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SEDIMENT REMOVAL PILOT DEMONSTATION PROJECT AT RIBAULT RIVER NAS JACKSONVILLE FL

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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

RIBAULT RIVER (STOKES PARK) SEDIMENT REMOVAL PILOT DEMONSTRATION PROJECT

for

FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

by

CAMP DRESSER & McKEE INC.

Jacksonville, Florida

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SECTION ONE

1.0 EXECUTIVE SUMMARY

1.1 PURPOSE

The purpose of this pilot study was to gather data to allow preliminary evaluation of the feasibility of removing large quantities of organic bottom sediments (benthos) from selected zones of river systems. However, it must be emphasized that this project's scope was limited to the engineering aspects of removing and dewatering the sediment material from the bottom of a shallow embayment. Field measurements and observations conducted to assess the water quality impacts during extraction and dewatering operations were designed as indicators of conditions during full-scale operations. The test program keyed upon the following elements:

- Hydraulic Dredge - Removal Characteristics
- Centrifuge Dewatering - Solids Capture Efficiency
- Solids Cake - Constituents and Characteristics
- Centrate - Constituents and Characteristics

1.2 BACKGROUND

During the past 20 years, water quality studies performed throughout the country and the State of Florida have identified bottom deposits (benthos) as the most complex element of a water body's composition. In bays, estuaries, lakes, and to a great extent, in riverine systems, the benthos have been shown to have a primary impact upon water quality. Each water body has its own history of contributing land uses and natural assimilative capacity. A deteriorated water quality can best be documented through analyzing the benthos.

Previous water quality studies performed throughout Florida demonstrated the enormous reservoir of nutrients and oxygen demanding substances trapped in the benthos. To illustrate this process, results from a recent

Hillsborough Bay (Tampa) assessment (Tampa Bay Water Quality Assessment (205(j) Water Quality Study) showed that the bay contains a reservoir of some 80 million pounds of nitrogen and exhibits a benthic export of only 123,000 pounds per day. Therefore, if all the nitrogen sources (point and non-point) ceased discharge to the bay, it would take 650 years to "naturally" consume the reservoir of nitrogen.

The impact of this enormous storage of nutrients is the result of the flux or exchange between the sediments and the water column. This flux (release of nutrients to the water column) promotes the growth of all forms of aquatic vegetation (algae, phyto-plankton, etc.), which, in turn, through the growth cycle create a self-shading phenomena from top to bottom. This decreasing light penetration supports super-saturated oxygen conditions near the water surface and anoxic conditions at or near the bottom. In turn, this process enhances the release of nutrients into the water column. This phenomenon is generally referred to as the nutrient flux -- movement/transfer of constituents from sediment into the water column. The natural flux is greatly increased during storm events when the bottom deposits are agitated. This flux has been shown in study after study, not only in Florida, but all over the country, to be the over-powering driving force in highly stressed water bodies.

1.3 REMOVAL OF SEDIMENT MATERIAL

The pilot test site was located adjacent to the Ribault River in a boat ramp basin in T.K. Stokes Park. The mudcat dredge dislodged river sediment from the basin bottom for deposit in continuously mixed storage holding tanks. These tanks were continuously mixed through a recirculation pump system and constant flow maintained through a "day" tank.

Sediment material contained in the day tank was fed by sludge feed pumps to the centrifuge for dewatering. A test centrifuge (supplied by Humboldt Decanter, Inc.) was operated for a period of 2 weeks. The dewatered cake was discharged to a dumpster for ultimate disposal, while the clear centrate was returned to the Ribault River through discharge and flow through a wetlands area.

1.4 DEWATERING SYSTEM RESULTS

Between October 31, 1988, and November 11, 1988, 43 independent tests were performed using the dewatering equipment. Each of these tests consisted of a stabilization period, followed by an operational period during which three independent samples were collected to analyze system performance. Each of these samples was collected to characterize sediment material fed to the centrifuge, dewatered cake obtained from the centrifuge, and centrate discharged from the centrifuge. A broad spectrum of operating parameters was evaluated to characterize centrifuge dewatering efficiency relative to sediment material feed rate, centrifuge gravitational force, polymer addition, and centrifuge differential. The following results were obtained relative to solids handling:

- Total suspended solids capture or recovery can exceed 95 percent with polymer addition; 50 percent without polymer.
- Total suspended solids in the centrate can be controlled to below 1.0 percent and possibly 0.5 percent with polymer addition, 4.5 percent without polymer.
- Total suspended solids in the dewatered cake of 30.0 percent can be obtained with polymer addition. With further refinements during startup, a dewatered cake containing 33 percent total suspended solids with polymer addition should be possible.
- Total suspended solids in the dewatered cake of 37-38 percent (solids fraction) can be achieved without polymer addition. Since the total solids retained in the cake is less (lower solids capture), the percent solids in the cake is higher than with polymer addition.
- A centrifuge operating in the range between 700-1,000 times the gravitational forces (Gs) is feasible to accomplish the identified solids results.

