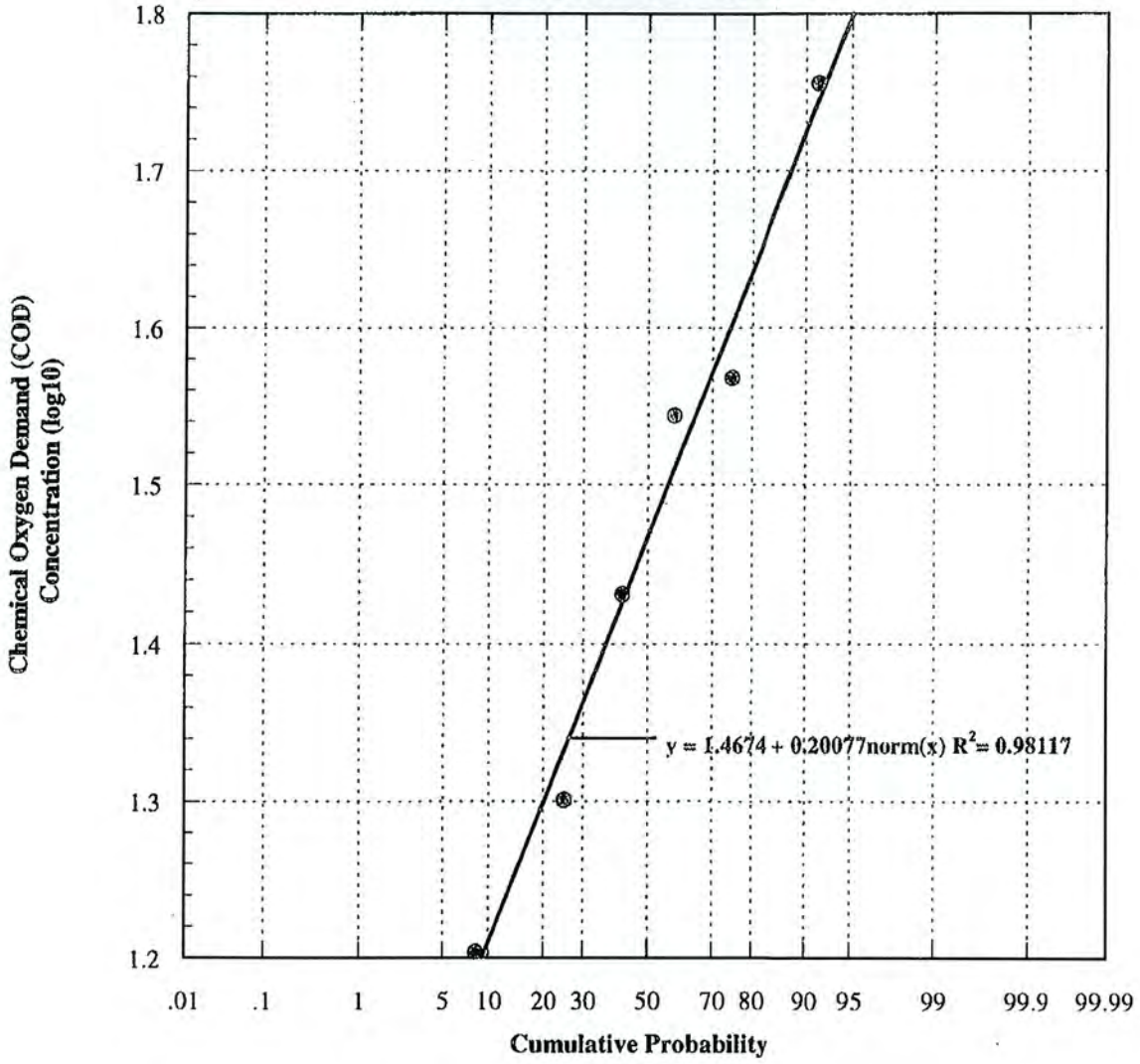
Note: There were no non-detected values in the data set.

GRAPH 16
Detention Basin "C" Effluent Flow
Total Organic Carbon (TOC)



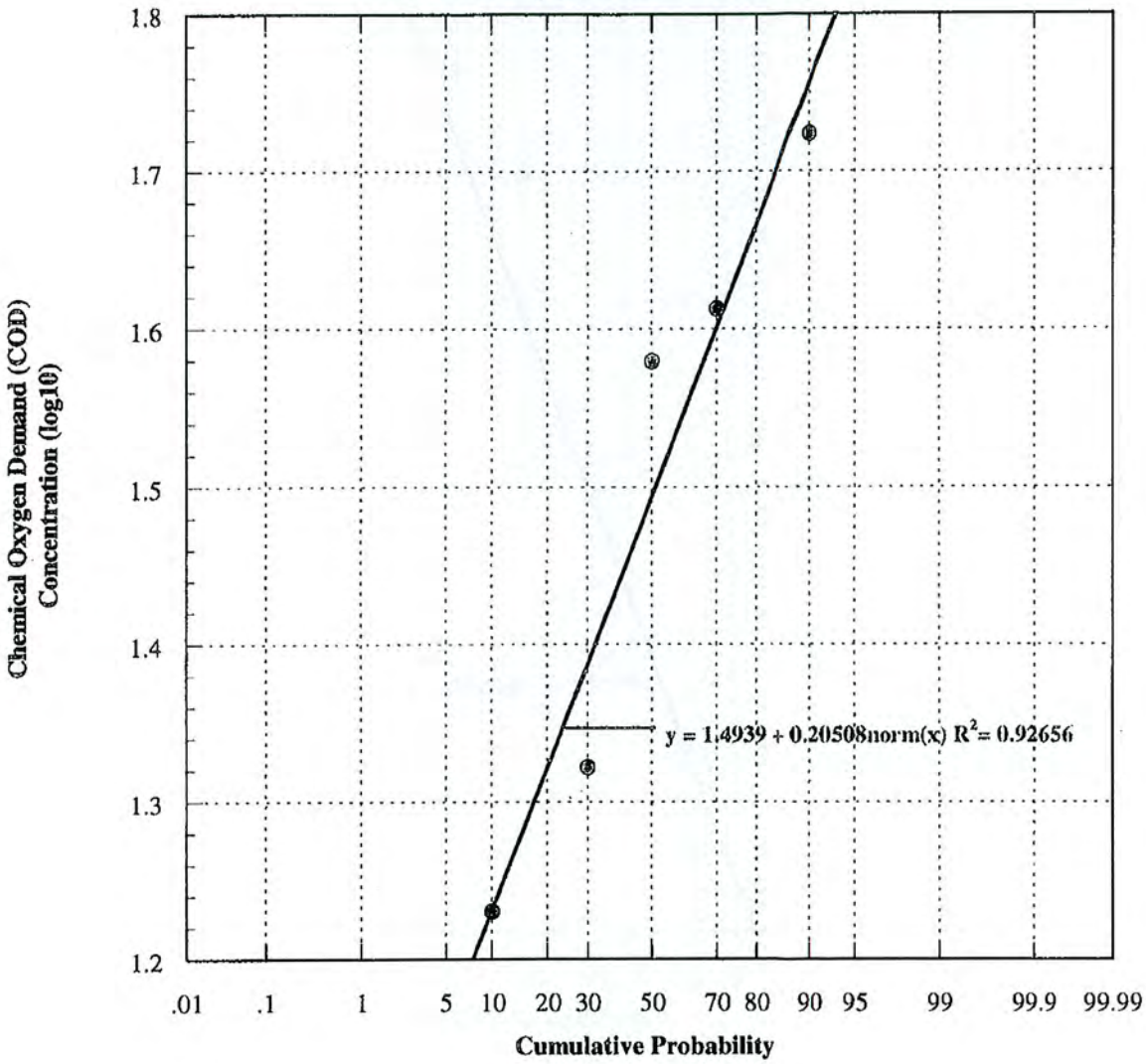
Note: There were no non-detected values in the data set.

GRAPH 17
Detention Basin "C" Influent Flow
Chemical Oxygen Demand (COD)



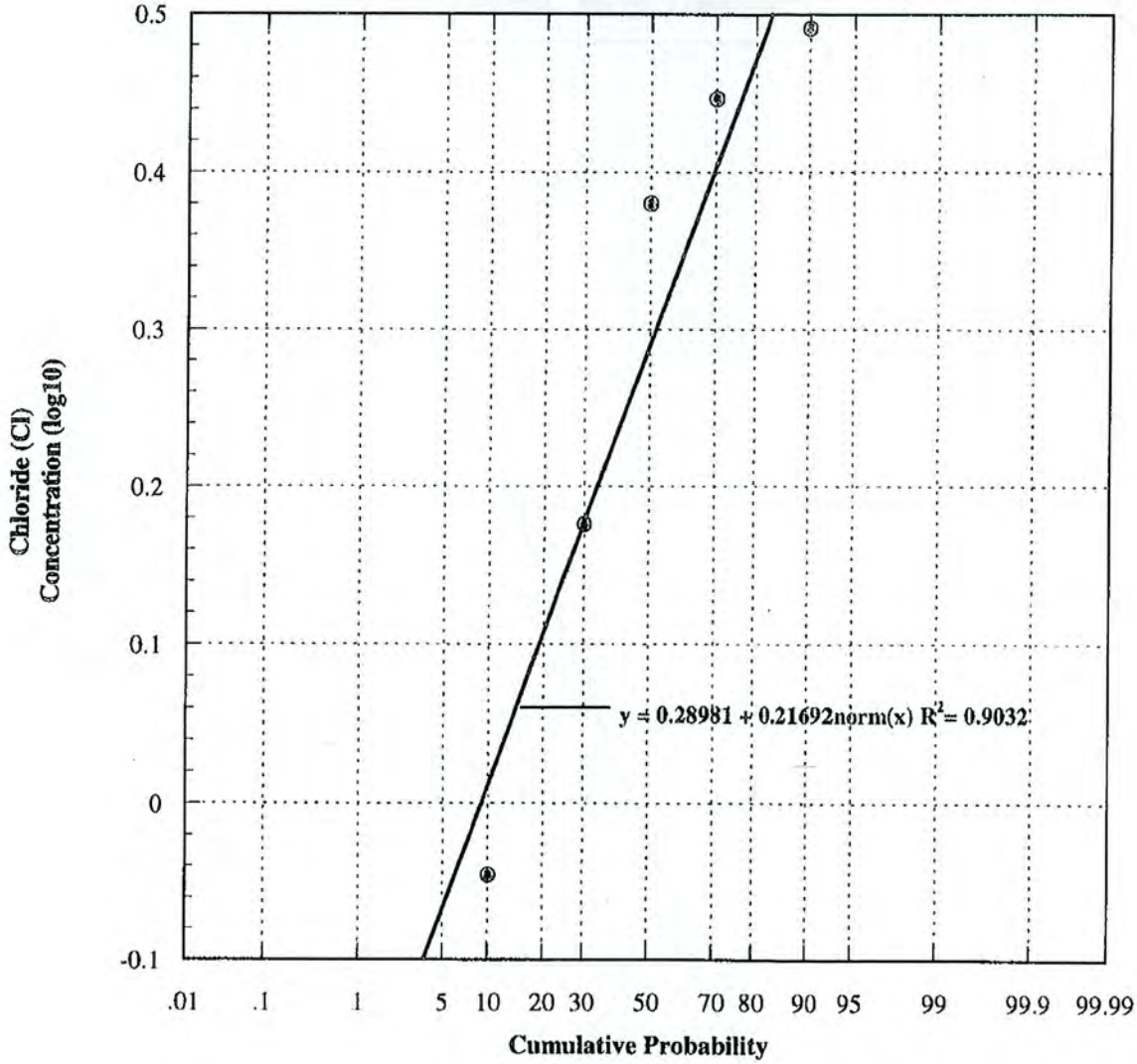
Note: There were no non-detected values in the data set.

GRAPH 18
Detention Basin "C" Effluent Flow
Chemical Oxygen Demand (COD)



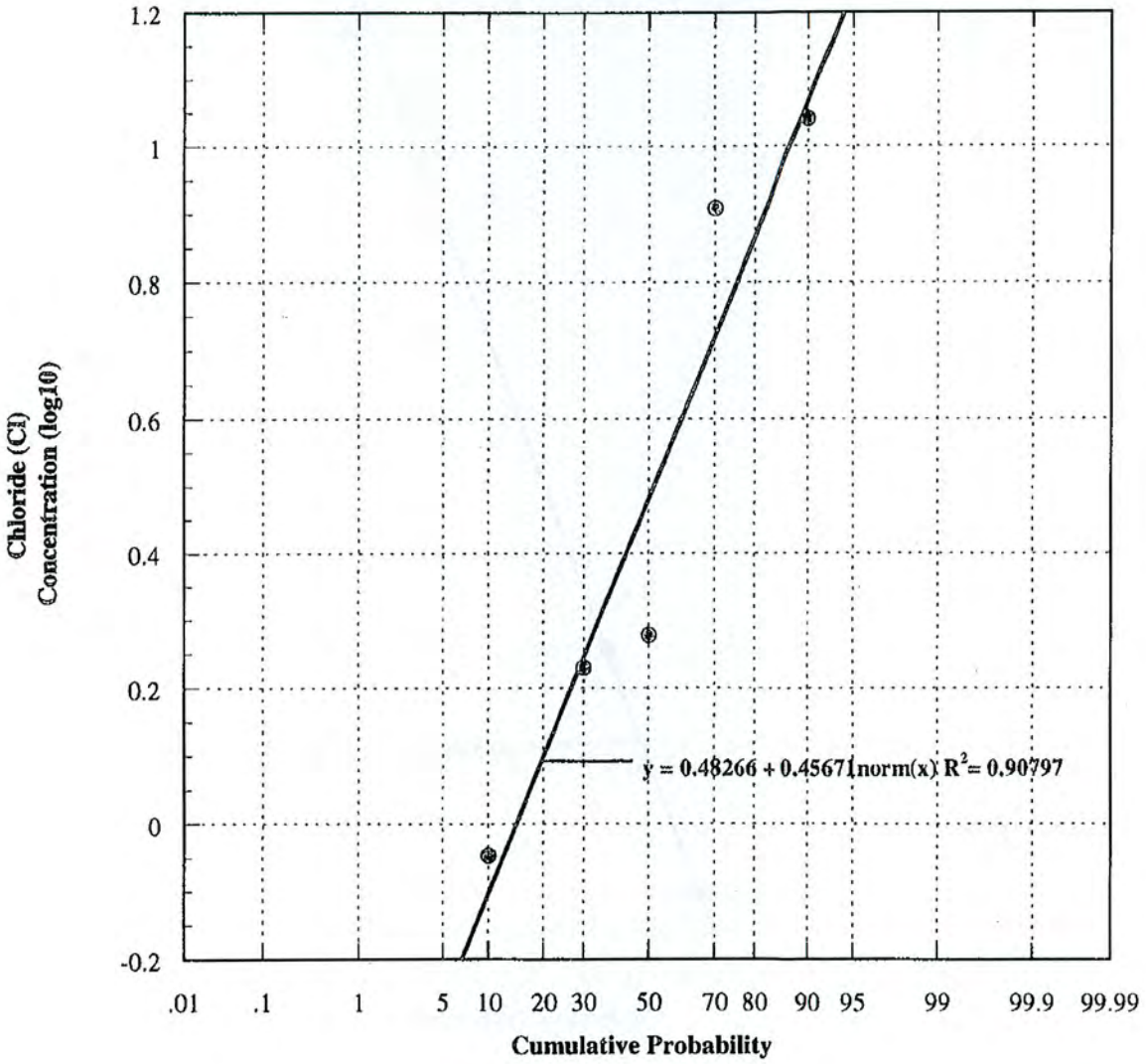
Note: There were no non-detected values in the data set.

GRAPH 19
Detention Basin "C" Influent Flow
Chloride

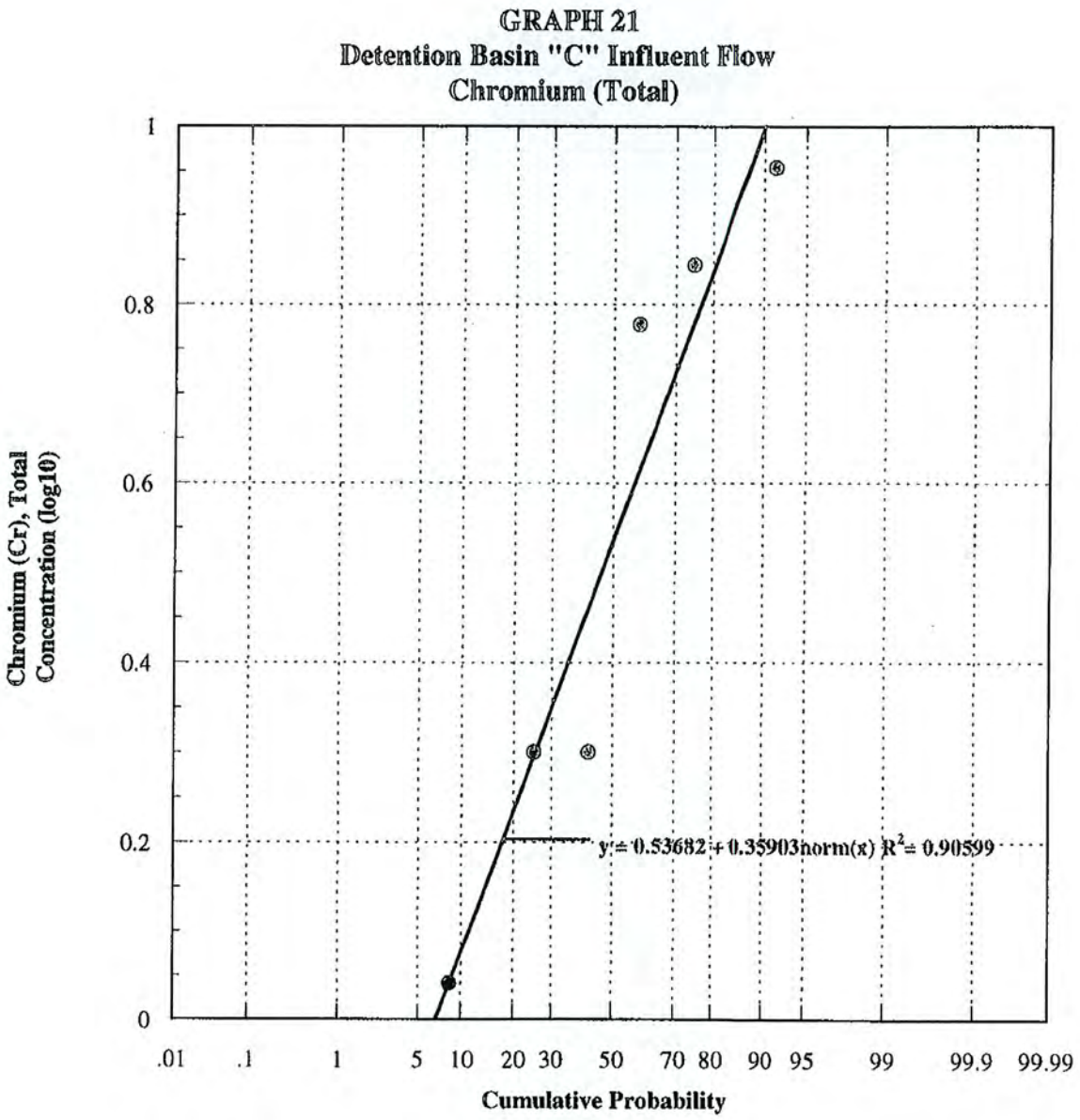


Note: There were no non-detected values in the data set.

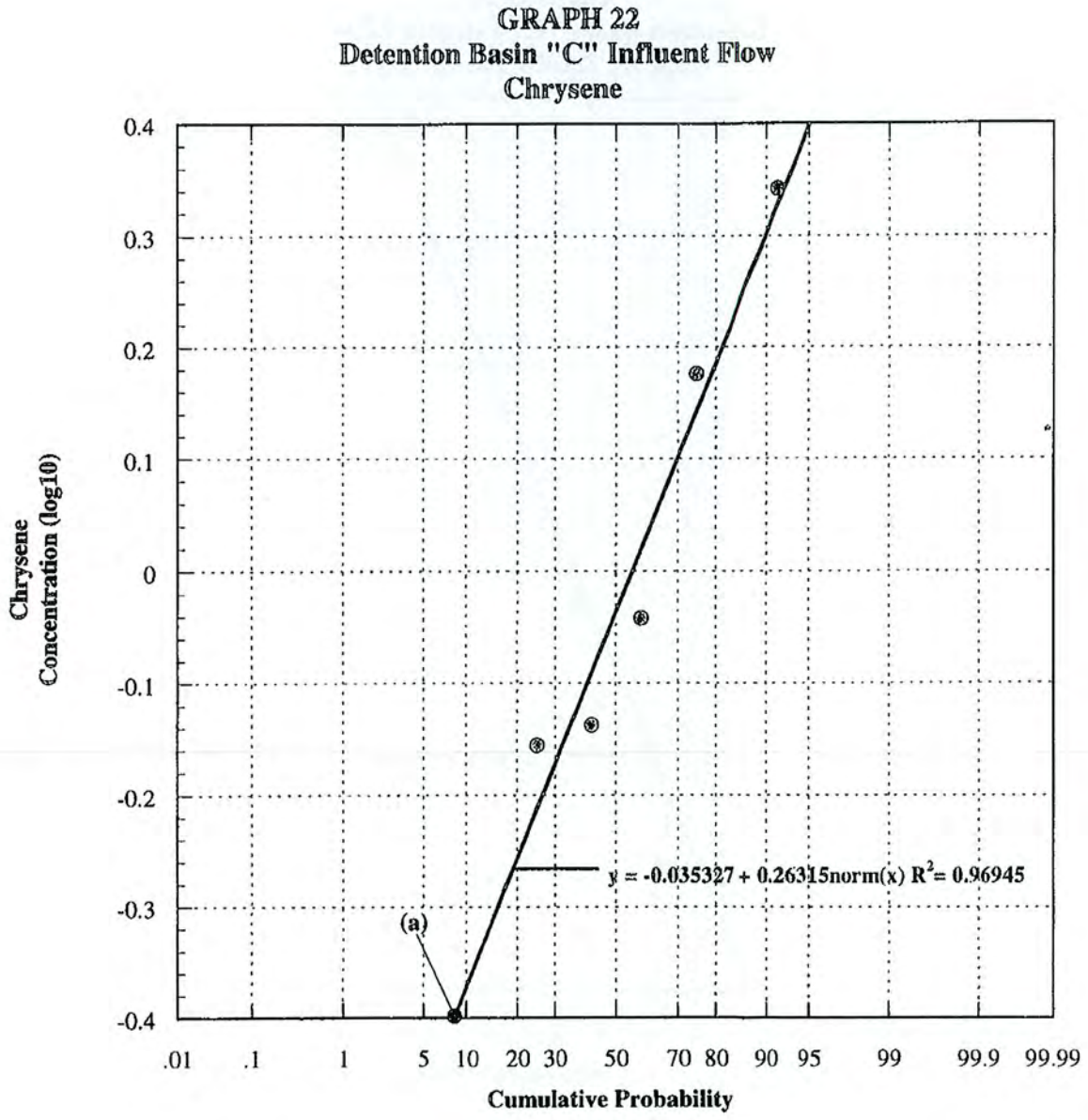
GRAPH 20
Detention Basin "C" Effluent Flow
Chloride



Note: There were no non-detected values in the data set.

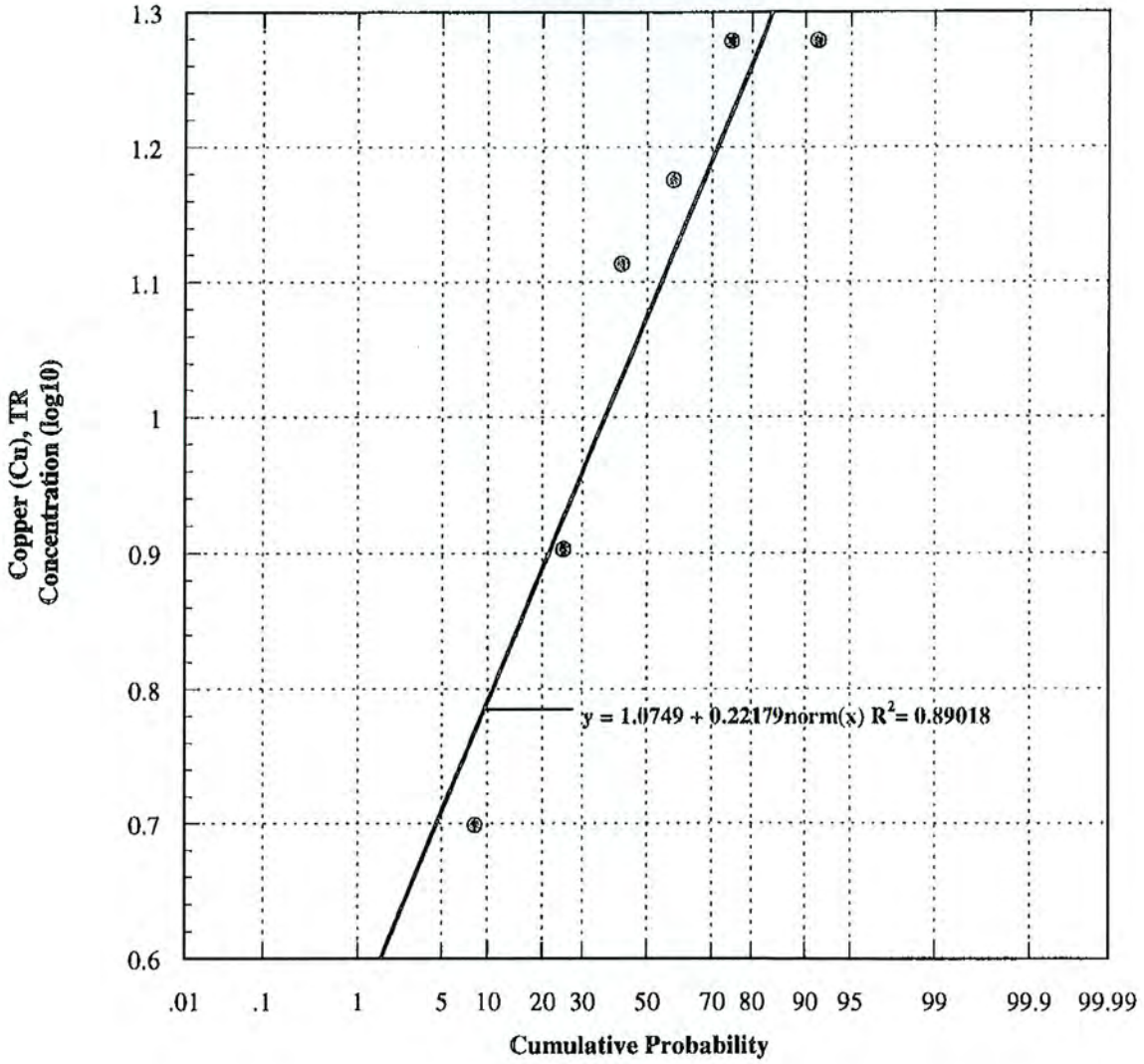


(a) Calculated non-detect values of1.097 ug/L using Robust Method.



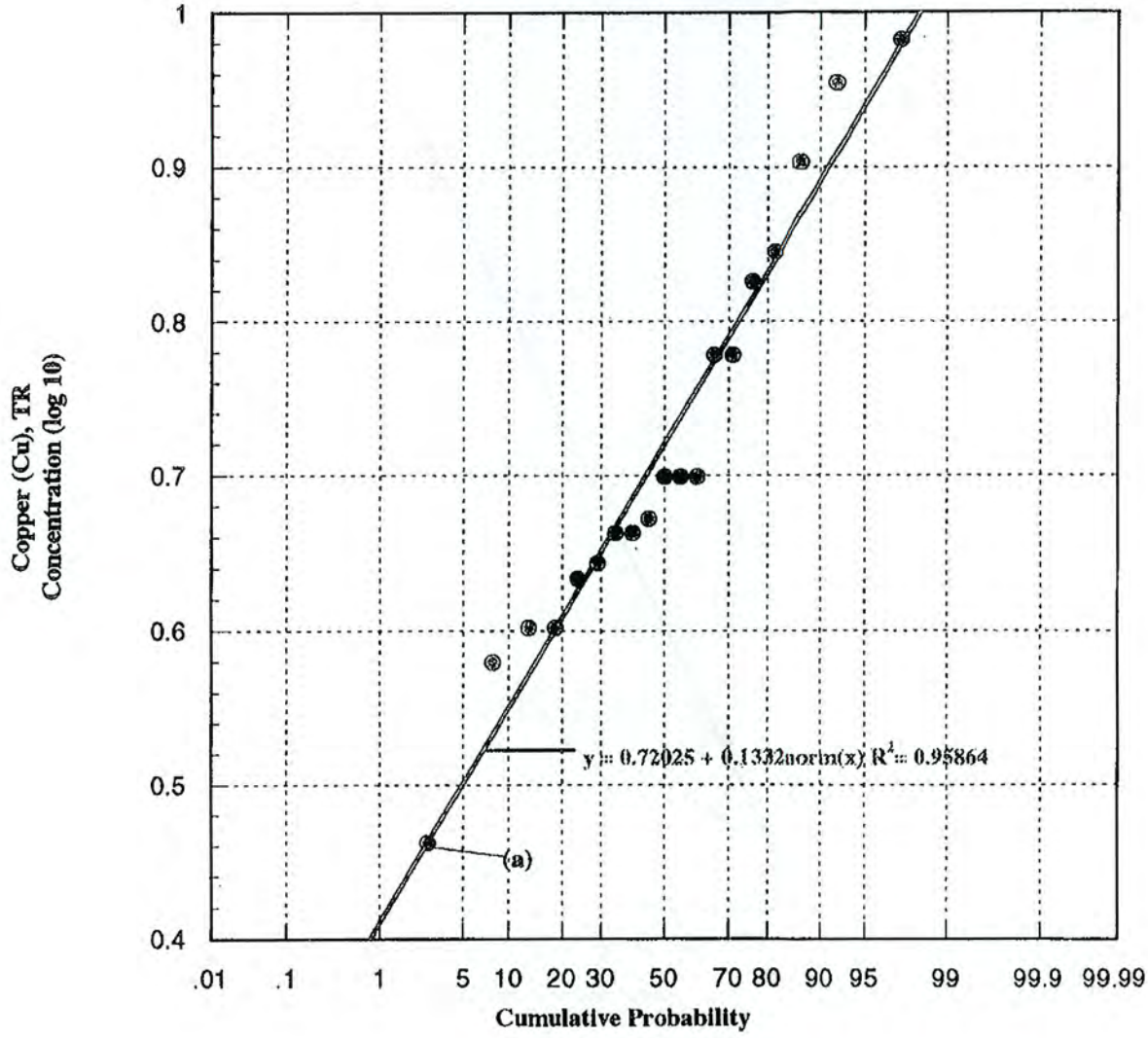
(a) Calculated non-detect values of 0.398 ug/L using Robust Method.

GRAPH 23
Detention Basin "C" Influent Flow
Copper, Total Recoverable



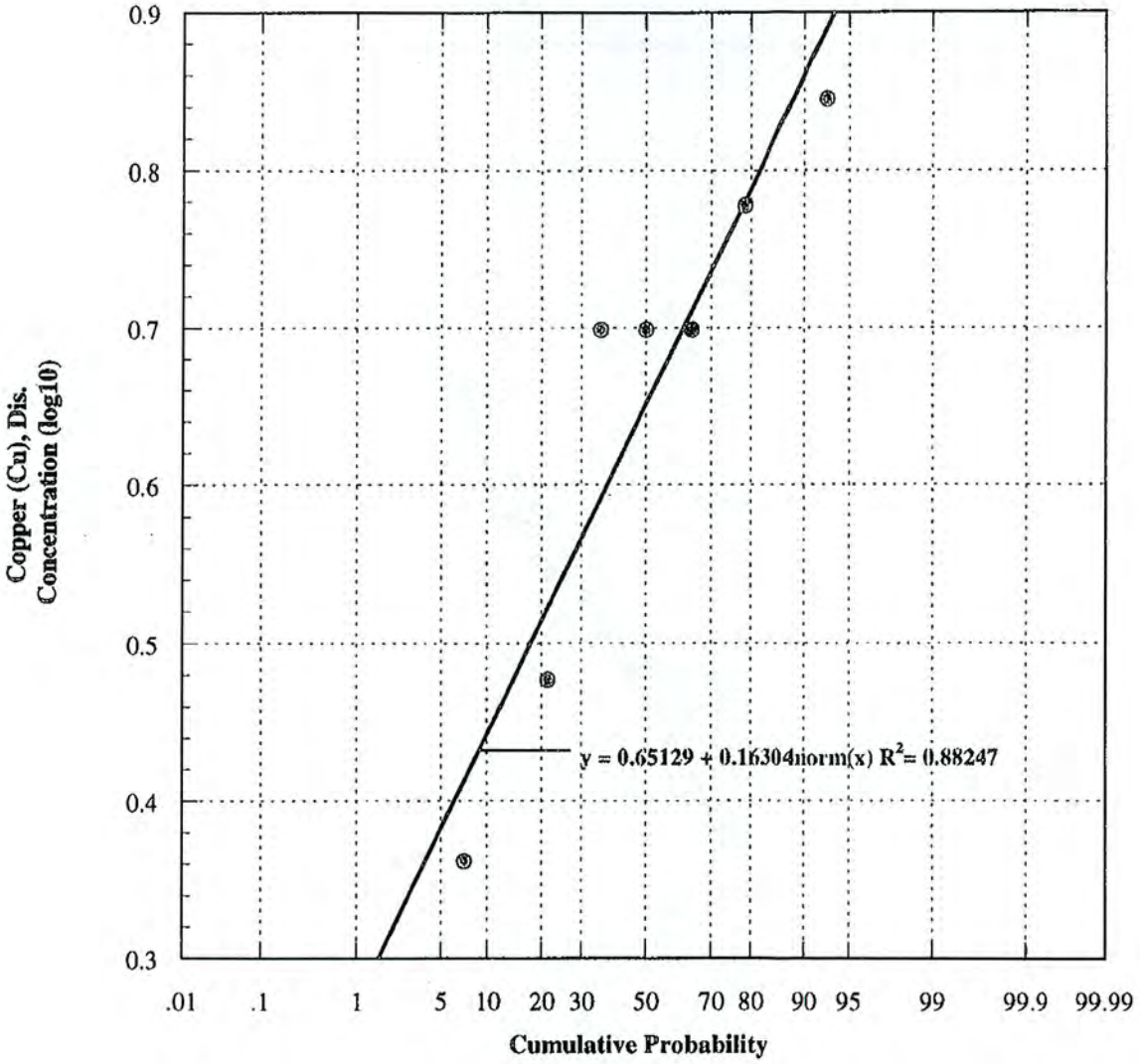
Note: There were no non-detect values in the data set.

GRAPH 24
Detention Basin "C" Effluent Flow
Copper, Total Recoverable



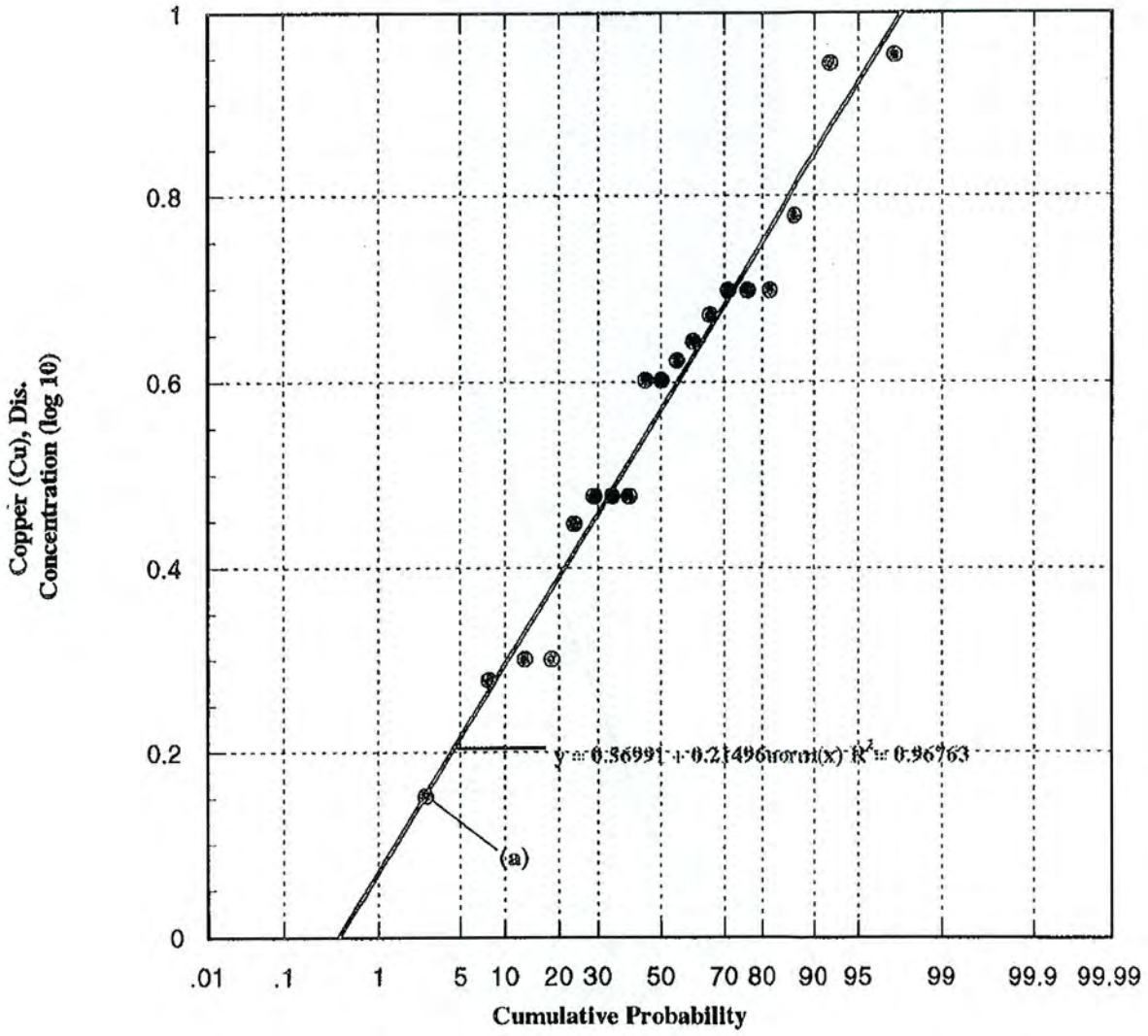
(a) Calculated non-detect values of 2.90 ug/L using Robust Method.

GRAPH 25
Detention Basin "C" Influent Flow
Copper, Dissolved



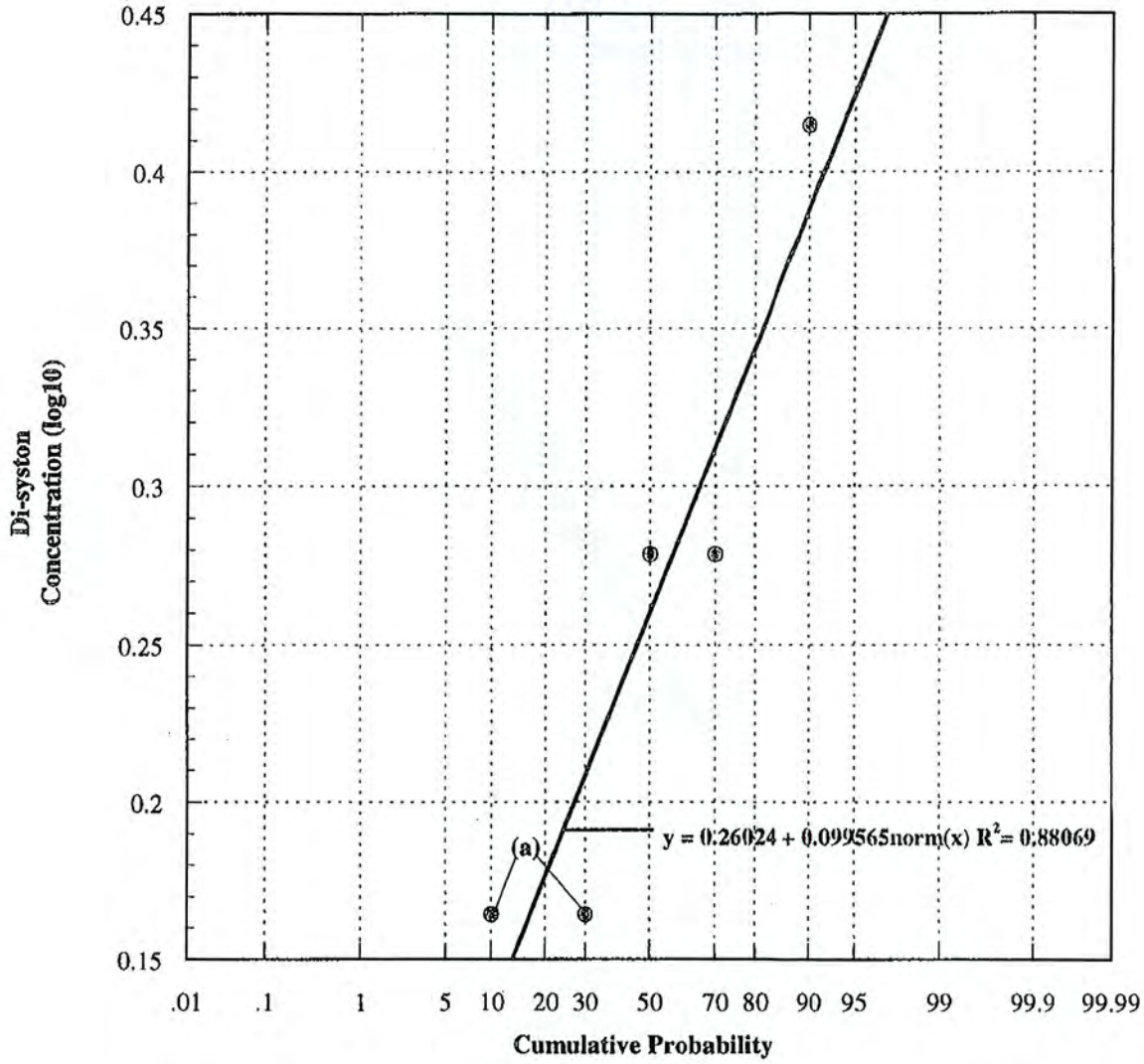
Note: there were no non-detected values in the data set.

GRAPH 26
Detention Basin "C" Effluent Flow
Copper, Dissolved

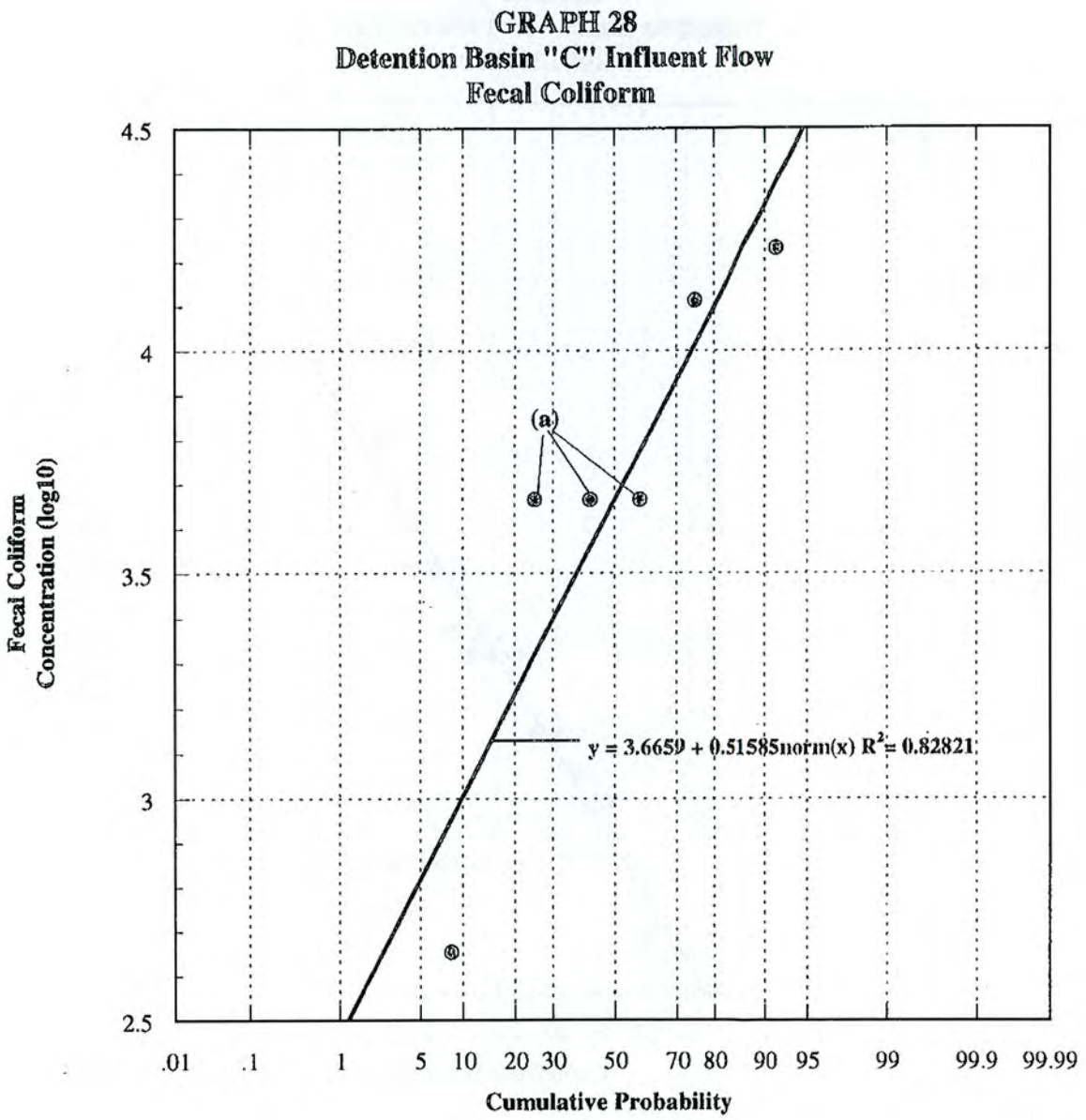


(a) Calculated non-detect values of 1.42 ug/L using Robust Method.

GRAPH 27
Detention Basin "C" Effluent Flow
Di-syston

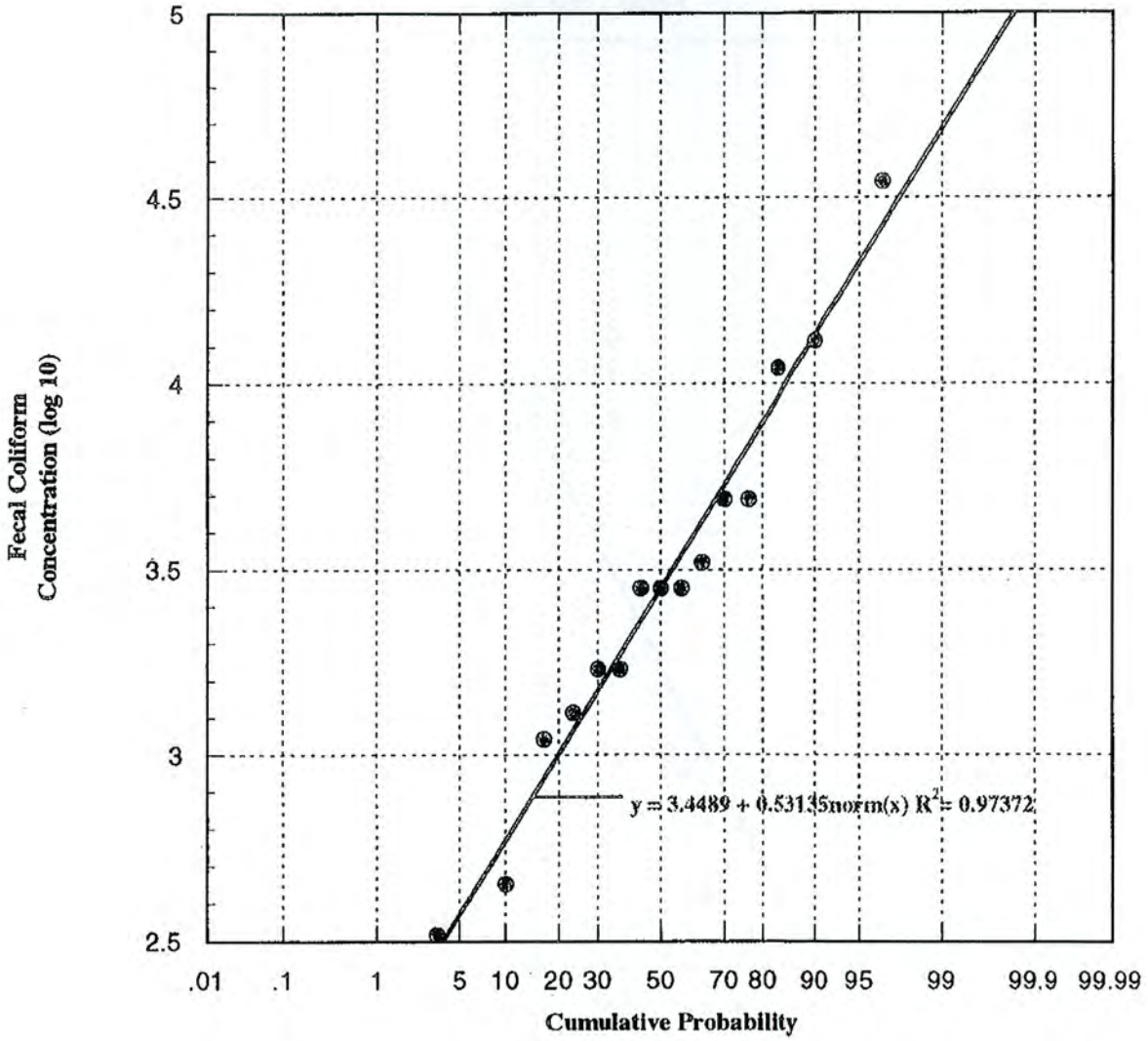


(a) Calculated non-detect values of 1.456 ug/L using Robust Method.



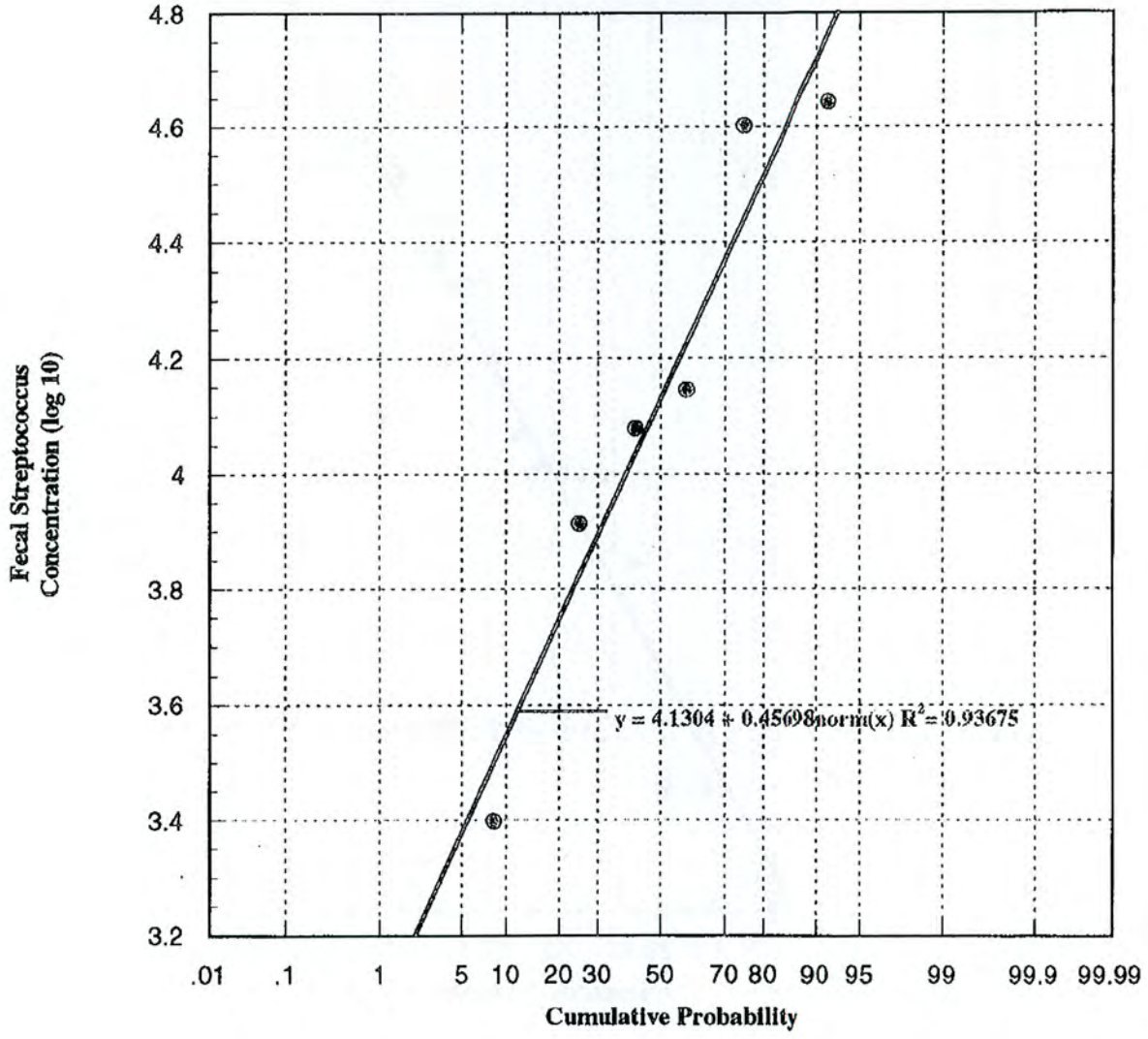
(a) Calculated non-detect values of 4633 MPN/100ml using Robust Method.

GRAPH 29
Detention Basin "C" Effluent Flow
Fecal Coliform



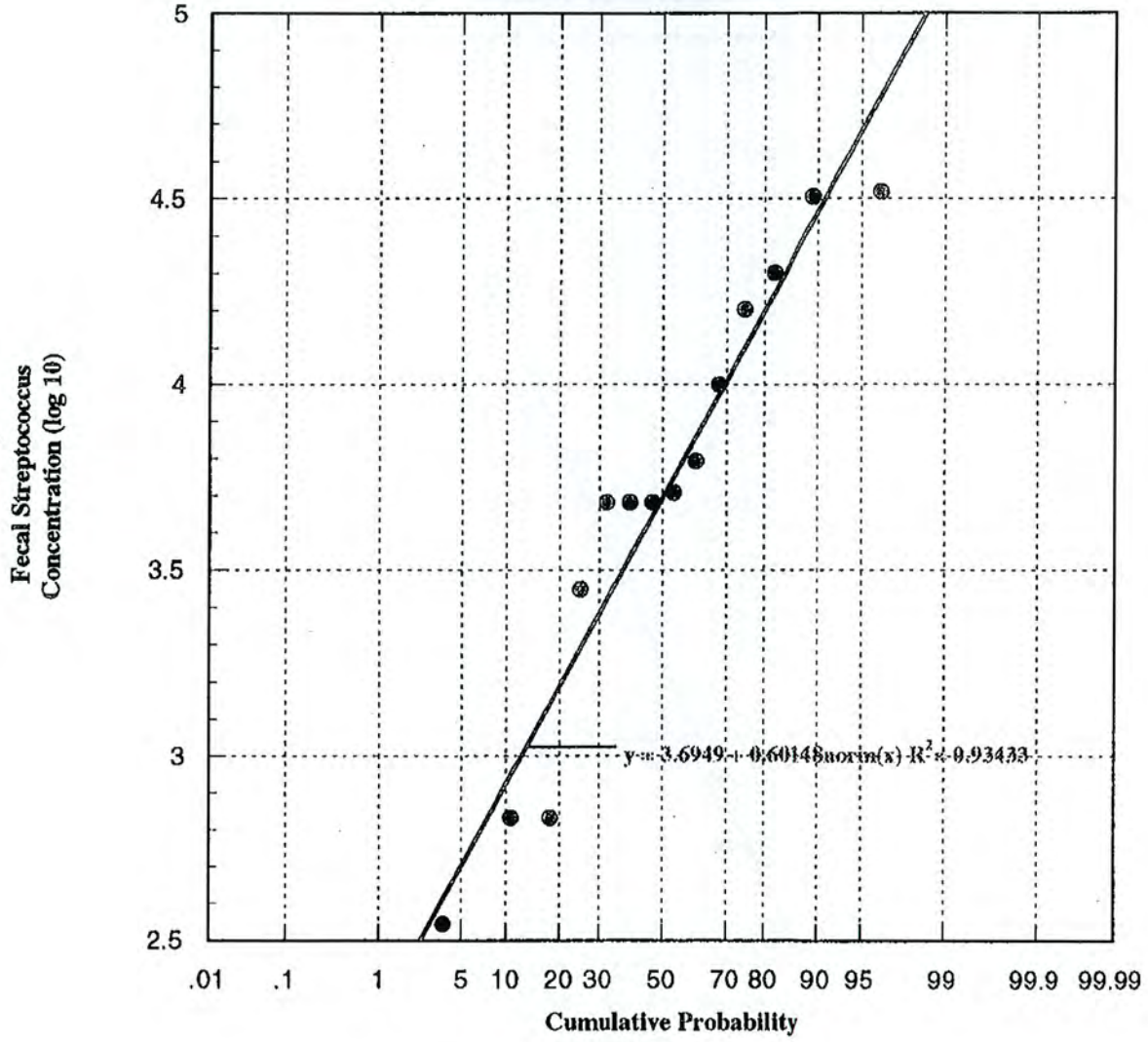
Note: There were no non-detected values in the data set.

GRAPH 30
Detention Basin "C" Influent Flow
Fecal Streptococcus



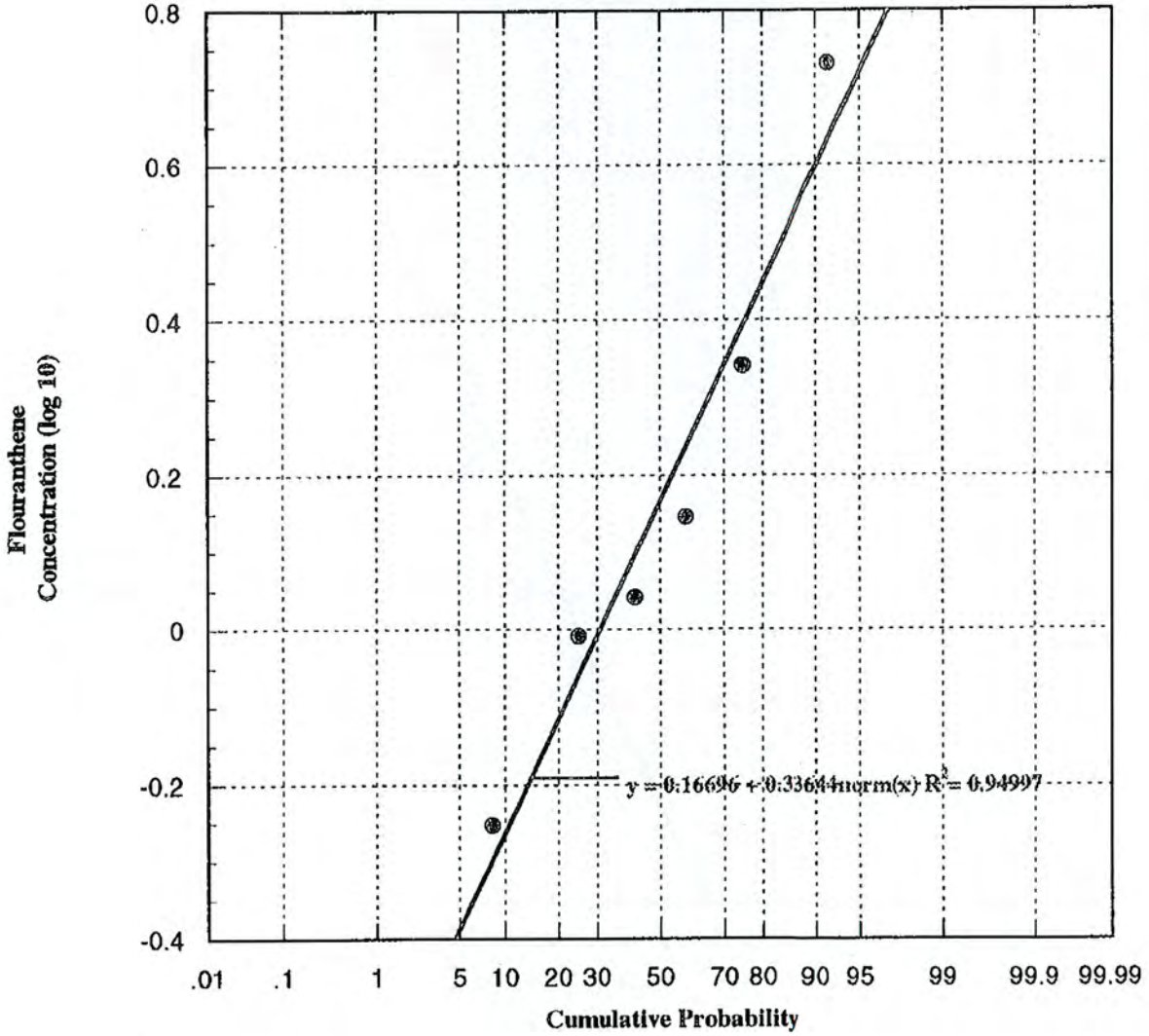
Note: There were no non-detected values in the data set.

GRAPH 31
Detention Basin "C" Effluent Flow
Fecal Streptococcus



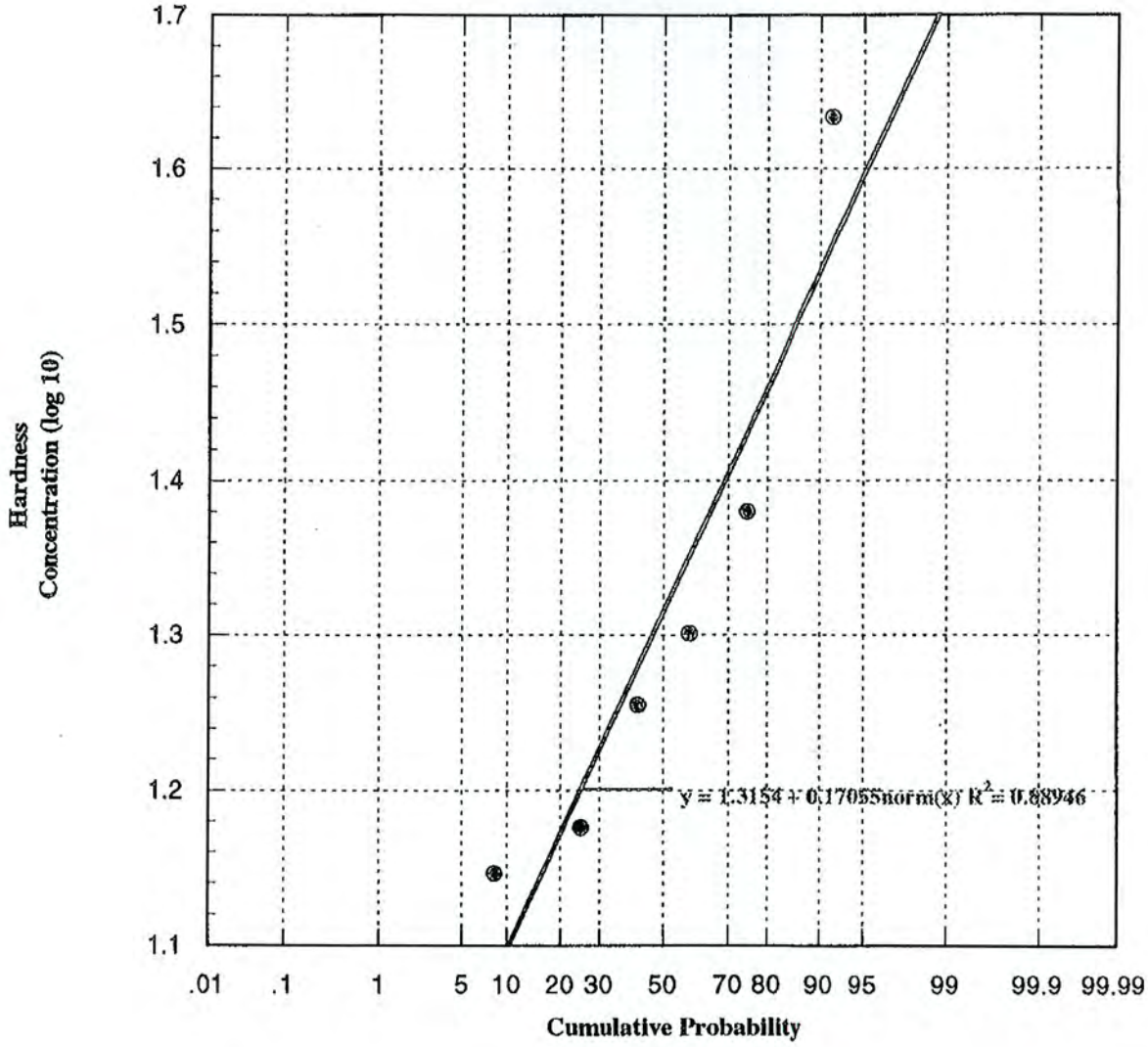
Note: There were no non-detected values in the data set.

GRAPH 32
Detention Basin "C" Influent Flow
Flouranthene



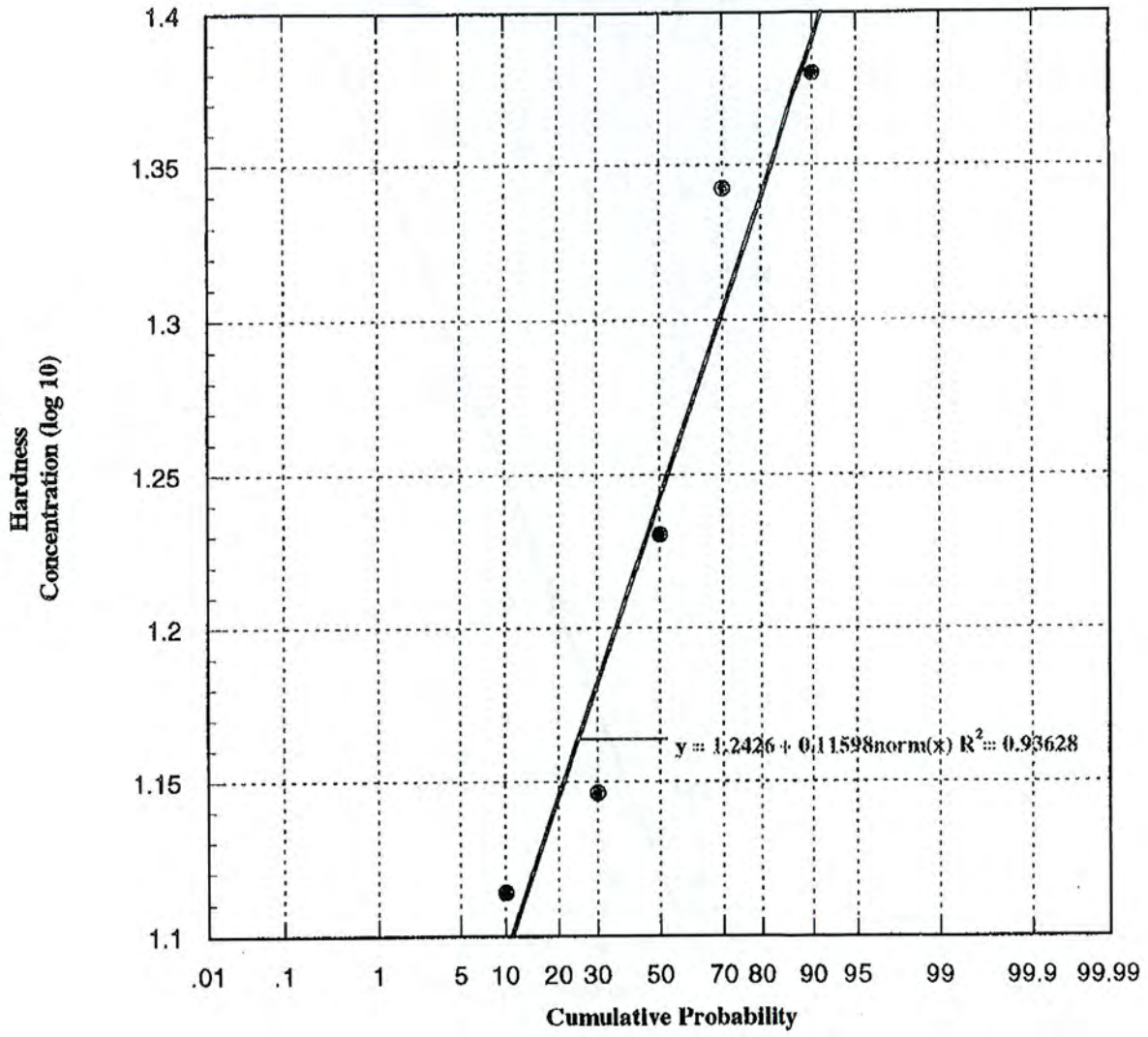
Note: There were no non-detected values in the data set.

GRAPH 33
Detention Basin "C" Influent Flow
Hardness



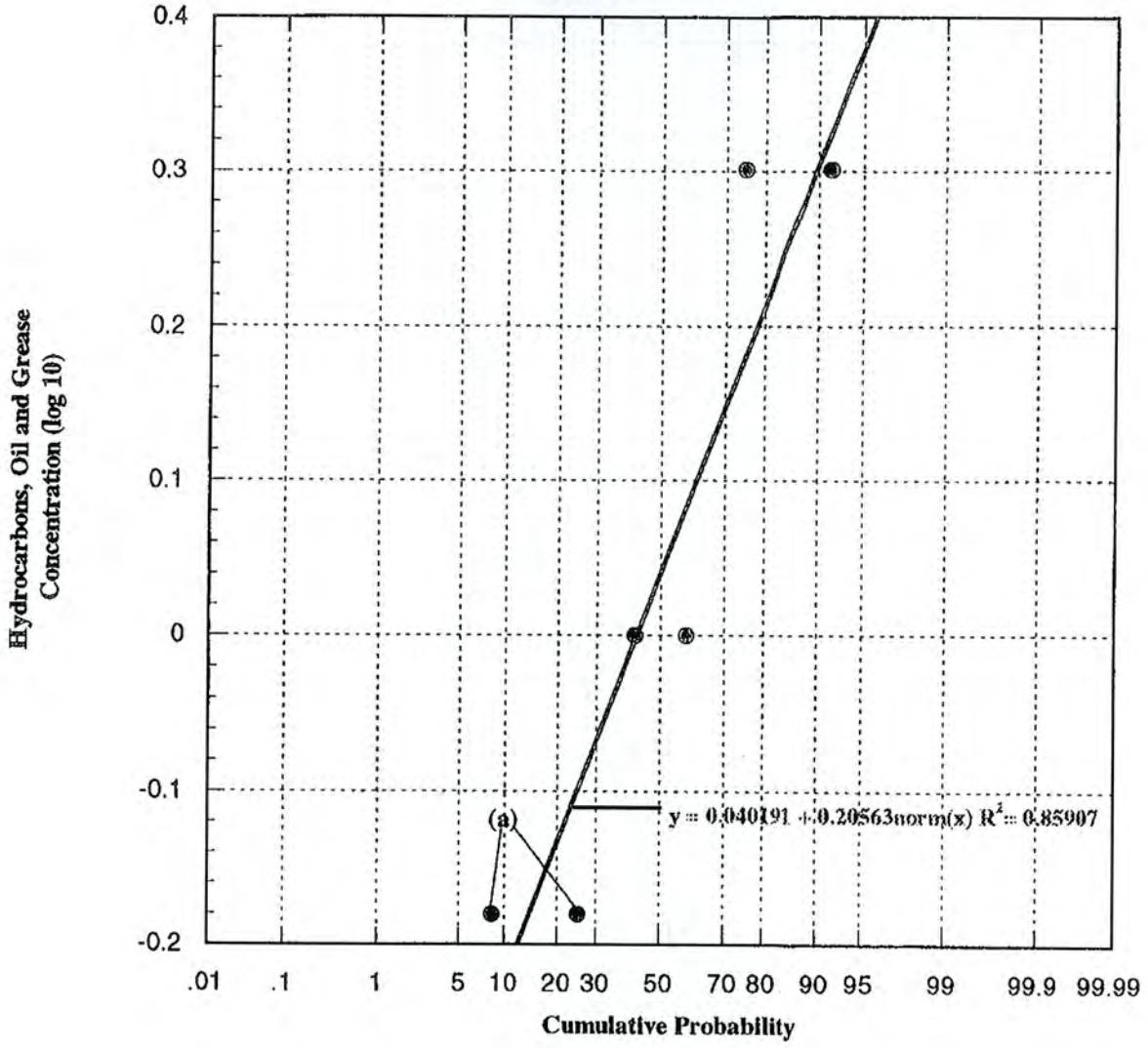
Note: There were no non-detected values in the data set.

GRAPH 34
Detention Basin "C" Effluent Flow
Hardness



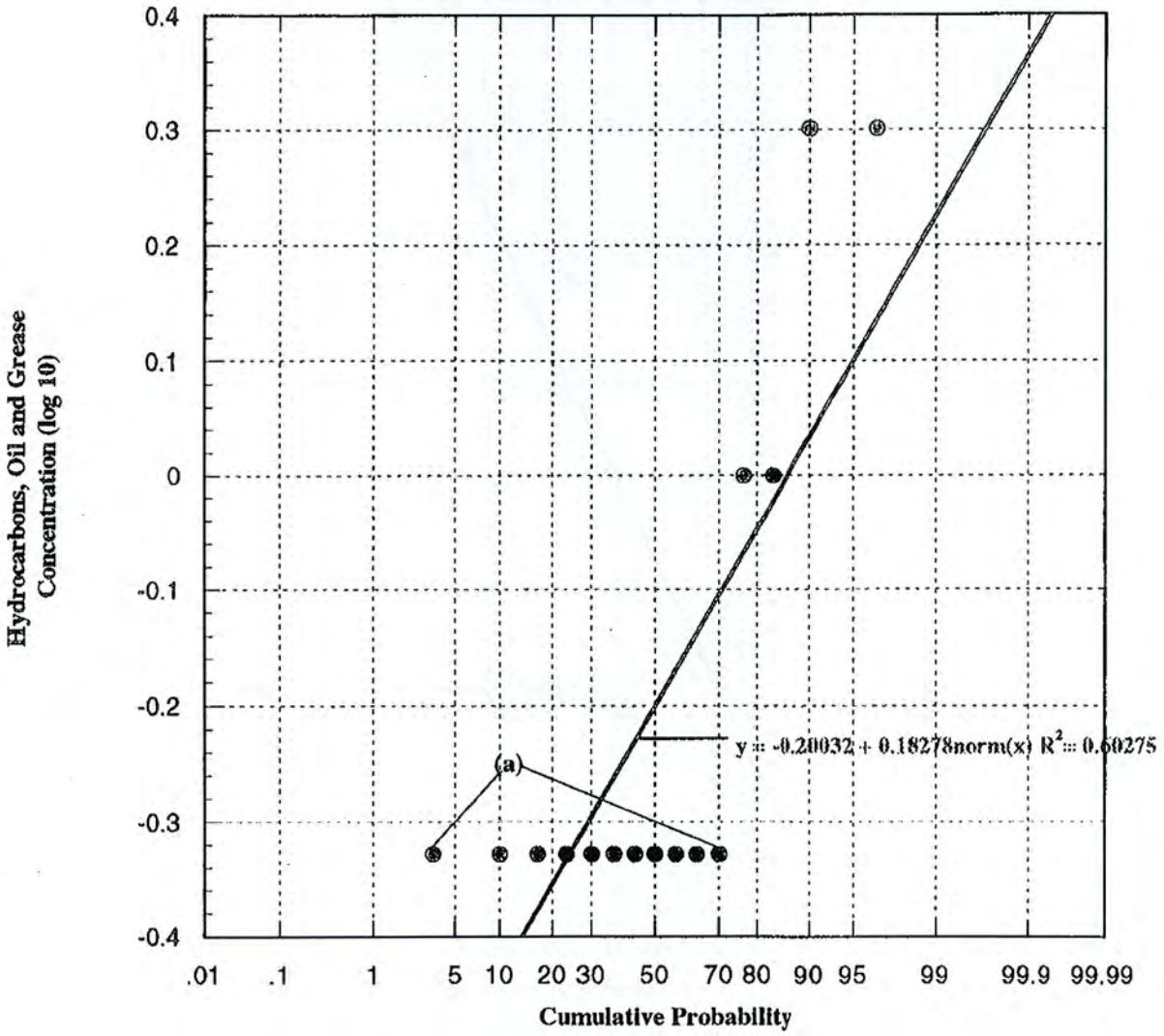
Note: There were no non-detected values in the data set.

GRAPH 35
Detention Basin "C" Influent Flow
Hydrocarbons, Oil and Grease



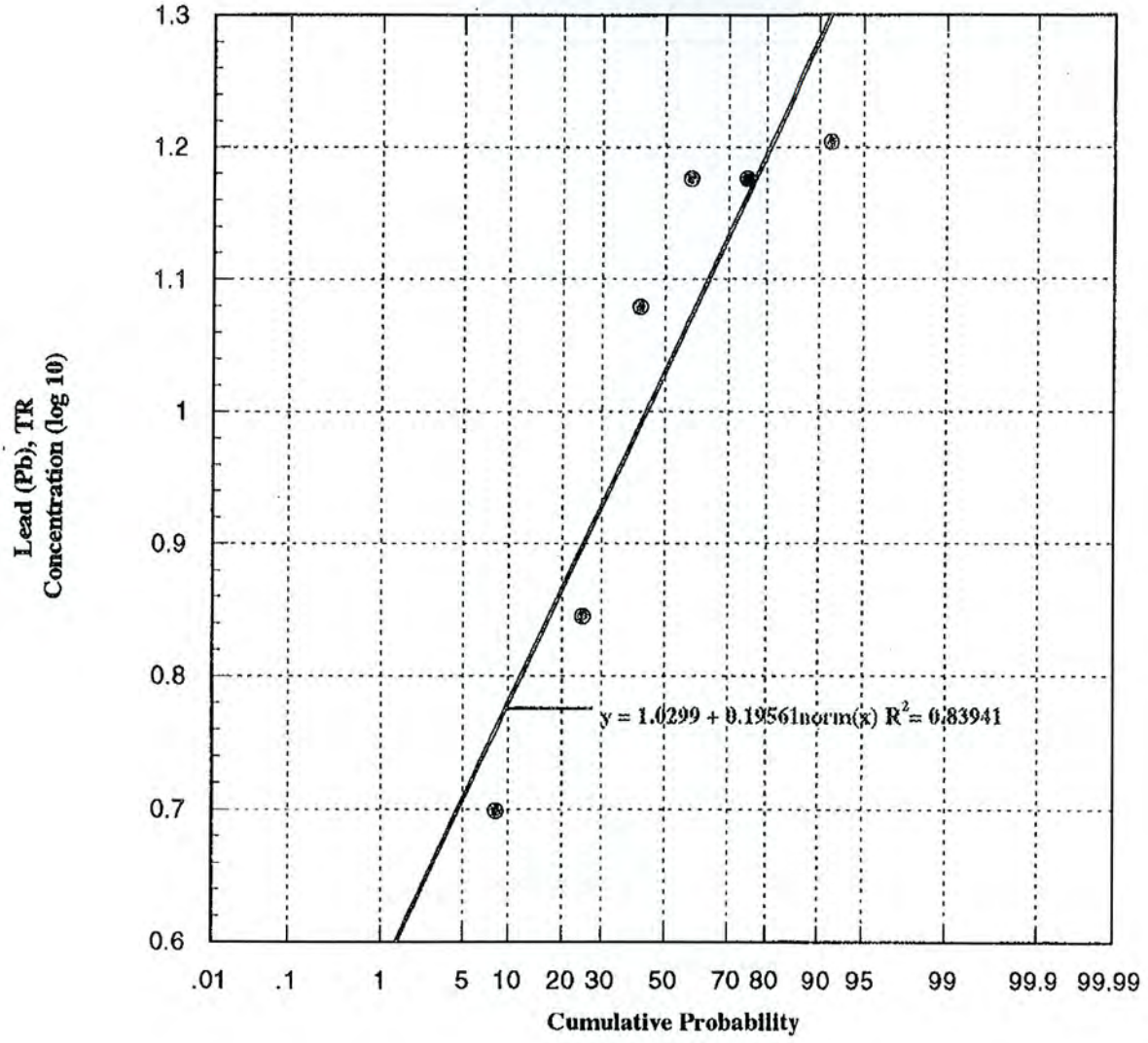
(a) Calculated non-detect values of 0.66 mg/L using Robust Method.

GRAPH 36
Detention Basin "C" Effluent Flow
Hydrocarbons, Oil and Grease



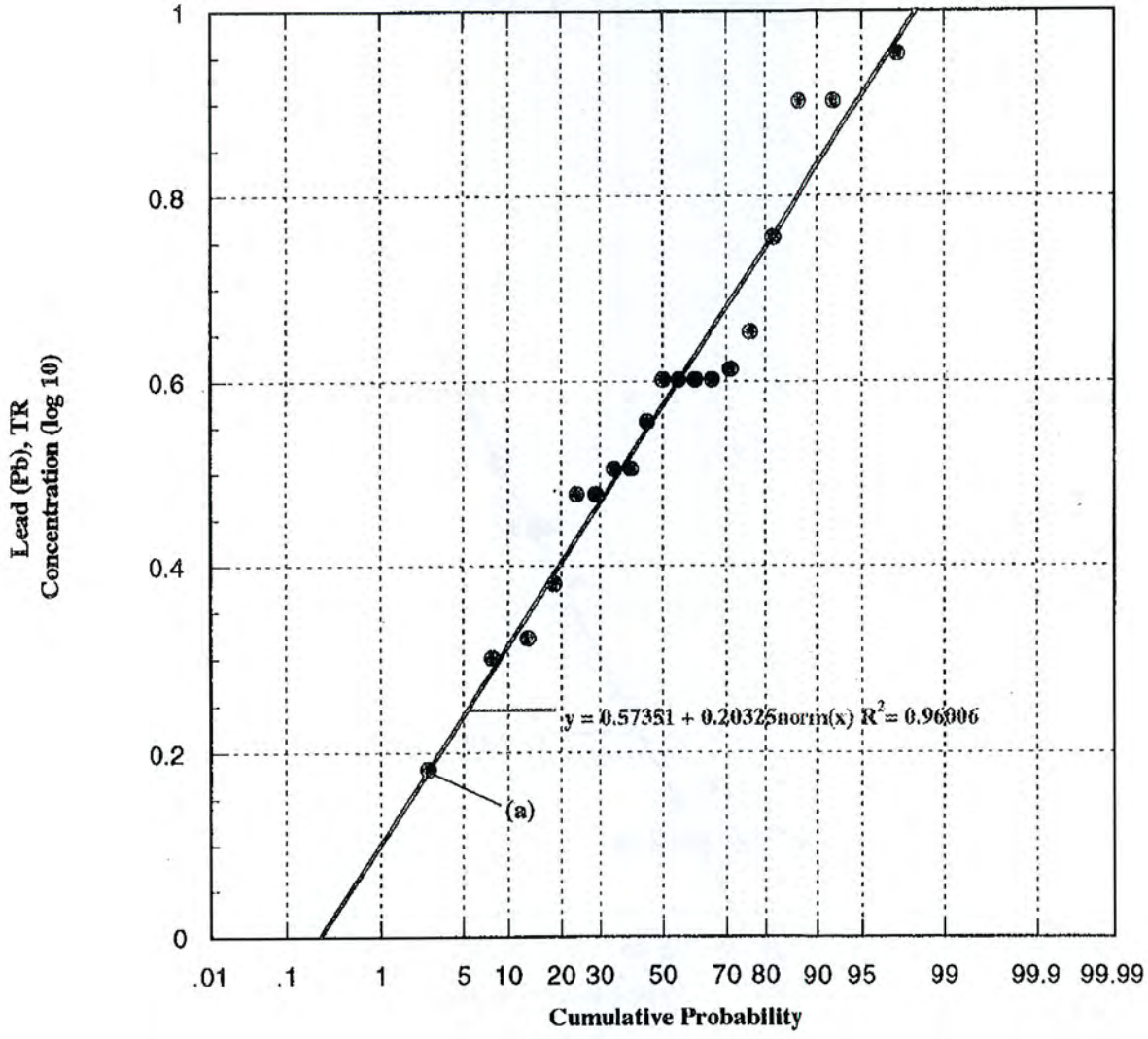
(a) Calculated non-detect values of 0.467 mg/L using Robust Method.

GRAPH 37
Detention Basin "C" Influent Flow
Lead, Total Recoverable



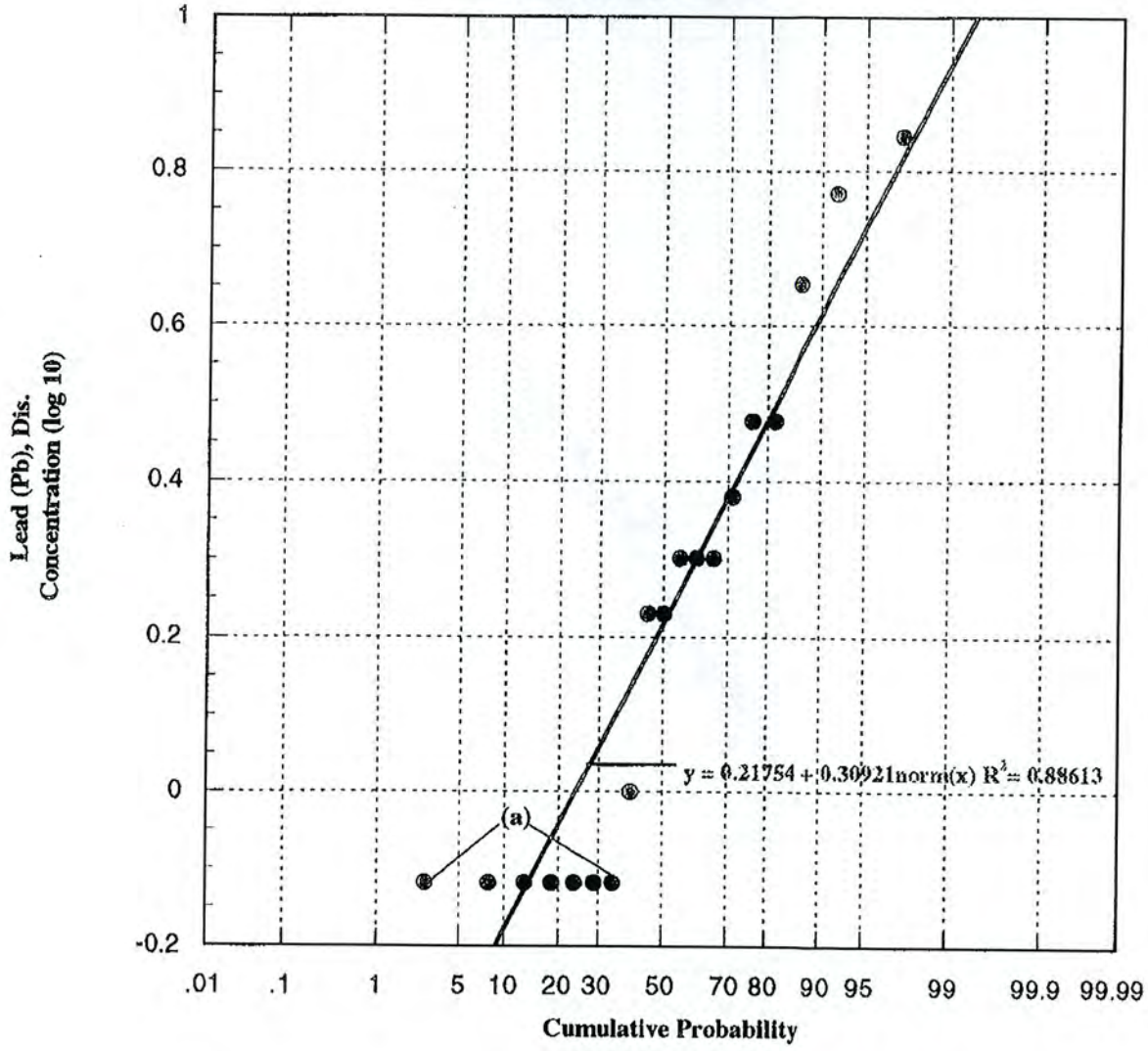
Note: There were no non-detect values in the data set.