Primary emphasis of the study was placed upon the capability of a centrifuge to dewater the river sediment (solids). A secondary interest was directed towards the removal/recovery of nitrogen and phosphorus contained in the river sediment. Analyses were performed for nutrients contained in the river sediment fed to the centrifuge, the dewatered cake, and the centrate. This testing showed that more than 95 percent of total nitrogen and total phosphorus in the sediment fed to the centrifuge was captured in the dewatered cake. This result dramatically supports the hypothesis of the pilot testing program: The dewatering process is very effective in retaining nutrients in the dewatered sediment.

1.5 SUMMARY

The pilot testing program has proven that river sediments can be effectively dewatered. The retention in the dewatered cake of greater than 95 percent of total nitrogen and total phosphorus verifies the effectiveness of the dewatering process. These results strongly support this operation as an effective process for long-term water quality enhancement. With the results obtained from the pilot test program, a brief test case was explored to display the potential benefit of conducting this program on the Miami River.

The U.S. Army Corps of Engineers, Jacksonville District, had investigated the feasibility of removing 521,000 cubic yards of sediment from the Miami River. The results of this investigation indicated that approximately $8,400,000 would be needed to dredge and dispose of this material at an ocean dumping site. In light of the results from the present pilot testing program, the material could be removed using dredges and dewatered at a temporary centrifuge operation established adjacent to the Virginia Key Wastewater Pollution Control Plant. Through utilizing 300-400 gpm centrifuges operating at approximately 500-800 Gs, all the sediment could be dredged and processed within approximately 9 months. The total cost to dredge, dewater, and haul dewatered sludge to potential agricultural land, would be approximately $6,700,000.

Results obtained from the dredging/dewatering pilot project are significant. The long-term impact upon Florida waters could be dramatic. Through removing and dewatering these materials, long-term water quality enhancement could be obtained. Naturally, site-specific investigations will need to be conducted relative to heavy metals, pesticides, and related hazardous materials before ultimate disposal sites can be selected.

SECTION TWO

2.0 RIVER SEDIMENT CONDITION

2.1 INTRODUCTION

The primary purpose of the pilot plant investigation was to determine the feasibility of dewatering river bottom sediment and concentrating the material utilizing a continuous mechanical dewatering process. The scope of the project was limited to obtaining practical operational characteristics, while identifying principal impacts resulting from both the sediment removal and the sediment dewatering processes.

Previous water quality investigations had identified the river/estuarine sediments to be a principal contributor to poor water column quality. Particular emphasis had been placed upon the total nitrogen and total phosphorus contained in these sediments and the resultant impacts caused by release to the water column. Furthermore, the presence of heavy metals in the sediments caused by long-term precipitation, are also causes for concern with respect to water quality. Therefore, the pilot investigation had to address at least the preliminary total nitrogen, total phosphorus, and metals removal capabilities associated with the dewatered sediment material.

2.2 SITE SELECTION

The pilot plant project site had to contain a sufficient quantity of sediment, have easy land access to the river, and possess physical features capable of supporting the pilot test equipment. In order to identify an appropriate sediment source, the Northeast Florida District Office of the Florida Department of Environmental Regulation (FDER) and the Bioenvironmental Services Division (Health, Welfare, and Bioenvironmental Department, City of Jacksonville) assisted CDM in identifying areas which contained reasonable quantities of river sediment material and that did not possess chemical constituents representative of heavily polluted industrial discharges.

The initial investigations identified two suitable sites along the Trout River. One site on the Trout River was rejected because the property was privately owned and access would not be permitted. A second Trout River site was publicly owned, but land access was impractical. The selected site, identified on Figure 2-1, is located in northwest Jacksonville along the Ribault River. This site, the "T.K. Stokes Park," is owned by the City of Jacksonville, Department of Recreation and Public Affairs. As displayed on Figure 2-2, the site contained a partially abandoned set of boat ramps and an asphalt surface parking area.

Samples were collected in the Ribault River, the boat basin area, and in the river sediment at the bottom of the boat basin. Preliminary analysis of the water column and sediment showed they contained constituents identified in Table 2-1. A sample of the sediment material was also analyzed for toxicity using the extraction procedure (EP toxicity). The results of these analyses identified trace quantities of each constituent in the EP toxicity test with none above the specified limit.