GRAPH 38
Detention Basin "C" Effluent Flow
Lead, Total Recoverable



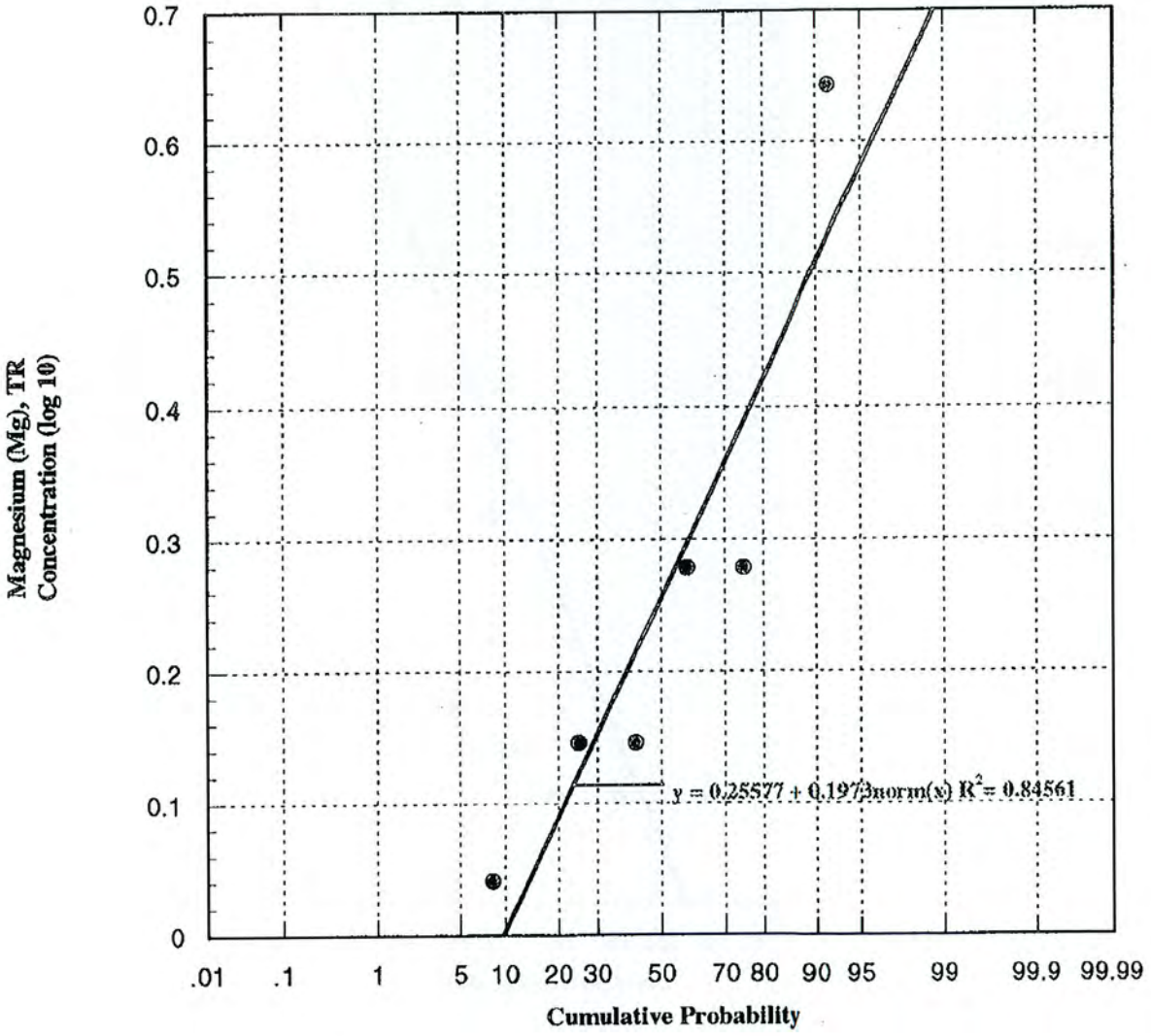
(a) Calculated non-detect value of 1.51 ug/L using Robust Method.

GRAPH 39
Detention Basin "C" Effluent Flow
Lead, Dissolved



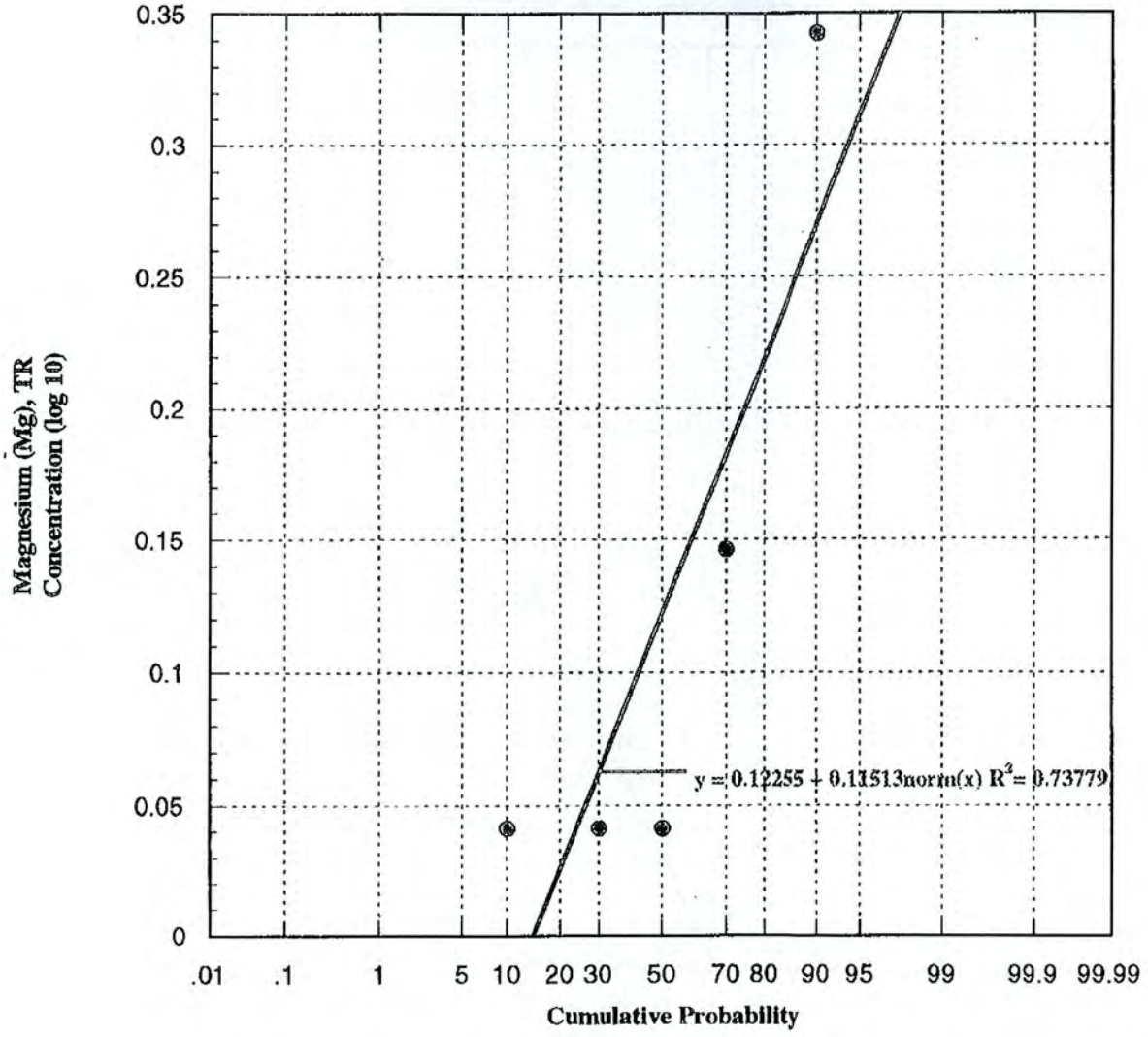
(a) Calculated non-detect values of 0.76 ug/L using Robust Method.

GRAPH 40
Detention Basin "C" Influent Flow
Magnesium, Total Recoverable



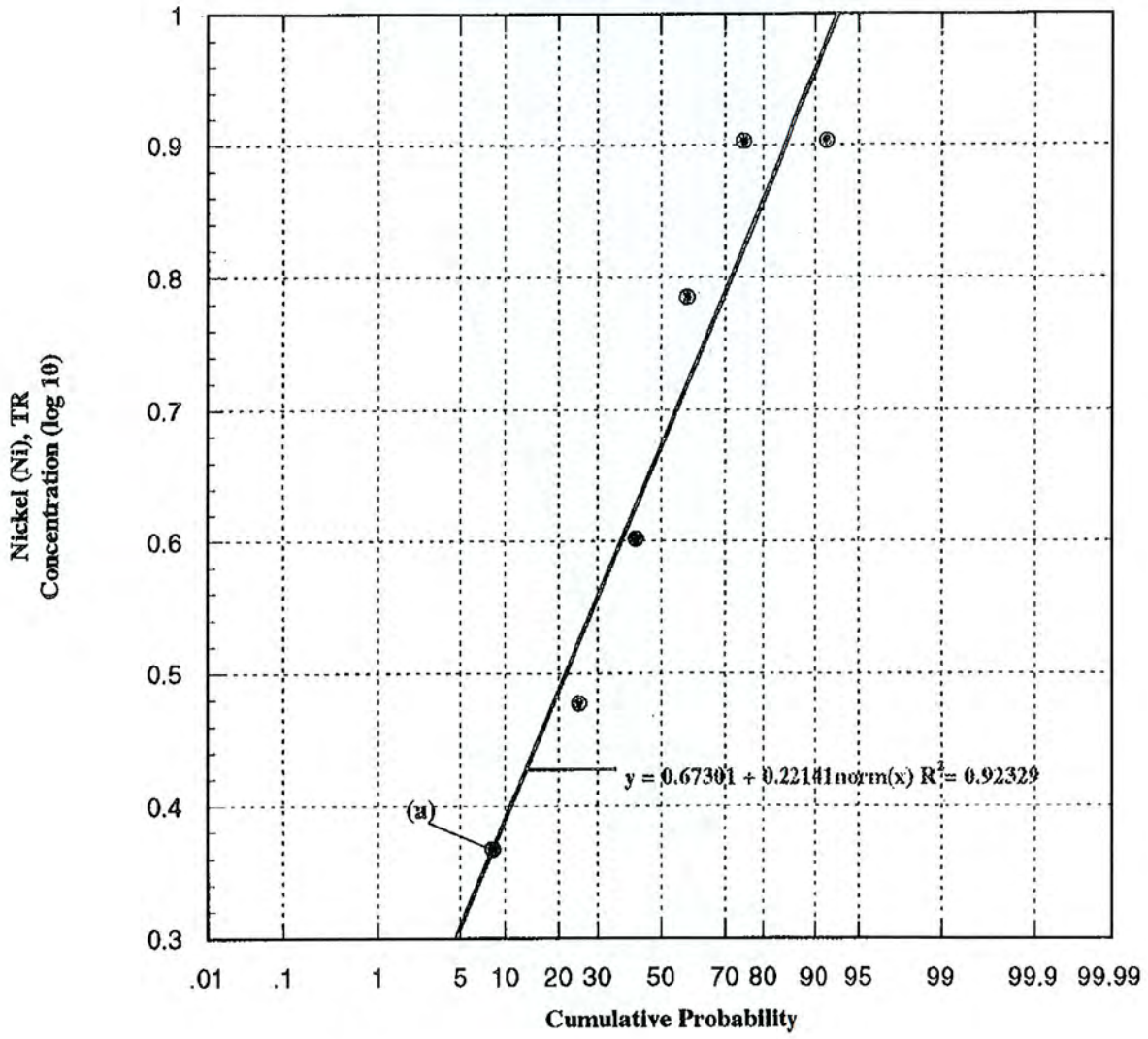
Note: There were no non-detected values in the data set.

GRAPH 41
Detention Basin "C" Effluent Flow
Magnesium, Total Recoverable



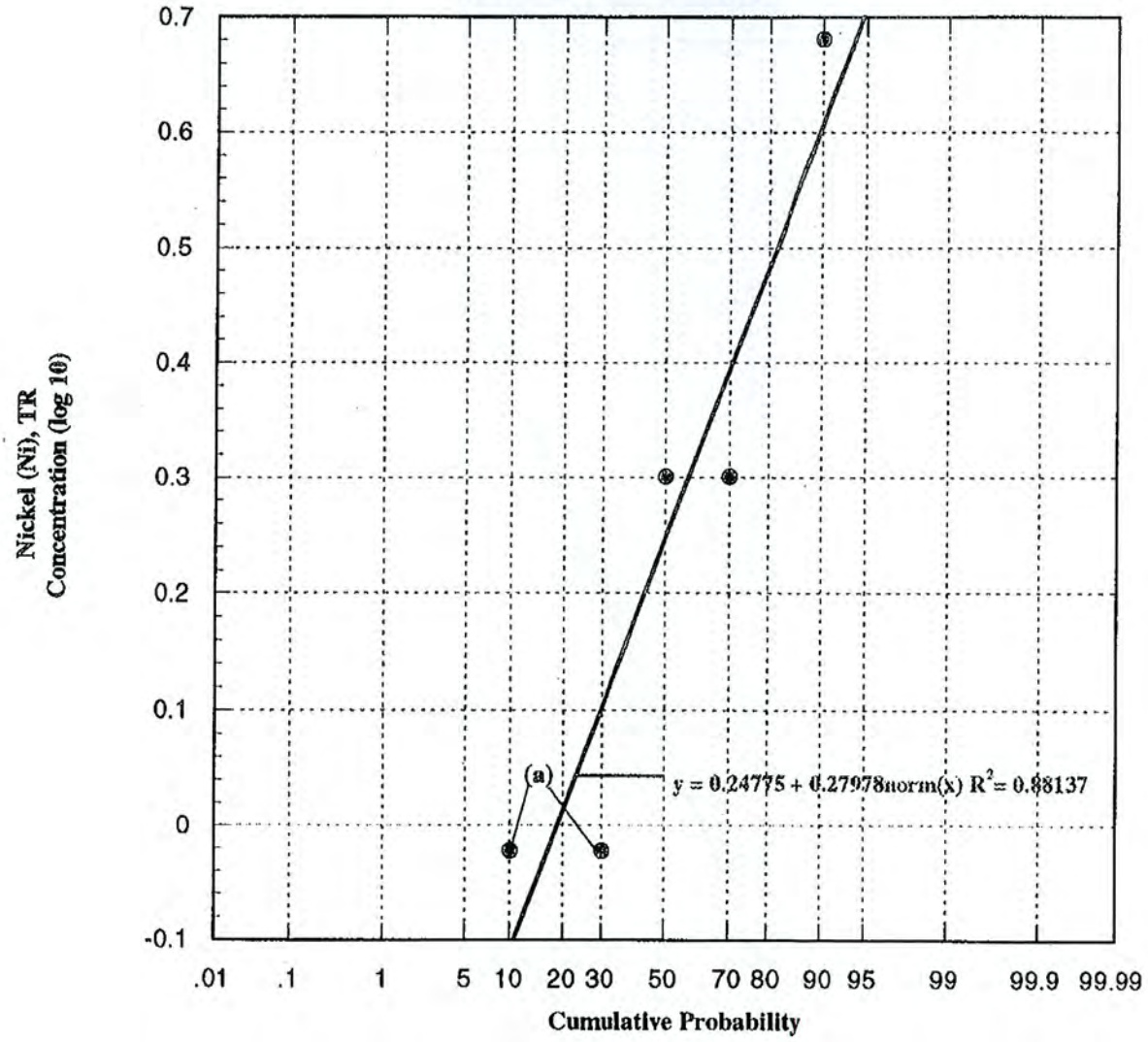
Note: There were no non-detected values in the data set.

GRAPH 42
Detention Basin "C" Influent Flow
Nickel, Total Recoverable



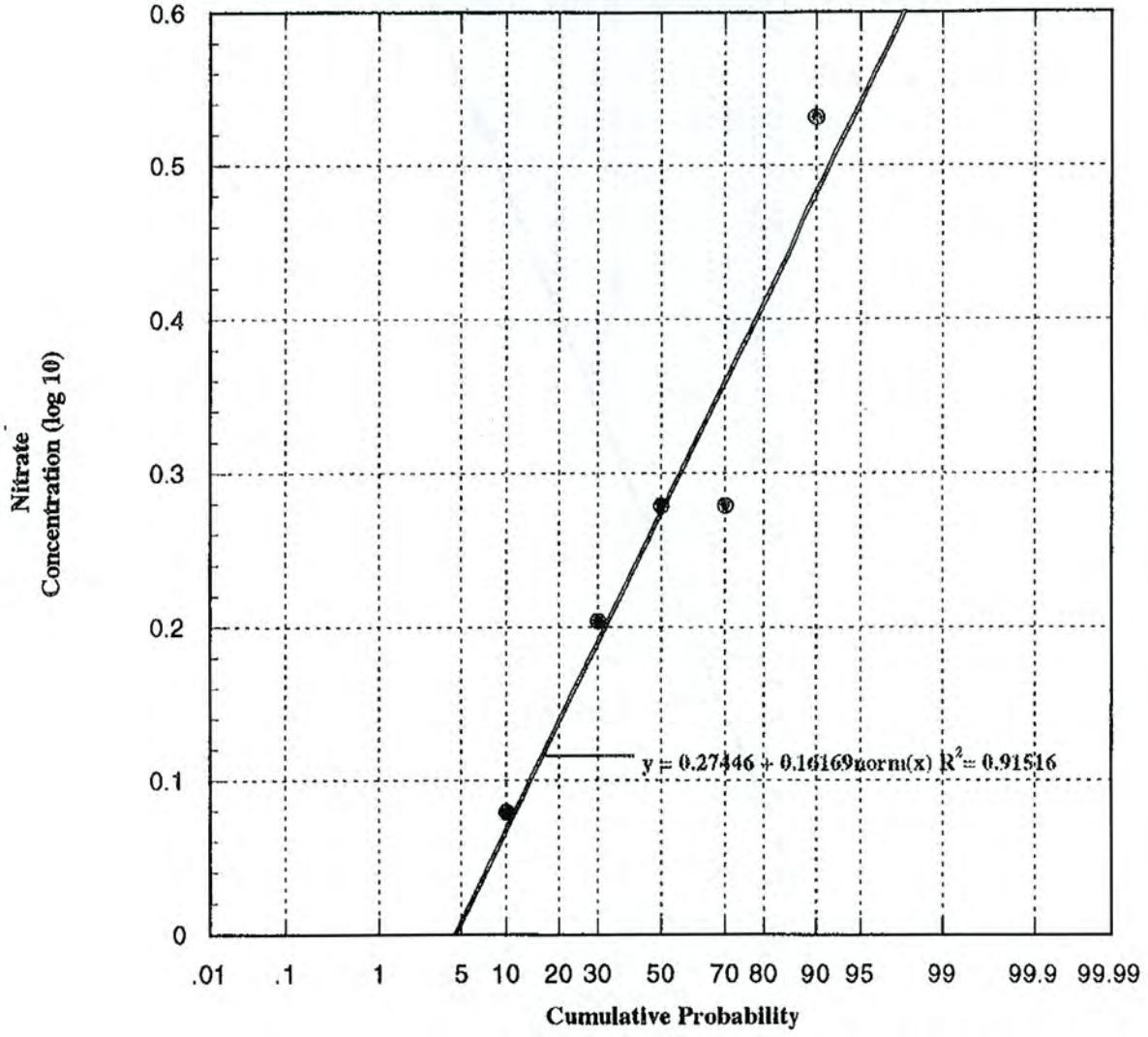
(a) Calculated nondetect values of 2.33 ug/L using Robust Method.

GRAPH 43
Detention Basin "C" Effluent Flow
Nickel, Total Recoverable



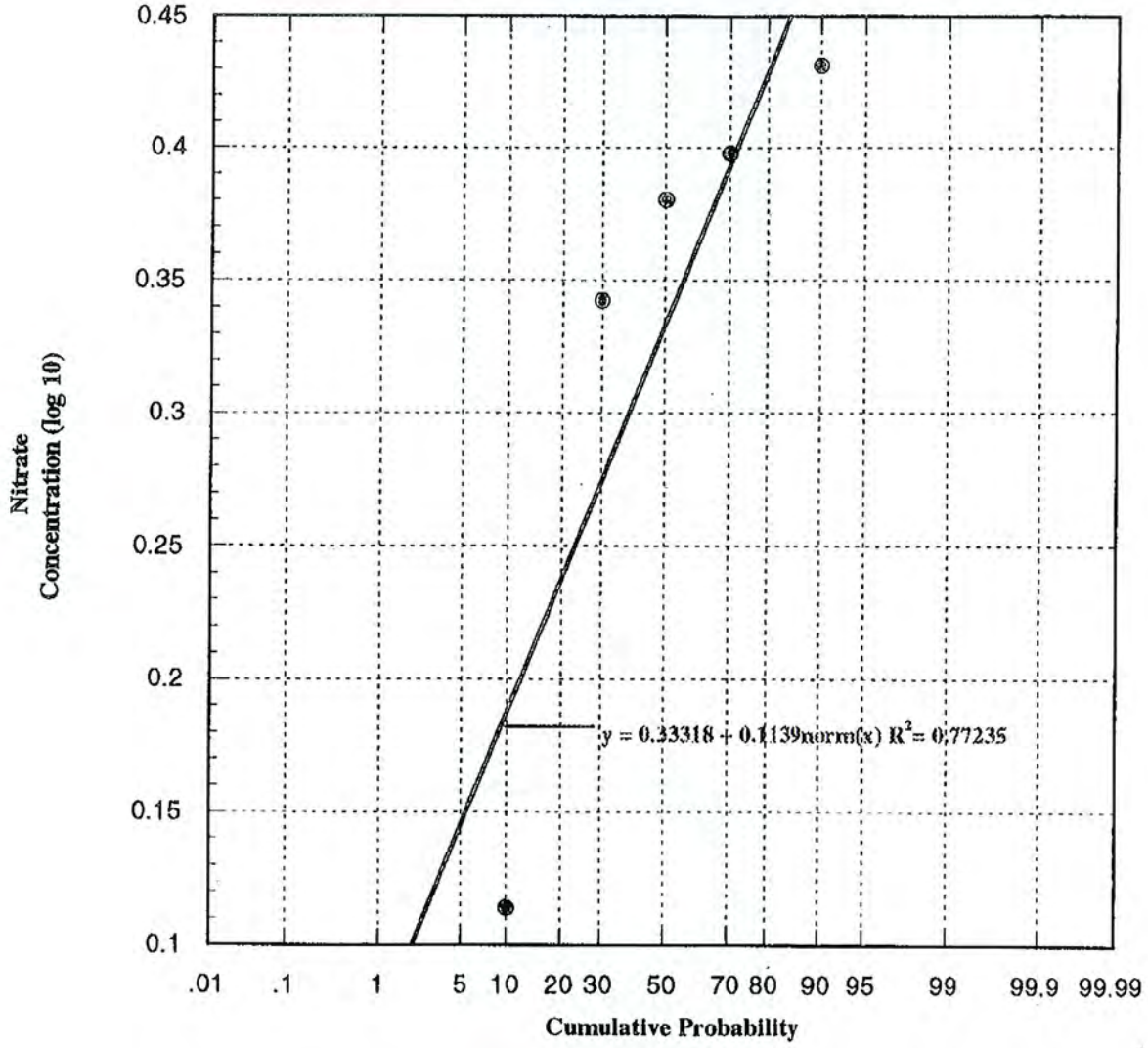
(a) Calculated nondetect values of 0.95 ug/L using Robust Method.

GRAPH 44
Detention Basin "C" Influent Flow
Nitrate



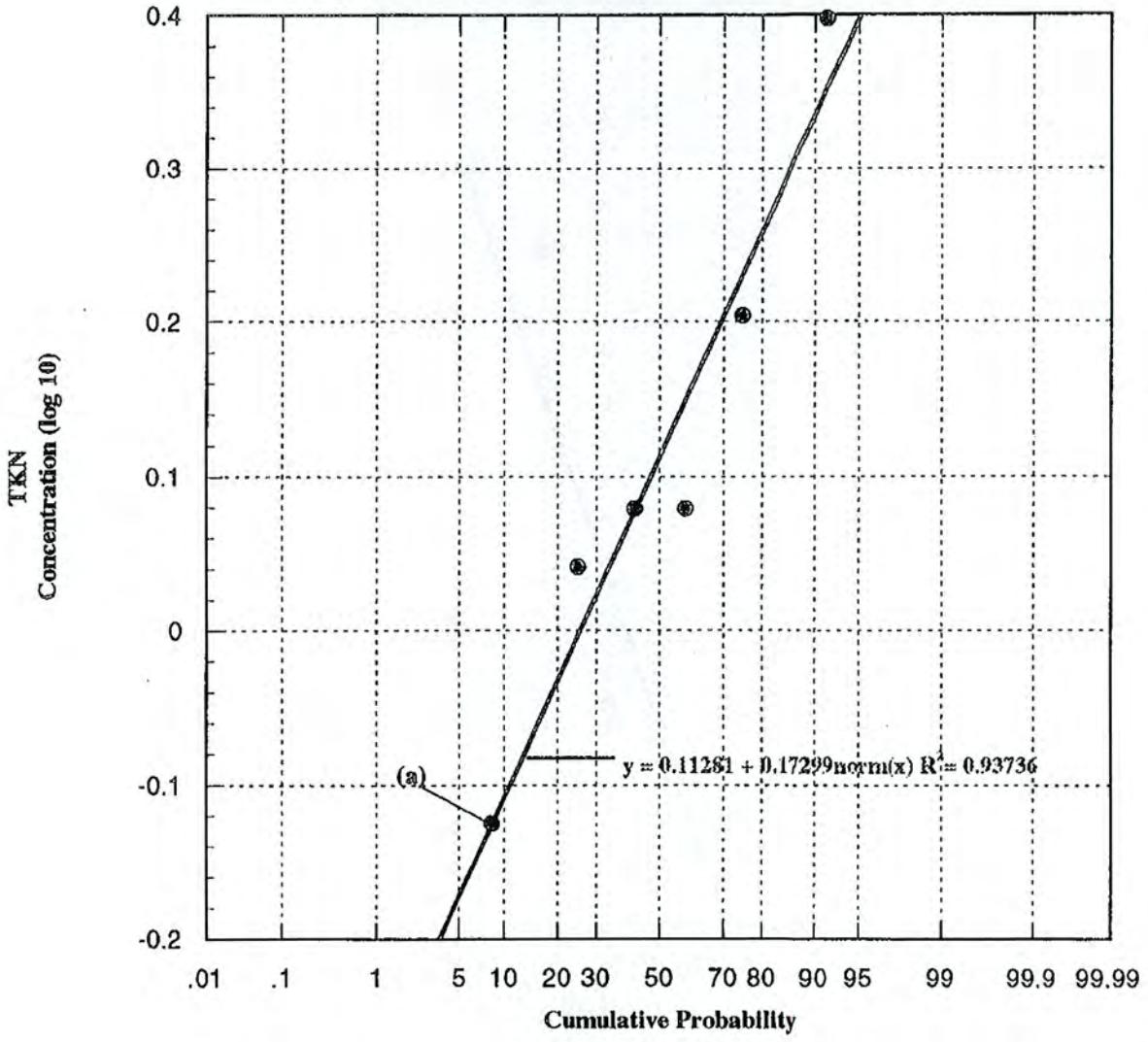
Note: There were no non-detected values in this data set.

GRAPH 45
Detention Basin "C" Effluent Flow
Nitrate



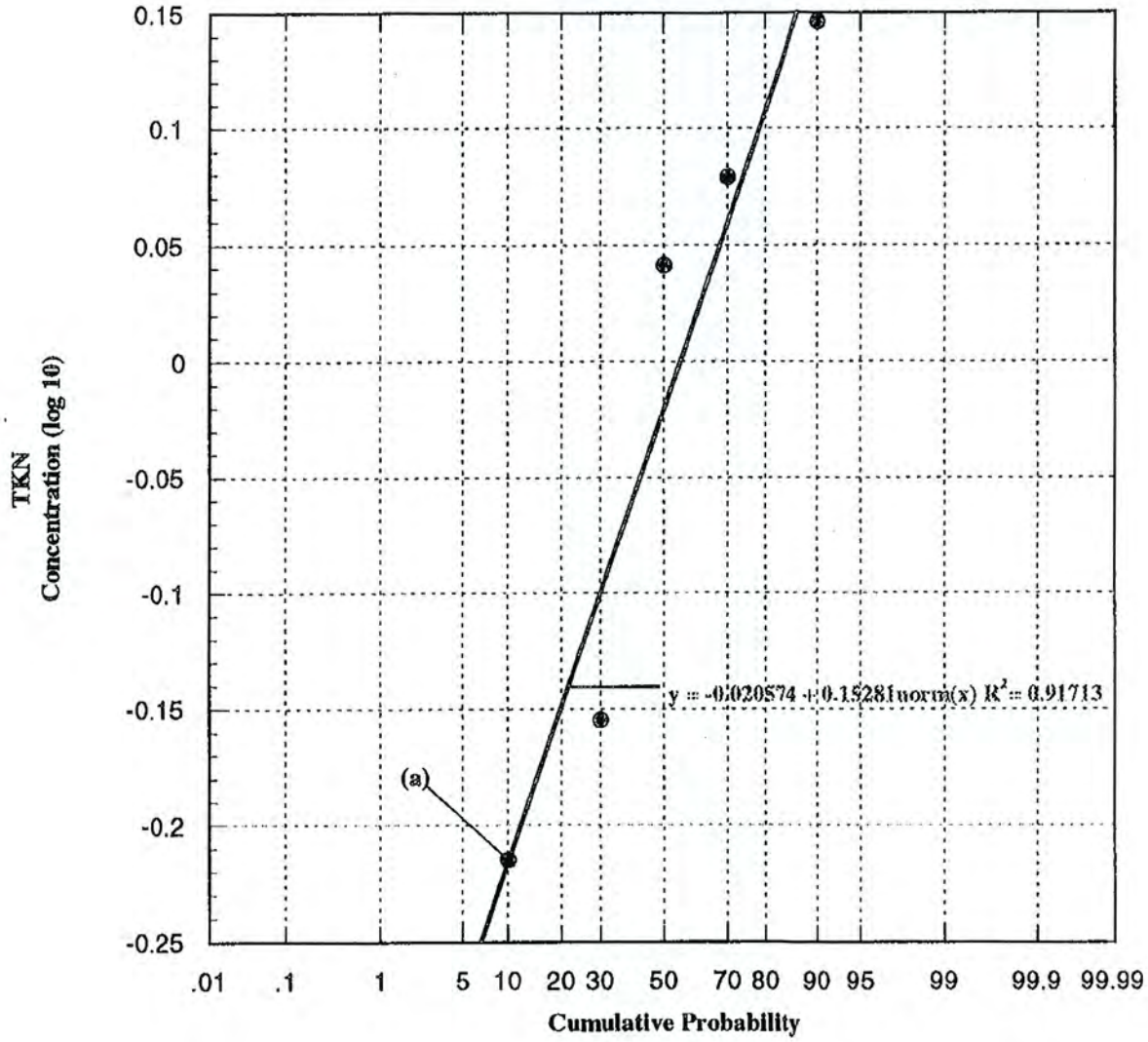
Note: There were no non-detected values in this data set.

GRAPH 46
Detention Basin "C" Influent Flow
TKN



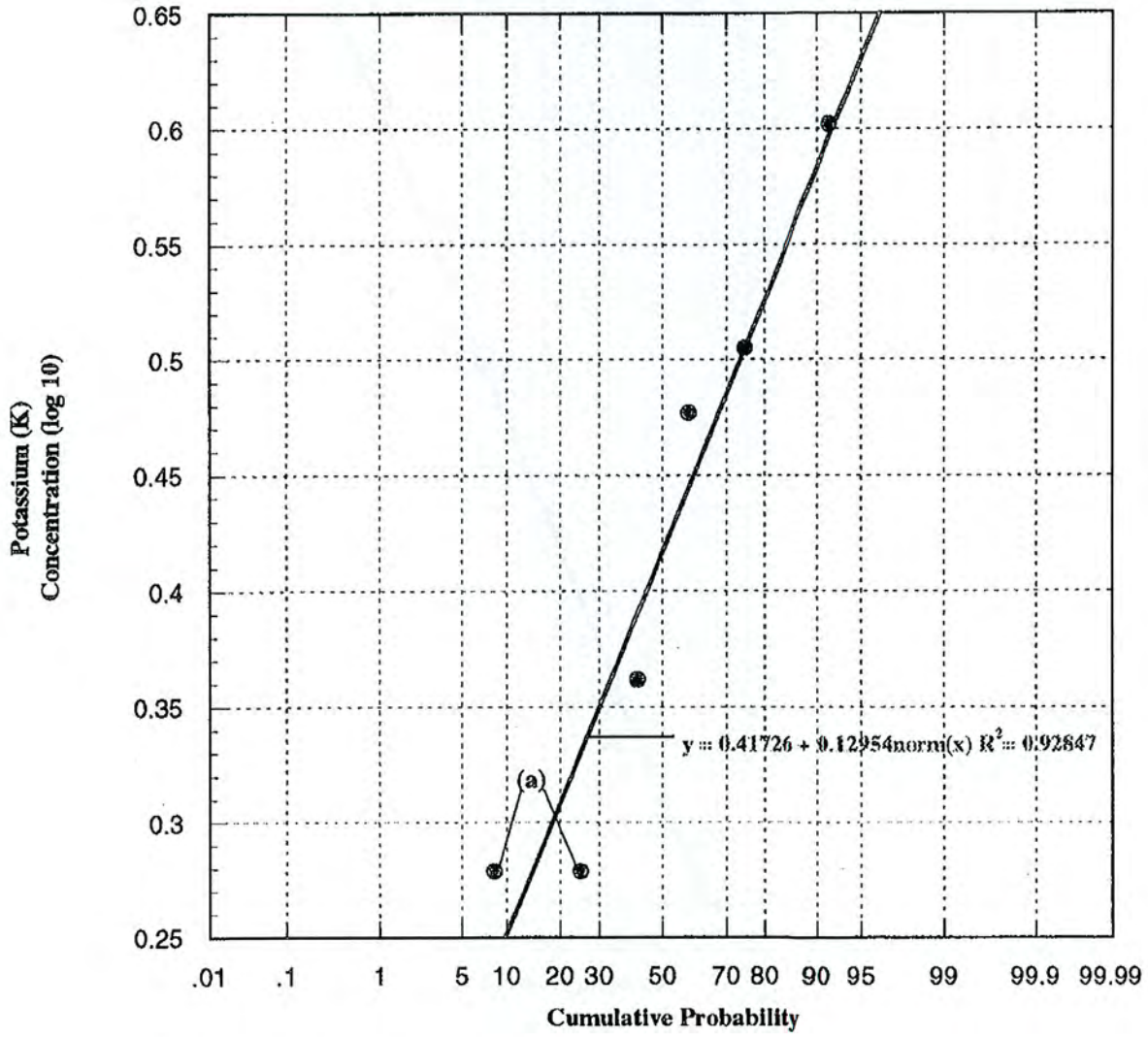
(a) Calculated non-detect values of 0.75 mg/L using Robust Method.

GRAPH 47
Detention Basin "C" Effluent Flow
TKN



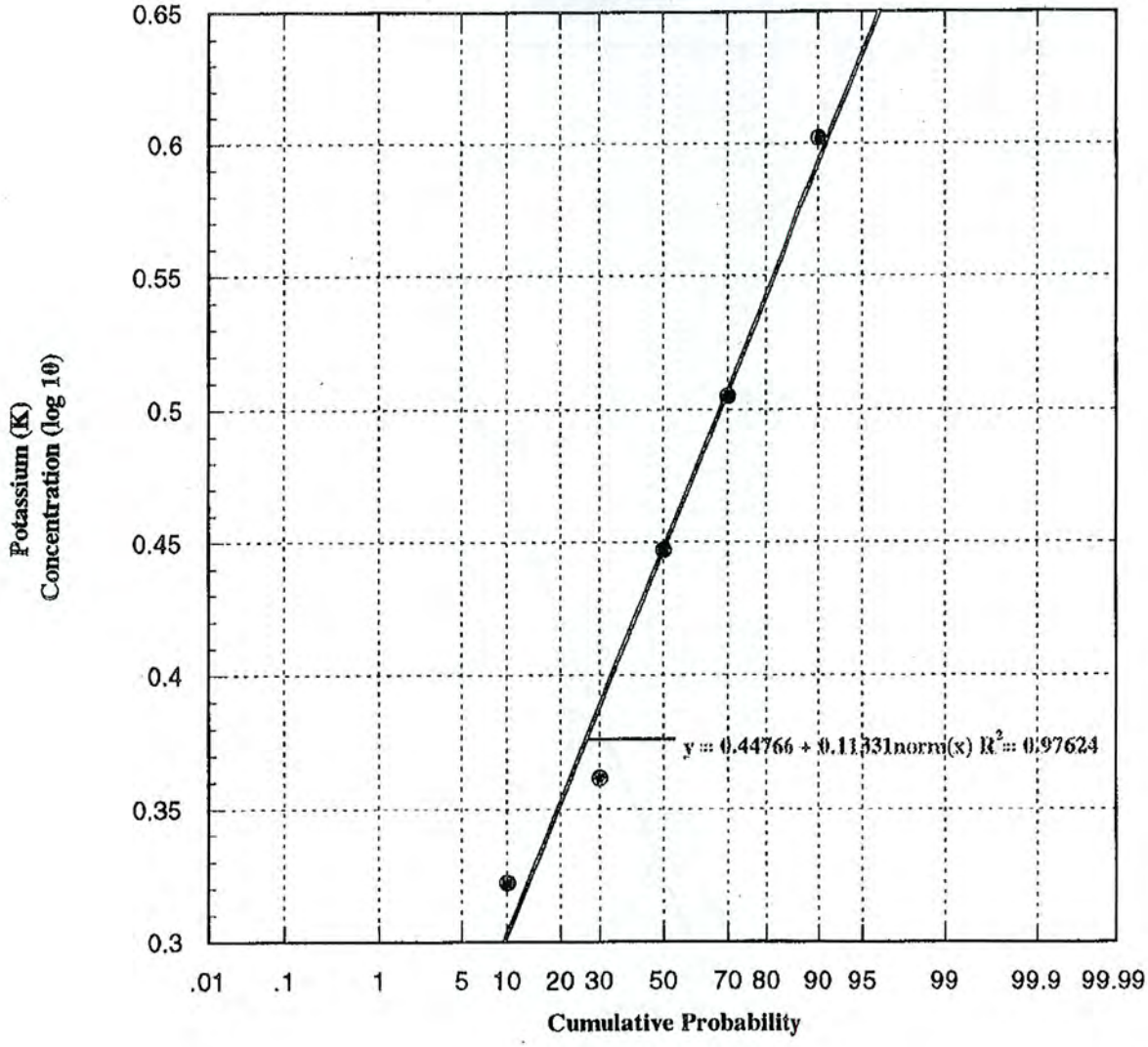
(a) Calculated non-detect values of 0.60 mg/L using Robust Method.

GRAPH 48
Detention Basin "C" Influent Flow
Potassium



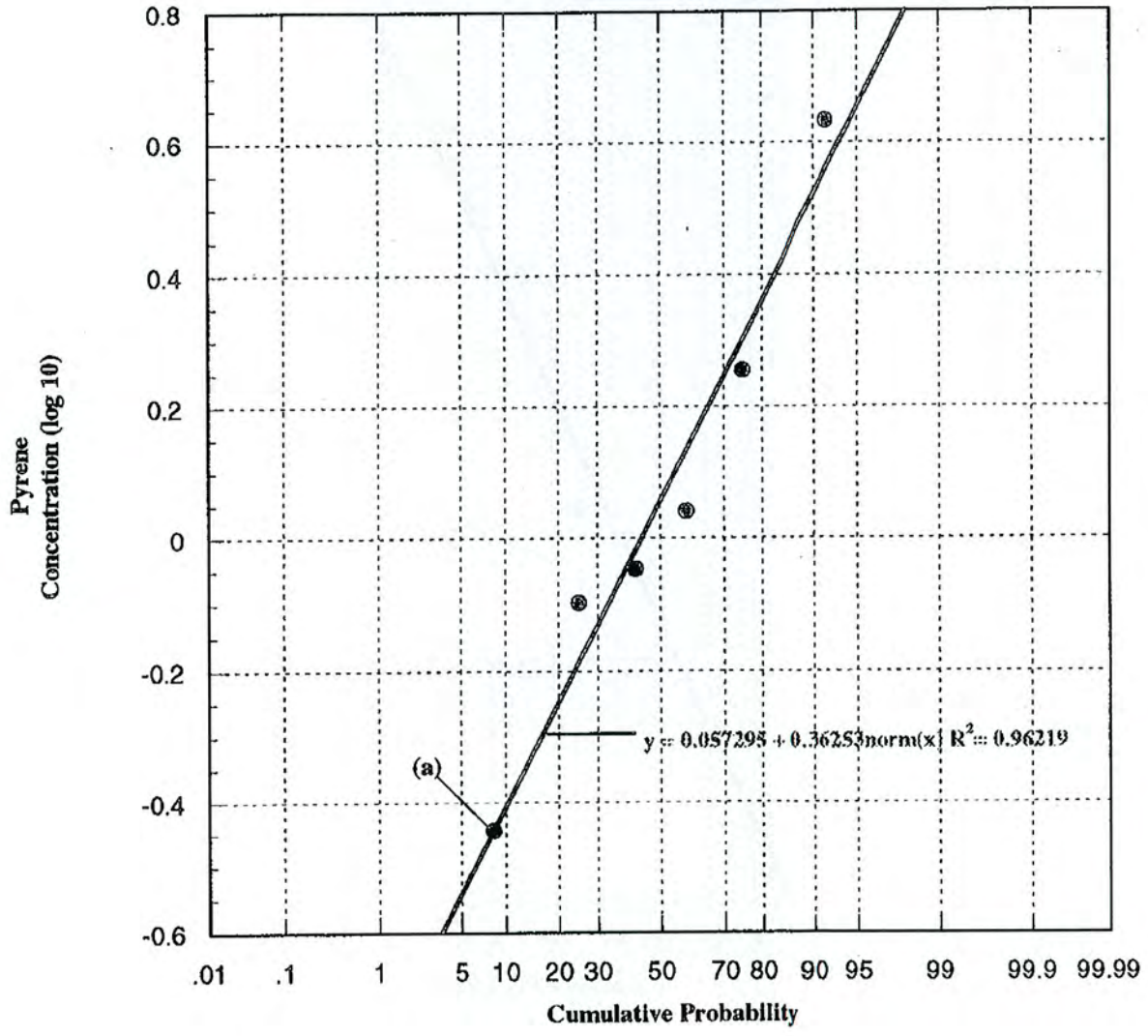
(a) Calculated non-detect values of 1.90 mg/L using Robust Method.

GRAPH 49
Detention Basin "C" Effluent Flow
Potassium



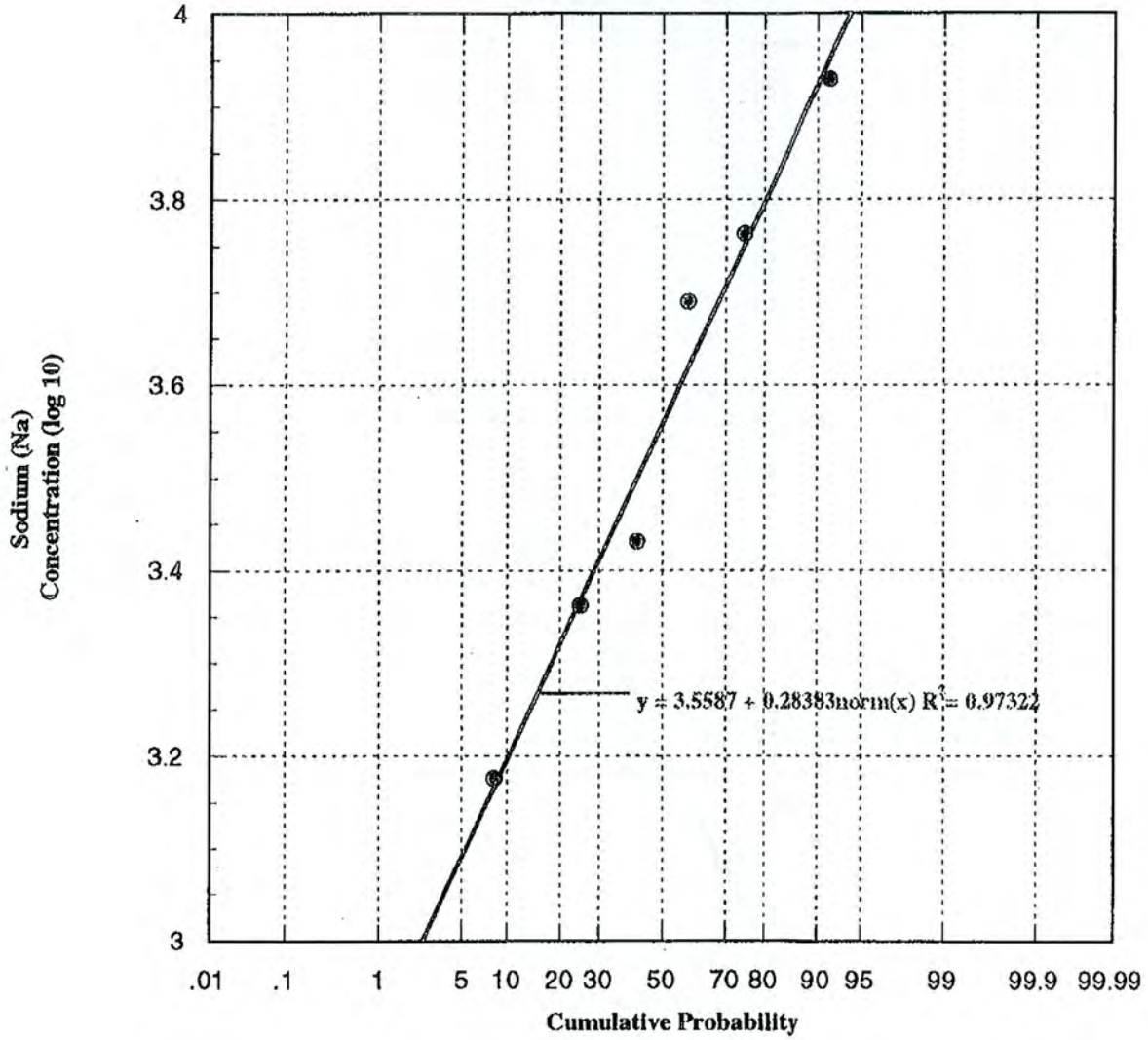
Note: There were no non-detected values in the data set.