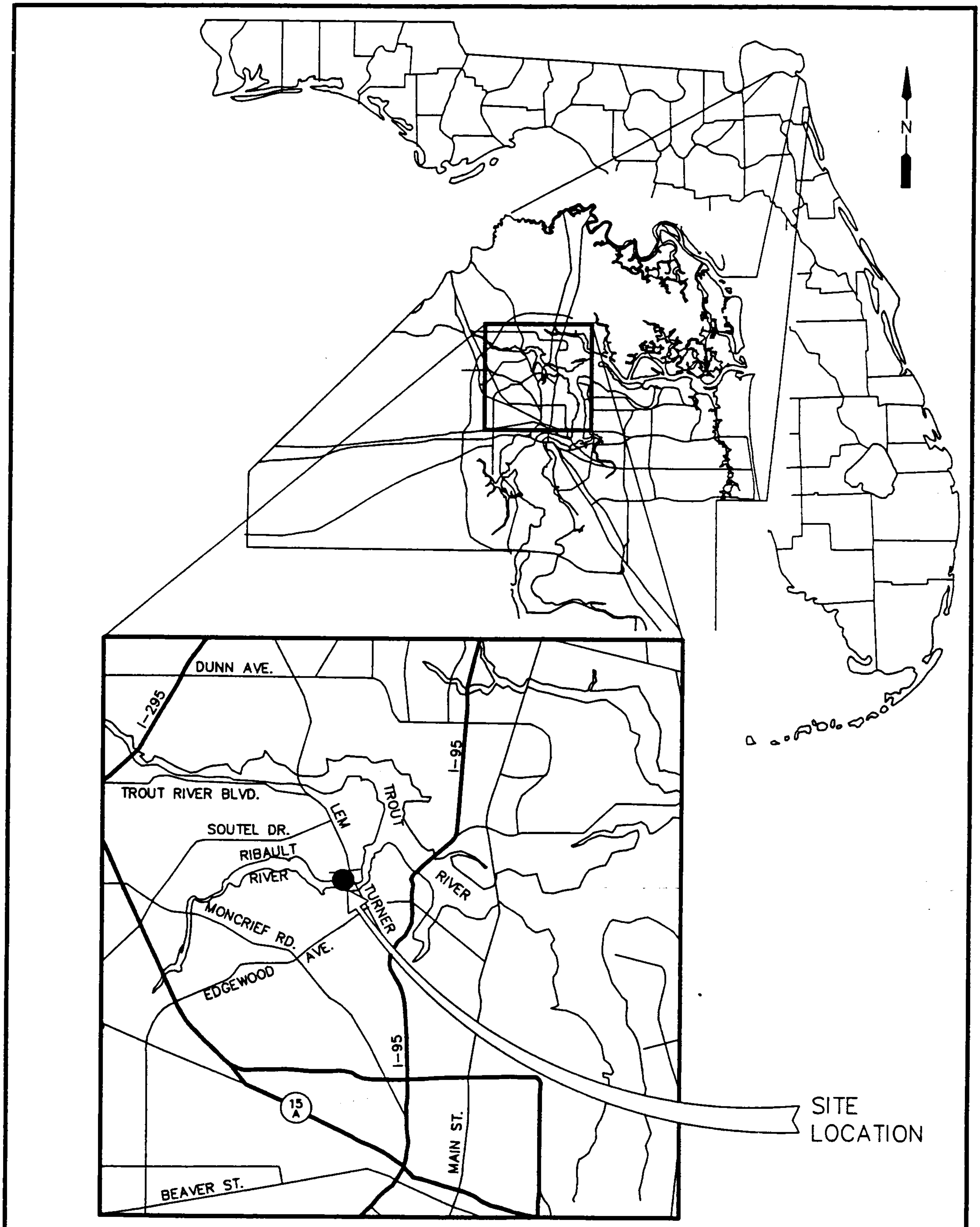
2.3 TYPICAL SEDIMENT MUCK CHARACTERISTICS

As an adjunct to the pilot study conducted to quantify operating characteristics for the dewatering process, Dr. John H. Trefry (Professor of Chemical Oceanography, Florida Institute of Technology) conducted an on-site investigation directed toward:

1) Determining concentrations of dissolved particulate trace metals in river water, the intake sediment/water mixture, and the centrate; and

2) Determining concentrations of selected components in the sediment interstitial water.

A brief summary of these results indicates that the material identified at this location are very typical of organic-rich sediments found in other



LOCATION MAP

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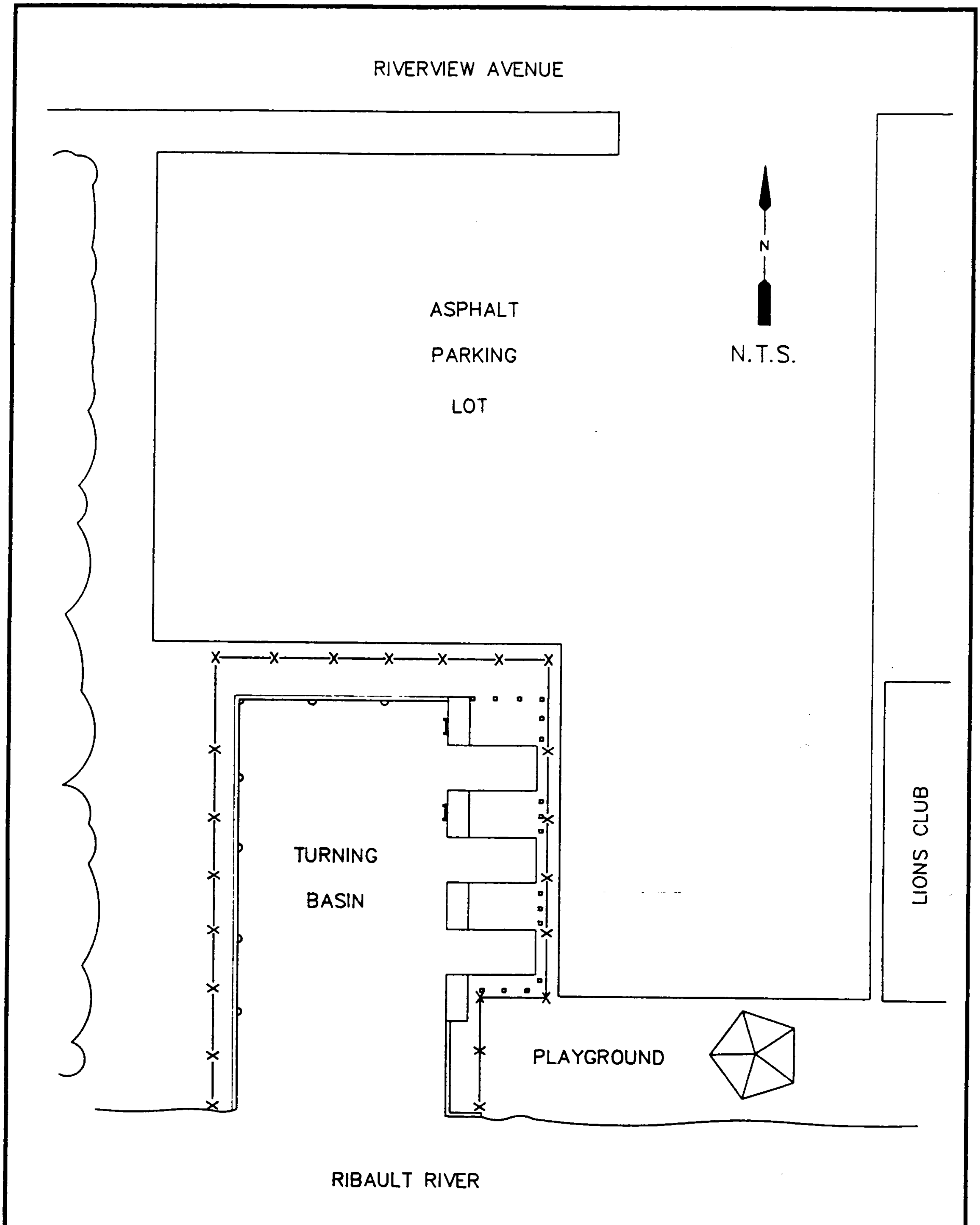
FIGURE 2-1



PROJECT SITE PLAN

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FIGURE 2-2

TABLE 2-1

BACKGROUND CONCENTRATIONS
WATER AND SEDIMENT SAMPLES
RIBAULT RIVER SEDIMENT STUDY

	SAMPLE #1 (mg/Kg)	SAMPLE #2 (mg/Kg)	EP TOXICITY (mg/l)	WATER[1] SAMPLE #1 (mg/l)	WATER[2] SAMPLE #2 (mg/l)
Cadmium	0.5	1.1	<0.5		
Calcium	14867	9450			
Chromium	90.5	97.0	<0.5		
Copper	35.8	61.8			
Iron	32415	31190			
Lead	66.3	118	<0.5		
Magnesium	7046	4638			
Nickel	16.5	17.1			
Potassium	3523	2911			
Selenium	<0.6	<0.6	<0.05		
Sodium	12692	9355			
Zinc	193	251			
Arsenic			<0.05		
Barium			<1		
Mercury			<0.01		
Silver			<0.5		
Total Suspended Solids		15.0		26	280
Total Solids	208,000	150,000		922	1485
Ammonia-N	68.3	85.6		0.107	0.126
TKN	1323	1122		1.34	3.67
N02-N03	0.693	<0.5		0.176	0.172
Total PO_4	395.8	13.15		0.473	1.29