GRAPH 50
Detention Basin "C" Influent Flow
Pyrene



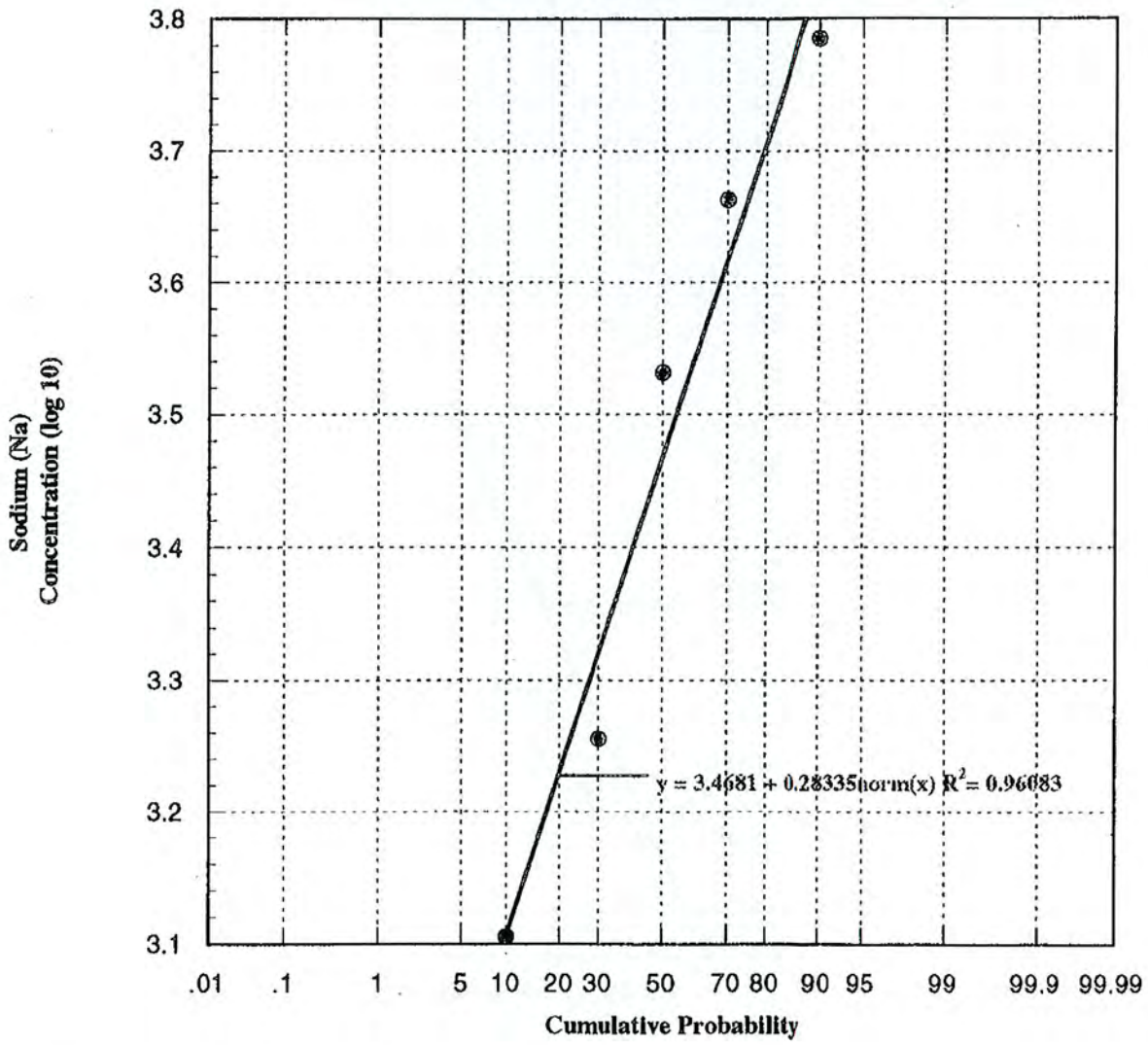
(a) Calculated non-detect values of 0.361 ug/L using Robust Method.

GRAPH 51
Detention Basin "C" Influent Flow
Sodium



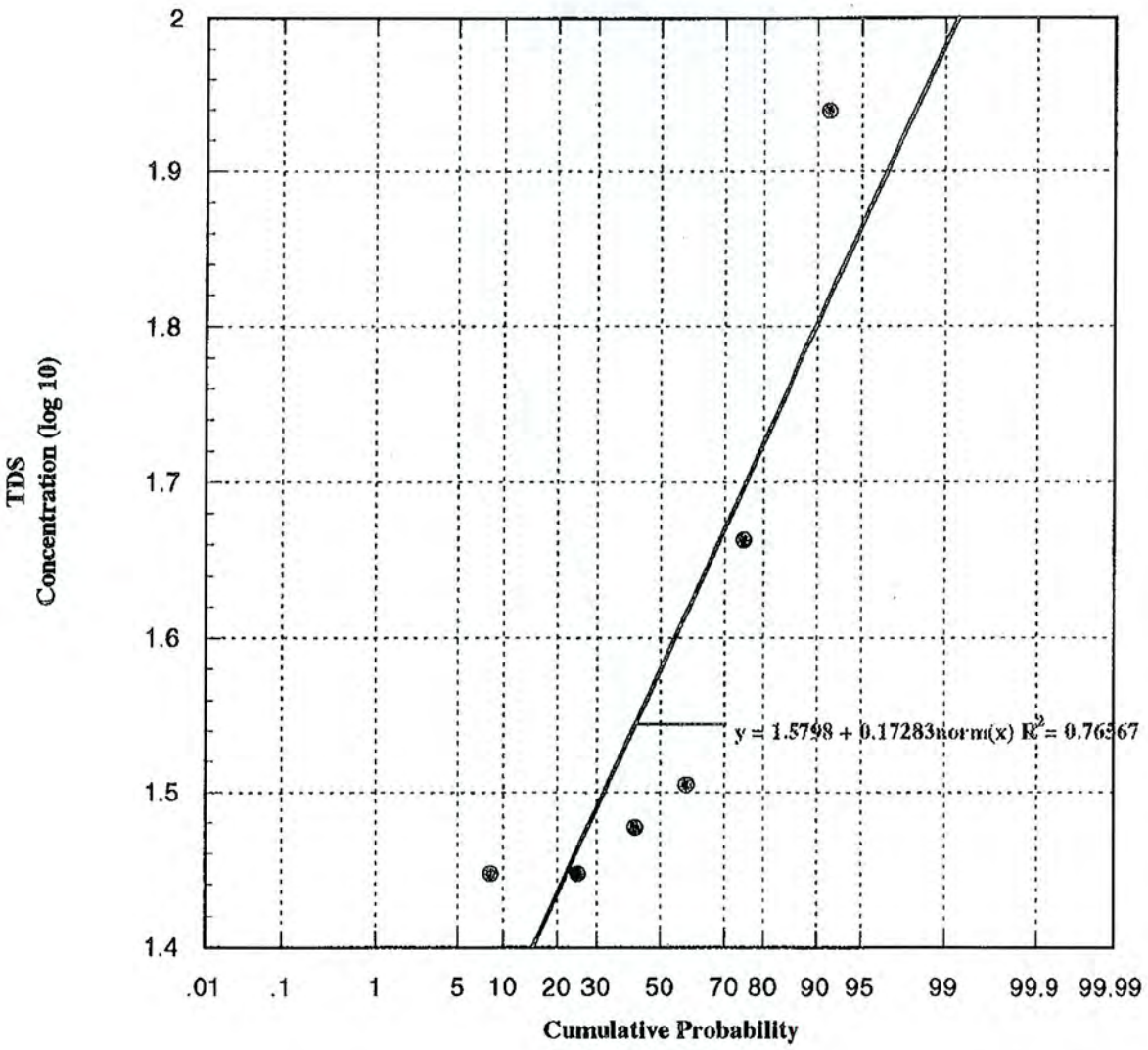
Note: There were no non-detected values in the data set.

GRAPH 52
Detention Basin "C" Effluent Flow
Sodium



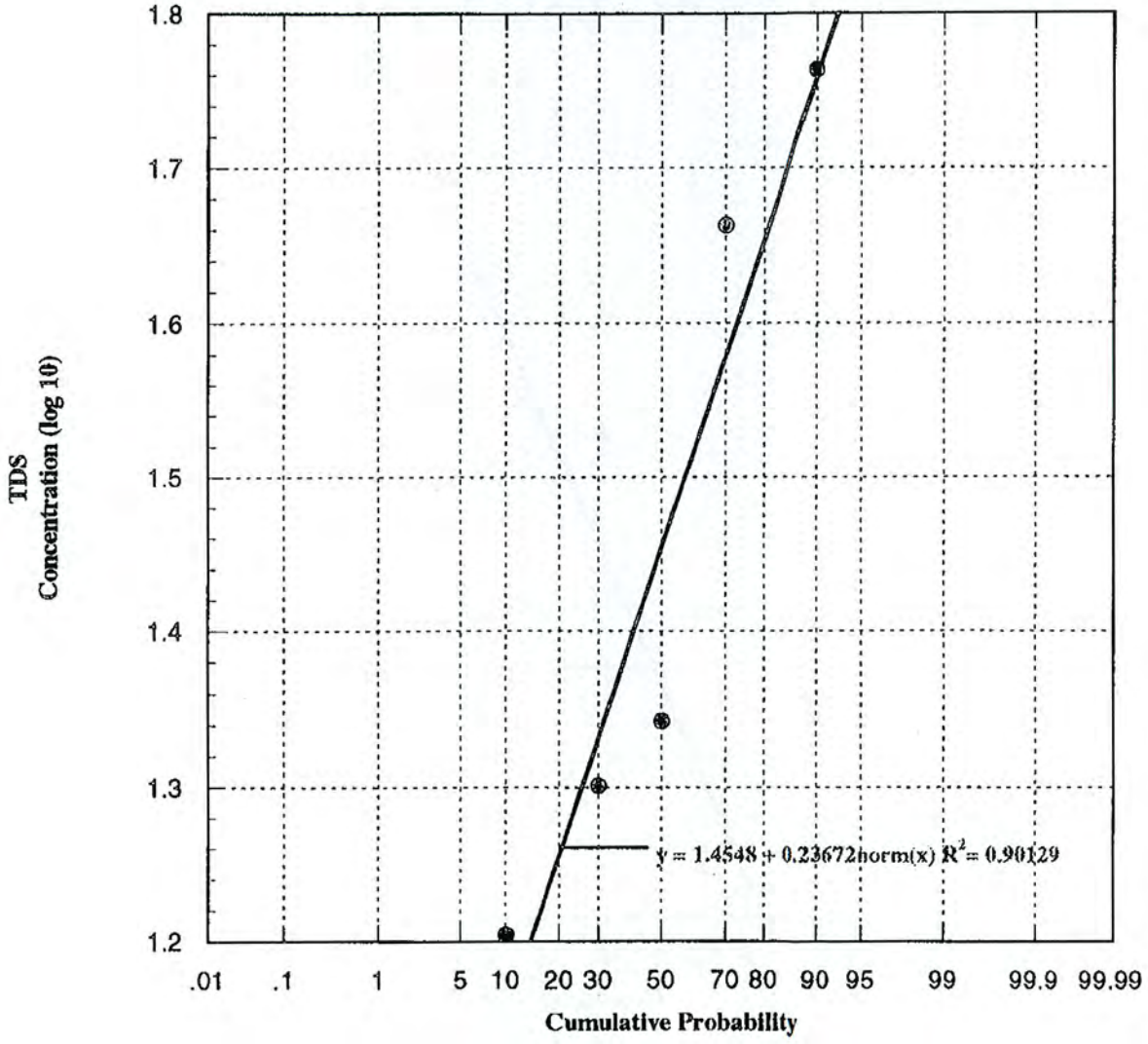
(a) Calculated non-detect values of 1274.91 ug/L using Robust Method.

GRAPH 53
Detention Basin "C" Influent Flow
Total Dissolved Solids



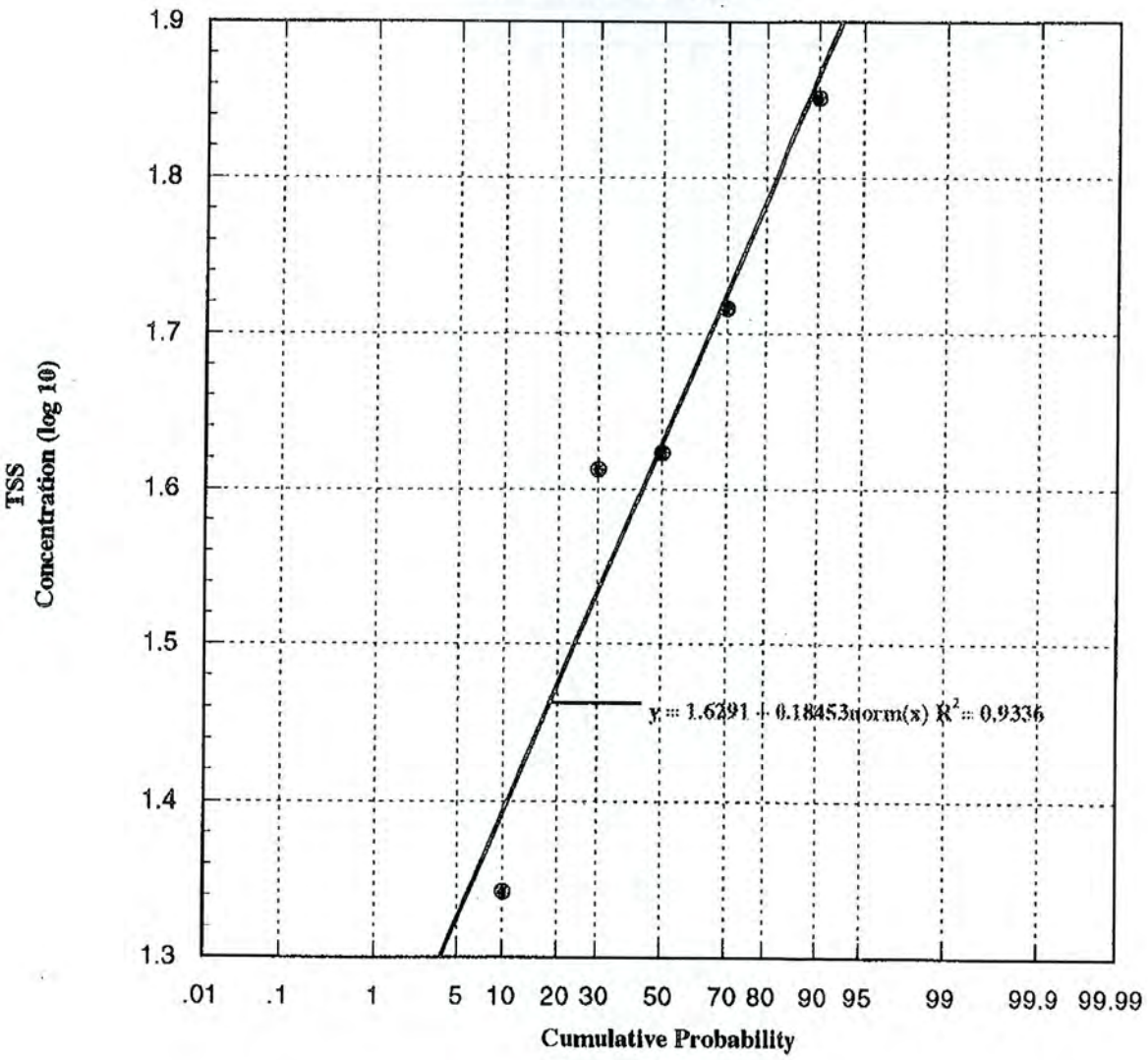
Note: There were no non-detected values in the data set.

GRAPH 54
Detention Basin "C" Effluent Flow
Total Dissolved Solids



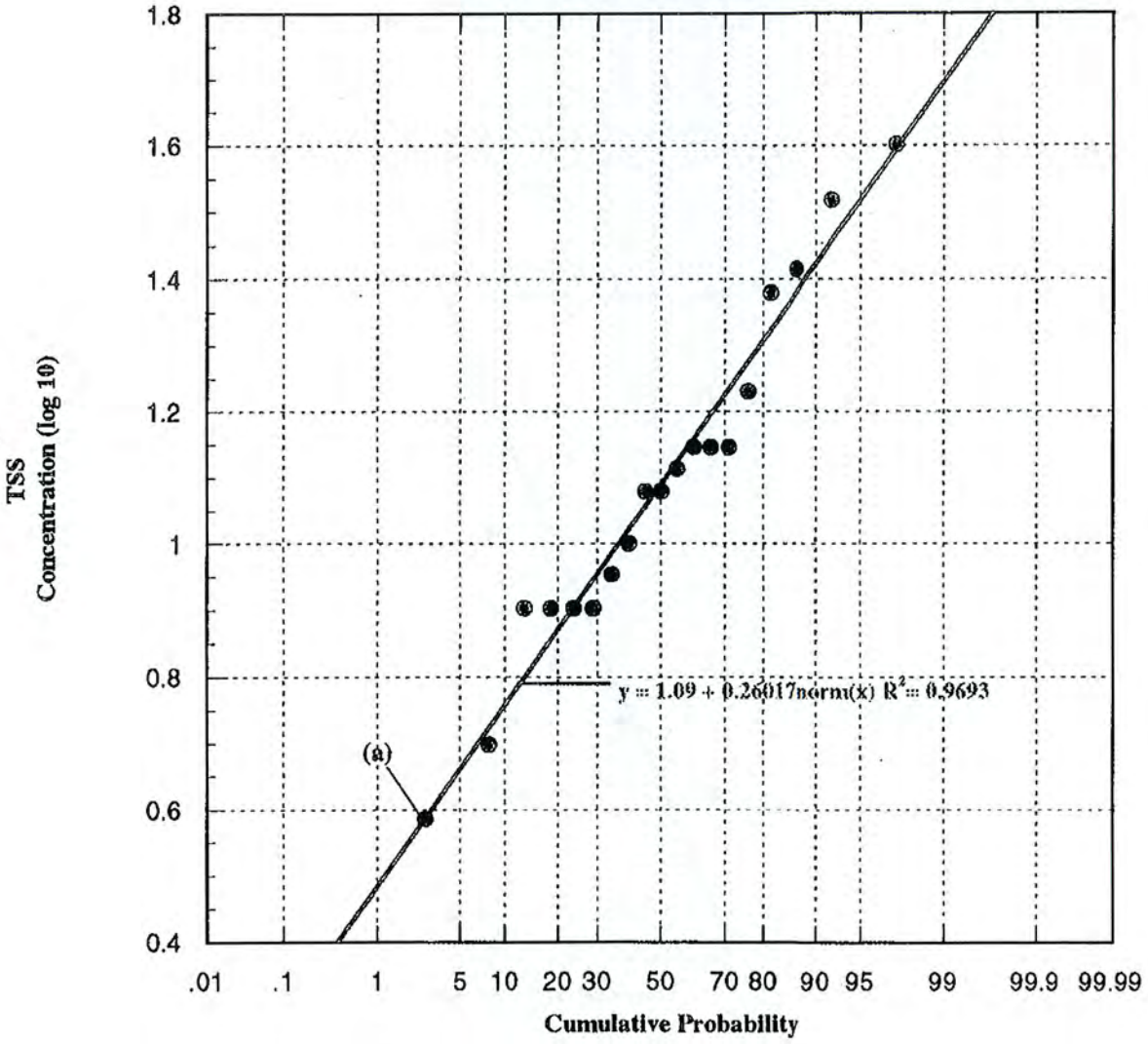
Note: There were no non-detected values in the data set.

GRAPH 55
Detention Basin "C" Influent Flow
Total Suspended Solids



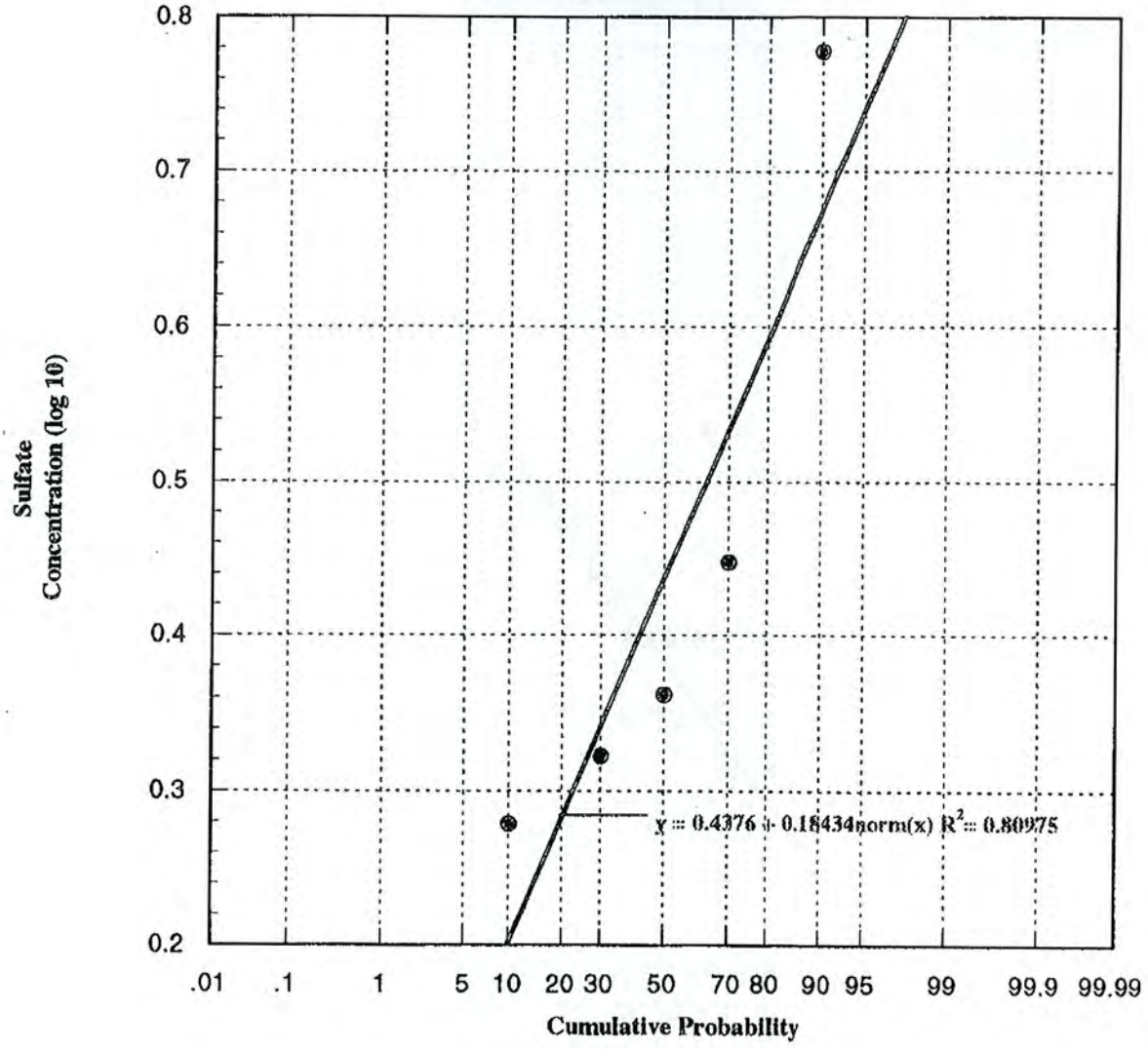
Note: There were no non-detected values in the data set.

GRAPH 56
Detention Basin "C" Effluent Flow
Total Suspended Solids



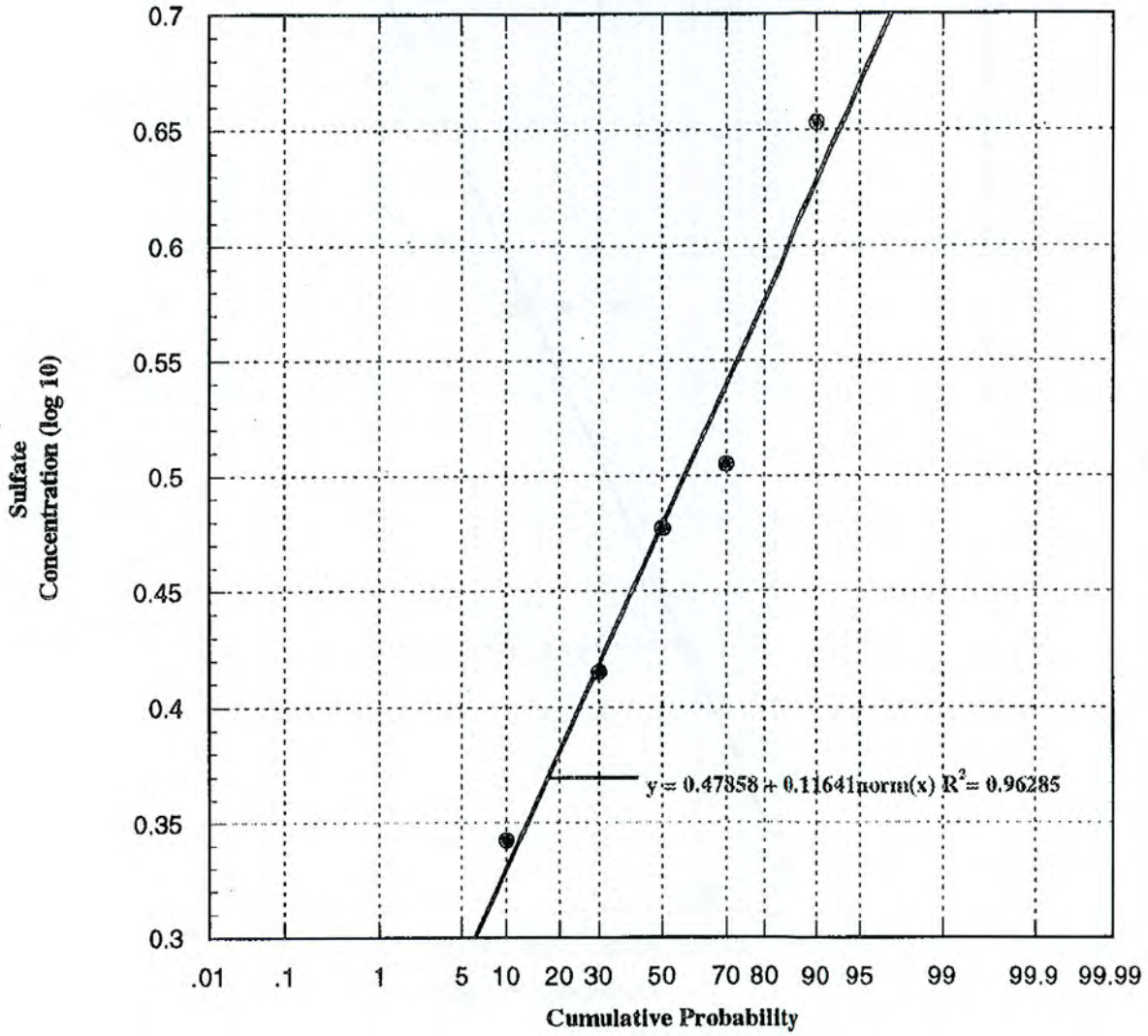
(a) Calculated non-detect value of 3.86 mg/L using Robust Method.

GRAPH 57
Detention Basin "C" Influent Flow
Sulfate



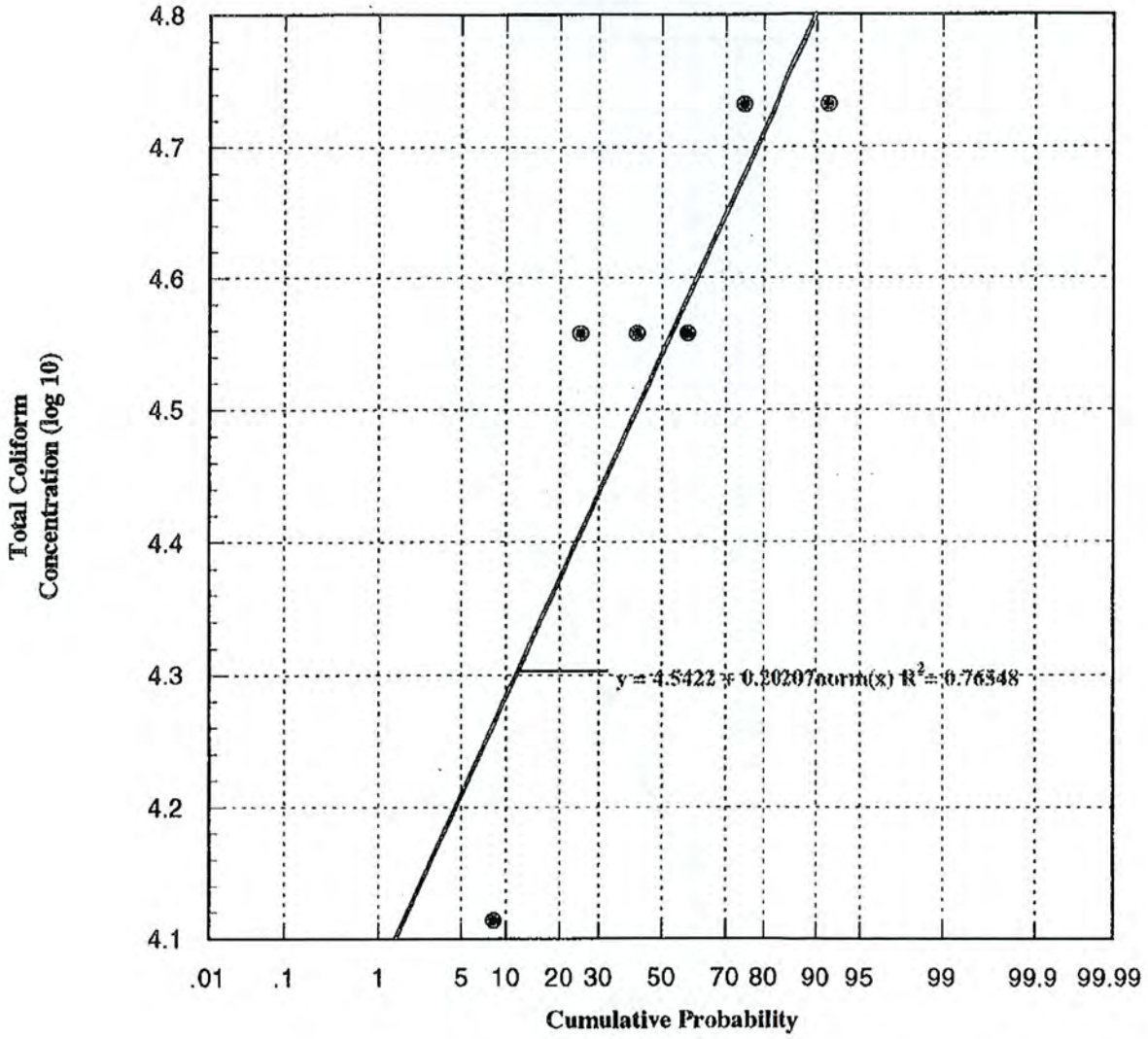
Note: There were no non-detected values in the data set.

GRAPH 58
Detention Basin "C" Effluent Flow
Sulfate



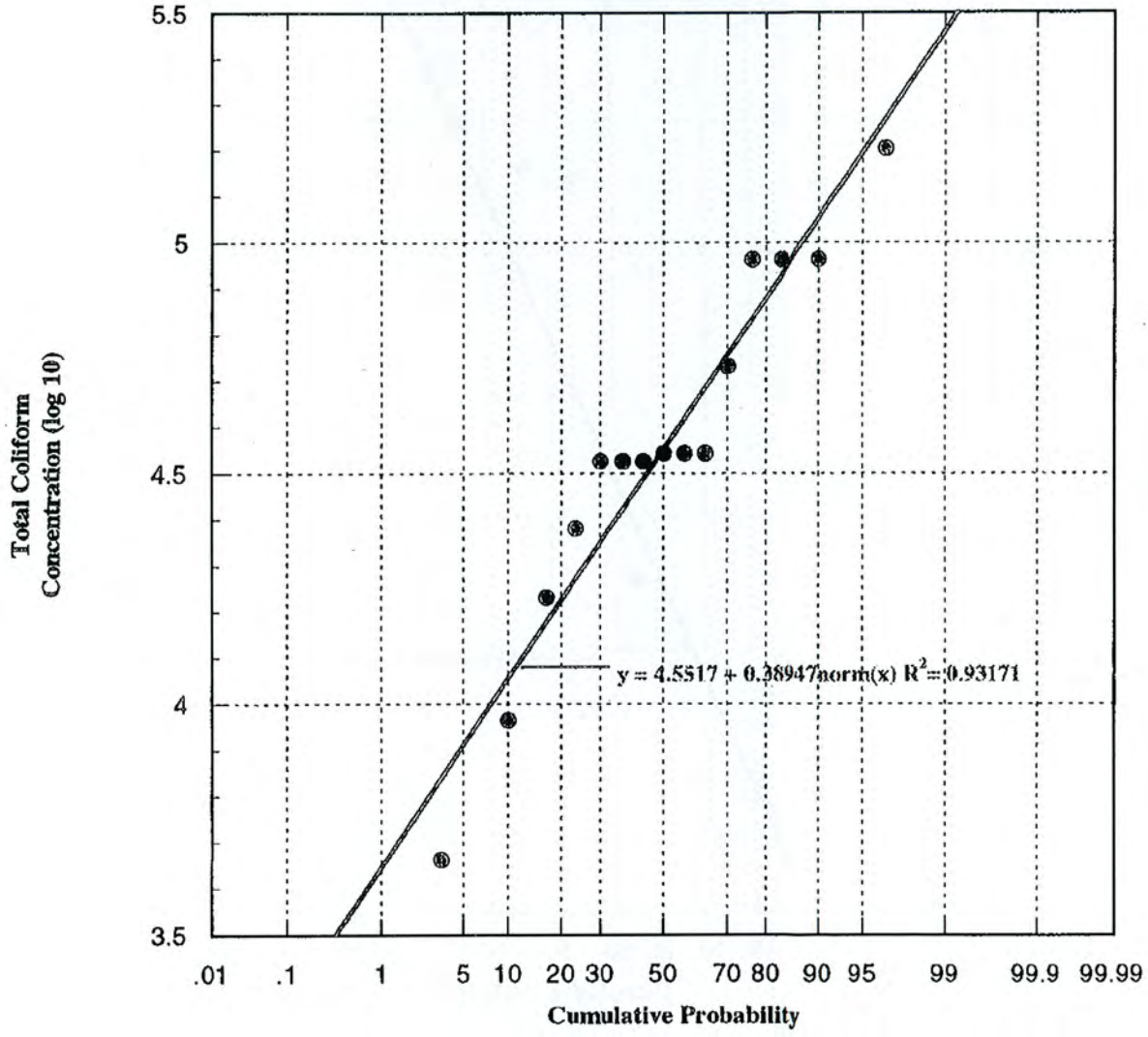
Note: There were no non-detected values in the data set.

GRAPH 59
Detention Basin "C" Influent Flow
Total Coliform



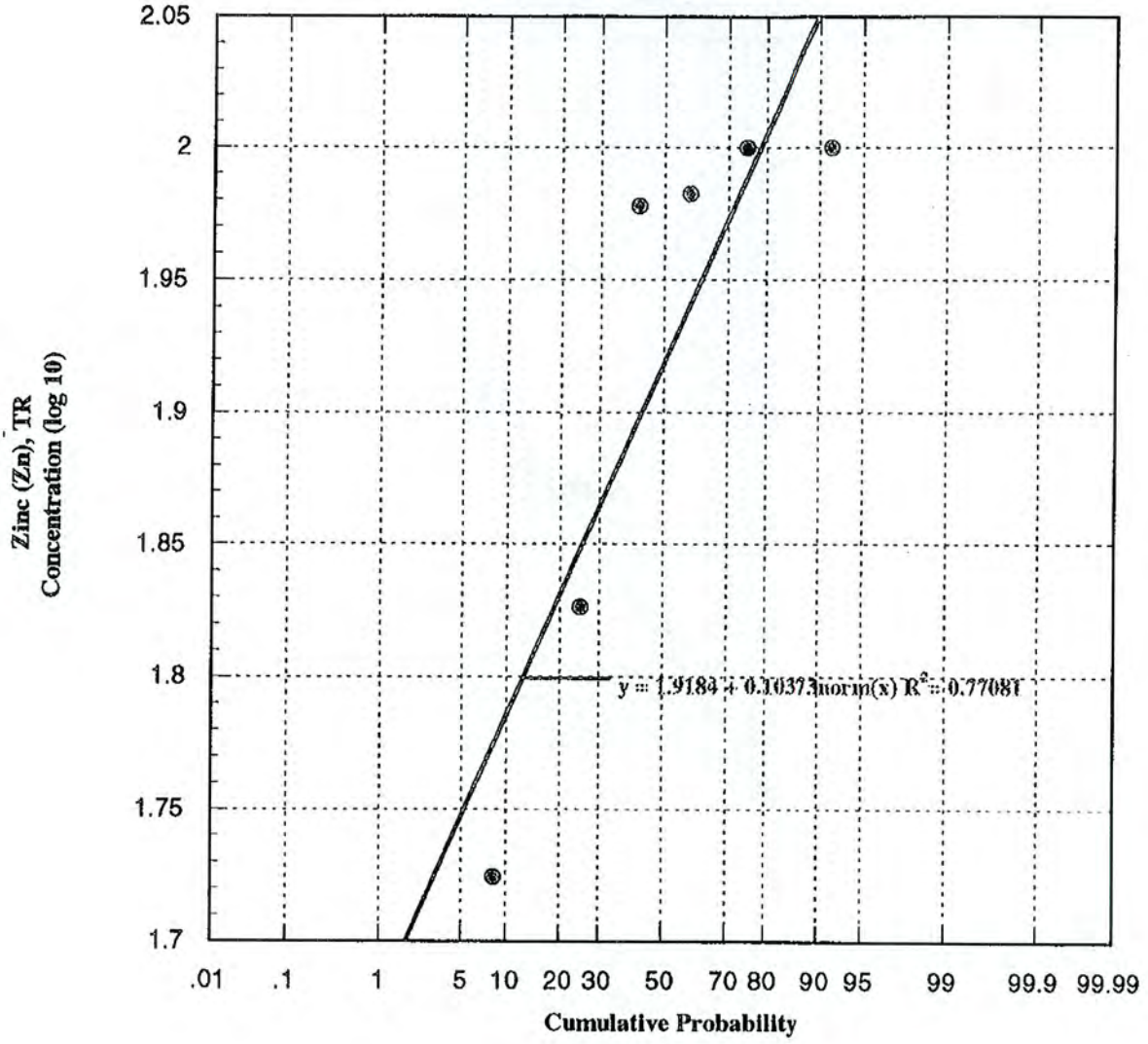
Note: There were no non-detected values in the data set.

GRAPH 60
Detention Basin "C" Effluent Flow
Total Coliform



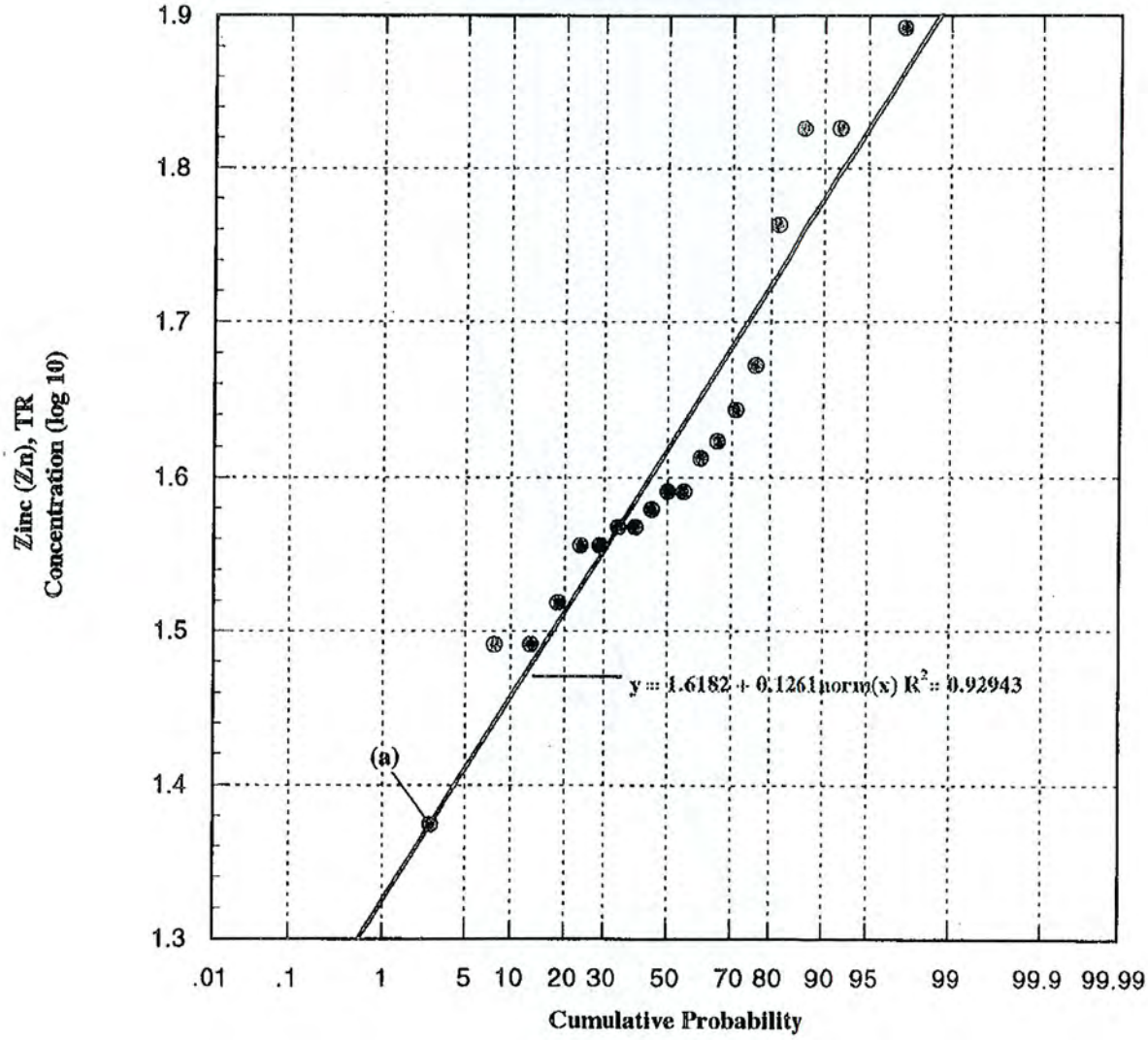
Note: There were no non-detected values in the data set.