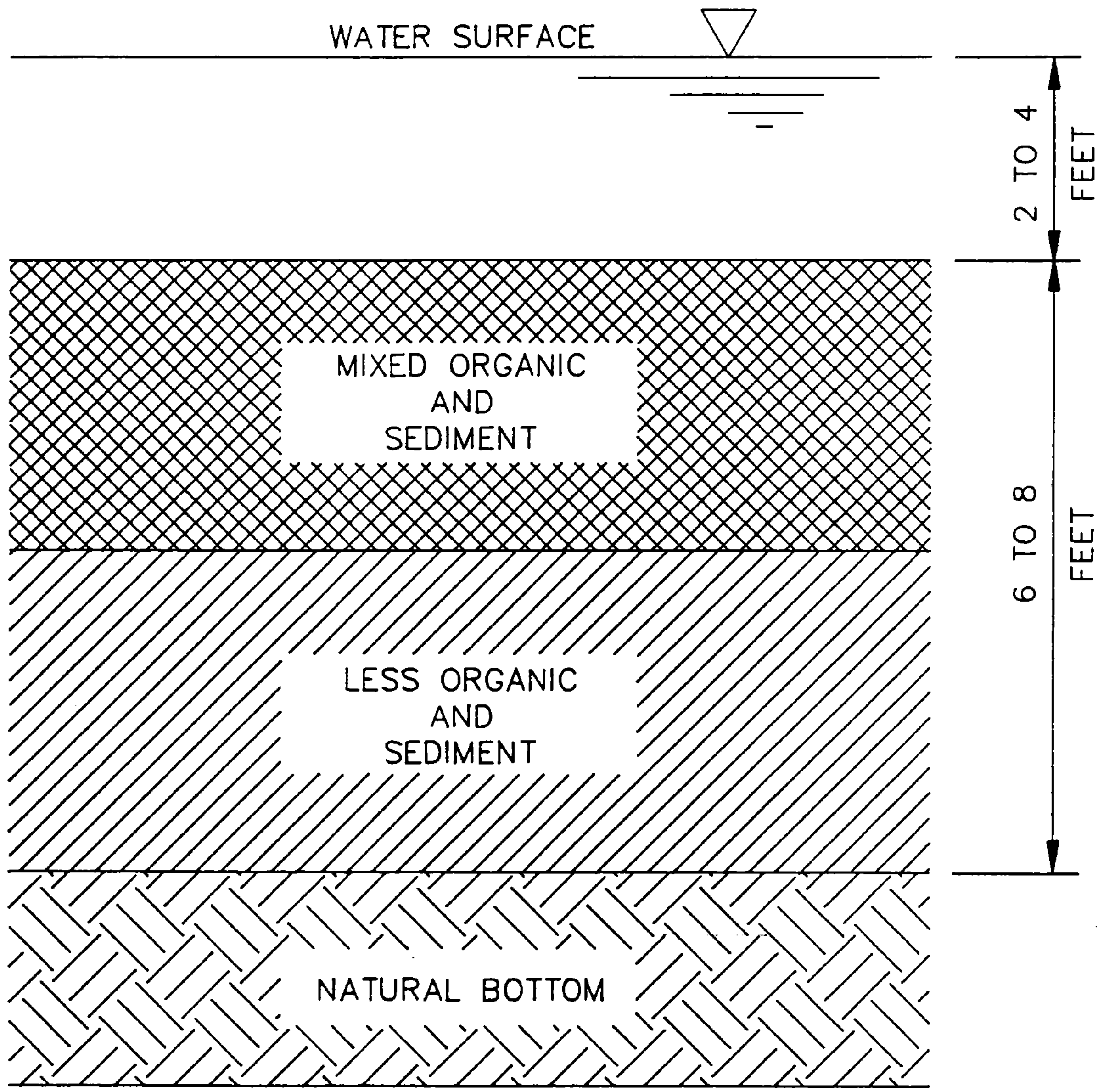
1) Sample collected 6 inches below water surface.

2) Sample collected 26 inches below water surface.

portions of Florida in estuarine and freshwater systems. The complete report is included as Appendix A.

Riverine sediments typically represent the deposition/accumulation of inorganic and organic matter. As seen on Figure 2-3, the sediment varies from a deep, dark colored solid phase to a lighter colored material representing the natural channel bottom. The degree and depth of river sediment varies with both the accumulation characteristics of the channel and the hydraulic removal characteristics displayed by the river movement. Within the boat basin zone, representative sample sediment cores indicated 8 feet of material comprising the typical sediment deposits.

Dr. Trefry collected two core samples for detailed analyses. These evaluations indicated that the sediment averaged approximately 80 percent water by weight and contained approximately 200,000 mg solids/Kg of sediment. The organic matter content in the sediment ranged between 15 and 24 percent, typical of muck found in natural estuarine sediments. With respect to interstitial constituent concentrations found in the sediment, the values obtained were representative of riverine sediment. The interstitial water concentrations were all higher than values observed in the Ribault River samples.