GRAPH 61
Detention Basin "C" Influent Flow
Zinc, Total Recoverable



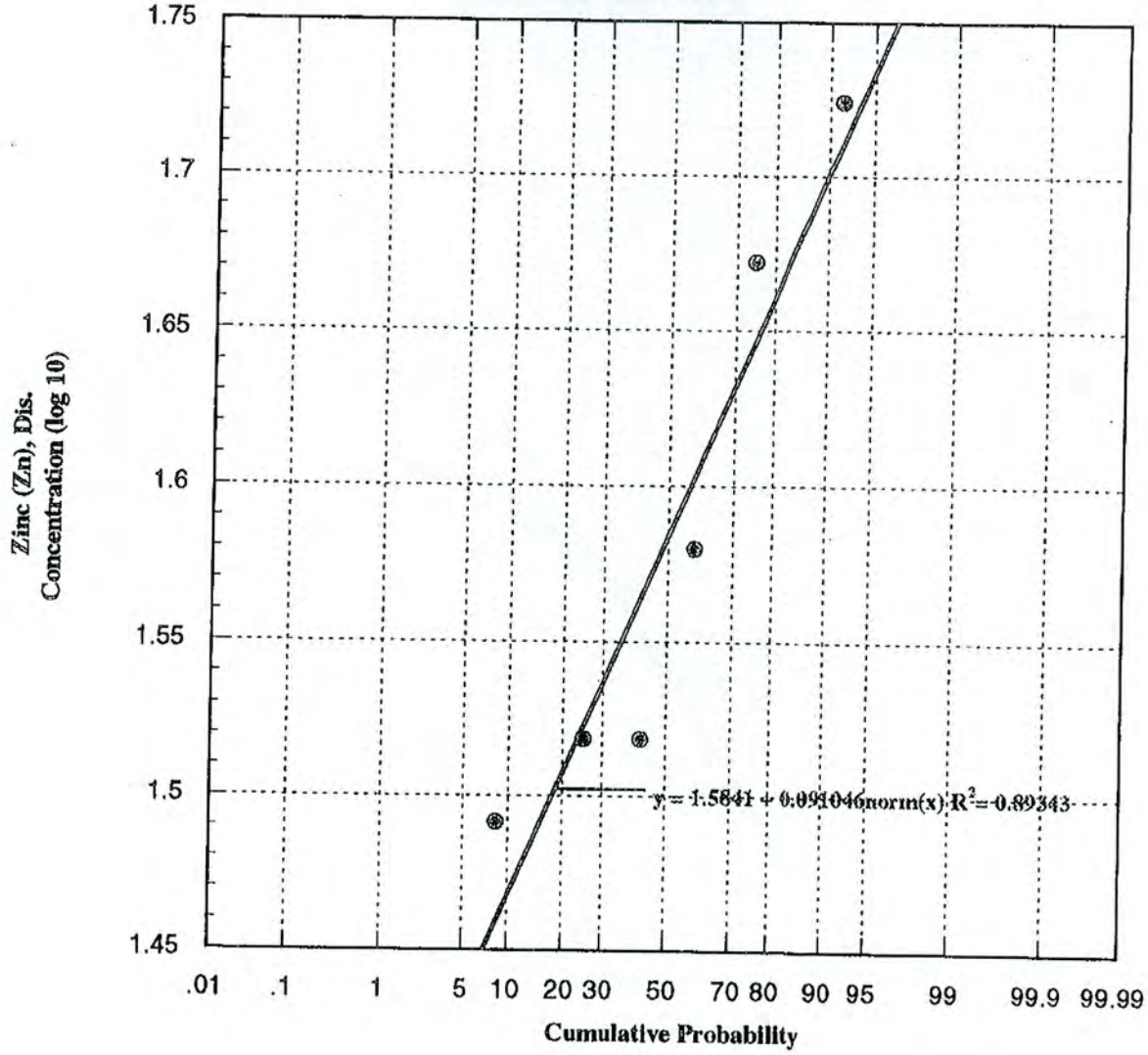
Note: There were no non-detected values in the data set.

GRAPH 62
Detention Basin "C" Effluent Flow
Zinc, Total Recoverable



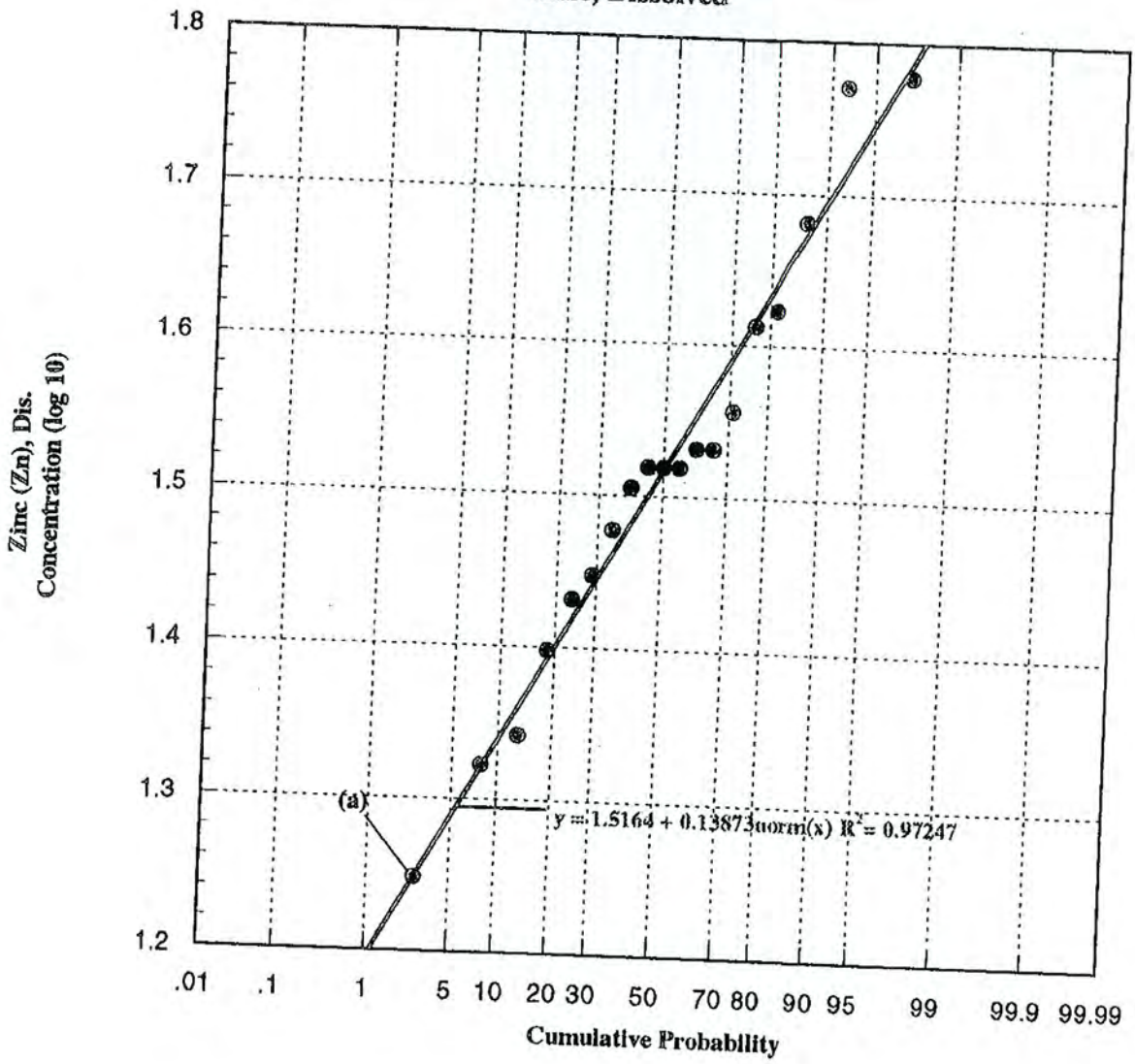
(a) Calculated non-detect value of 23.67 ug/L using Robust Method.

GRAPH 63
Detention Basin "C" influent Flow
Zinc, Dissolved



Note: There were no non-detected values in the data set.

GRAPH 64
Detention Basin "C" Effluent Flow
Zinc, Dissolved



(a) Calculated non-detect value of 17.70 ug/L using Robust Method.

Trails of Clovis

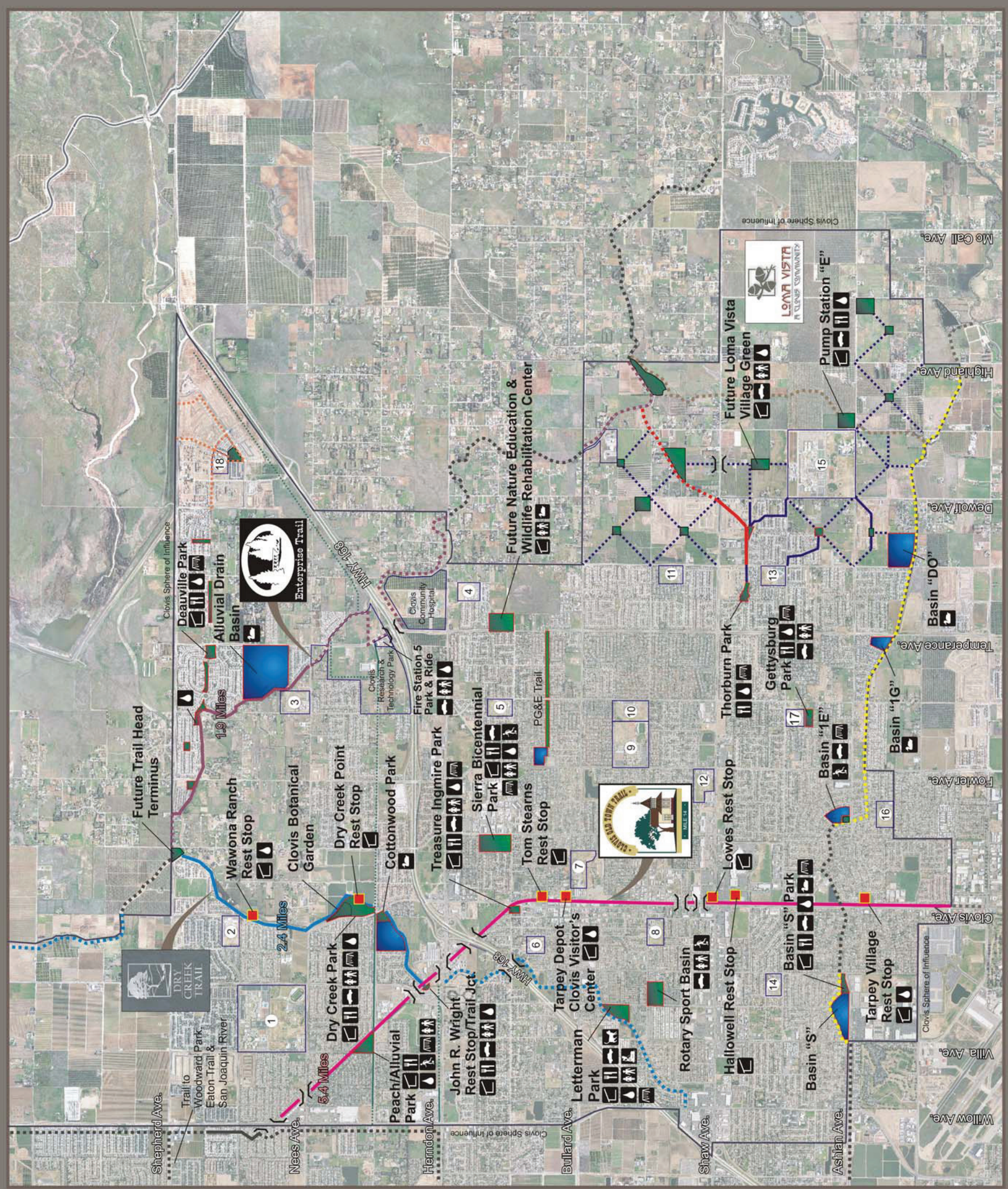


Exhibit 7-8 Federal Aviation Administration's E-Mail

From: Robert.Y.Lee@faa.gov [mailto:Robert.Y.Lee@faa.gov]
Sent: Tuesday, December 04, 2012 11:45 AM
To: Daniel Yrigollen
Cc: Arlene.Draper@faa.gov
Subject: Re: FAT Land Release

Mr. Yrigollen,

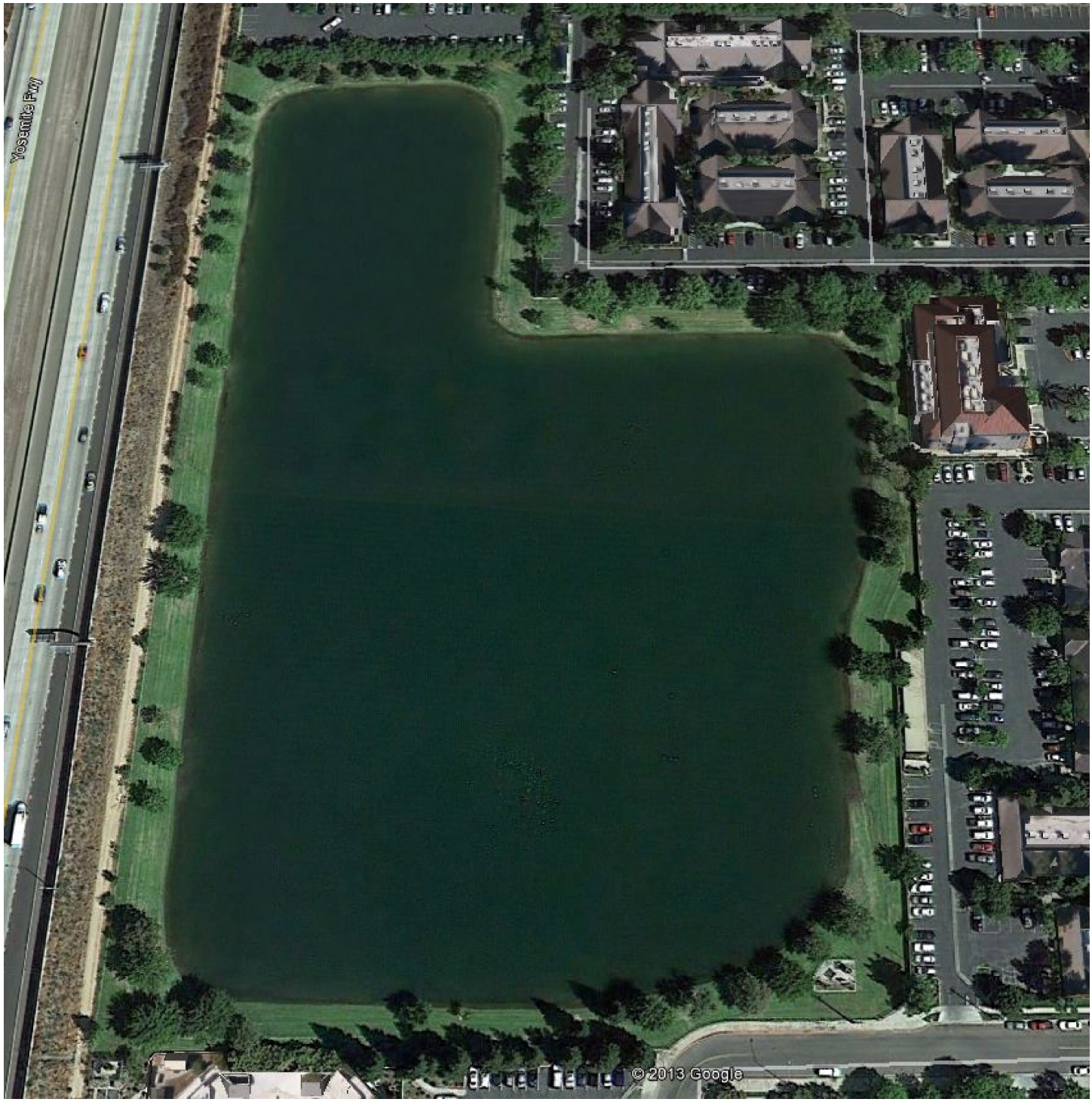
Yes - we have reached the last step of the land release process. The last step is to obtain the necessary signatures for the land release documents.

Regards,
Robert Lee
Airports Compliance Specialist
Federal Aviation administration
San Francisco Airports District Office
(650) 827-7629

Basin "R"

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

Prepared by: kyles
Date: 11/1/2012
Path: \\Gis\gis_data\TEMPLATES\Exhibit.mxd



N

Basin "N"

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

Prepared by: kyles
Date: 11/1/2012
Path: \\Gis\gis_data\TEMPLATES\Exhibit.mxd

E & J EXCAVATION

4974 North Fresno Street #569
Fresno, California 93726-0387
Off: 1-559-447-3280
Fax: 1-559-447-3285

160.8378
630.2064

Jerry Lakeman
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 93727

January 8, 2012

Dear Jerry,

Subject: Parcel Easterly of Dry Creek Extension Basin

As you are aware, I am the owner of the 24 acre parcel adjoining and easterly of the Dry Creek Extension Basin. I am a willing seller of the 24 acres, provided you pay me fair market value compensation for the property. I recognize the public benefit that would be accomplished with the expansion of the Dry Creek Extension Basin and I can assure you that the basin soil is sandy and it will percolate water rapidly. I also recognize the efficiency of expanding the current basin onto my property rather than onto other property that would not be a continuous excavation and storage area.

I also understand you are seeking a grant to assist you with the funding for the acquisition of my property and I will await approval of the grant within the next 6 months.

Sincerely,

Eugene Qualls

Eugene Qualls

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

DRAFT

2010 ANNUAL GROUNDWATER REPORT

• Fresno Irrigation District • City of Clovis • Fresno Metropolitan Flood Control District •
• County of Fresno • City of Fresno • City of Kerman • Bakman Water Company •
• Garfield Water District • Malaga County Water District • Pinedale County Water District

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1 - INTRODUCTION

In 2006, a group of nine public agencies and one private water company in the Fresno-Clovis Metropolitan Area adopted a regional Groundwater Management Plan (GMP or Plan). The Plan documents a regional approach toward groundwater management, while still addressing individual goals and issues for each of the participants. The Plan satisfies the new requirements for Groundwater Management Plans created by the September 2002 California State Senate Bill No. 1938, which amended Sections 10753 and 10795 of the California Water Code. The Plan also addresses recommended components for a Groundwater Management Plan described in Appendix C of Department of Water Resources Bulletin 118 (2003 Update). This report is the fourth Annual Groundwater Report prepared by the regional group and covers the 2010 calendar year.

1.1 - Plan Area

The Plan Area lies within the Kings Groundwater Sub-basin, which is located within the San Joaquin Basin Hydrologic Study Area (HSA). The Plan boundary generally follows the boundary of the Fresno Irrigation District (FID), extending north and east beyond the FID boundary to the Friant-Kern Canal. The participants to this Plan include:

- Fresno Irrigation District
- County of Fresno
- City of Fresno
- City of Clovis
- City of Kerman
- Malaga County Water District
- Pinedale County Water District
- Fresno Metropolitan Flood Control District
- Bakman Water Company
- Garfield Water District

Refer to **Figure 1** for a map showing the Plan Area and the location of each participant. The Plan Area covers approximately 455 square miles and is located entirely within Fresno County. In 2000, the total Plan Area population was approximately 600,000, according to US census data.

1.2 - Report Objectives

The purpose of this annual report is to:

1. Document any changes in ongoing activities
2. Document progress on planned activities identified in the GMP or previous annual reports
3. Identify any new activities that are being planned or implemented

4. Increase awareness of groundwater management efforts being performed by other local parties
5. Recommend changes to the Groundwater Management Plan
6. Document water supply statistics
7. Develop regional groundwater contour maps and evaluate trends in groundwater levels
8. Document all relevant groundwater management information to facilitate discussions among Plan participants

The following sections outline work completed by the plan participants for each of the GMP components. Specifically, the following sections describe changes in existing activities, progress on planned actions, and new activities. Existing activities described in the 2006 GMP are still being maintained, unless stated otherwise. Therefore, only changes in the existing activities are described in this report. Progress on planned actions includes progress on planned activities that were mentioned in the GMP or past annual groundwater reports. New activities include groundwater management projects that have not been mentioned in the GMP or any previous annual reports.

2 - STAKEHOLDER INVOLVEMENT
(SECTION 5 of the Plan)

2.1 - Advisory Committee of Stakeholders

Changes in Existing Activities
Al Steele of the Department of Water Resources was added to the Advisory Committee in 2006. Mr. Steel will provide input on DWR programs and third party comments on the group's efforts. Some agency representatives on the Committee have changed. The members of the committee now include:

- Laurence Kimura, Assistant General Manager, Fresno Irrigation District
- Bill Stretch, District Engineer, Fresno Irrigation District
- Brock Buche, Water Division, City of Fresno
- Lisa Koehn, Assistant Public Utilities Director, City of Clovis
- Alan Weaver, Public Works Director, County of Fresno
- Jerry Lakeman, Fresno Metropolitan Flood Control District
- Ken Moore, Public Works Director, City of Kerman
- Tim Bakman, Bakman Water Company
- Russ Holcomb, General Manager, Malaga County Water District
- Larry DeSantos, General Manager, Pinedale County Water District
- Dennis Keller, Engineer, Garfield Water District

Progress on Planned Actions
None

New Activities
None

2.2 - Relationships with Other Agencies

Changes in Existing Activities
None

Progress on Planned Actions
The Upper Kings Basin Integrated Regional Water Management Plan has been completed and is in the process of being adopted. The Upper Kings Basin Integrated Regional Water Management Plan was adopted during 2007. The Forum applied for and received approval of funding under Proposition 50 for two groundwater banking projects during 2009.

New Activities
The Cities of Clovis, Fresno, County of Fresno, FID and FMFCD staff developed a group during 2007, which meets bi-monthly to discuss operational issues related to water treatment, surface water deliveries, groundwater monitoring and recharge.

2.3 - Plan to Involve the Public and Non-Participating Agencies

Changes in Existing Activities
None

Progress on Planned Actions
Press releases are regularly issued regarding UKBWF activities.
MCWD has prepared their 2010 Bi-Annual Water Supply Report.

New Activities
None

3 - MONITORING PROGRAM
(SECTION 6 OF THE PLAN)

3.1 - Groundwater Level Monitoring

Water level measurements were collected from more than 240 wells to prepare a groundwater contour map of water levels measured from January through April 2011. Data was collected and included in the groundwater database developed for FID. Some monitored wells had no records for Spring 2010 but did have readings for Spring 2011, or vice versa. This can be problematic when calculating change between datasets and calculating average water levels for Township/Range regions. The problem is highlighted when shallow and deep wells exist within the same region. Future analysis of changing water levels will benefit from the same wells being consistently measured at the same time each year by all of the participating agencies.

Figure 2 shows the locations of the wells used to generate the contours. Refer to **Figures 3 and 4** for groundwater elevation and groundwater depth for the Plan Area, respectively. As indicated in Figures 3 and 4, a large cone of depression exists beneath the urban areas of Fresno and Clovis. Figure 4 shows depth to water in wells to be deepest in the northeastern portion of the City of Fresno area, as well as the central portion of the City of Clovis. Within the urban area, the deepest depth to water measurement recorded was 173.2 ft.

Figure 5 is a contour map showing the change in water surface elevation over the previous year. Areas of increased water levels (0-10ft) appear throughout the Plan area in both urban and agricultural regions. Some areas of decreased water levels were evident in the urban areas and the southern east central portion of the Plan Area (see Appendix A 12S21E32K, 13S21E28G, 14S21E29D). The eastern most well in the Plan Area showed an increase of 16 ft. (13S23E33B). In general the western portion of the Plan Area showed increased water levels from 2-17ft with a few pockets having slightly decreased water levels (13S19E29A, 14S19E03Q). A review of the change in water level measurements from Appendix A shows: approximately 16% of the wells were relatively unchanged (increase or decrease less than 1 ft.), 66% showed an increase in water levels (majority show 1-6 ft increase), and 18% showed a decrease in water levels.

Appendix A includes tables with groundwater level data collected by the Plan participants, and **Appendix B** includes a few selected hydrographs with historical groundwater level data.

Table 1 summarizes the groundwater pumping performed by the participants. The reporting Participants pumped more than 157,755 AF of water during the 2010 calendar year. Values in the table do not include pumping from private wells in the Plan Area.

Table 2 provides a summary of the changes that have occurred within the Plan area over the last 10 years, including the change in average depth to groundwater, and the estimated groundwater storage change per year. The average depth to groundwater within the Plan Area was calculated to be **87.0** feet below ground surface, up 3.0 feet from the previous year. To calculate the average depth to water, the method that FID historically used was calculated with some minor modifications. FID's historically used method includes:

1. FID was divided into three divisions; Southwest, Northwest and East, as shown in **Figure 2**. The reasoning behind the boundaries of each of these divisions is not known, but it is assumed to be based on hydrogeologic conditions within FID, and is roughly consistent with recent findings as part of the Upper Kings Forum groundwater investigations for the area. Although the reasoning could not be verified, it was determined to maintain these divisions, and the method used in order to keep continuity with historic data.
2. After the average depth to water for each division was calculated, the average depth for each division was then multiplied by a weighted factor for that division based on the total acreage within that division as compared to the smallest division. Because land outside of FID's boundary was added to the Plan, these acreages and weighting factors were modified. The acreages and weighting factors for each division are shown below.

Division	Acreage	Factor
East	71,848	1.00
Northwest	115,253	1.60
Southwest	104,400	1.45
Totals	291,501	4.05

3. Then to determine the overall Plan area average, the total of each division average depth to groundwater multiplied by its weighting factor was then divided by the total of all weighting factors. For example, where AD = average depth:

$$\text{Plan Area Average} = \frac{[(\text{East Division AD} * 1.00) + (\text{NW AD} * 1.60) + (\text{SW AD} * 1.45)]}{4.05}$$

The storage change calculation was also performed in the same manner that FID has historically calculated. The calculation of storage change assumes a base depth of 200 feet below ground surface and calculates the change in groundwater that occurs above that baseline. FID has included specific yields for each Township within FID for depths of 0-50ft, 50-100ft, and 100-200ft below the ground surface. The source of those specific yields has not been identified in FID reports. A review of available data found specific yields for each Township for the same depth ranges in USGS Water Supply Paper No. 1469 dated 1959, however these specific yields did not match the same numbers indicated in FID's historic data. Because the origin of the data could not be

verified, the specific yields indicated in the USGS paper were used for each Township. The specific yields for each Township are shown in Table 3. The process for calculating storage capacity includes the following steps:

1. Calculate average depth to groundwater for each Township based on the well data collected.
2. Multiply the height of water within each depth zone by the specific yield for that depth zone and by the area of that Township within the Plan area.
3. Sum the total storage capacity for all Townships.
4. Then compare the storage capacity from one year to the next. These values are shown in Table 3. Since the specific yield values changed, as well as the total acreage because of the increase to the Plan area, values for 2006 indicate a change in calculations. To more accurately represent the change from 2005 to 2006, values for 2005 were calculated using the revised specific yields and modified acreage.

A lack of well data exists for Township 12S, Range 22E, so this area was not included in the storage change calculations. Additional wells in this township, and generally in the area between the Enterprise Canal and the Friant Kern Canal need to be identified and included in the water level monitoring network.

Figure 6 graphs some of the data from Table 2, including average depth to groundwater, estimated storage change, and total surface water delivered.

Changes in Existing Activities
None

Progress on Planned Actions
Some participants will begin sounding water levels in different months to be consistent with other participants.

New Activities
Clovis will begin documenting the reference point for depth to groundwater measurements to come up with groundwater elevations. Clovis has decided that this year we will also collect static water levels around April 1 as a comparison to the February levels.
Bakman Water Company will alter its schedule for well sounding and try to gather the data twice per year in January and April to correspond with other agencies.

3.2 - Groundwater Quality Monitoring

Changes in Existing Activities

None

Progress on Planned Actions
None

New Activities
None

3.3 - Monitoring Protocols

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

3.4 - Land Surface Subsidence Monitoring

Changes in Existing Activities
In the City of Clovis staff has become aware of potential subsidence in the Herndon Avenue corridor from Peach Avenue to Minnewawa Avenue.

Progress on Planned Actions
None

New Activities
None

3.5 - Surface Water Monitoring
Table 4 summarizes surface water deliveries made by the Plan participants during the 2010 calendar year. FID and GWD deliver surface water to the plan area. FID and GWD combined to deliver nearly **553,191** AF of water during 2010 into the Plan area. Although International WD is not a Plan participant, they delivered **1,185** into the Plan area. Not included in the delivery totals for FID is **11,091** AF of reclaimed groundwater. Water was delivered to growers for agricultural irrigation, the cities of Fresno and Clovis for treatment for domestic uses, and to numerous basins and ponds for groundwater recharge.

Changes in Existing Activities

None

Progress on Planned Actions
None

New Activities
None

4 - GROUNDWATER RESOURCES PROTECTION
(SECTION 7 OF THE PLAN)

4.1 - Well Destruction

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

4.2 - Well Construction Policies

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

4.3 - Wellhead Protection

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

4.4 - Saline Water Intrusion

Changes in Existing Activities
None

Progress on Planned Actions

None

New Activities
None

4.5 - Migration of Contaminated Groundwater

Changes in Existing Activities
None

Progress on Planned Actions
Refer to **Figure 7** for a map of contaminant plumes in the Plan Area. This map does not include all of the known plumes in the Plan Area, but represents the City of Fresno's efforts during 2006 to document the location of most of the known plumes as part of an update to the City's Water Resources Management Plan. Primary concerns include EDB, TCP, DBCP, and areas of higher nitrate levels. A brief description of each plume is also included.

New Activities
None

4.6 - Groundwater Quality Protection

Changes in Existing Activities
None

Progress on Planned Actions
Clovis has upgraded security at some of its water facilities within the past year by replacing and upgrading fencing and adding surveillance cameras.

New Activities
None

5 - GROUNDWATER SUSTAINABILITY

5.1 - Groundwater Recharge

Included in **Table 4** are the total deliveries made for groundwater recharge to City of Fresno, City of Clovis and FMFCD facilities. These deliveries totaled more than **87,380** AF in 2010, including delivery to more than 60 different FMFCD basins. Not all FID-owned recharge ponds have measurement devices, so the amount of recharge at FID ponds has not been separately quantified in this report. Recharge deliveries to FID-owned facilities is included in the total deliveries shown in **Table 2.**

Changes in Existing Activities
None

Progress on Planned Actions
Bakman Water Company and Fresno Metropolitan Flood Control District have completed the joint effort of establishing a pipeline from Basin W to Basin X and the installation of a meter for recharge water. Bakman and Fresno Irrigation District are working out the details for the recharge water.

Improvements to several FMFCD basins for use as part of the Groundwater Recharge program were completed, including:

- FMFCD completed excavation in Basin "CS" and amended agreements with FID and the City of Fresno to add this 22 acre basin to the groundwater recharge program.
- FMFCD constructed pump stations to improve the maintenance of Basins "AB" and "1G", basins used for groundwater recharge purposes during the FID irrigation season.
- The excavation of Basins "J", "GG" and "BE" was completed and expanded the capacity of the basins for groundwater recharge purposes during the FID irrigation season.
- The excavation of Basin "BM" was completed, expanding the capacity of the basin for groundwater recharge purposes. FMFCD began working on the facilities necessary to deliver water to the basin.
- FMFCD completed the connection of Basin "BH" to Fancher Creek pursuant to previously amended agreements with FID and the City of Fresno to add this 16.6 acre basin to the groundwater recharge program.
- Clovis requested and FMFCD agreed to design the landscape irrigation for Basin S utilizing surface water. (2008).

New Activities
None

5.2 - Water Conservation and Education

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
In March 2006, the City of Fresno initiated a rebate program for the installation of ultra-low flush toilets.
In June 2007, the City of Clovis began offering rebates to customers for purchase of water efficient washing machines.

5.3 - Groundwater Use Limitations

Changes in Existing Activities
None

Progress on Planned Actions
The Cities of Clovis and Fresno and FID have been working with the County of Fresno to provide a surface water supply and treatment for the Dry Creek area of Fresno County. (2008)

New Activities
None

5.4 - Conjunctive Use of Water Resources

Changes in Existing Activities
None

Progress on Planned Actions
The Cities of Fresno and Clovis require land with surface water rights to retain those rights in order to be considered for annexation.

Clovis is considering additional water banking opportunities with other agencies for lands that do not have surface water rights.

Fresno Irrigation District investigated the feasibility of groundwater banking sites in the Fancher Creek System of their service area.

The City of Kerman desires to enter into an agreement similar to the 'Conveyance Agreement' that FID has with both the Cities of Fresno and Clovis. The Conveyance Agreement allows cities to receive surface water entitlements on annexed lands that were originally delivered to crops on those lands, as long as the cities continue to pay the water user fees.

Fresno Irrigation District completed construction of most of the Waldron Pond Groundwater Banking Project and part of the facilities was used in 2006. Construction was completed in 2007.

New Activities
None

5.5 - Wastewater Reclamation and Recycling

Changes in Existing Activities
None

Progress on Planned Actions
The City of Clovis has developed its recycled water rules, regulations, and ordinance for use once the new Water Reuse Facility near Ashlan and McCall is completed in 2008.

Landscape areas within the City of Clovis' proposed recycled water use area are being plumbed to accept recycled water from the new Water Reuse Facility.

Malaga CWD submitted an application to FID and the RWQCB to increase the discharge of tertiary treated effluent into FID canals. FID has allowed MCWD to increase to 0.45 mgd per day, however, the MCWD is pursuing disposal alternatives that will allow MCWD to limit discharges to the water run.

Malaga CWD held discussions with Caltrans in 2007 on the use of tertiary treated effluent on Highway 99 landscaping. Caltrans did not wish to use the treated effluent on their landscaping.

The City of Kerman is looking into developing an untreated surface water delivery system that would convey surface water from FID's canal system to non-potable demands within the City, such as landscaping.

New Activities
None

5.6 - Operation of Facilities

Changes in Existing Activities
FID initiated a 3-year improvement plan for their extensive canal system. The improvements will aid in the delivery of surface water to recharge basins.

Progress on Planned Actions
None

New Activities
None

6 - GROUNDWATER PLANNING AND MANAGEMENT

6.1 - Groundwater Reports

Changes in Existing Activities
None

Progress on Planned Actions
This annual report was prepared as a collective effort by all of the GMP participants.

New Activities
None

6.2 - Plan Re-evaluation

Changes in Existing Activities
None

Progress on Planned Actions
The California Department of Water Resources provided comments on the Draft GMP in January 2006. Most of their comments were incorporated into the Final GMP. However some were not incorporated due to lack of data or time constraints and will be considered during the next GMP update. Below is a summary of possible updates to the GMP based on the DWR comments:

1. Map of areas with groundwater quality degradation
2. Development of detailed, standardized monitoring protocols
3. More detailed discussions on historic land-surface subsidence based on published literature
4. Discuss availability of well construction records from Fresno County
5. Discuss base of fresh water in aquifer based on published literature
6. On-going and Changes in Existing Activities for contaminant plume management
7. Banning of recreational lakes that are maintained by groundwater pumping

New Activities
None

6.3 - Land Use Planning

Changes in Existing Activities
None

Progress on Planned Actions
The Upper Kings Basin Water Forum has developed an Integrated Regional Water Management Plan. One of the components of that plan is a discussion of land use planning and its relationship with water supply. Regional planning activities that include the blueprint process are now reaching out to the Forum for information on water supply. The Forum will designate members to participate in regional planning activities. (2008).

New Activities
None

6.4 - Dispute Resolution

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

6.5 - Program Funding and Fees

Changes in Existing Activities
None

Progress on Planned Actions
None

New Activities
None

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

2010 ANNUAL REPORT

TABLES

Fresno Area Regional Groundwater Management Group
2010 Annual Groundwater Report
Groundwater Pumping

Table 1

(all values in acre-feet)

Participant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Fresno Irrigation District													0
County of Fresno													0
City of Fresno	6,909	5,119	6,920	7,248	11,431	15,286	17,508	16,693	14,242	11,044	9,117	7,052	128,569
City of Clovis	956	497	849	955	1770	2460	2602	2666	1852	1431	1348	815	18,200
City of Kerman	138	122	173	219	321	421	472	431	386	294	191	144	3,311
Malaga County Water District	97	93	110	107	127	178	208	197	136	142	112	105	1,613
Pinedale County Water District	104	105	178	142	222	196	239	325	239	125	96	39	2,010
Fresno Metropolitan Flood Control District													0
Bakman Water Company	169	170	243	243	349	502	604	553	416	369	252	182	4,052
Garfield Water District (3)													0
Total	8,373	6,105	8,473	8,914	14,220	19,043	21,633	20,865	17,270	13,405	11,116	8,337	157,755

Notes:
1) Values in the table do not include pumping from private wells in the participant's service area.
2) The City of Fresno pumps reclaimed groundwater near the Fresno wastewater treatment plant and delivers it to the FID Canal system. These volumes are not included in the values in the table.
3) No data available at the time of this report.

TABLE 2

GROUNDWATER DEPTH, STORAGE, & DELIVERIES

REPORT YEAR	AVERAGE DEPTH (1)	FID & CITY DIVISIONAL DEPTHS (2)			STORAGE CHANGE (AF)	STORAGE VOLUME (AF)	TOTAL DEL (AF) (8)	RECHARGE DEL. (AF)
		NW	SW	EAST				
2000	68.1	90.7	71.7	33.2	-22,935	3,718,248	389,895	59,046
2001	70.4	93.3	71.3	39.2	-29,564	3,688,684	470,394	56,509
2002	74.5	96.4	76.1	43.1	-83,673	3,605,011	486,975	62,066
2003	75.8	94.5	80.1	44.9	-86,721	3,518,290	438,747 (5)	55,576 [66,345]
2004	76.1	96.9	79.5	43.8	7,358	3,525,648	477,460 (5)	51,971 [77,738]
2005	74.9	99.5	71.6	47.7	69,386	3,561,277	518,203 (5)	50,158 [80,061]
2006	81.2 (4)	105.9	77.7	46.7	-7,106 (6)	4,020,245 (6)	616,227 (7)	49,280 [77,112]
2007	85.5	111.3	81.0	50.5	-125,494	3,836,247	414272	42,409 [67,695]
2008	86.6	109.6	83.7	53.8	-34,439	3,801,808	564,899	58,406 [86,505]
2009	91.0	113.2	85.5	63.5	-72,389	3,705,296	560,897	62,474 [90,438]
2010	87.0	109.2	85.1	54.4	100,850	3,776,825	641,758	60,361 [87,382]

Notes:
(1) Depths are weighted by division area.
(2) See Figure 2, Quarterly Wells & Divisional Map for NW, SW & East Divisions
(3) See Appendix A, Quarterly Groundwater Report Database for well data
(4) Average depth to groundwater calculated with modified weighting factors in 2006 and following years.
(5) Deliveries after October 1 are included in total deliveries for the following calendar year
(6) Specific yield for several Townships modified in 2006 to be consistent with USGS Paper 1469. 2005 storage volume was recalculated using the new specific yields to determine the storage change from 2005 to 2006.
(7) 2006 and following years include FID, Garfield WD and International WD deliveries. Previous years only included FID deliveries.
(8) 2000 and following years do not have reclaimed groundwater in delivery totals.
[ ] Includes deliveries to Surface Water Treatment Plants in both City of Fresno & City of Clovis

Fresno Irrigation District

TABLE 3

Annual Groundwater Report

Underground Storage Capacity and Change

January2011

			Specific Yield			Depth of Water			0-200' Storage		Storage Change	
Township	Range	FID Acres	0-50' %Yield	50-100' %Yield	100-200' %Yield	Average Depth(ft)		Yearly Change(ft)	Capacity (AC-FT)	Existing (AC-FT)		Yearly Change(AF)
12	19	3,600	15.6%	15.1%	10.3%	124		-1.3	92,340	28,309		-486
12	20	12,300	13.5%	11.7%	15.3%	157		0.5	343,170	80,680		1,017
12	21	19,300	11.2%	13.1%	13.9%	131		-3.4	502,765	184,282		-9,255
13	17	12,900	10.3%	6.9%	8.8%	57		4.1	224,460	151,676		3,617
13	18	20,100	11.8%	10.2%	12.6%	55		6.1	474,360	344,887		12,412
13	19	22,900	14.5%	13.5%	14.3%	96		0.9	648,070	340,067		2,735
13	20	23,000	10.6%	12.2%	10.9%	129		6.3	512,900	177,171		15,870
13	21	23,000	10.6%	12.2%	10.9%	126		3.9	512,900	185,113		9,827
13	22	22,500	7.4%	7.5%	4.4%	27		6.5	266,625	220,949		10,838
13	23	6,100	16.4%	7.2%	7.4%	6		4.2	117,120	111,518		4,202
14	17	5,800	9.6%	15.7%	16.0%	90		-4.5	166,170	102,361		-4,098
14	18	23,000	9.6%	15.7%	16.0%	63		10.4	658,950	502,370		37,656
14	19	23,000	14.5%	13.5%	14.3%	59		3.0	650,900	457,074		9,290
14	20	23,000	10.6%	12.2%	10.9%	95		3.1	512,900	266,063		8,604
14	21	18,500	15.9%	12.7%	8.5%	85		-3.6	421,800	191,349		-8,494
14	22	7,100	17.8%	15.8%	10.4%	40		12.4	193,120	143,155		15,412
15	19	6,400	13.0%	10.9%	13.9%	106		-6.5	165,440	83,252		-5,795
15	20	9,400	13.8%	13.4%	13.4%	73		-4.7	253,800	160,032		-5,927
15	21	2,400	13.8%	13.4%	13.4%	55		10.7	64,800	46,519		3,425
							TOTALS:		6,782,590	3,776,825		100,850

Fresno Area Regional Groundwater Management Group
2010 Annual Groundwater Report
Surface Water Usage (direct deliveries and groundwater recharge)

TABLE 4

(all values in acre-feet)

Fresno Irrigation District Surface Water

Participant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Fresno SWTP	173	1,180	1,338	1,906	2,131	2,512	2,745	2,753	2,483	2,117	0	244	19,582
Fresno Recharge	248	1,218	2,772	2,895	7,240	7,620	9,031	9,816	6,845	4,855	0	57	52,597
Clovis SWTP	46	408	424	555	693	828	1,040	1,188	1,154	946	0	157	7,439
Clovis Recharge	153	321	699	619	982	1,179	1,193	997	712	703	0	206	7,764
FID Growers and Recharge Basins	14	3,867	30,834	53,134	70,226	78,573	83,660	57,034	36,691	49,798	69	0	463,900
Total Fresno Irrigation District	634	6,994	36,067	59,109	81,272	90,712	97,669	71,788	47,885	58,419	69	664	551,282

Other Agencies

County of Fresno													0
City of Kerman													0
Malaga County Water District	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinedale County Water District	0	0	0	0	0	0	0	0	0	0	0	0	0
Fresno Metropolitan Flood Control District	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakman Water Company	0	0	0	0	0	0	0	0	0	0	0	0	0
Garfield Water District													1,909
International Water District (3)													1,185
Total	0	0	0	0	0	0	0	0	0	0	0	0	3,094

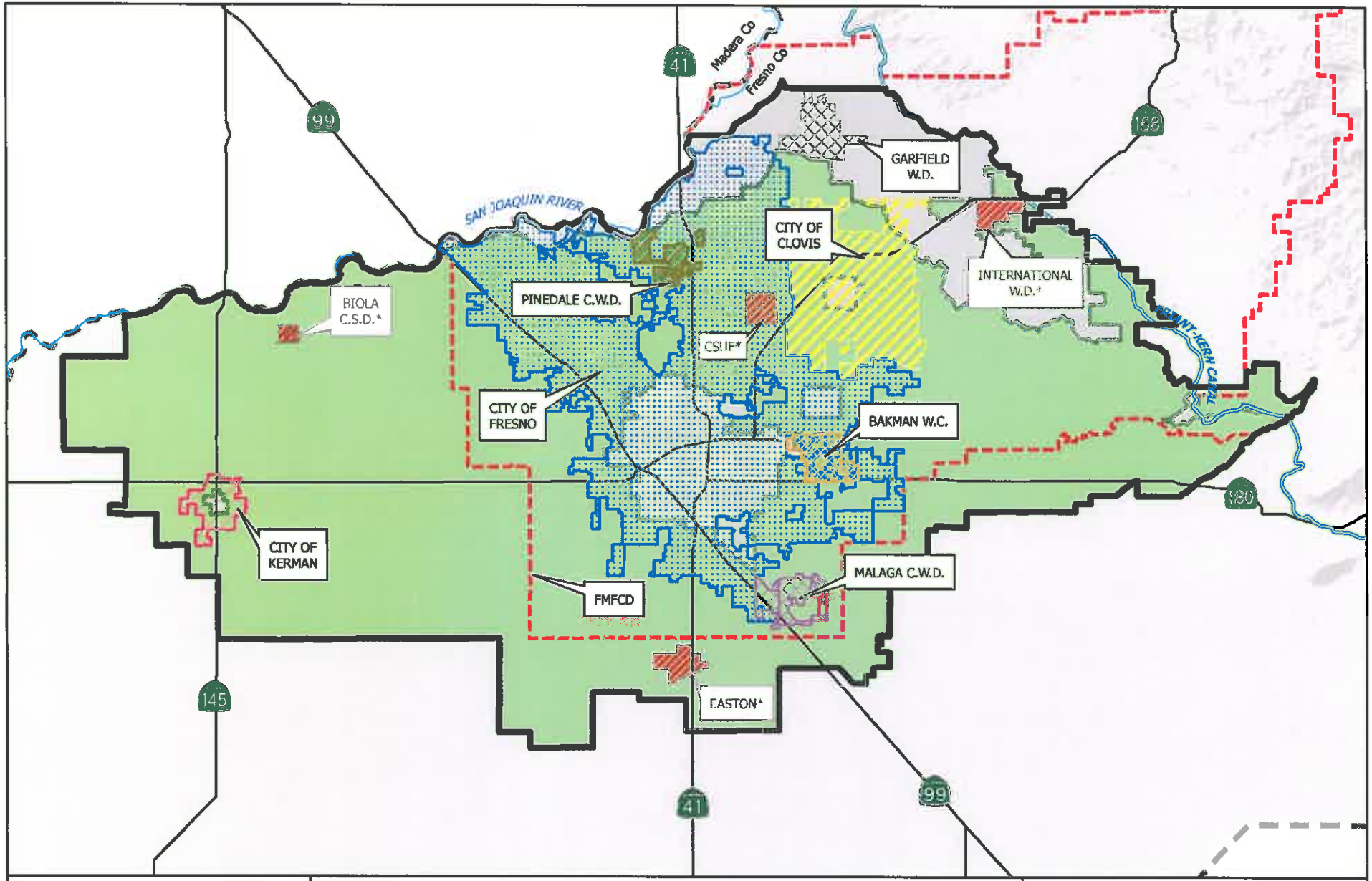
Notes:

1) Bakman Water Company does not currently perform direct groundwater recharge but provides an annual payment to FID to fund groundwater recharge projects in the area.
2) Delivery of surface water to FMFCD is included under recharge for the cities of Fresno and Clovis. Incidental recharge of stormwater also occurs in FMFCD but is not quantified herein.
3) Not a participant to the Plan.

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

2010 ANNUAL REPORT

FIGURES



0 1 2 3 4 Miles

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LEGEND

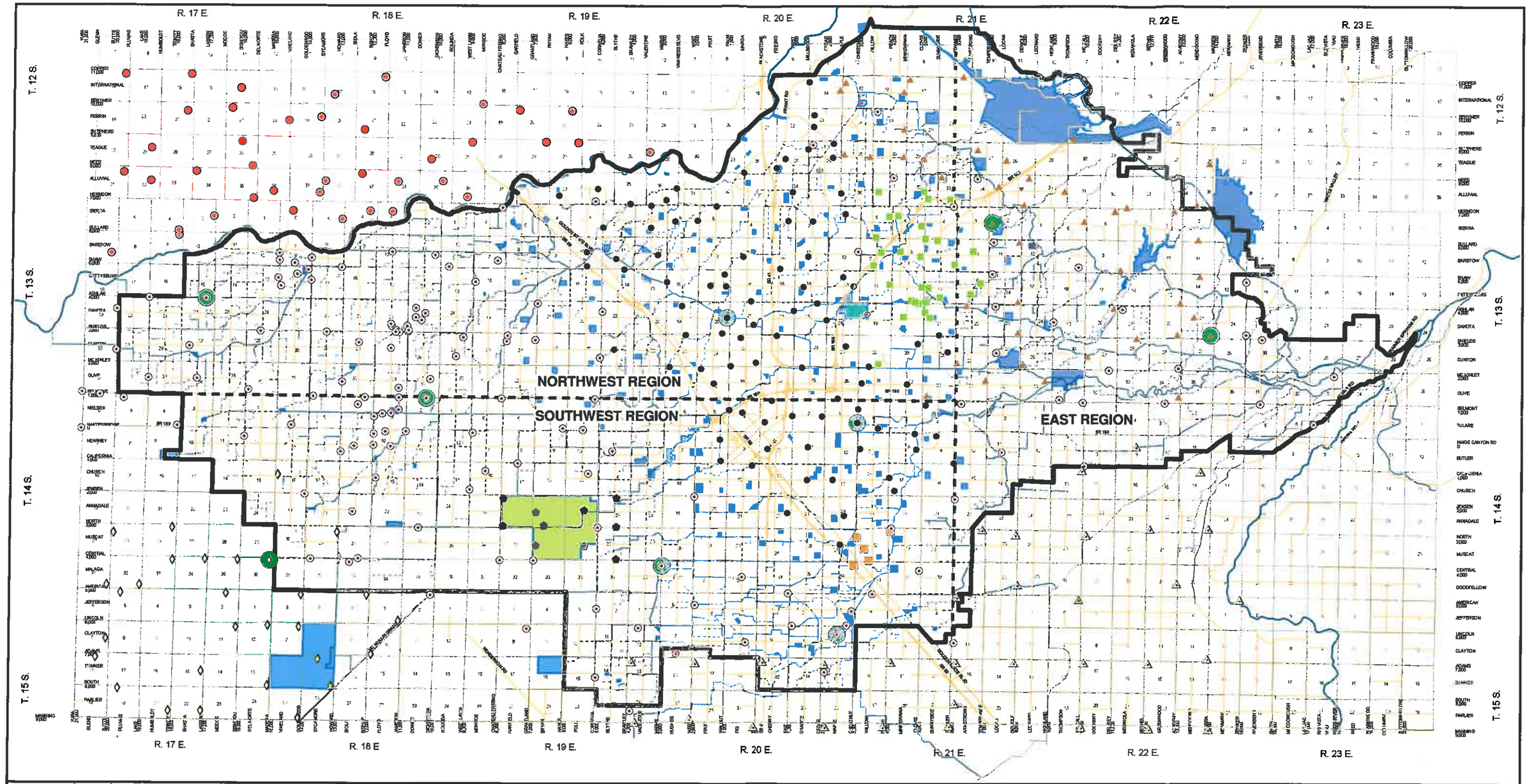
- COUNTY OF FRESNO
- CITY OF FRESNO
- CITY OF KERMAN
- PINEDALE W.D.
- CITY OF CLOVIS
- BAKMAN W.D.
- GARFIELD W.D.
- MALAGA C.W.D.
- FRESNO I.D.
- FMFCD Boundary
- *Agencies within plan boundary, not participating
- GWMP BOUNDARY
- FRIANT-KERN CANAL

The Plan area lies entirely within the County of Fresno, and the County is a participant to the Plan.
The Plan area lies within the Kings River Conservation District.

Figure 1

Participating Agencies

Fresno-Area Regional Groundwater Management Plan



Legend

Well Location (FID Database)

Agency Measuring Well Depth

- California Department of Water Resources
- City of Clovis
- City of Fresno
- Consolidated Irrigation District
- Fresno Clovis Waste Water Sewage Treatment
- Fresno Irrigation District
- James Irrigation District
- Madera Irrigation District
- Malaga County Water District

- GWMP Boundary
- Sections
- Major Streets
- *Hydrograph Provided in Appendix*
- Groundwater Regions

- Waste Water Treatment Plant
- Leaky Acres
- FID Pond / Basin
- FMFCD Basin
- Surface Water Treatment Plant

Facilities

- Canal
- Creek
- Culvert
- Flume
- Pipeline
- River

0 1 2 3 4 5 Miles

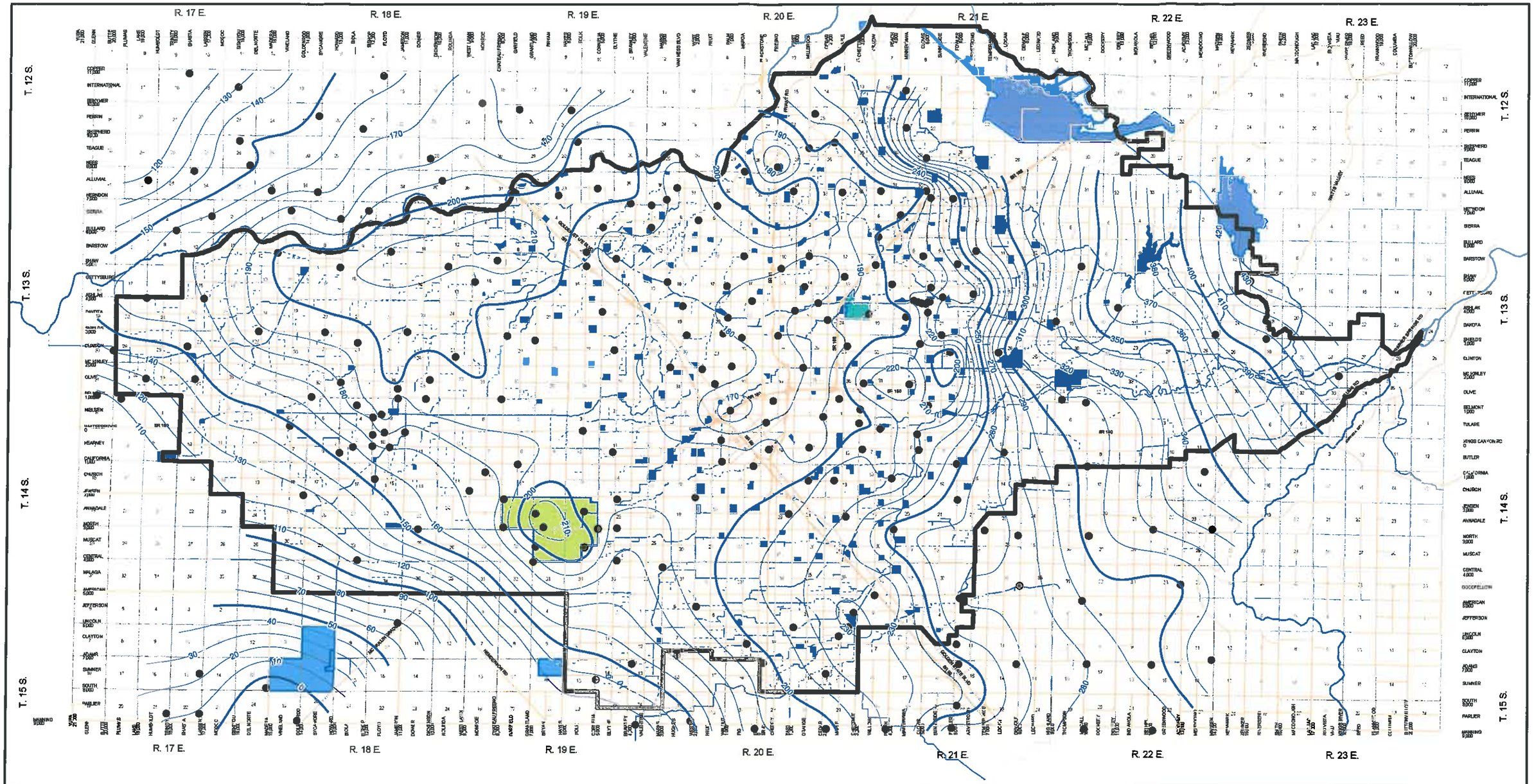
Approximate Scale

Fresno Area-Regional Groundwater Management Plan

Annual Report

Well Location Map, By Agency

Figure 2



Legend

- Well Location

Lines of Equal Elevation(Feet Above Sea Level, NAVD88)

- 10 foot interval
- 50 foot interval

- GWMP Boundary
- Major Streets
- Sections

- Waste Water Treatment Plant
- Leaky Acres
- FID Pond / Basin
- FMFCD Basin
- Surface Water Treatment Plant

Facilities

- Canal
- Creek
- Culvert
- Flume
- Pipeline
- River

0 1 2 3 4 5 Miles

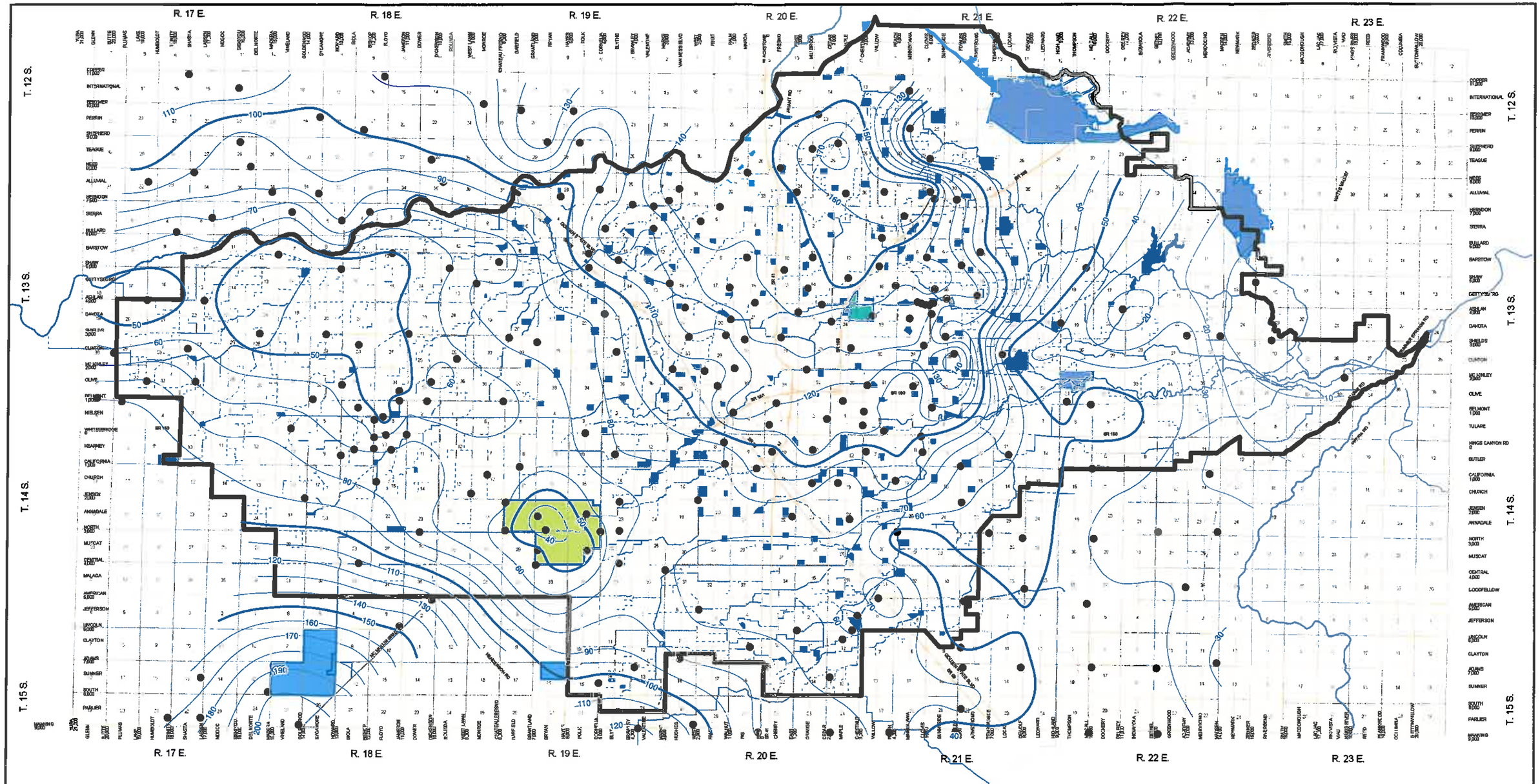
Approximate Scale

Fresno Area-Regional
Groundwater Management Plan

Annual Report

2010 Elevation of Water In Wells
(Spring 2011)

Figure 3



Legend

- Well Location

Lines of Equal Depth(Depth Below Ground Surface)

- 10 foot interval
- 50 foot interval

- GWMP Boundary
- Major Streets
- Sections

- Waste Water Treatment Plant
- Leaky Acres
- FID Pond / Basin
- FMFCD Basin
- Surface Water Treatment Plant

Facilities

- Canal
- Creek
- Culvert
- Flume
- Pipeline
- River

0 1 2 3 4 5 Miles

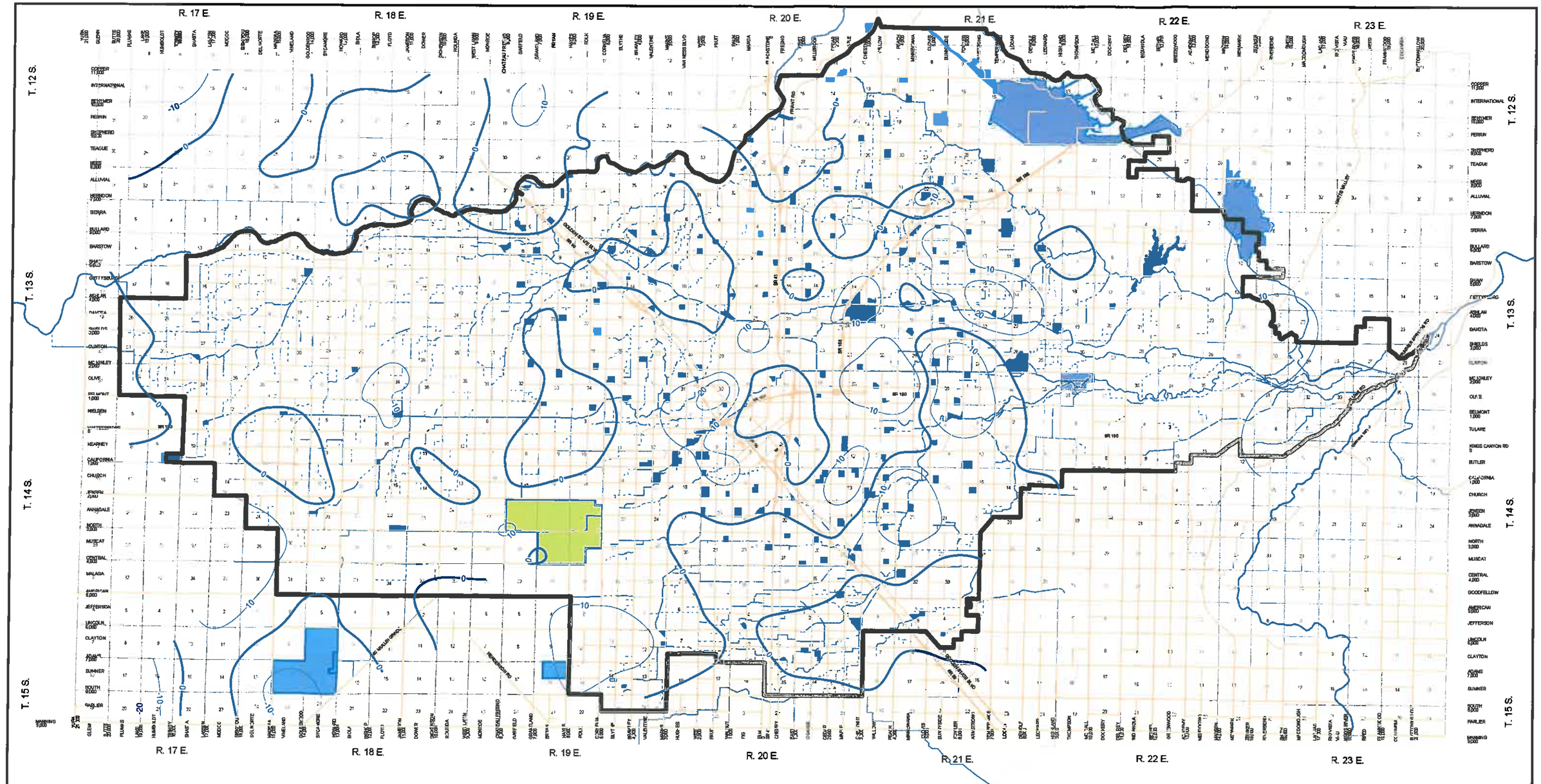
Approximate Scale

Fresno Area-Regional
Groundwater Management Plan

Annual Report

2010 Depth To Water In Wells
(Spring 2011)

Figure 4



Legend

Lines of Equal Change
- 10 foot Interval
- No Change

- GWMP Boundary
- Major Streets
- Sections

- Waste Water Treatment Plant
- Leaky Acres
- FID Pond / Basin
- FMFCD Basin
- Surface Water Treatment Plant

Facilities
- Canal
- Creek
- Culvert
- Flume
- Pipeline
- River
- 10 foot interval

0 1 2 3 4 5 Miles

Approximate Scale

*Contours of equal change are based on current year and previous year modeled groundwater elevation surfaces. Inconsistancies in data collection locations (ie. a well is measured one year and not the next) may lead to modeled change discrepencies.

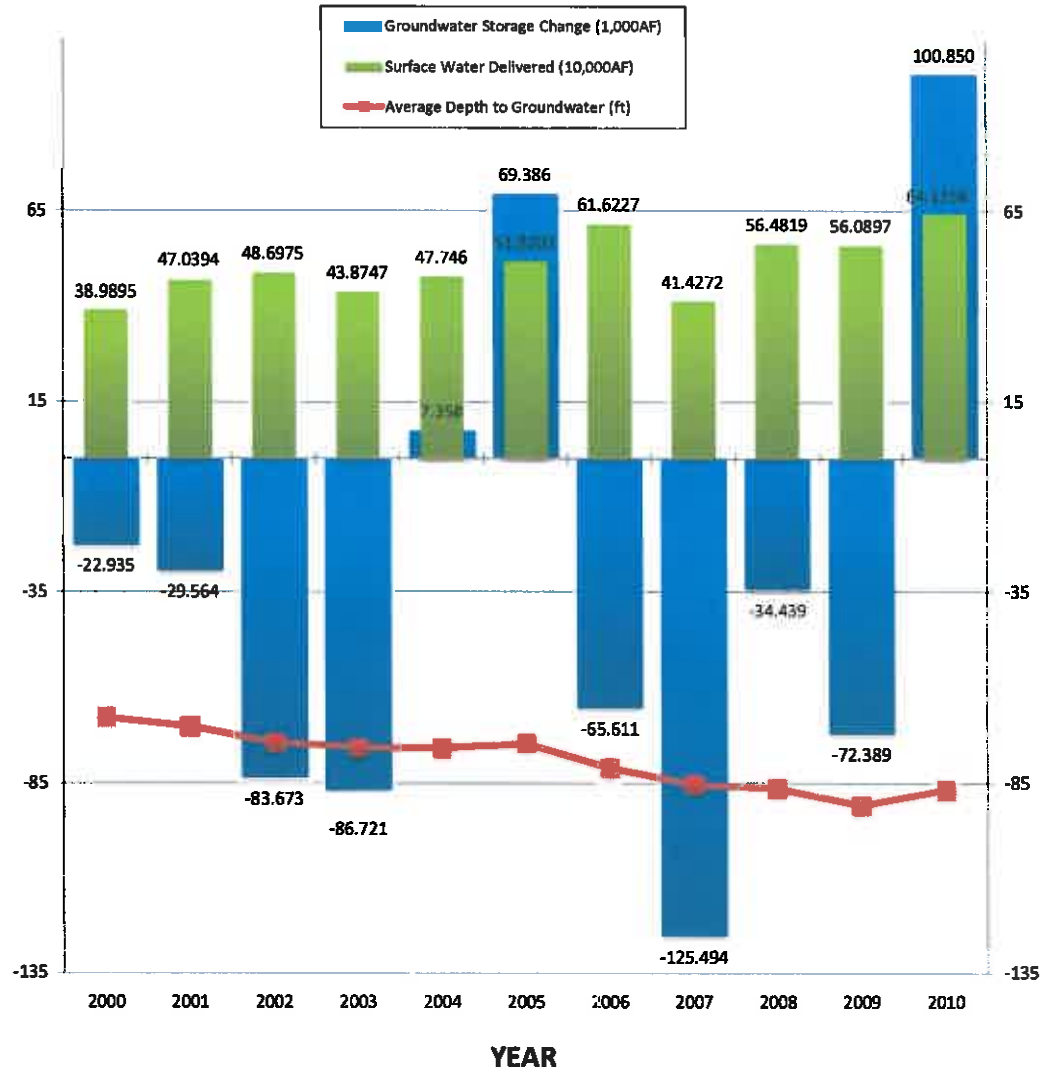
Fresno Area-Regional Groundwater Management Plan

Annual Report

Elevation of Water In Wells 2010-2011 Change

Figure 5

FIGURE 6
GROUNDWATER DEPTH & STORAGE, 2000- 2010



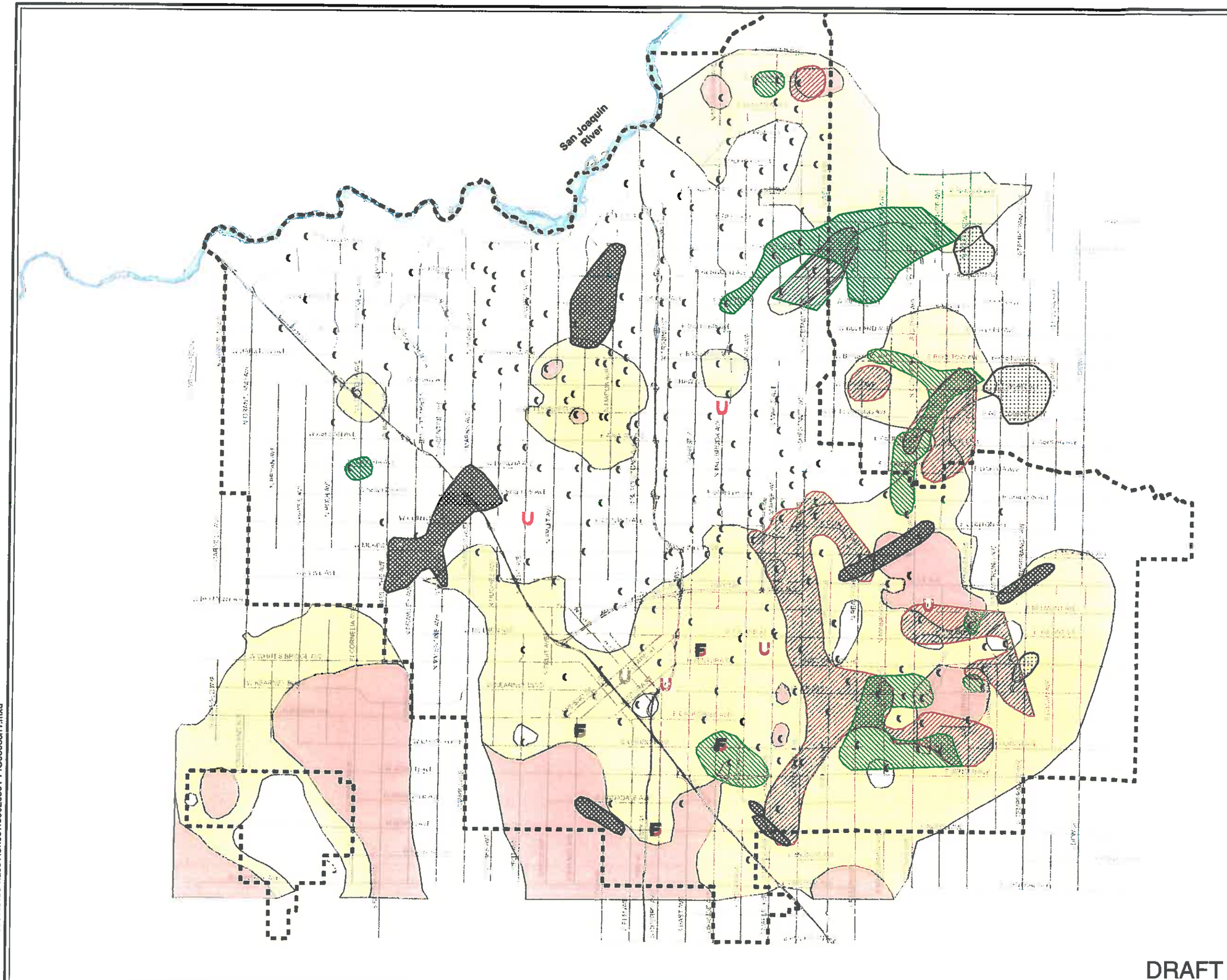


FIGURE 7
Page 1 of 2

City of Fresno
Metropolitan Water Resources Management Plan Update

REGIONAL GROUNDWATER CONTAMINATION

N

0 0.5 1 2
Scale in Miles

NOTES:

LEGEND:

- City of Fresno Sphere of Influence
- Active City Wells
- F Superfund Site (Old)
- U Gasoline Case (Old)
- EDB Plume (Old)
- Point Source Plume (Old)
- DBCP Plume (> 0.1 ppb)
- TCP Plume (> 0.01 ppb)

Nitrates

- Nitrate > 20 mg/L
- Nitrate > 40 mg/L

Fresno All-America City 2006

WEST YOST ASSOCIATES Consulting Engineers

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Table 5-2. Summary of Major Point Sources of Contamination[a]

Point Source	Approximate Location	Type of Contaminants
Fresno Railroad Yard	Along Hwy 99, between Clinton and Dakota Avenue	Salinity and Chloride
Fresno Meat Co	South of W. North Avenue, along S. Fig Street	Salinity, Chloride, Nitrate
Pinedale Groundwater Site	Near Sierra and Palm Avenue	VOCs
Thompson-Hayward Agricultural and Nutrition Co.	Southeast of Temperance and McKinley Avenue	Chloroform, 1,2-DCE, DBCP, Dieldrin, 1,2,3-TCP
Purity Oil Sales (Superfund)	Northwest of Maple and Muscat Avenue	VOCs, Manganese, Iron
Fresno Air Terminal	Near the intersection of E. McKinley and N. Clovis Avenue	VOCs, including TCE and PCE
FMC Superfund Site	Southeast of S. Walnut and E. Annandale Avenue	Numerous VOCs and Pesticides
Former Dow Brands Facility	South-central Fresno	PCE and 1,1-DCE
Wilbur-Ellis	Northwest of Maple and Muscat Avenue	Pesticides
Fruit and Church Junkyard	Near the intersection of S. Fruit and E. Church Avenue	No data available on extent of Groundwater Contamination
Fresno County Credit Union	Near the intersection of E. Kings Canyon Road and Hwy 41	No data available on extent of Groundwater Contamination
Commercial Electroplaters	Near W. North Avenue and Hwy 41	No data available on extent of Groundwater Contamination
ACE Trans State Tires	W. Kearney Boulevard and Hwy 41	Petroleum
ARCO Gas Station	N. Millbrook and W. Gettysburg Avenue	Petroleum
Beacon Gas Station	N. Clovis and E. Belmont Avenue	Petroleum
Chevron #1	Near the intersection of Hwy 99 and 41	Petroleum
Chevron #2	Near N. Maple and E. Kings Canyon Avenue	Petroleum
Fast Gas	Near N. West and E. Clinton Avenue	Petroleum

[a] List of point sources and data obtained from: CH2M Hill, 1992. Fresno/Clovis Metropolitan Water Resources Management Plan, Phase 1 Report, Existing Water Supply System Assessment, Volume 1 and 2. January 1992.

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

2010 ANNUAL REPORT

APPENDIX A – GROUNDWATER LEVEL DATA

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

2010 ANNUAL REPORT

APPENDICES

APPENDIX A
Groundwater Level Data (Depth to Water Surface) - Wells Measured Quarterly
(Datum NAVD88)

			2006				2007				2008				2009				2010				2011
T/R	Well ID	FID Data ID	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN
1219	12S19E35Q001MX	FC097	121.7				118.9			126.7	117.2	123.5	127.3	128.0	120.5				129.0				124.0
	12S19E36J001MX	FC091	136.1				140.3			143.4	139.0	136.5	145.7	142.2	139.2				147.0				147.7
	12S19E36Q001MX	FC136	136.2				140.1			147.5	140.1	136.9	141.5	141.7	146.9				141.0				141.7
1220	12S20E26K001MX	FC089	158.8				152.0			80.1	159.3	158.8		160.2	160.0				164.1				
	12S20E27H001MX	FC086	163.8				157.0			167.3	161.1	165.0	204.1		163.0				165.2				166.9
	12S20E27L001MX	FC094	155.2				155.0			158.2	155.0	154.2	159.8	158.8	159.2				159.9				
	12S20E27N001MX	FC096	153.8				150.3			157.8	150.5	153.0	158.9	158.6	151.6				157.7				152.1
1221	12S21E19J001MX	FC19J1	86.0				86.0				86.0				90.0								91.7
	12S21E26M001MX	FC26M2																					
	12S21E33P001MX	FD33P1																					
1222	12S22E32R001MX	FC32R2	49.6																				
1317	13S17E12J001MX	FD12J2	40.1	42.1	44.1	41.1	46.1	50.1	56.1	50.1	48.1	47.1	43.1	43.1	48.1	51.1	48.1	44.1	48.1	46.1	45.1	47.1	45.1
	13S17E19H001MX	FD19H1	49.0	47.0	51.0	53.0	55.0																
	13S17E20A001MX	FD20A2	40.7	39.7	40.7	37.7	37.7		36.7	47.7		44.7	44.7		45.7	46.7	50.7	45.7	46.7		48.7	45.7	43.7
	13S17E22B001MX	FD22B1		47.0	45.5	44.5	43.5						50.5	53.5	52.5	56.5	55.5	56.5	54.5		56.5	52.5	51.5
	13S17E25C001MX	FD25C1	53.1	55.1	56.1	49.1	53.1	55.1	64.1	57.1	56.1	53.1	48.1	47.1	56.1	87.1	56.1	57.1	54.1	56.1	60.1	49.1	44.1
	13S17E27L001MX	FD27F1	59.6	51.6	53.6	54.6	52.6		59.6		61.6	58.6	58.6	63.6	51.6	62.6	62.6	63.6	62.6		65.6	64.6	62.6
	13S17E30J001MX	FD30J2	65.2	62.2	71.2	71.2	77.2	104.2	75.2	71.2	65.2	65.2	65.2	60.2	55.2	68.2	74.2	69.2	57.2		76.2	65.2	62.2
	13S17E33M001MX	FD32H1	71.4	75.4	79.4	79.4	85.4	101.4	79.4	80.4	76.4					86.4	89.4	84.4	83.4		85.4	86.4	80.4
	13S17E34L001MX	FD34F1	76.8	63.8	65.8	65.8	60.8	66.8	67.8	71.8	67.8	67.8	68.8	71.8	70.8	72.8	75.8	74.8	71.8		73.8	72.8	69.8
1318	13S18E10L001MX	FD10C1	54.8	54.8	51.8	53.8	53.8	56.8	56.8	59.8	58.8	51.8	50.8	50.8	52.8	55.8			52.8	57.8	46.8	50.8	49.8
	13S18E12P001MX	FD12P1	54.4	50.4	62.4	61.4	60.4	65.4	63.4	65.4	66.4		61.4	58.4	60.4	64.4	65.4	62.4	63.4	64.4	63.4	60.4	59.4
	13S18E17A001MX	FD17A1	51.8	48.0	48.0	51.0	53.0	59.0	58.0	56.0	57.0	43.0	42.0	44.0	43.0	49.0	50.0	49.0	51.0	52.0	46.0	49.0	43.0
	13S18E23N001MX	FD23N1	49.0	49.0	49.0	51.0	54.0	63.0	55.0	57.0	55.0	53.0	48.0	54.0	54.0	55.0	56.0	58.0	55.0	52.0	48.0	56.0	47.0
	13S18E25K001MX	FD25K1	50.0	49.0	46.0	58.0	63.0	80.0	64.0	71.0	64.0	61.0	55.0	55.0	63.0	62.0	64.0	64.0	63.0	64.0	64.0	60.0	59.0
	13S18E28F001MX	FD28F1	49.7	46.7	47.7	55.7	47.7	52.7	52.7	53.7	52.7	46.7	48.7	45.7	52.7	50.7	54.7	54.7	52.7	48.7	53.7	47.7	48.7
	13S18E29C001MX	FD29C1	44.0	49.0	51.0	48.0	50.0	51.0	52.0	53.0	53.0	50.0	44.0	46.0	51.0	49.0	52.0	52.0	53.0	54.0	51.0	52.0	38.0
	13S18E33M001MX	FD32J1	57.5	54.5	56.5	54.5	56.5	61.5	61.5	61.5	59.5	52.5	53.5	49.5	56.5	60.5	58.5	58.5	61.5	55.5	56.5	58.5	57.5
	13S18E34K001MX	FD34K1	54.1	54.1	53.1	54.1	52.1	56.1	62.1	62.1	51.1	29.1		47.1	48.1	52.1	52.1	57.1	55.1	39.1	50.1	49.1	42.1
	13S18E35G001MX	FD35G1	59.0	60.0	61.0	59.0	60.0	65.0	65.0	63.0	63.0	61.0	62.0	63.0	63.0	66.0	67.0	63.0	66.0	65.0	65.0	63.0	62.0
1319	13S19E06A001MX	FD6G1	77.5	77.5	78.5	72.5	71.5	80.5	82.5	82.5	82.5	85.5	84.5	79.5	83.5	83.5	79.5	79.5	78.5		81.5	81.5	85.5
	13S19E07R001MX	FD7A1	68.2	68.2	68.2	68.2	69.2	71.2	72.2	73.2	68.2	66.2	67.2	68.2	57.2	72.2	72.2	73.2	71.2			64.2	64.2
	13S19E10F001MX	FC087	106.1				107.3			109.5	110.4		110.3	110.6	107.6				111.6				111.0
	13S19E18E001MX	FD18E1	67.1	66.1					67.1														
	13S19E18E002MX	FD18E2		66.4	66.4	65.4	66.4	68.4	69.4	70.4	70.4	70.4	68.4	72.4	71.4	72.4	72.4	72.4	72.4	72.4	70.4	70.4	70.4
	13S19E21D001MX	FD21D1																					

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(Datum NAVD88)

			2006				2007				2008				2009				2010				2011
T/R	Well iD	FID Data ID	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN
1319	13S19E23E001MX	FD23E1	85.0	84.0	85.0	79.0	88.0	88.0	89.0	92.0	86.0	81.0	84.0	84.0				84.0	90.0		85.0	92.0	85.0
	13S19E29A001MX	FD29A1	61.7	67.7	68.7	68.7	76.7	68.7	70.7	71.7	68.7	70.7	70.7	71.7	71.7	71.7	73.7	72.7	72.7		75.7	74.7	73.7
	13S19E29D001MX	FD29D1	66.3	66.3	69.3	69.3	69.3	69.3	69.3	71.3	69.3	71.3	69.3	72.3	72.3	73.3	73.3	73.3	73.3		74.3	74.3	72.3

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(Datum NAVD88)

			2006				2007				2008				2009				2010				2011
T/R	Well ID	FID Data ID	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN
1320	13S20E02G001MX	FC076									104.2												
	13S20E09L001MX	FC267	136.8				135.7			144.0	139.8	139.4	144.6	144.5	136.1				139.0				138.2
	13S20E16Q001MX	FC067	130.5							140.0	138.9		137.9	140.8	139.6				139.7				135.0
	13S20E18E001MX	FC078	117.2				116.0			119.4	116.8	119.5	122.0	121.9	118.0				118.1				119.5
	13S20E23B001MX	FC045	145.2				143.3			145.2	141.0	140.2	146.0	147.9					151.1				144.8
	13S20E30B001MX	FC074	116.6				114.1			118.9	117.1	118.1	120.2	122.4	121.9				122.1				119.0
	13S20E36P001MX	FC030	114.5				115.3				117.6	117.4	124.2	126.3					121.0				113.0
1321	13S21E10G001MX	CC20	98.5				100.0		105.5		105.3		110.3		103.5				107.0				105.8
	13S21E15H001MX	CC13																					
	13S21E16P001MX	CCT-5	117.5				119.5		129.5		122.5		140.5		130.5				133.3				127.0
	13S21E18H001MX	CC10	125.5				129.5		141.0		134.0		146.0		139.0				141.8				141.0
	13S21E19E001MX	FC080	131.7				130.2			124.2	133.0	125.1		122.1	139.0				139.9				137.0
	13S21E21P001MX	FC055	102.1				100.9			146.7	102.3	142.3	145.2	109.2	101.9				102.5				108.1
	13S21E24J001MX	FD24J1	36.6	35.6	36.6	33.6	33.6	36.6	38.6	41.6	41.6	41.6	41.6	42.6	42.6	44.6	44.6	43.6	45.6		43.1	45.6	41.6
	13S21E26M001MX	FD26L1	51.3	52.3	52.3	44.3	50.3	52.3	67.3	57.3	55.3	54.3	56.3	56.3	57.3		56.3	56.3	58.3		55.3	54.3	57.3
	13S21E28G001MX	FC101	112.8				114.2			127.4	113.0	112.3	129.5	125.1	115.2				124.3				142.2
	13S21E30P001MX	FC063	116.9				117.0			125.2			125.2										
1322	13S22E02Q001MX	FC2Q1																					
	13S22E07R001MX	FD7R1	43.5	41.5	42.5	39.5	42.5	42.5	44.5	45.5	46.5	47.5	46.5	48.5	47.5	50.5	49.5	48.5	49.5		46.5	50.5	50.5
	13S22E13A001MX	FD13A1	8.3	8.3	8.3	8.3	9.3	8.3	12.3	12.3	10.3	10.3	13.3	13.3	11.3	11.3	14.3	13.3	16.3		9.3	8.3	5.3
	13S22E15R001MX	FC15R1	39.7																				
	13S22E27R001MX	FD27R1																					
	13S22E28B001MX	FC28B3																					
	13S22E31N001MX	FD31N1	41.5	41.5	42.5	42.5	43.5	47.5	46.5	51.5	51.5	48.5	41.5	47.5	48.5	53.5	53.5	49.5	52.5		47.5	46.5	47.5
	13S22E32A001MX	FD32B1	30.7	22.7	22.7	30.7	29.7	32.7	33.7	42.7	40.7	37.7	38.7	42.7	40.7	44.7	40.7	41.7	43.7		40.7	41.7	
1323	13S23E19N001MX	FD19N1	9.0	3.0	4.0	9.0	10.0	11.0	17.0	19.0	18.0	24.0	17.0										
	13S23E30B001MX	FD30C1	4.2	2.2	3.2	5.2	5.2	5.2	7.2	8.2	8.2	7.2	7.2	9.2	9.2	9.2	10.2	9.2	8.2		6.7	7.2	3.2
	13S23E33B001MX	FD33B1	9.9	9.9	9.9	9.9	13.9	13.9	14.9	17.9	16.9	16.9	13.9		15.9	15.9	13.9	13.9	24.9	24.9	12.9	11.9	8.0
1417	14S17E05C001MX	FD5D1	89.0	91.0	98.0	98.0	88.0	128.0		97.0	89.0	89.0	94.0	79.0	65.0	102.0	105.0	94.0	84.0		110.0	101.0	90.0
	14S17E06B001MX	FD6C1	89	88	92	94	83	99	111		85	84	82	84	87			85	86		127	103	89