TYPICAL SEDIMENT PROFILE

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FIGURE 2-3

SECTION THREE

3.0 DREDGE OPERATION

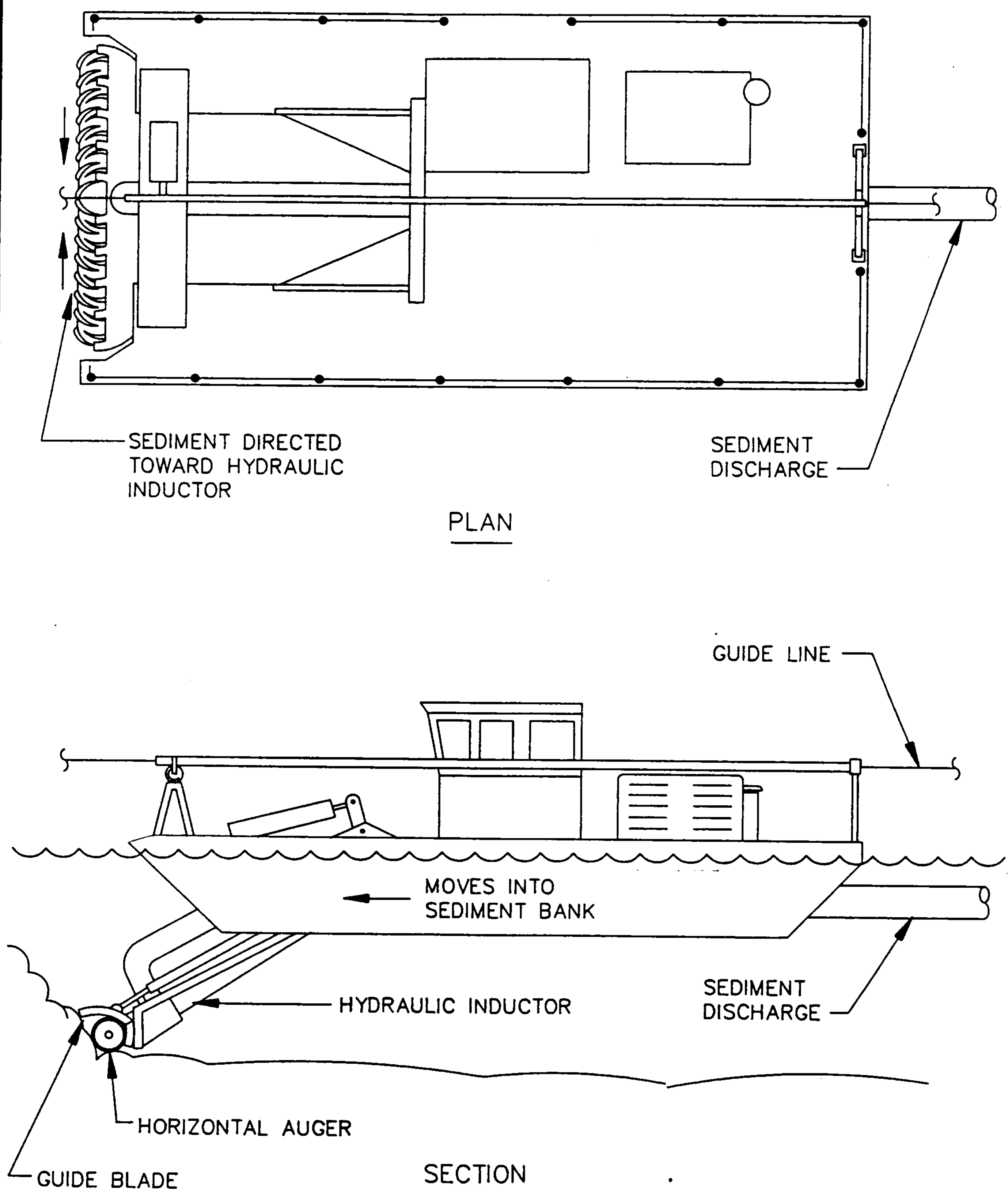
3.1 INTRODUCTION

In order to simulate full-scale sediment removal operations and potential qualitative impacts upon the water column quality, a mudcat dredge was selected to perform the removal and transport of sediment muck. This particular unit was selected to assure minimum disturbance and minimum releases of sediment material into the surrounding water column. As indicated on Figure 3-1, the mudcat dredge moves into the sediment layer with the combined forward thrust of the boom and winch, and dislodges sediment with a horizontal rotary auger. With the blade surrounding the auger, the maximum quantity of sediment is retained and mechanically conveyed to the center of the dredge head. Once the material reaches the center, an induction system hydraulically removes the sediment/river water and conveys the material through a transfer line. This removal process assures minimum release of sediment material to the surrounding waters.

As displayed on Figure 3-2, the mudcat dredge was located in the boat basin and hydraulically transported the sediment to storage tanks. The contents of these tanks were continuously mixed and as the centrifuge dewatering operation proceeded, a continuous sediment stream was conveyed to the centrifuge (Figure 3-2). Excess materials remaining after dewatering operations were returned to the boat basin.

3.2 MUDCAT PERFORMANCE/OPERATION

Since the field evaluation program had to be accomplished within two 5-day work weeks, the mobilization was completed on Sunday, October 30, 1988. Initial testing and shake-down operations were initiated on October 31, 1988. The subsequent dredging/dewatering was to be performed in a sequenced testing procedure. The initial objective was to remove enough sediment material during the early morning to allow the subsequent recirculation of screening processes to maintain continuous operation of the



MUDCAT DREDGE

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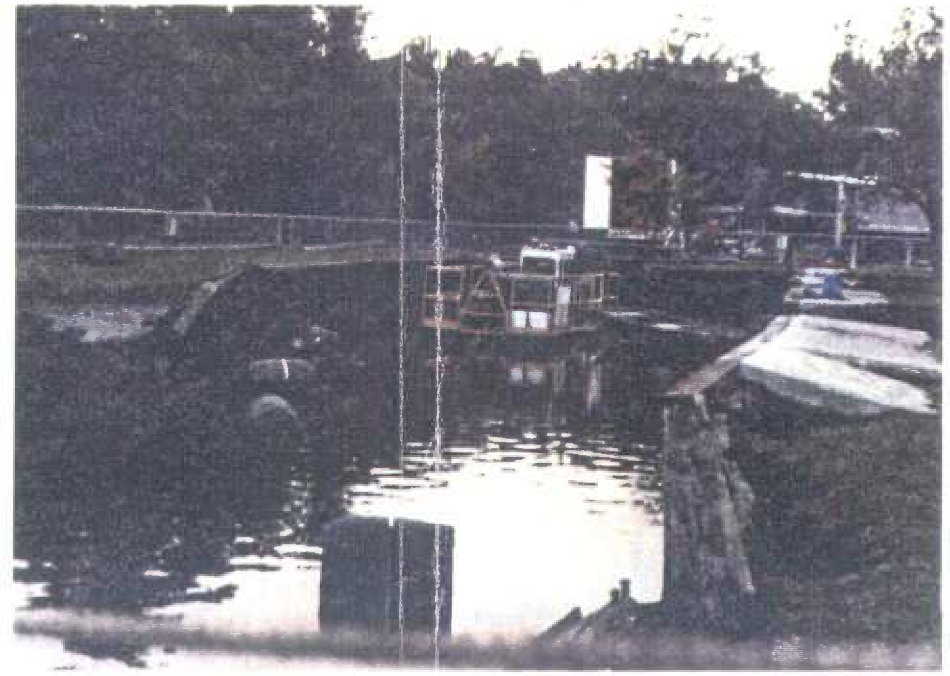
FIGURE 3-1

RIBAULT RIVER – BOAT BASIN



MUDCAT DREDGE

DREDGE IN
BOAT BASIN
HIGH TIDE

BOAT BASIN SITE
MUDCAT DREDGE

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FIGURE 3–2

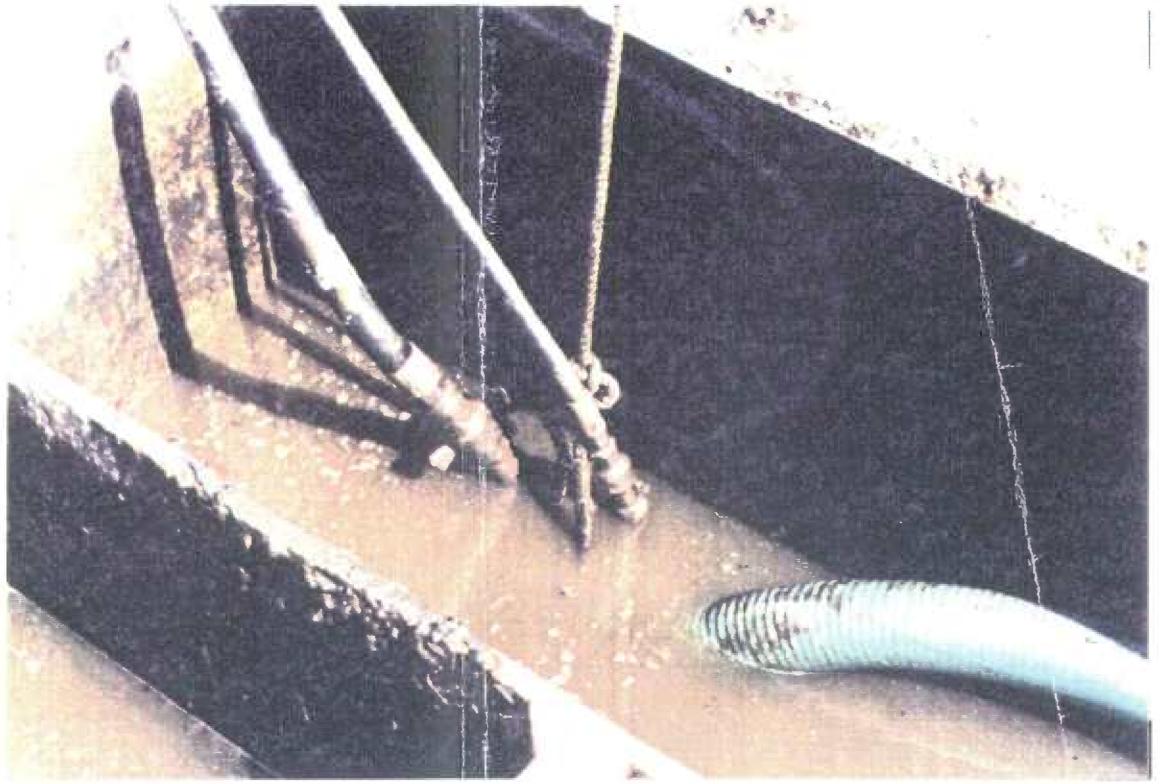
centrifuge dewatering system during the day. Since the mudcat dredge has a capacity much in excess of the centrifuge dewatering system (dredge approximately 1500 gpm; centrifuge approximately 20 to 35 gpm), a storage, recirculation, and day feed tank system was required to sustain a consistent flow of sediment to the dewatering components.

Through moving the Mudcat approximately 8-12 feet horizontally towards the bulkhead, enough sediment material could be conveyed into the storage tank to allow the centrifuge dewatering operation to proceed for the entire morning. Each dredging cycle typically lasted for approximately 10 to 15 minutes. Material transported to the storage tank was first diverted to a waste tank (Figure 3-2). Through observing this material, the initial liquid (containing little sediment) was discharged to the waste tank. When the dredge stream became thicker, the sediment material was diverted to the other storage tank for use as feed to the dewatering operation. When dewatering operations ceased, the contents of these two tanks were returned to the boat basin area.