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			2006				2007				2008				2009				2010				2011
T/R	Well ID	FID Data ID	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN
1418	14S18E02B001MX	FD2B1	56.1	58.1	58.1	57.1	59.1	65.1	63.1	63.1	62.1	59.1	59.1	61.1	60.1	64.1	63.1	62.1	63.1	61.1	62.1	62.1	57.1
	14S18E03B001MX	FD03B1	55.1	65.1	65.1	55.1	56.1	62.1	67.1	62.1	58.1	49.1	54.1	56.1	60.1	67.1	62.1	58.1	59.1	54.1	63.1	59.1	51.1
	14S18E03L001MX	FD03L1	58.0	58.0	57.9	57.0	60.0	75.0	61.0	66.0	61.0	52.0	64.0	62.0	62.0	72.0	68.0	66.0	65.0	49.0	53.5	62.0	46.0
	14S18E04B001MX	FD4A1	54.7	52.7																			
	14S18E04G001MX	FD04G1	75.3	57.3	57.3	56.3	59.3	82.3	61.3	67.3	60.3	53.3	53.3	56.3	56.3	61.3	64.3	62.3	62.3	59.3	61.3	62.3	52.3
	14S18E04J001MX	FD04J1	60.0	63.0	60.0	61.0	62.0	61.0	62.0	66.0	63.0	57.0	55.0	53.0	62.0	66.0	68.0	63.0	58.0	54.0	62.0	57.0	54.0
1418	14S18E05D001MX	FD32N1	56.2	55.2	59.2	58.2	59.2				61.2	61.2	58.2	63.2	64.2	68.2	69.2	64.2	67.2		64.2	63.2	65.2
	14S18E06P001MX	FD06P1	63.3	61.3	62.3	67.3	60.3	66.3	69.3	70.3	70.3	69.3	66.3	69.3	71.3	73.3	75.3	69.3	73.3		72.3	72.3	75.3
	14S18E09H001MX	FD9H1	63.2	61.2	69.2	63.2	61.2	68.2	66.2	68.2	67.2	62.2	62.2	64.2	61.2	70.2	72.2	69.2	70.2	65.2	71.2	71.2	68.2
	14S18E09L001MX	FD09L1	66.2	65.2	67.2	63.2	67.2	78.2	71.2	67.2	67.2	61.2	61.2	66.2	67.2	71.2	74.2	74.2	72.2	69.2	73.2	71.2	70.2
	14S18E09M001MX	FD8J1	67.2	66.2	68.2	67.2	87.2	87.2	69.2	74.2	69.2	62.2			67.2	73.2	75.2	76.2	75.2	73.2	73.2	72.2	73.2
	14S18E10A001MX	FD10A1	62.0	62.0	62.0	62.0	71.0	70.0	65.0	64.0	66.0	60.0	60.0	60.0	64.0	66.0	69.0	67.0	69.0	60.0	62.0	66.0	67.0
	14S18E10C001MX	FD10C1	63.0	64.0	70.0	60.0	62.0	66.0	64.0	67.0	64.0	61.0	61.0	59.0	64.0	68.0	68.0	69.0	65.0	62.0	65.0	68.0	59.0
	14S18E10D001MX	FD10D1	61.3	63.3	63.3	59.3	61.3	73.3	65.3	74.3	66.3	55.3	59.3	56.3	59.3	64.3	67.3	70.3	67.3	58.3	58.3	67.3	60.3
	14S18E10K001MX	FD10K1	64.5			59.5	57.5	90.5	63.5	65.5	67.5	57.5	64.5	64.5	67.5	71.5	73.5	69.5	71.5		69.5	71.5	69.5
	14S18E15M001MX	FD15E1	68.0	65.0	68.0	68.0	66.0	71.0	71.0	73.0	73.0	73.0	72.0	74.0	75.0	78.0	79.0	75.0	80.0		79.0	78.0	77.0
	14S18E19A001MX	FD19A1	82.7	81.7	78.7	76.7	74.7	84.7	86.7	87.7	85.7	81.7	76.7	79.7	80.7	85.7	83.7	80.7	87.7		88.7	91.7	88.7
	14S18E26C001MX	FD26C1	74.0	72.0	74.0	76.0	71.0	76.0	77.0	79.0	74.0	73.0	74.0	76.0	77.0	81.0	78.0	76.0	80.0		79.0	79.0	75.0
	14S18E28Q001MX	FD28R1		99.1	102.1	102.1	101.1	101.1			105.1	103.1	105.1	107.1	109.1	109.1	114.1	108.1	113.1			114.1	112.1
	14S18E32D001MX	FD32D1	107.7			111.7	106.7	109.7	116.7	120.7	112.7	116.7	120.7	124.7	116.7	120.7		123.7	121.7		125.7		
1419	14S19E03Q001MX	FD03Q1	70.8	68.8	68.8	70.8	70.8	70.8	71.8	75.2	64.8	56.8	62.8	63.8	59.8	66.8	71.8	68.8	68.8		65.8	74.8	72.8
	14S19E06A001MX	FD6A1	59.2	61.2	62.2	62.2	59.2	75.2	62.2	64.2	54.2	57.2	56.2		60.2	63.2	63.2	63.2	62.2		66.2	62.2	57.2
	14S19E11L001MX	FD11H1	73.8	72.8	72.8	73.8	74.8	73.8	73.8	80.8	71.8	75.8	79.8	80.8	81.8	79.8		80.8	80.8				78.8
	14S19E17C001MX	FD17C1	57.9	57.9	53.9	54.9	52.9	53.9	59.9	64.9	57.9	56.9	58.9	59.9	62.9			60.9	59.9			64.9	63.9
	14S19E18G001MX	FD18C1	61.0	59.0	59.0	59.0	59.0	62.0	62.0		62.0	61.0	62.0	67.0	66.0	66.0	68.0	66.0	68.0		65.5	68.0	65.0
	14S19E18N001MX	FD13R1		67.2	63.2	60.2	60.2	61.2	63.2	64.2	62.2	60.2	62.2	62.2	63.2	67.2	67.2	64.2	65.2		64.2	67.2	66.2
	14S19E26D001MX	FD22R1	51.0	50.0	51.0	52.0	50.0	50.0			54.0	54.0	59.0	63.0	58.0	57.0		59.0	59.0		58.0	63.0	57.0
	14S19E33D001MX	FD33D1	46.0	46.0	44.0	44.0	43.0	48.0			46.0	40.0	47.0	53.0	51.0			53.0	53.0			57.0	53.0
1420	14S20E03M001MX	FC021	108.1				112.2					118.1	128.6						111.3				114.0
	14S20E04E001MX	FC11A	122.2				119.2			126.0	122.4	122.6	126.7	127.1					126.2				123.0
	14S20E04F001MX	FC002	103.1	101.3	105.9		105.9			132.1			132.1		148.8				114.0				
	14S20E08H001MX	FC027	85.3				90.1			99.7	101.1		99.3	98.7					96.9				93.0
	14S20E13F001MX	FC205	79.0				81.2				86.5		98.6	95.5					93.0				74.0
	14S20E14L001MX	FC036	84.5				84.6			84.8	88.0	84.8	84.8						88.0				85.0
	14S20E19A001MX	FD19B1	64.0	64.0	65.0	65.0	65.0	70.0	72.0	73.0	73.0	75.0	75.0	75.0	75.0	75.0	78.0	75.0	75.0		74.0	74.0	73.0
	14S20E31D001MX	FD36A1	61.2	61.2	67.2	63.2	56.2	65.2	68.2	64.2	66.2	54.2	64.2	72.2	75.2	73.2	72.2	72.2	72.2		71.2	71.2	71.2
	14S20E33F001MX	FD33F1	57.7	57.7	61.7	64.7	57.7	64.7	61.7										62.7				

APPENDIX A

Groundwater Level Data (Depth to Water Surface) - Wells Measured Quarterly

(Datum NAVD88)

			2006				2007				2008				2009				2010				2011
T/R	Well ID	FID Data ID	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN
1421	14S21E06Q001MX	FC077	104.1				107.6						135.7	114.1	110.9				111.3				108.0
	14S21E08A001MX	FC298	98.9				96.8			100.8	99.8				100.6				103.1				100.0
	14S21E08J001MX	FC224	92.7											118.4	141.1								95.0
	14S21E09R001MX	FC276	67.4				68.3			65.5	70.3			65.5	67.7								70.0
	14S21E11L001MX	FD11N1	59.4	58.4	58.4	57.4	51.4	59.4	60.4	63.4	60.4	56.4	58.4		60.4	69.4	63.4	59.4	61.4		63.4	62.4	62.4
	14S21E17E001MX	FC100-1	93.6				91.4			132.6	95.6												
	14S21E22D001MX	FD22D1	57.2	57.2	57.2	58.2	56.2	60.2		59.2	58.2	53.2	60.2	58.2	59.2	62.2	66.2	61.2	59.2		59.2	61.2	61.2
	14S21E27A001MX	CD04	51.5		50.8			51.9		55.5	55.3			57.0	57.7	58.3							57.8
	14S21E29D001MX	FD29D1	33.0	33.0	33.0	33.0	33.0	46.0	46.0	47.0									34.0		47.0	49.0	49.0
1422	14S22E03C001MX	FD3B1	30.9	30.9	28.9	28.9	28.9	29.9	26.9	33.9	35.9												
	14S22E06A001MX	FD6A1	40.9	39.9	40.9	40.9	40.9	41.9	45.9	50.9	48.9	48.9	50.9	51.9	49.9	52.9	54.9	52.9	54.9		52.9	51.9	53.9
	14S22E08N001MX	FD8N1	41.0	42.0	42.0	42.0	42.0	43.0	42.0	43.0	48.0	44.0	45.0	46.0	48.0		48.0	47.0	49.0		46.0	49.0	46.0
1423	14S23E06C001MX	FD6C1	29.6	27.6		29.6	29.6	29.6	31.6	32.6	32.6	32.6	33.6	32.6	33.6	33.6	34.6	32.6	33.6		31.6	31.6	
1518	15S18E02A001MX	FD2A1	112.8	109.8	113.8	110.8	108.8	110.8	114.8	120.8	115.8	112.8	119.8	124.8	118.8	120.8	126.8	125.8	121.8		124.8	127.8	123.8
1519	15S19E02M001MX	FD3J1	77.3		90.3	89.3	73.3	112.3	78.3	84.3	75.3	74.3	79.3	89.3	80.3	82.3		86.3	86.3		81.3	90.3	
	15S19E14M001MX	FD14M1	104.5	102.5	109.5	104.5	100.5	107.5	109.5	114.5	104.5	103.5	108.5	111.5	109.5	114.5	115.5	113.5	113.5		113.5	106.5	103.5
	15S19E25C001MX	CD71	110.0		117.8		112.1	115.0		115.9	114.1			121.2	120.6	121.2							120.8
1520	15S20E02N001MX	FD2N1	55.2	53.2	58.2	58.2	57.2	32.2	58.2	59.2	60.2	63.2	72.2		65.2		67.2	69.2	72.2		68.2	65.2	66.2
	15S20E03A001MX	FD34R1	56.0	54.0	57.0	56.0	55.0	55.0	58.0	57.0	59.0	59.0	51.0	51.0	62.0	63.0	64.0	58.0	59.0		63.0	62.0	
	15S20E05E001MX	FD05E1	62.4	60.4	61.4	63.4	62.4	65.4	67.4	67.4	62.4	63.4	64.4	67.4	71.4	71.4	71.4	68.4	68.4		76.4	68.4	68.4
	15S20E07Q001MX	FD7P1	71.3	67.3	69.3	71.3	71.3	74.3	79.3	76.3	73.3	77.3	80.3	80.3	80.3	81.3	86.3	84.3	84.3		85.3	84.3	80.3
	15S20E09K001MX	FD9K1	66.1	64.1	66.1	67.1	60.1	68.1	68.1							68.1	70.1	69.1	72.1		68.1	70.1	73.1
	15S20E12F001MX	FD12F1	51.5	51.5	54.5	51.5	51.5	53.5		52.5		59.5	58.5	59.5	60.5	62.5	63.5	66.5	68.5		64.5	62.5	62.5
	15S20E13E001MX	FD13E2	56.0	56.0	58.0	56.0	51.0	56.0	55.0	60.0	58.0	60.0	62.0	62.0	63.0	66.0	65.0	63.0	67.0		67.0	67.0	66.0
1521	15S21E06B001MX	FD6C1-B	49.0	52.0	52.0	52.0	48.0	49.0	52.0		77.0								77.0		76.0		76.0
	15S21E10M001MX	FD10E1	44.0	43.0	43.0	43.0	42.0	45.0	58.0	48.0	47.0	50.0	50.0	51.0	51.0	54.0	55.0	53.0	55.0		55.0	54.0	50.0

Groundwater Level Data (Depth to Water Surface) - Wells Measured Annually (Datum NAVD 88)

Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
12	17	14	12S17E14L001MX	Madera Irrigation District	241.0	98.1	104.3	108.6	112.0	116.0	116.0
12	17	16	12S17E16A001MX	Madera Irrigation District	230.0	110.9	111.2	113.8	118.0	119.6	118.5
12	17	18	12S17E18A001MX	Madera Irrigation District	220.0						
12	17	21	12S17E21H001MX	Madera Irrigation District	228.0	95.1					
12	17	23	12S17E23D001MX	Madera Irrigation District	237.0						
12	17	24	12S17E24J001MX	Madera Irrigation District	246.0						
12	17	26	12S17E26B001MX	Madera Irrigation District	235.0	90.6	83.4	85.7	87.9	88.4	86.0
12	17	26	12S17E26R001MX	Madera Irrigation District	233.0	77.7	76.1	78.2	82.6	84.5	84.3
12	17	29	12S17E29G001MX	Madera Irrigation District	218.0						
12	17	31	12S17E31A001MX	Madera Irrigation District	212.0						
12	17	32	12S17E32G001MX	Madera Irrigation District	217.0	85.2	86.4	87.1	93.1	95.2	94.8
12	17	34	12S17E34D001MX	Madera Irrigation District	225.0	83.9		88.9	92.4	92.5	89.5
12	17	35	12S17E35R001MX	Madera Irrigation District	239.0	83.9	79.4	83.7	78.1		
12	17	36	12S17E36K001MX	Madera Irrigation District	243.0	81.0	71.2	76.5	78.3	80.4	78.9
12	18	13	12S18E13R001MX	Madera Irrigation District	288.0	107.8	107.5	110.9	110.6	113.7	113.0
12	18	16	12S18E16A001MX	Madera Irrigation District	268.0	108.7	106.0	110.6	114.7	108.9	110.8
12	18	17	12S18E17L001MX	Madera Irrigation District	257.0	99.8	99.3	102.4			
12	18	19	12S18E19H001MX	Madera Irrigation District	251.0	97.5	96.9	91.6	96.1	98.7	98.9
12	18	21	12S18E21P001MX	Madera Irrigation District	267.0	93.2	89.3	97.0	103.8	105.1	100.9
12	18	25	12S18E25B001MX	Madera Irrigation District	284.0						
12	18	26	12S18E26L001MX	Madera Irrigation District	276.0	93.0	92.2	94.4	97.6	99.0	98.0
12	18	31	12S18E31J001MX	Madera Irrigation District	254.0	92.3	88.4	87.2	83.8	85.4	84.3
12	18	32	12S18E32E001MX	Madera Irrigation District	253.0						
12	18	33	12S18E33D001MX	Madera Irrigation District	261.0						
12	18	34	12S18E34F001MX	Madera Irrigation District	269.0	78.3	73.7	76.4	78.1	80.4	
12	18	35	12S18E35G001MX	Madera Irrigation District	278.0	76.8	84.0	88.3	86.5	89.5	88.7
12	18	36	12S18E36P001MX	Madera Irrigation District	280.0						
12	19	20	12S19E20D001MX	Madera Irrigation District	293.0	112.9	120.3	127.3	113.1	118.0	131.5
12	19	21	12S19E21B001MX	Madera Irrigation District	300.0	120.8	120.6		123.9	125.1	125.8
12	19	25	12S19E25E001MX	Madera Irrigation District	251.0						
12	19	28	12S19E28A001MX	Madera Irrigation District	307.5		96.5	101.6	102.9	103.1	103.5
12	19	29	12S19E29A001MX	Madera Irrigation District	301.0	99.9	115.4	114.8	116.9	131.1	133.0
12	19	33	12S19E33P001MX	City of Fresno	300.9	90.7	91.7	94.4	94.6	95.4	95.7
12	19	34	12S19E34L001MX	City of Fresno	315.4	105.9	106.6	109.1	111.0	111.4	110.0
12	19	34	12S19E34P001MX	Fresno Irrigation District	317.8						
12	19	35	12S19E35Q001MX	City of Fresno	323.1	121.7	118.9	117.2	120.5	129.0	124.0
12	19	36	12S19E36J001MX	City of Fresno	331.8	136.1	140.3	139.0	139.2	147.0	147.7
12	19	36	12S19E36Q001MX	City of Fresno	332.1	136.2	140.1	140.1	146.9	141.0	141.7
12	20	13	12S20E13D001MX	California Department of Water Resources	388.0						
12	20	14	12S20E14H001MX	California Department of Water Resources	372.0						
12	20	15	12S20E15A001MX	City of Fresno	361.3	132.0		141.6	195.9		
12	20	23	12S20E23D001MX	City of Fresno	364.4	146.7	144.7	147.4	148.8	148.2	150.3
12	20	23	12S20E23M001MX	City of Fresno	354.2	136.6	127.9	140.3	142.2	145.0	
12	20	25	12S20E25E001MX	California Department of Water Resources	362.0						
12	20	25	12S20E25J001MX	California Department of Water Resources	366.0						
12	20	26	12S20E26A001MX	City of Fresno	373.0	166.0	166.4	169.5	169.4	173.0	173.2
12	20	26	12S20E26D001MX	Fresno Irrigation District	370.7						
12	20	26	12S20E26K001MX	City of Fresno	360.2	158.8	152.0	159.3	160.0	164.1	
12	20	26	12S20E26P001MX	California Department of Water Resources	353.0						
12	20	27	12S20E27H001MX	City of Fresno	367.0	163.8	157.0	161.1	163.0	165.2	166.9
12	20	27	12S20E27L001MX	City of Fresno	358.0	155.2	155.0	155.0	159.2	159.9	
12	20	27	12S20E27N001MX	City of Fresno	351.0	153.8	150.3	150.5	151.6	157.7	152.1
12	20	32	12S20E32A001MX	City of Fresno	346.5	141.7	141.7	147.4	149.8	146.0	143.0
12	20	34	12S20E34K001MX	City of Fresno	360.1	148.7	145.0	150.0	153.1	153.5	151.5
12	20	36	12S20E36M001MX	City of Fresno	349.9	160.0	132.0	142.0	161.1	164.1	162.9
12	21	16	12S21E16B001MX	California Department of Water Resources	400.0						
12	21	17	12S21E17D001MX	California Department of Water Resources	394.0	118.0					
12	21	18	12S21E18J001MX	California Department of Water Resources	390.0	128.0	128.0	128.0	128.0		128.1
12	21	19	12S21E19D001MX	Fresno Irrigation District	380.0						
12	21	19	12S21E19J001MX	California Department of Water Resources	376.2	86.0	86.0	86.0	90.0		91.7
12	21	26	12S21E26M001MX	California Department of Water Resources	403.0						
12	21	27	12S21E27E001MX	California Department of Water Resources	390.0						
12	21	29	12S21E29K001MX	California Department of Water Resources	379.0	76.6	76.8	76.3	83.0		85.1
12	21	30	12S21E30H001MX	California Department of Water Resources	374.0						
12	21	31	12S21E31B001MX	Fresno Irrigation District	368.8						
12	21	31	12S21E31M001MX	City of Clovis	361.5	165.0	159.5	164.8	166.5	170.5	166.0
12	21	32	12S21E32K001MX	City of Clovis	370.1		163.0	168.0	141.0	148.8	167.0
12	21	32	12S21E32Q001MX	City of Clovis	370.5	130.0	138.5	150.5	135.0	144.0	152.3
12	21	33	12S21E33D001MX	California Department of Water Resources	376.0	83.5					
12	21	33	12S21E33P001MX	Fresno Irrigation District	374.2						
12	21	33	12S21E33P002MX	City of Clovis	371.2	113.8	123.5	127.0	121.3	130.3	129.0
12	21	34	12S21E34D001MX	Fresno Irrigation District	387.7						
12	21	34	12S21E34H001MX	California Department of Water Resources	390.0	58.1					
12	21	35	12S21E35A001MX	California Department of Water Resources	402.0						
12	21	35	12S21E35Q001MX	California Department of Water Resources	419.0						
12	21	36	12S21E36J001MX	California Department of Water Resources	419.0						
12	22	19	12S22E19N001MX	California Department of Water Resources	438.0	32.9					
12	22	26	12S22E26L001MX	California Department of Water Resources	485.0	20.1					
12	22	32	12S22E32R001MX	California Department of Water Resources	438.0	49.6					
12	22	35	12S22E35N001MX	California Department of Water Resources	445.0						

Groundwater Level Data (Depth to Water Surface) - Wells Measured Annually (Datum NAVD 88)

Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
13	16	36	13S16E36R001MX	Fresno Irrigation District	195.0						
13	17	03	13S17E03J001MX	Madera Irrigation District	232.0	72.8	66.0	68.0	75.8	76.0	71.1
13	17	04	13S17E04R001MX	Madera Irrigation District	222.0	65.0	72.1	74.3	72.3	65.0	61.0
13	17	07	13S17E07J001MX	Madera Irrigation District	206.0						
13	17	09	13S17E09A001MX	Madera Irrigation District	220.0	62.0	64.6	69.8	66.7	66.0	
13	17	12	13S17E12J001MX	Fresno Irrigation District	244.2	40.1	46.1	48.1	49.1	48.1	45.1
13	17	13	13S17E13H001MX	Fresno Irrigation District					48.0	50.0	36.0
13	17	19	13S17E19H001MX	Fresno Irrigation District	205.3	49.0	55.0				
13	17	20	13S17E20A001MX	Fresno Irrigation District	209.9	40.7	37.7		45.7	46.7	43.7
13	17	22	13S17E22B001MX	Fresno Irrigation District	221.9		43.5		52.5	54.5	51.5
13	17	25	13S17E25C001MX	Fresno Irrigation District	231.8	53.1	53.1	56.1	56.1	54.1	44.1
13	17	27	13S17E27L001MX	Fresno Irrigation District	215.6	59.6	52.6	61.6	51.6	62.6	62.6
13	17	30	13S17E30J001MX	Fresno Irrigation District	203.2	65.2	77.2	65.2	55.2	65.2	62.2
13	17	33	13S17E33M001MX	Fresno Irrigation District	210.1	71.4	85.4	76.4	85.4	81.4	80.4
13	17	34	13S17E34L001MX	Fresno Irrigation District	214.7	76.8	60.8	67.8	70.8	71.8	69.8
13	17	36	13S17E36N001MX	Fresno Irrigation District	220.6						
13	18	03	13S18E03F001MX	Madera Irrigation District	265.0						
13	18	04	13S18E04H001MX	Madera Irrigation District	261.0		65.9	69.7	71.1	72.0	71.4
13	18	05	13S18E05J001MX	Madera Irrigation District	259.0		68.0	80.1	79.8	79.1	79.7
13	18	06	13S18E06F001MX	Madera Irrigation District	246.0	61.5	61.5	67.6	69.2	70.0	63.6
13	18	10	13S18E10L001MX	Fresno Irrigation District	261.4	54.8	53.8	58.8	52.8	51.8	49.8
13	18	11	13S18E11J001MX	Fresno Irrigation District	271.5						
13	18	12	13S18E12P001MX	Fresno Irrigation District	270.8	54.4	60.4	66.4	62.4	64.4	59.4
13	18	17	13S18E17A001MX	Fresno Irrigation District	253.2	51.8	53.0	57.0	44.0	51.0	45.0
13	18	18	13S18E18A001MX	Fresno Irrigation District					57.0	60.0	46.0
13	18	18	13S18E18M001MX	Fresno Irrigation District					49.0	50.0	46.0
13	18	22	13S18E22P002MX	Fresno Irrigation District					64.0	67.0	70.0
13	18	22	13S18E22R001MX	Fresno Irrigation District					67.0	69.0	64.5
13	18	23	13S18E23N001MX	Fresno Irrigation District	255.1	49.0	54.0	55.0	54.0	55.0	51.0
13	18	25	13S18E25B001MX	Fresno Irrigation District	265.9						
13	18	25	13S18E25K001MX	Fresno Irrigation District	261.0	50.0	63.0	64.0	63.0	63.0	59.0
13	18	27	13S18E27B001MX	Fresno Irrigation District					55.0	60.0	55.0
13	18	28	13S18E28F001MX	Fresno Irrigation District	243.1	49.7	47.7	52.7	52.7	53.7	48.7
13	18	29	13S18E29C001MX	Fresno Irrigation District	238.5	44.0	50.0	53.0	52.0	55.0	38.0
13	18	33	13S18E33M001MX	Fresno Irrigation District	237.3	57.5	56.5	59.5	56.5	60.5	57.5
13	18	34	13S18E34K001MX	Fresno Irrigation District	242.7	54.1	52.1	51.1	48.1	45.1	42.1
13	18	35	13S18E35G001MX	Fresno Irrigation District	253.2	59.0	60.0	63.0	64.0	66.0	62.0
13	19	01	13S19E01C001MX	City of Fresno	329.3	127.5	119.9	128.4	131.1	134.0	132.3
13	19	01	13S19E01L001MX	City of Fresno	312.8	120.6	101.2	126.7	122.2	123.8	121.0
13	19	02	13S19E02M001MX	City of Fresno	314.4	117.0	117.9	115.1		123.3	122.6
13	19	06	13S19E06A001MX	Fresno Irrigation District	291.2	77.5	71.5	82.5	83.5	80.5	85.5
13	19	07	13S19E07R001MX	Fresno Irrigation District	279.4	68.2	69.2	68.2	57.2	71.2	64.2
13	19	10	13S19E10F001MX	City of Fresno	304.4	106.1	107.3	110.4	107.6	111.6	111.0
13	19	10	13S19E10Q001MX	City of Fresno	298.0	99.9	97.3	103.5	102.0	102.0	104.0
13	19	11	13S19E11L001MX	City of Fresno	304.7	112.5	107.7	115.0		115.7	118.0
13	19	12	13S19E12K001MX	City of Fresno	307.9						
13	19	14	13S19E14B001MX	City of Fresno	300.5						
13	19	18	13S19E18E001MX	Fresno Irrigation District	273.4	67.1					
13	19	18	13S19E18E002MX	Fresno Irrigation District	274.2		66.4	70.4	72.4	72.4	70.4
13	19	21	13S19E21D001MX	Fresno Irrigation District	282.9						
13	19	23	13S19E23E001MX	Fresno Irrigation District	284.6	85.0	88.0	86.0		90.0	85.0
13	19	26	13S19E26L001MX	City of Fresno	279.3	84.2	82.6	87.7	86.1	90.0	87.0
13	19	27	13S19E27R001MX	Fresno Irrigation District	390.0						
13	19	29	13S19E29A001MX	Fresno Irrigation District	266.9	61.7	76.7	68.7	71.7	72.7	73.7
13	19	29	13S19E29D001MX	Fresno Irrigation District	268.2	66.3	69.3	69.3	72.3	73.3	72.3
13	19	29	13S19E29E001MX	Fresno Irrigation District	268.0						
13	20	01	13S20E01G001MX	City of Fresno	348.4	163.4		161.2		163.0	
13	20	02	13S20E02G001MX	City of Fresno	345.2			104.2			
13	20	03	13S20E03H001MX	City of Fresno	333.4			139.0			
13	20	05	13S20E05B001MX	City of Fresno	338.7	143.2	142.8	146.2	145.2	148.3	145.0
13	20	06	13S20E06H001MX	City of Fresno	329.3	141.8	142.5	147.6	148.3	148.0	148.0
13	20	06	13S20E06M001MX	City of Fresno	326.5	131.3	171.4	137.4	137.9	138.3	
13	20	09	13S20E09L001MX	City of Fresno	321.6	136.8	135.7	139.8	136.1	139.0	138.2
13	20	10	13S20E10Q001MX	City of Fresno	327.5	145.6	144.6	147.0	147.4	147.0	146.5
13	20	11	13S20E11L001MX	City of Fresno	329.2	149.6	149.1	152.8	153.7	152.0	148.7
13	20	12	13S20E12H001MX	Fresno Irrigation District	343.4						
13	20	13	13S20E13C001MX	City of Fresno	335.2	121.5	125.8	128.1	151.8	153.4	153.0
13	20	13	13S20E13H001MX	City of Fresno	335.6	135.1	137.1	138.0	149.8	150.1	106.0
13	20	14	13S20E14L001MX	City of Fresno	312.9	140.2	138.9	143.0	145.2	140.3	144.0
13	20	16	13S20E16Q001MX	City of Fresno	312.4	130.5		138.9	139.6	139.7	135.0
13	20	17	13S20E17A001MX	City of Fresno	319.9	135.7		142.5			
13	20	17	13S20E17J001MX	City of Fresno	317.0		131.5	132.0	136.1	136.6	136.0
13	20	17	13S20E17L001MX	City of Fresno	319.0	130.1		134.9	136.1	135.4	
13	20	18	13S20E18E001MX	City of Fresno	304.0	117.2	116.0	116.8	118.0	118.1	119.5
13	20	19	13S20E19C001MX	City of Fresno	307.6	138.9	117.0	118.5		121.2	124.0
13	20	20	13S20E20J001MX	City of Fresno	304.4	126.2	137.0	128.0		128.5	126.0
13	20	20	13S20E20R001MX	City of Fresno	300.2	122.0	115.5	121.0		122.4	119.0
13	20	22	13S20E22H001MX	City of Fresno	320.6	141.3	143.1	143.8		146.1	141.5
13	20	23	13S20E23B001MX	City of Fresno	324.7	145.2	143.3	141.0		151.1	144.8
13	20	23	13S20E23J001MX	City of Fresno	322.2	130.5	133.2	133.3	142.5	143.0	133.0

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Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
13	20	25	13S20E25G001MX	City of Fresno	321.9	129.0	130.1	134.9	137.1	135.0	131.0
13	20	26	13S20E26P001MX	City of Fresno	307.9	126.4	124.5	127.9		130.2	128.2
13	20	27	13S20E27C001MX	City of Fresno	310.1	134.9	135.6	134.5	134.0	136.7	131.5
13	20	28	13S20E28C001MX	City of Fresno	307.0	127.4	122.0	130.5		132.1	128.0
13	20	28	13S20E28N001MX	City of Fresno	299.5	106.9	107.1	109.9		115.8	113.0
13	20	28	13S20E28R001MX	City of Fresno	300.8						
13	20	30	13S20E30B001MX	City of Fresno	304.0	116.6	114.1	117.1	121.9	122.1	119.0
13	20	31	13S20E31D001MX	City of Fresno	292.4	98.5	98.8	102.2		108.0	104.0
13	20	32	13S20E32D001MX	City of Fresno	293.3	106.7	103.4	103.4	107.4	111.1	107.0
13	20	32	13S20E32K001MX	City of Fresno	292.1	103.2	103.8	106.1		136.3	109.0
13	20	36	13S20E36P001MX	City of Fresno	306.5	114.5	115.3	117.6		121.0	113.0
13	21	02	13S21E02E001MX	California Department of Water Resources	382.0						
13	21	05	13S21E05E001MX	City of Clovis	364.6	160.5	165.5	164.0	159.0	167.0	166.5
13	21	05	13S21E05J001MX	City of Clovis	361.3						
13	21	06	13S21E06H001MX	City of Clovis	358.0	155.8	165.0	164.0			
13	21	06	13S21E06P001MX	City of Clovis	354.8	146.5	148.0	155.0	155.8	159.0	154.0
13	21	07	13S21E07G001MX	City of Clovis	345.8						
13	21	07	13S21E07P001MX	City of Clovis	345.0	136.5	140.0	144.0	148.5	150.3	148.0
13	21	08	13S21E08F001MX	City of Clovis	349.0						
13	21	08	13S21E08J001MX	City of Clovis	355.0	129.0	128.3	142.0		149.0	140.0
13	21	09	13S21E09C001MX	City of Clovis	360.7	123.0	123.8	133.8	130.0	139.0	
13	21	09	13S21E09D001MX	City of Clovis	359.9						
13	21	09	13S21E09R001MX	City of Clovis	365.0	131.3	133.0	140.3	152.5	143.8	130.3
13	21	10	13S21E10G001MX	City of Clovis	373.1	98.5	100.0	105.3	103.5	107.0	105.8
13	21	11	13S21E11A001MX	California Department of Water Resources	386.0	52.0	60.0	61.6			
13	21	11	13S21E11D001MX	Fresno Irrigation District	379.0						
13	21	14	13S21E14D001MX	Fresno Irrigation District	378.0						
13	21	14	13S21E14R001MX	California Department of Water Resources	370.0		40.2	45.3			
13	21	15	13S21E15H001MX	City of Clovis	377.4						
13	21	15	13S21E15L001MX	City of Clovis	357.0	128.8	131.5	134.3	154.0	158.5	129.8
13	21	16	13S21E16M001MX	City of Clovis	354.8	141.3	140.0	148.0	143.0	157.8	146.3
13	21	16	13S21E16N001MX	City of Clovis	347.6	112.5	117.5	124.0	123.8	128.0	127.0
13	21	16	13S21E16N002MX	City of Clovis	347.0	113.5	119.0	123.3	125.5	131.0	128.0
13	21	16	13S21E16P001MX	City of Clovis	354.7	117.5	119.5	122.5	130.5	133.3	127.0
13	21	17	13S21E17J001MX	City of Clovis	355.0						
13	21	17	13S21E17Q001MX	City of Clovis	345.5	117.0	122.0	127.0	130.0	134.0	133.5
13	21	17	13S21E17Q002MX	City of Clovis	349.4	120.5	125.5	130.5	133.5	138.0	137.3
13	21	18	13S21E18H001MX	City of Clovis	343.0	125.5	129.5	134.0	139.0	141.8	141.0
13	21	19	13S21E19E001MX	City of Fresno	334.8	131.7	130.2	133.0	139.0	139.9	137.0
13	21	20	13S21E20A001MX	City of Clovis	347.0	115.3	121.5	126.3	126.3	131.5	130.0
13	21	20	13S21E20A002MX	City of Clovis	347.0	116.0	123.0	128.3	128.0	134.0	133.3
13	21	20	13S21E20F001MX	City of Clovis	338.0	124.5	128.0	133.5	136.5	145.5	140.5
13	21	21	13S21E21E001MX	City of Clovis	347.0	112.8	117.8	121.5	124.8	131.0	127.8
13	21	21	13S21E21E002MX	City of Clovis	347.0		114.5	118.5			
13	21	21	13S21E21P001MX	City of Fresno	340.0	102.1	100.9	102.3	101.9	102.5	108.1
13	21	22	13S21E22C001MX	California Department of Water Resources	369.0						
13	21	23	13S21E23D001MX	Fresno Irrigation District	362.0						
13	21	23	13S21E23R001MX	California Department of Water Resources	357.0	40.6	38.6	44.7			
13	21	24	13S21E24J001MX	Fresno Irrigation District	370.8	36.6	33.6	41.6	42.6	44.6	41.6
13	21	25	13S21E25N001MX	California Department of Water Resources	354.0	48.9	47.5	52.7	57.9		
13	21	26	13S21E26M001MX	Fresno Irrigation District	348.1	51.3	50.3	55.3	57.3	58.3	57.3
13	21	27	13S21E27N001MX	California Department of Water Resources	339.0						
13	21	28	13S21E28G001MX	City of Fresno	338.7	112.8	114.2	113.0	115.2	124.3	142.2
13	21	29	13S21E29H001MX	City of Fresno	335.3	108.4				120.3	127.3
13	21	30	13S21E30P001MX	City of Fresno	318.9	116.9	117.0				
13	21	30	13S21E30Q001MX	City of Clovis	370.0	150.8	156.5	160.3	162.8		
13	21	31	13S21E31E001MX	City of Fresno	312.2	118.7	121.1	117.1	123.0	124.7	119.0
13	21	32	13S21E32G001MX	City of Fresno	327.7	111.2	113.6	114.1	117.8	117.4	102.0
13	21	33	13S21E33N001MX	California Department of Water Resources	328.0						
13	21	34	13S21E34H001MX	California Department of Water Resources	342.0						
13	21	36	13S21E36H001MX	California Department of Water Resources	351.0						
13	22	02	13S22E02Q001MX	California Department of Water Resources	444.9						
13	22	03	13S22E03B001MX	California Department of Water Resources	434.0	22.4					
13	22	05	13S22E05A001MX	California Department of Water Resources	420.0						
13	22	06	13S22E06H001MX	California Department of Water Resources	415.0	72.9					
13	22	07	13S22E07R001MX	Fresno Irrigation District	391.6	43.5	42.5	46.5	47.5	49.5	50.5
13	22	09	13S22E09N001MX	California Department of Water Resources	403.0						
13	22	13	13S22E13A001MX	Fresno Irrigation District	436.6	8.3	9.3	10.3	11.3	16.3	5.3
13	22	14	13S22E14B001MX	California Department of Water Resources	434.0	32.1	31.2	32.0			
13	22	15	13S22E15R001MX	California Department of Water Resources	414.0	39.7					
13	22	20	13S22E20A001MX	California Department of Water Resources	380.0	14.8	14.1	20.0	20.6		15.2
13	22	21	13S22E21D001MX	Fresno Irrigation District	400.8						
13	22	22	13S22E22R001MX	California Department of Water Resources	393.0	26.8	24.1	30.2	33.7		34.1
13	22	23	13S22E23F001MX	California Department of Water Resources	405.0	25.0					
13	22	23	13S22E23R001MX	California Department of Water Resources	405.0	16.2	16.0	23.4	23.7		12.1
13	22	27	13S22E27R001MX	Fresno Irrigation District	390.0						
13	22	28	13S22E28B001MX	California Department of Water Resources	385.3						
13	22	29	13S22E29M001MX	California Department of Water Resources	374.0	35.0					
13	22	31	13S22E31N001MX	Fresno Irrigation District	356.5	41.5	43.5	51.5	48.5	52.5	47.5
13	22	32	13S22E32A001MX	Fresno Irrigation District	370.8	30.7	29.7	40.7	40.7	43.7	

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Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
13	22	34	13S22E34R001MX	California Department of Water Resources	384.0	34.4	31.7	35.3	45.4		
13	23	19	13S23E19N001MX	Fresno Irrigation District	410.3	9.0	10.0	18.0			
13	23	30	13S23E30B001MX	Fresno Irrigation District	410.8	4.2	5.2	8.2	9.2	8.2	3.2
13	23	33	13S23E33B001MX	Fresno Irrigation District	431.8	9.9	13.9	16.9	15.9	24.9	8.0
14	16	12	14S16E12A001MX	Fresno Irrigation District	188.4						
14	17	04	14S17E04R001MX	Fresno Irrigation District	205.2						
14	17	05	14S17E05C001MX	Fresno Irrigation District	202.9	89.0	88.0	89.0	65.0	84.0	90.0
14	17	06	14S17E06B001MX	Fresno Irrigation District	196.5	89.0	83.0	85.0	87.0	88.0	89.0
14	17	11	14S17E11H001MX	Fresno Irrigation District	214.4	86.3					
14	17	28	14S17E28A001MX	James Irrigation District	195.0						
14	17	29	14S17E29E001MX	James Irrigation District	185.0						
14	17	31	14S17E31R001MX	James Irrigation District	180.0						
14	17	32	14S17E32R001MX	James Irrigation District	184.5						
14	17	33	14S17E33A001MX	James Irrigation District	191.0						
14	17	34	14S17E34A001MX	James Irrigation District	197.0						
14	17	35	14S17E35A001MX	James Irrigation District	200.0						
14	17	36	14S17E36A001MX	James Irrigation District	207.0						
14	18	02	14S18E02B001MX	Fresno Irrigation District	249.7	56.1	59.1	62.1	61.1	63.1	53.1
14	18	03	14S18E03B001MX	Fresno Irrigation District	245.6	55.1	56.1	58.1	60.1	59.1	58.1
14	18	03	14S18E03G001MX	Fresno Irrigation District					68.0	53.0	37.0
14	18	03	14S18E03K001MX	Fresno Irrigation District					77.0	74.0	71.0
14	18	03	14S18E03L001MX	Fresno Irrigation District	239.1	58.0	60.0	61.0	63.0	65.0	46.0
14	18	04	14S18E04B001MX	Fresno Irrigation District	239.3	54.7					
14	18	04	14S18E04G001MX	Fresno Irrigation District	238.4	75.3	59.3	60.3	57.3	62.3	54.3
14	18	04	14S18E04J001MX	Fresno Irrigation District	237.9	60.0	62.0	63.0	67.0	54.0	55.0
14	18	05	14S18E05D001MX	Fresno Irrigation District	230.5	56.2	59.2	61.2	64.2	67.2	65.2
14	18	06	14S18E06P001MX	Fresno Irrigation District	224.2	63.3	60.3	70.3	71.3	75.3	75.3
14	18	09	14S18E09H001MX	Fresno Irrigation District	236.3	63.2	61.2	67.2	66.2	70.2	68.2
14	18	09	14S18E09L001MX	Fresno Irrigation District	229.2	66.2	67.2	67.2	67.2	72.2	70.2
14	18	09	14S18E09M001MX	Fresno Irrigation District	226.3	67.2	87.2	69.2	67.2	75.2	73.2
14	18	10	14S18E10A001MX	Fresno Irrigation District	243.6	62.0	71.0	66.0	66.0	69.0	69.0
14	18	10	14S18E10C001MX	Fresno Irrigation District	240.3	63.0	62.0	64.0	64.0	63.0	58.0
14	18	10	14S18E10D001MX	Fresno Irrigation District	234.7	61.3	61.3	66.3	62.3	67.3	60.3
14	18	10	14S18E10K001MX	Fresno Irrigation District	240.8	64.5	57.5	67.5	67.5	71.5	69.5
14	18	15	14S18E15M001MX	Fresno Irrigation District	230.9	68.0	66.0	73.0	75.0	80.0	77.0
14	18	18	14S18E18E001MX	James Irrigation District	214.0						
14	18	19	14S18E19A001MX	Fresno Irrigation District	215.9	82.7	74.7	85.7	80.7	87.7	88.7
14	18	21	14S18E21L001MX	Fresno Irrigation District	223.4						
14	18	26	14S18E26C001MX	Fresno Irrigation District	228.4	74.0	71.0	74.0	77.0	80.0	75.0
14	18	28	14S18E28Q001MX	Fresno Irrigation District	226.3		101.1	105.1	109.1	111.1	112.1
14	18	29	14S18E29A001MX	James Irrigation District	220.5						
14	18	32	14S18E32D001MX	Fresno Irrigation District	212.3	107.7	106.7	112.7	116.7	122.7	
14	18	33	14S18E33C001MX	Fresno Irrigation District	220.1						
14	19	03	14S19E03Q001MX	Fresno Irrigation District	264.7	70.8	70.8	64.8	59.8	66.8	72.8
14	19	04	14S19E04R001MX	Fresno Irrigation District	262.4						
14	19	06	14S19E06A001MX	Fresno Irrigation District	254.8	59.2	59.2	54.2	60.2	63.2	57.2
14	19	07	14S19E07D001MX	Fresno Irrigation District	248.3						
14	19	11	14S19E11L001MX	Fresno Irrigation District	272.7	73.8	74.8	71.8	81.8	78.8	78.8
14	19	15	14S19E15G001MX	Fresno Irrigation District	252.6						
14	19	17	14S19E17C001MX	Fresno Irrigation District	249.9	57.9	52.9	57.9	62.9	59.9	63.9
14	19	18	14S19E18G001MX	Fresno Irrigation District	243.6	61.0	59.0	62.0	66.0	68.0	65.0
14	19	18	14S19E18N001MX	Fresno Irrigation District	238.8		60.2	62.2	63.2	66.2	66.2
14	19	20	14S19E20D001MX	Fresno Clovis Waste Water Sewage Treatment	244.1	59.0	51.6	59.4	63.2	64.9	61.6
14	19	20	14S19E20N001MX	Fresno Clovis Waste Water Sewage Treatment	238.7	53.0	43.0	51.9	56.0	63.5	52.9
14	19	21	14S19E21M001MX	Fresno Clovis Waste Water Sewage Treatment	249.9	41.1	28.4	45.4	36.1	43.9	35.8
14	19	21	14S19E21P001MX	Fresno Clovis Waste Water Sewage Treatment	243.7	29.0	24.7	32.8	32.4	39.1	34.2
14	19	22	14S19E22G001MX	Fresno Clovis Waste Water Sewage Treatment	251.5	51.6	50.4	57.5	55.6	61.3	56.5
14	19	23	14S19E23B001MX	Fresno Clovis Waste Water Sewage Treatment	258.2	58.9	56.4	64.5	66.1	68.2	66.4
14	19	23	14S19E23Q001MX	Fresno Clovis Waste Water Sewage Treatment	254.4	58.8	57.4	63.7	66.2	69.2	66.6
14	19	26	14S19E26D001MX	Fresno Irrigation District	251.5	51.0	50.0	54.0	58.0	59.0	57.0
14	19	26	14S19E26Q001MX	Fresno Clovis Waste Water Sewage Treatment	250.1	65.5	62.0	68.3	72.2	74.9	72.0
14	19	27	14S19E27K001MX	Fresno Clovis Waste Water Sewage Treatment	250.9	43.2	32.9	44.1	42.5	50.8	45.9
14	19	28	14S19E28M001MX	Fresno Clovis Waste Water Sewage Treatment	248.9	41.0	39.9	41.6	52.3	50.8	51.4
14	19	32	14S19E32D001MX	Fresno Irrigation District	234.4			64.2	58.2	69.2	
14	19	33	14S19E33D001MX	Fresno Irrigation District	239.5	46.0	43.0	46.0	51.0	46.0	53.0
14	20	01	14S20E01J001MX	City of Fresno	312.6	113.0	113.1	115.7		119.1	114.0
14	20	02	14S20E02J001MX	City of Fresno	302.4	115.0	113.4	114.9		117.0	111.9
14	20	03	14S20E03C001MX	City of Fresno	296.5	112.3	114.6	116.6	108.8	109.3	120.5
14	20	03	14S20E03J001MX	City of Fresno	295.2						
14	20	03	14S20E03M001MX	City of Fresno	293.8	108.1	112.2			111.3	114.0
14	20	04	14S20E04E001MX	City of Fresno	287.0	122.2	119.2	122.4		126.2	123.0
14	20	04	14S20E04F001MX	City of Fresno	288.0	103.1	105.9		148.8	114.0	
14	20	08	14S20E08H001MX	City of Fresno	279.1	85.3	90.1	101.1		96.9	93.0
14	20	08	14S20E08R001MX	City of Fresno	279.9	86.1	92.8	100.1		95.3	81.0
14	20	10	14S20E10M001MX	City of Fresno	291.4		100.8	103.1		102.0	97.0
14	20	11	14S20E11F001MX	City of Fresno	295.4	101.3	103.3	104.6		106.5	113.8
14	20	13	14S20E13F001MX	City of Fresno	291.8	79.0	81.2	86.5		93.0	74.0
14	20	14	14S20E14L001MX	City of Fresno	288.1	84.5	84.6	88.0		88.0	85.0
14	20	16	14S20E16A001MX	City of Fresno	283.4	89.2	95.2	100.1		96.6	93.0
14	20	19	14S20E19A001MX	Fresno Irrigation District	267.4	64.0	65.0	73.0	75.0	76.0	73.0

Groundwater Level Data (Depth to Water Surface) - Wells Measured Annually (Datum NAVD 88)

Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
14	20	22	14S20E22J001MX	City of Fresno	282.5	67.7	70.3	75.4			74.0
14	20	24	14S20E24K001MX	City of Fresno	294.7	69.1	70.3	70.0	73.5	74.0	74.0
14	20	31	14S20E31D001MX	Fresno Irrigation District	258.1	61.2	56.2	66.2	75.2	70.2	71.2
14	20	33	14S20E33F001MX	Fresno Irrigation District	271.1	57.7	57.7			61.7	
14	20	36	14S20E36A001MX	Malaga Water District	289.7						
14	21	03	14S21E03D001MX	Fresno Irrigation District	333.0						
14	21	04	14S21E04D001MX	City of Fresno	324.4		119.6	120.6			118.0
14	21	06	14S21E06E001MX	City of Fresno	310.1	112.4	111.1	112.7		117.1	110.8
14	21	06	14S21E06Q001MX	City of Fresno	309.6	104.1	107.6		110.9	111.3	108.0
14	21	07	14S21E07M001MX	City of Fresno	302.8						95.0
14	21	08	14S21E08A001MX	City of Fresno	320.5	98.9	96.8	99.8	100.6	103.1	100.0
14	21	08	14S21E08J001MX	City of Fresno	317.1	92.7			141.1		95.0
14	21	09	14S21E09C001MX	City of Fresno	320.1					87.0	150.0
14	21	09	14S21E09R001MX	City of Fresno	316.9	67.4	68.3	70.3	67.7		70.0
14	21	11	14S21E11L001MX	Fresno Irrigation District	334.2	59.4	51.4	60.4	60.4	61.4	62.4
14	21	17	14S21E17E001MX	City of Fresno	307.5	93.6	91.4	95.6			97.0
14	21	17	14S21E17N001MX	City of Fresno	314.5						
14	21	22	14S21E22D001MX	Fresno Irrigation District	317.8	57.2	56.2	58.2	59.2	59.7	61.2
14	21	26	14S21E26A001MX	Consolidated Irrigation District	329.9	48.7		52.3	54.9		57.2
14	21	27	14S21E27A001MX	Consolidated Irrigation District	321.2	51.5		55.3	57.7		57.8
14	21	29	14S21E29D001MX	Fresno Irrigation District	302.0	33.0	33.0			34.0	49.0
14	21	30	14S21E30E001MX	Malaga Water District	285.2						
14	21	30	14S21E30L001MX	Malaga Water District	290.7						
14	21	30	14S21E30P001MX	Malaga Water District	290.1						
14	21	32	14S21E32H001MX	Fresno Irrigation District	306.7						
14	21	35	14S21E35J001MX	Consolidated Irrigation District	324.6	43.5		44.8	47.5		51.0
14	22	03	14S22E03C001MX	Fresno Irrigation District	379.7	30.9	28.9	35.9			
14	22	06	14S22E06A001MX	Fresno Irrigation District	362.2	40.9	40.9	48.9	49.9	54.9	53.9
14	22	08	14S22E08N001MX	Fresno Irrigation District	349.7	41.0	42.0	48.0	48.0	47.0	46.0
14	22	09	14S22E09G001MX	Consolidated Irrigation District	365.2						
14	22	14	14S22E14B001MX	Consolidated Irrigation District	374.4	24.1		35.6	37.1		29.2
14	22	18	14S22E18A001MX	Consolidated Irrigation District	348.8	42.1		45.9	49.8		
14	22	22	14S22E22N001MX	Consolidated Irrigation District	354.6	33.2		34.6	38.2		34.8
14	22	23	14S22E23R001MX	Consolidated Irrigation District	366.2	31.9		38.8	40.2		34.9
14	22	29	14S22E29D001MX	Consolidated Irrigation District	341.9	30.8		41.8	46.2		39.0
14	22	34	14S22E34J001MX	Consolidated Irrigation District	339.0	30.9		35.2	43.0		39.0
14	23	04	14S23E04M001MX	Fresno Irrigation District	396.0						
14	23	06	14S23E06C001MX	Fresno Irrigation District	409.4	29.6	29.6	32.6	33.6	32.6	
15	17	02	15S17E02B001MX	James Irrigation District	198.0		145.7		155.6	157.5	
15	17	05	15S17E05C001MX	James Irrigation District	181.0						
15	17	07	15S17E07J001MX	James Irrigation District	175.0						
15	17	11	15S17E11A001MX	James Irrigation District	195.0						
15	17	12	15S17E12A001MX	James Irrigation District	198.0						
15	17	13	15S17E13R001MX	James Irrigation District	193.0		184.5	177.7	182.6	186.9	198.1
15	17	15	15S17E15J001MX	James Irrigation District	187.0		158.0	175.2	161.4	169.1	164.8
15	17	18	15S17E18B001MX	James Irrigation District	173.0				104.2	109.0	
15	17	20	15S17E20C001MX	James Irrigation District	176.0				120.1	123.7	
15	17	21	15S17E21R001MX	James Irrigation District	180.0		159.1		160.1		168.4
15	17	22	15S17E22J001MX	James Irrigation District	186.0		174.5	170.5	173.1	185.4	177.1
15	18	02	15S18E02A001MX	Fresno Irrigation District	222.7	112.8	108.8	115.8	118.8	120.8	123.8
15	18	03	15S18E03R001MX	James Irrigation District	217.0		134.1	138.8	152.2	150.1	147.9
15	18	04	15S18E04A001MX	James Irrigation District	216.0						
15	18	06	15S18E06A001MX	James Irrigation District	207.0						
15	18	07	15S18E07A001MX	James Irrigation District	204.0						
15	18	10	15S18E10N001MX	James Irrigation District	209.0						
15	18	17	15S18E17C001MX	James Irrigation District	203.0						
15	18	17	15S18E17R001MX	James Irrigation District	200.6						
15	18	19	15S18E19R001MX	James Irrigation District	195.5			201.7	206.8		204.7
15	19	02	15S19E02M001MX	Fresno Irrigation District	242.9	77.3	73.3	75.3	80.3	81.3	
15	19	08	15S19E08A001MX	Fresno Irrigation District	234.0						
15	19	12	15S19E12C001MX	Fresno Irrigation District	249.5						
15	19	13	15S19E13D001MX	Consolidated Irrigation District	249.6	86.4	88.0	89.6	99.2		95.0
15	19	14	15S19E14M001MX	Fresno Irrigation District	241.3	104.5	100.5	104.5	109.5	113.5	103.5
15	19	24	15S19E24M001MX	Fresno Irrigation District	246.6						
15	19	25	15S19E25C001MX	Consolidated Irrigation District	246.1	110.0	112.1	114.1	120.6		120.8
15	20	01	15S20E01J001MX	Fresno Irrigation District	292.7	49.8	49.8	52.8		61.8	59.8
15	20	01	15S20E01R001MX	Fresno Irrigation District	290.1	49.0	46.0	54.0	58.0	61.0	59.0
15	20	02	15S20E02N001MX	Fresno Irrigation District	279.6	55.2	57.2	60.2	65.2	72.2	66.2
15	20	03	15S20E03A001MX	Fresno Irrigation District	279.6	56.0	55.0	59.0	62.0	59.0	
15	20	05	15S20E05E001MX	Fresno Irrigation District	260.8	62.4	62.4	62.4	71.4	75.4	68.4
15	20	07	15S20E07Q001MX	Fresno Irrigation District	252.2	71.3	71.3	73.3	80.3	84.3	80.3
15	20	09	15S20E09K001MX	Fresno Irrigation District	270.9	66.1	60.1			70.1	73.1
15	20	12	15S20E12F001MX	Fresno Irrigation District	288.9	51.5	51.5		60.5	67.5	62.5
15	20	13	15S20E13D001MX	Consolidated Irrigation District	283.4						
15	20	13	15S20E13E001MX	Fresno Irrigation District	282.1	56.0	51.0	58.0	63.0	67.0	66.0
15	20	15	15S20E15D001MX	Consolidated Irrigation District	272.8	65.6	70.6	69.7	75.7		76.0
15	20	17	15S20E17D001MX	Consolidated Irrigation District	261.5	78.0					
15	20	19	15S20E19R001MX	Consolidated Irrigation District	255.3	95.0	93.6	98.0	102.9		106.5
15	20	25	15S20E25D001MX	Consolidated Irrigation District	275.2	67.4	68.7	70.2	76.6		78.9
15	20	28	15S20E28A001MX	Consolidated Irrigation District	265.0	86.4	81.3	83.9	89.8		78.8

Groundwater Level Data (Depth to Water Surface) - Wells Measured Annually (Datum NAVD 88)

Town.	Ran.	Sec.	Well I.D.	AGENCY	Ground Elev at Well	JAN 2006	JAN 2007	JAN 2008	JAN 2009	JAN 2010	JAN 2011
15	21	03	15S21E03D001MX	Consolidated Irrigation District	313.4						43.8
15	21	06	15S21E06B001MX	Fresno Irrigation District	297.1	49.0	48.0	77.0		77.0	76.0
15	21	10	15S21E10M001MX	Fresno Irrigation District	305.7	44.0	42.0	47.0	51.0	55.5	50.0
15	21	14	15S21E14A001MX	Consolidated Irrigation District	318.8	45.8	47.2	49.4			51.1
15	21	15	15S21E15D001MX	Consolidated Irrigation District	300.5	44.4	46.4	48.4	54.7		53.7
15	21	17	15S21E17D001MX	Consolidated Irrigation District	292.2	45.2	46.5	47.9	49.8		
15	21	22	15S21E22E001MX	Consolidated Irrigation District	302.8	51.0	52.1	53.2	58.8		61.6
15	21	28	15S21E28A001MX	Consolidated Irrigation District	304.5	34.5	35.0	35.7	41.8		41.6
15	21	30	15S21E30A001MX	Consolidated Irrigation District	286.4	54.8	57.0	59.0	63.8		65.0
15	22	01	15S22E01A001MX	Consolidated Irrigation District	352.4	27.0		35.3	37.5		
15	22	06	15S22E06A001MX	Consolidated Irrigation District	334.0	35.2		39.2	46.4		44.0
15	22	11	15S22E11R001MX	Consolidated Irrigation District	347.3	32.8		31.1	30.9		28.6
15	22	15	15S22E15D001MX	Consolidated Irrigation District	338.3	36.2		40.1	46.3		42.6
15	22	17	15S22E17D001MX	Consolidated Irrigation District	325.1	37.8		38.9	41.4		45.2
15	22	26	15S22E26A001MX	Consolidated Irrigation District	338.7						
15	22	27	15S22E27D001MX	Consolidated Irrigation District	327.8			44.5	50.3		47.2
15	22	29	15S22E29D001MX	Consolidated Irrigation District	326.8	35.9		36.5	38.9		43.0

FRESNO AREA REGIONAL GROUNDWATER MANAGEMENT GROUP

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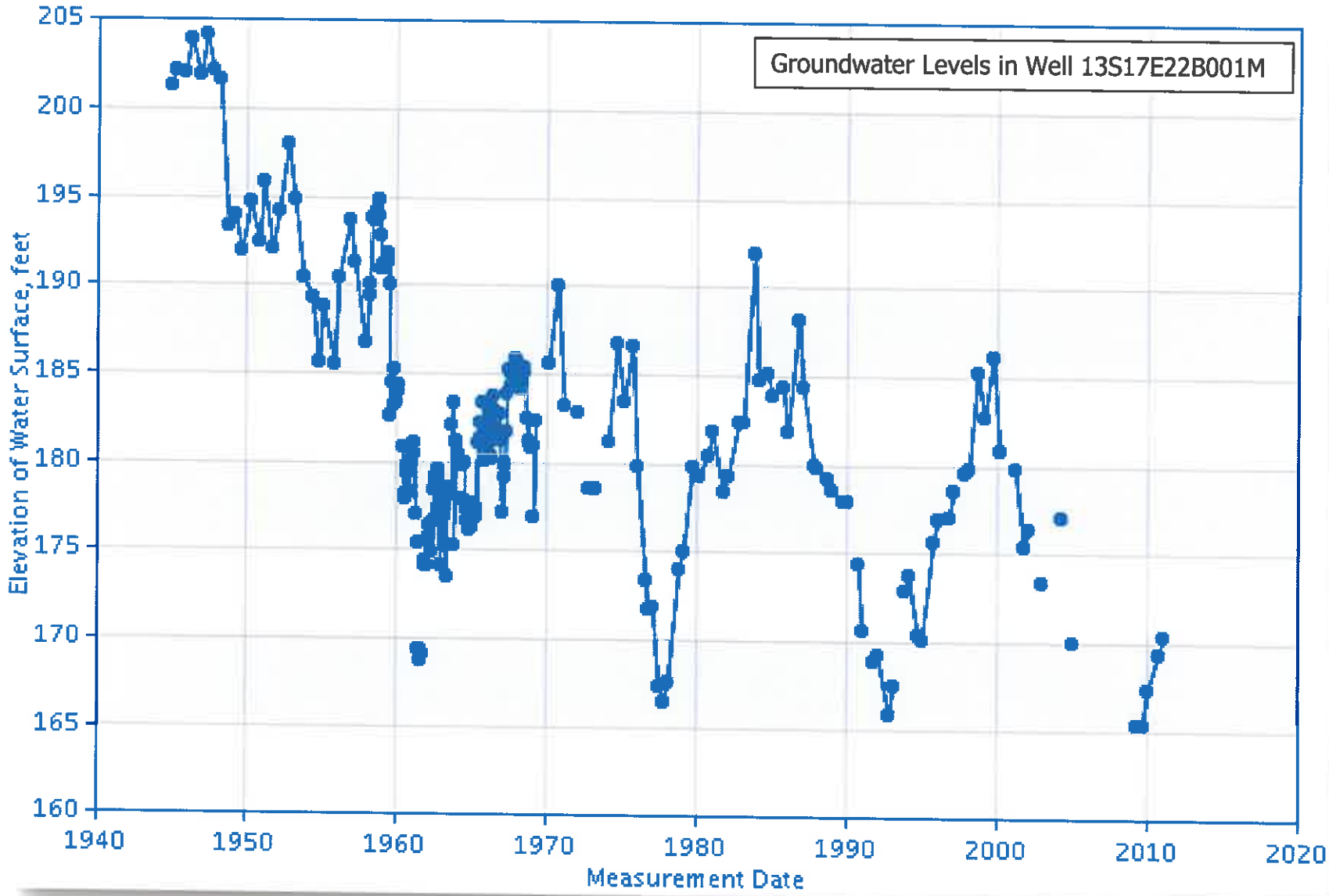
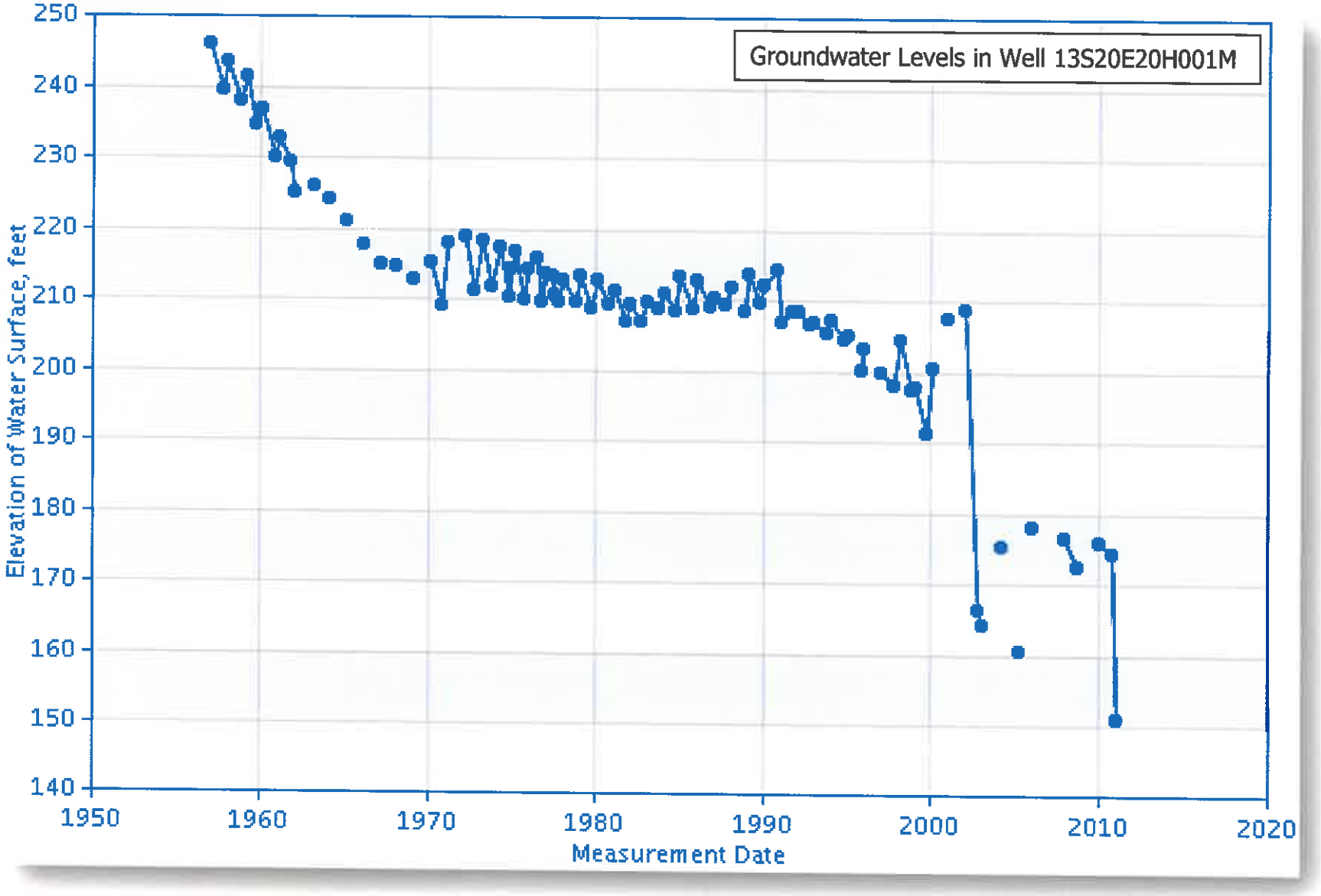
APPENDIX B – SELECTED WELL HYDROGRAPHS

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



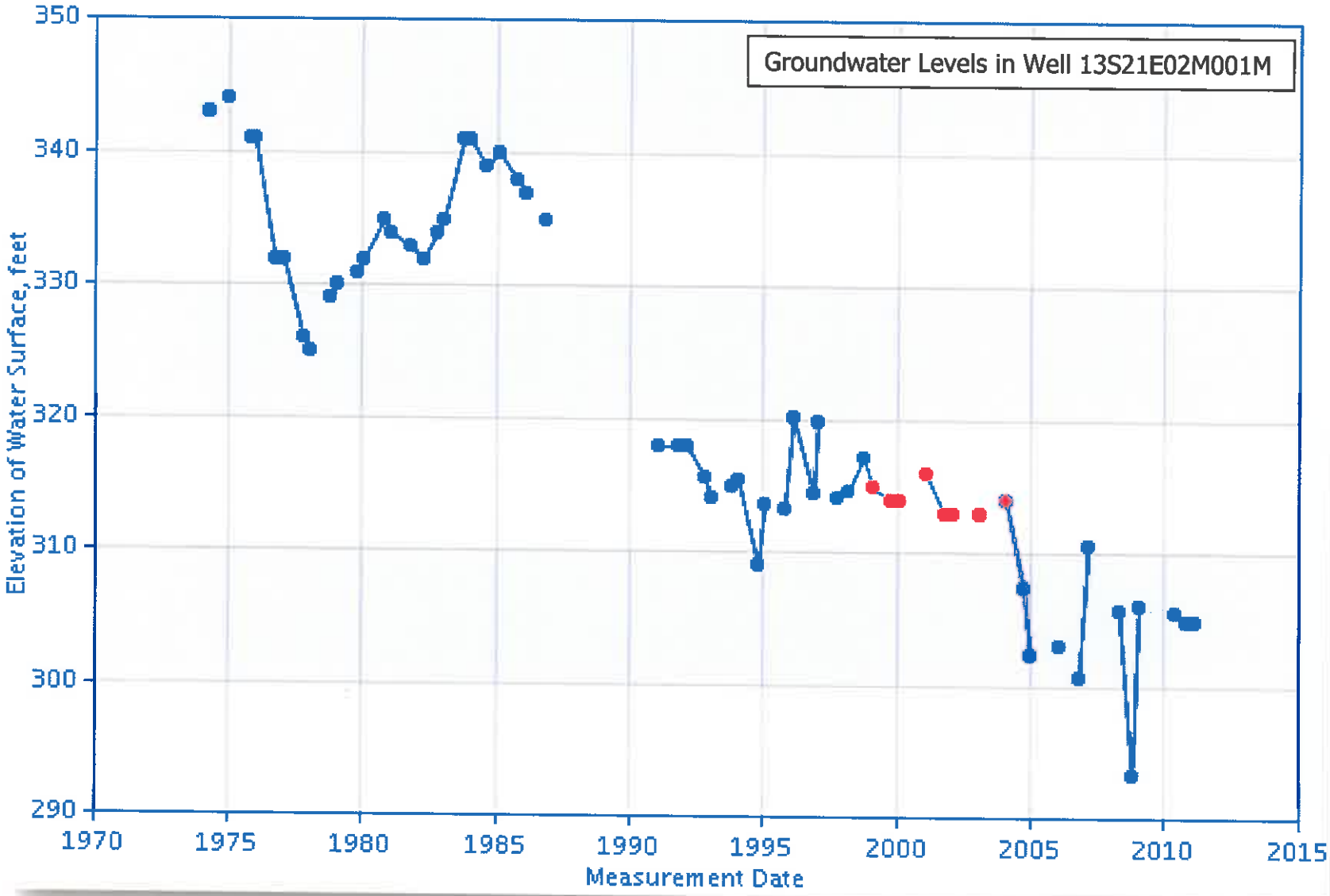
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



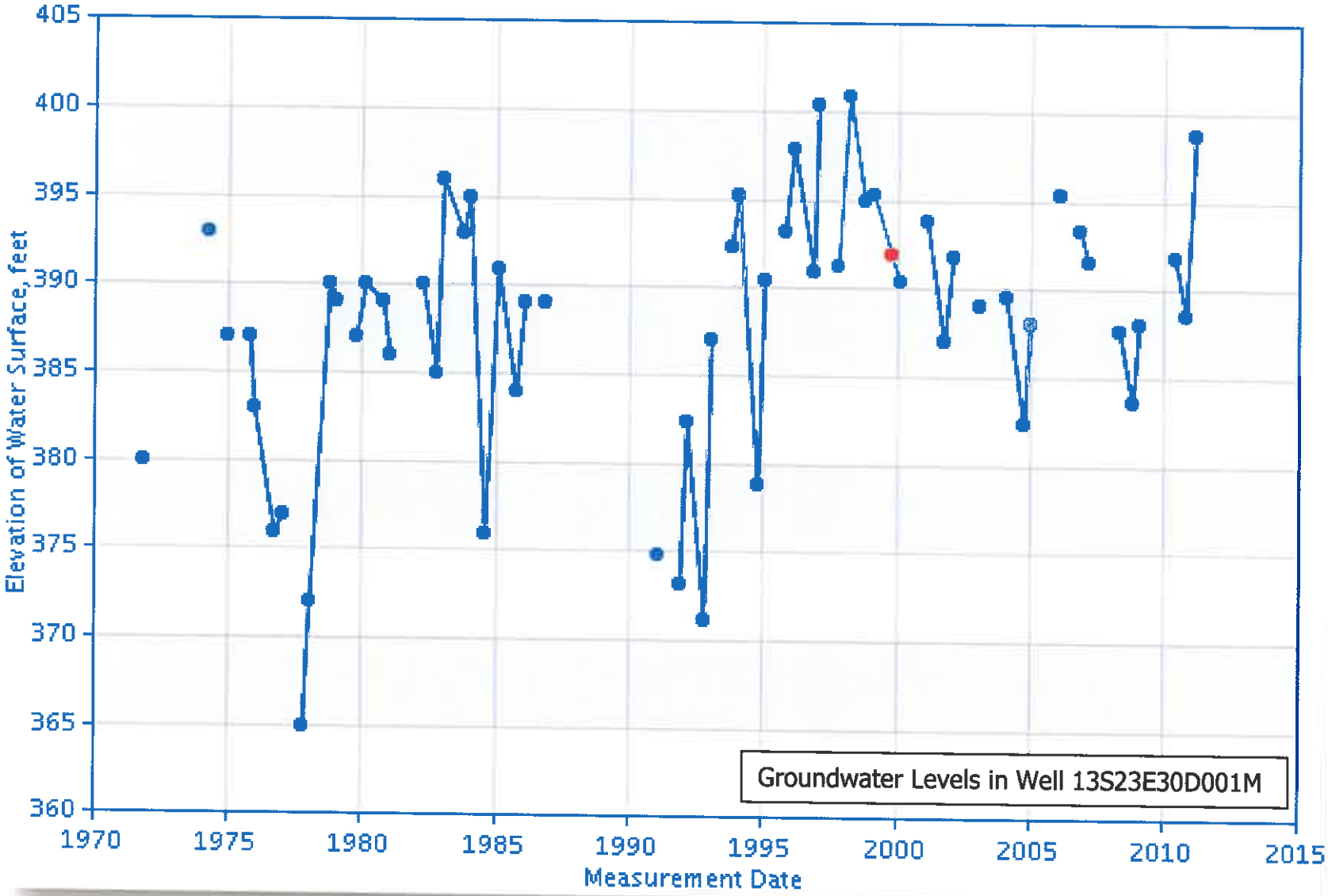
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



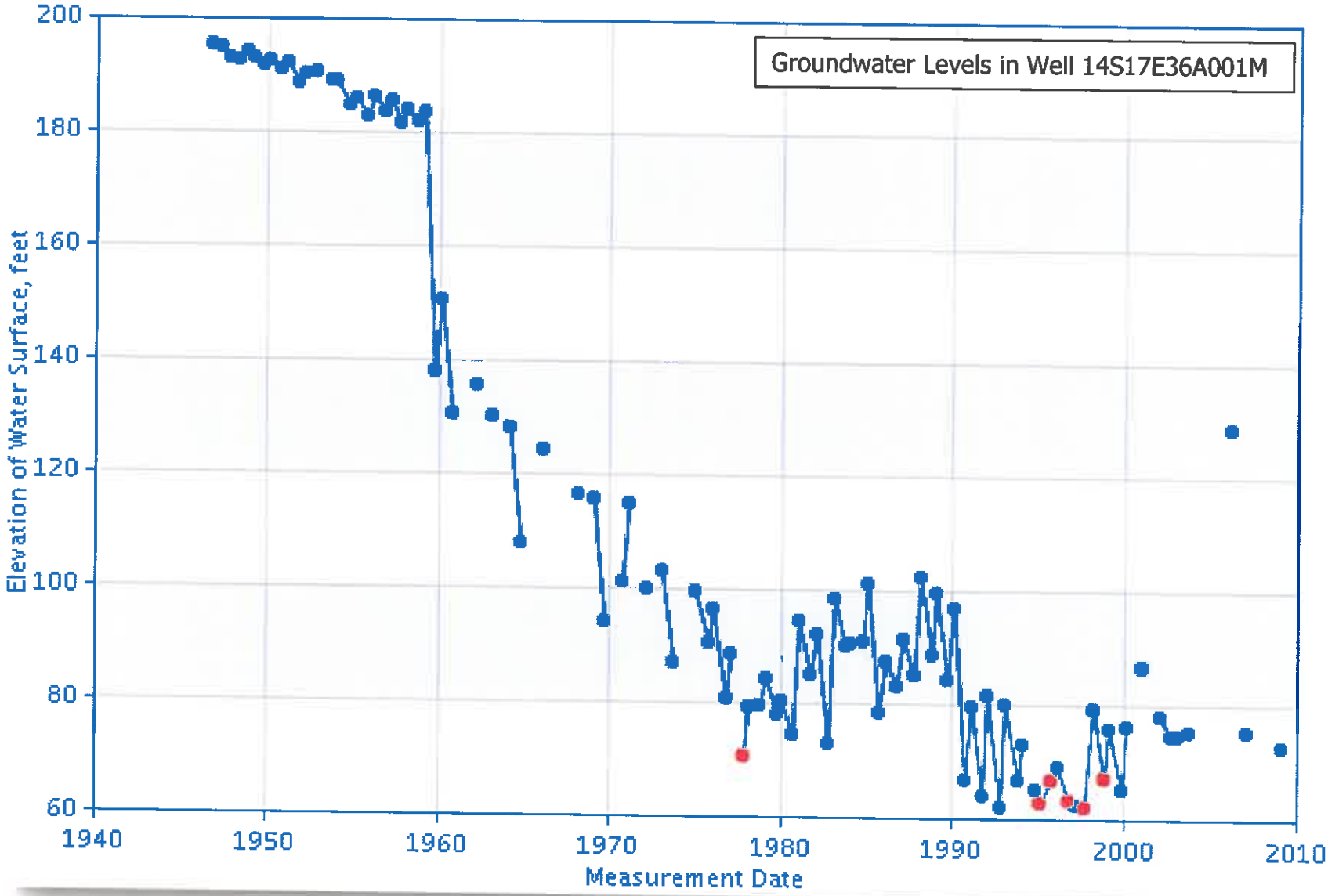
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



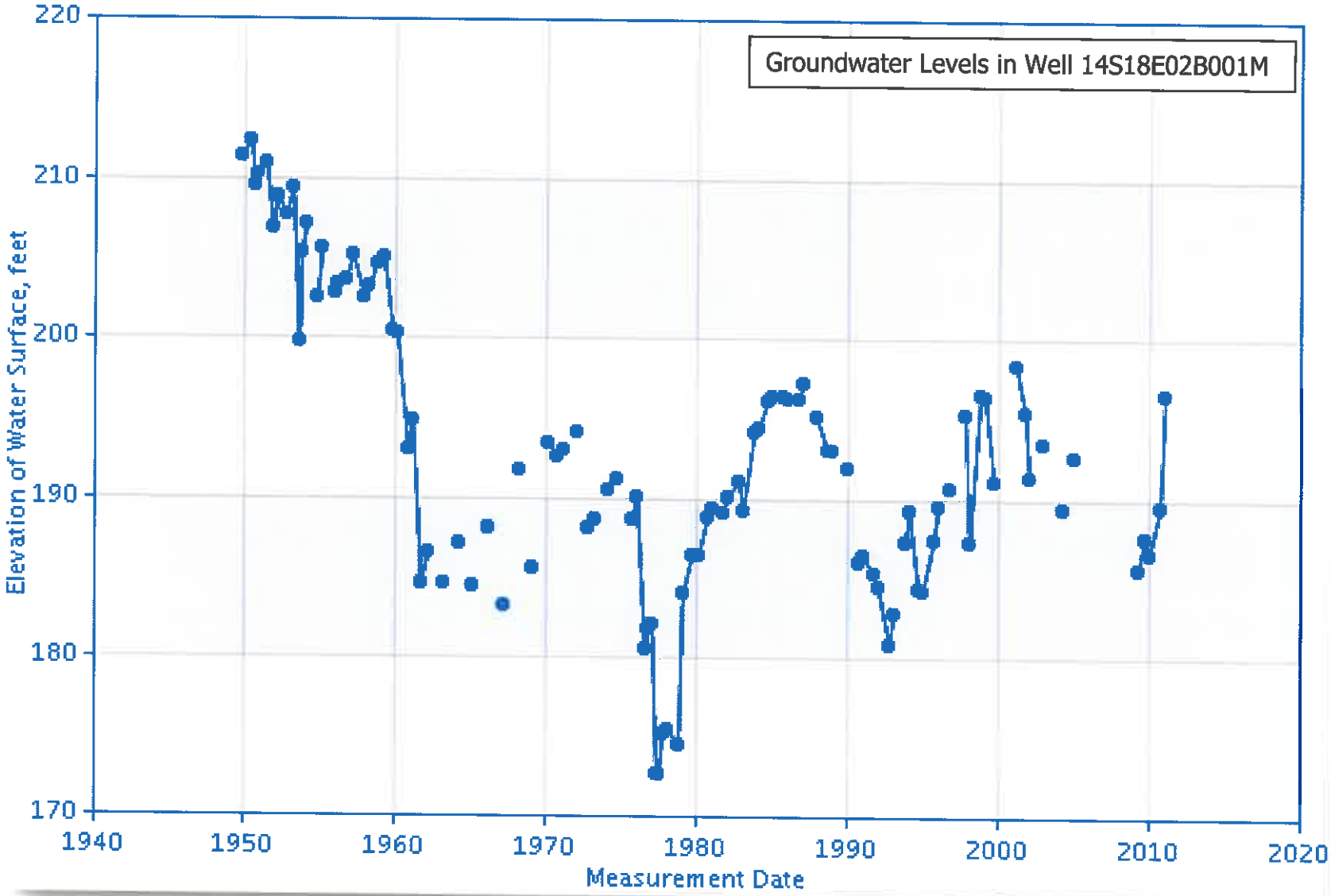
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



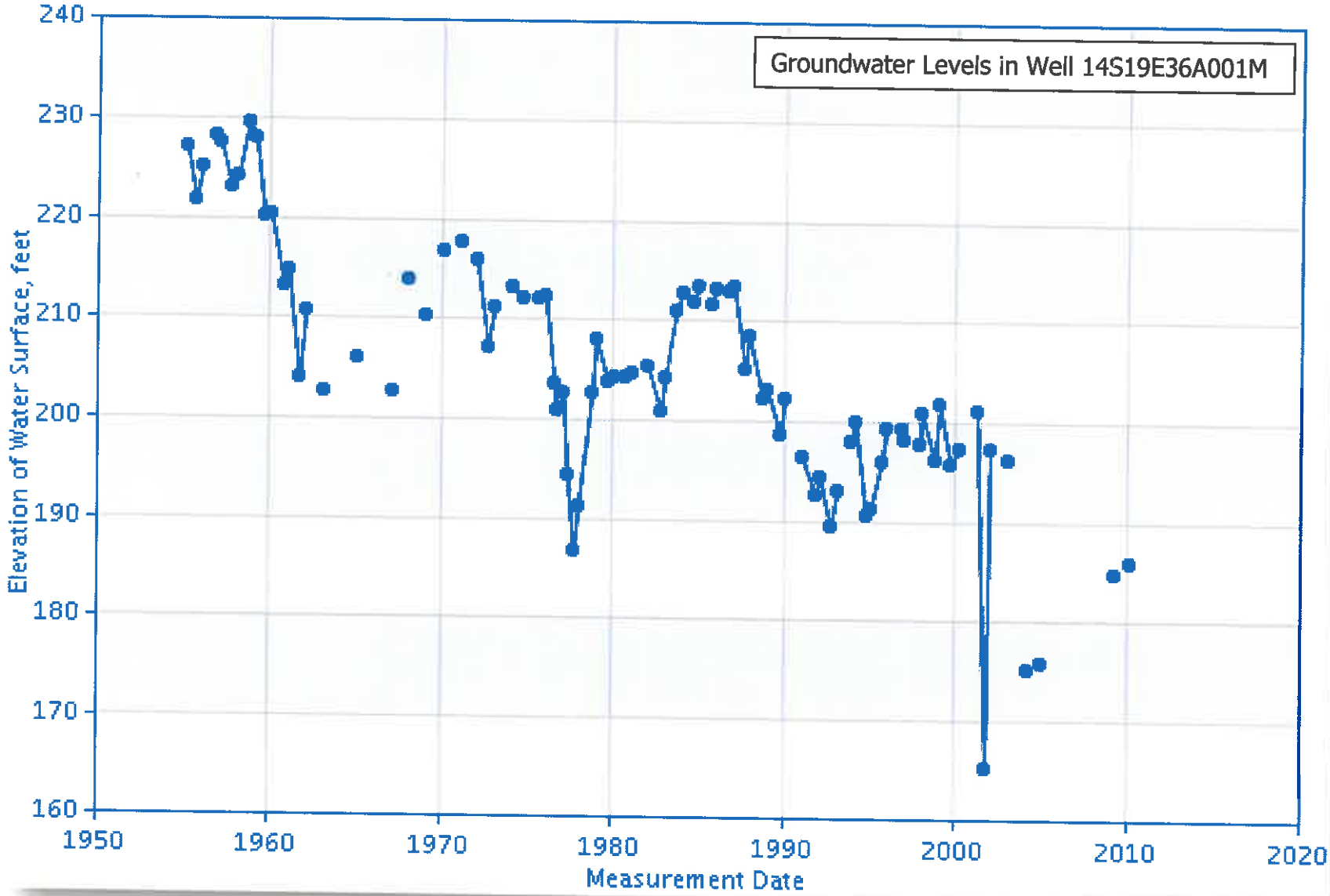
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



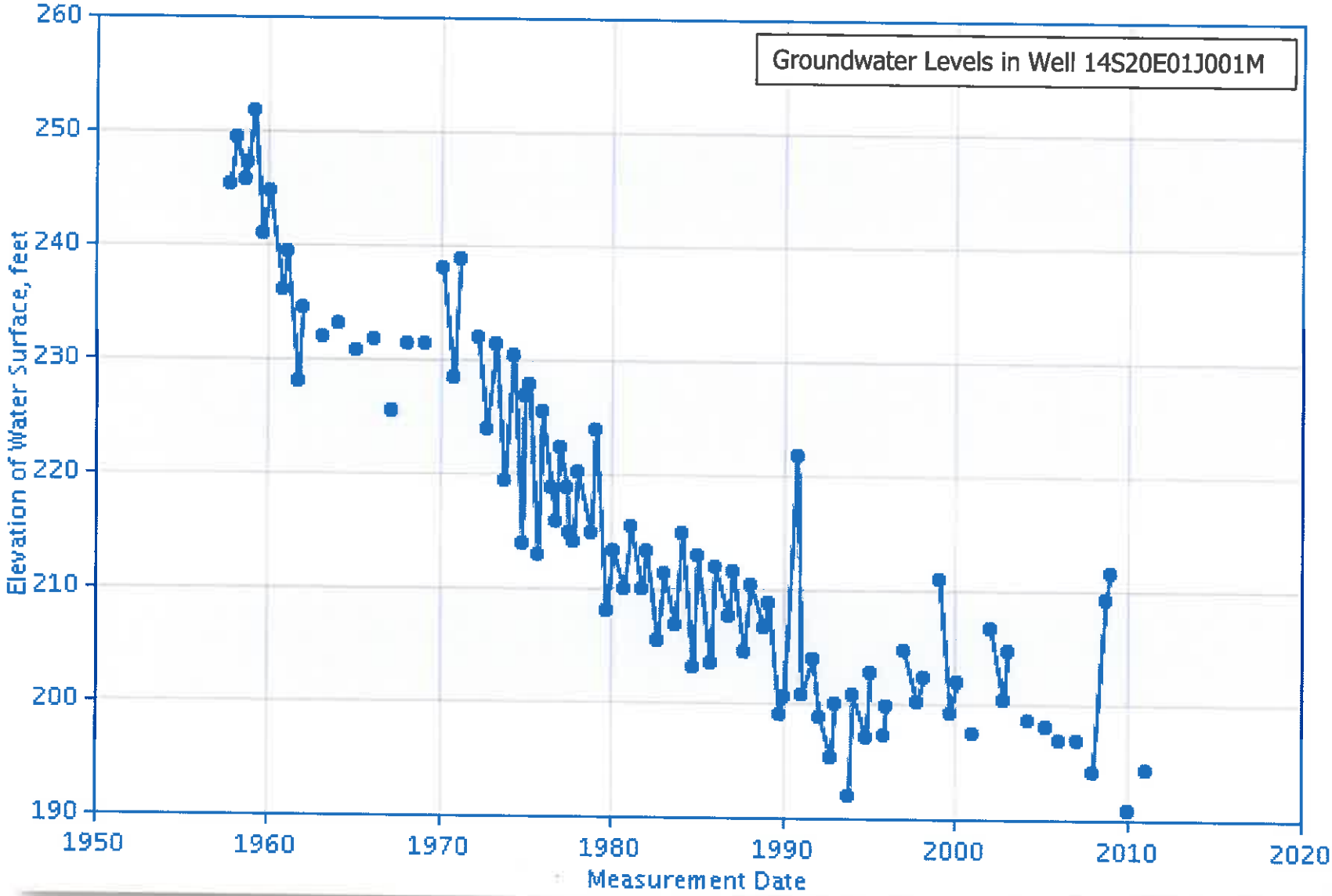
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



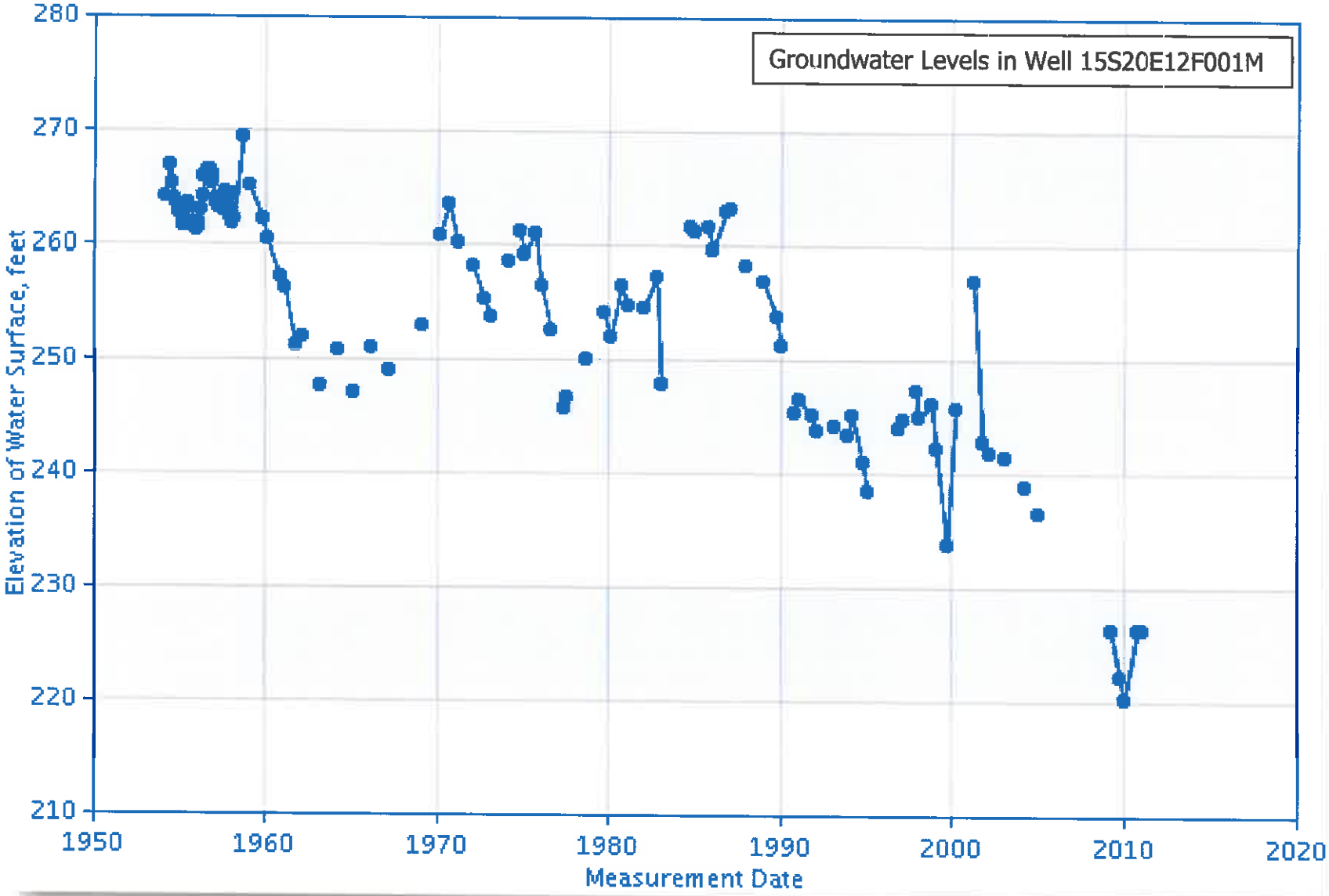
NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



NOTE: red circles denote questionable measurements.

San Joaquin Valley (Kings Basin), Source: CA DWR Groundwater Level Data



NOTE: red circles denote questionable measurements.