In order to maintain the consistency of the sediment material for the dewatering operation, additional sediments were removed and transported in the early afternoon to the storage tanks. As each of these operations (morning and afternoon) were performed, considerable material was being removed from the boat basin area. Once the Mudcat traversed the length of the boat basin, a channel had been established in the center of the basin (Figure 3-3). Therefore, during low tide conditions, additional dredging became difficult as the sediment/water concentration increased and hydraulic movement was impaired.

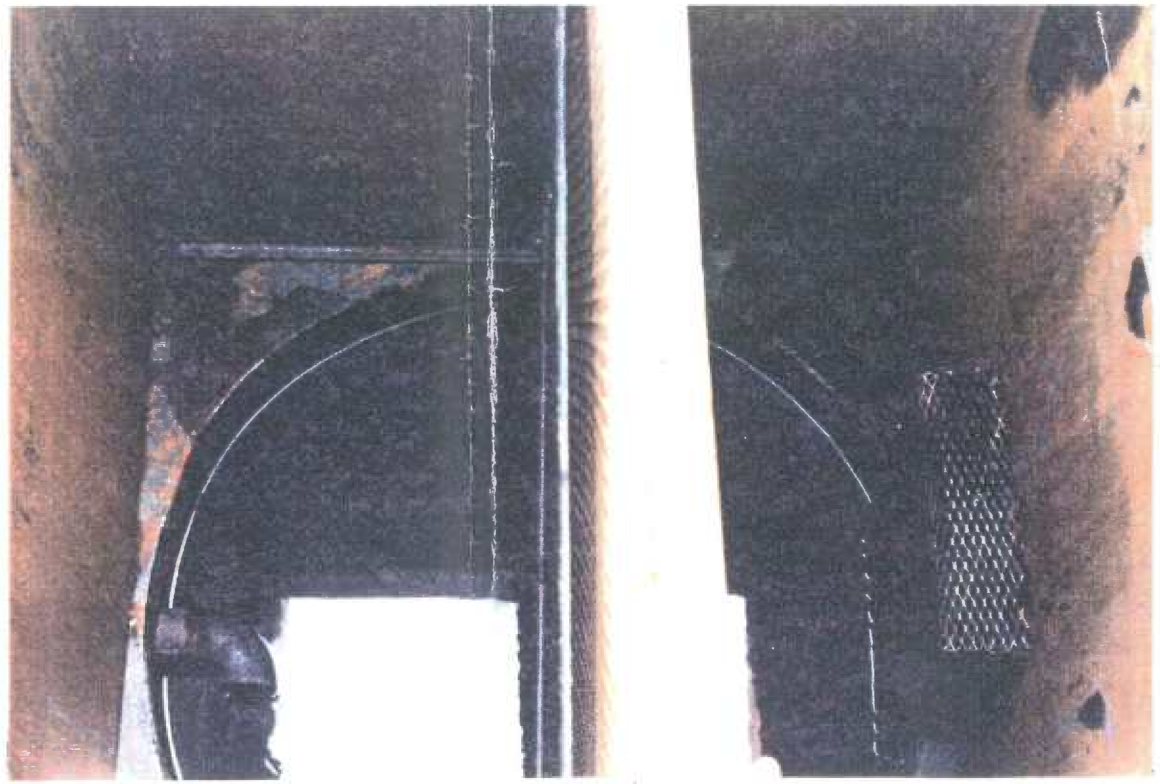
During the second week of operation (November 7 through 11), extreme precaution had to be maintained to conduct dredge movement during the high tide cycle (morning). Between the morning dredge operation and the early afternoon operation, the dredge had to be relocated further away from the dewatering operation and closer to the Ribault River. This movement was

MUDCAT DREDGE AT LOW TIDE
NOVEMBER 7-11, 1988



RECIRCULATION PUMP

EQUIPMENT ARRANGEMENT



DAY TANK WITH DUAL SCREENS

MUDCAT DREDGE AND
EQUIPMENT ARRANGEMENT

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FIGURE 3-3

accomplished easily during the morning and allowed a solution to the materials conveyance problem.

3.3 WATER QUALITY OBSERVATIONS

Between October 31 and November 7, 1988, samples were collected to describe the water quality before and during dredge operations. Samples were collected from a variety of locations to characterize the water quality, including the east side of the dredge, immediately behind the auger head, and between the west bulkhead and the turbidity barrier. Due to the low tide situations, the November 10 and 11 measurements had to be collected from the dredge adjacent to the boat basin entrance on the Ribault River.

Table 3-1 displays the results of the measurements obtained for temperature, salinity, pH, conductivity, and DO before, during, and between dredging operations. Upon reviewing the data, the only significant variation between observed values was the dissolved oxygen readings. The extreme high and low values indicated for non-dredging and dredging operations were obtained during the extreme low tide conditions experienced during November 10 and 11, 1988. The more meaningful results are the mean values represented for non-dredging and dredging. These values for dissolved oxygen were 5.6 and 7.4, respectively. The difference in readings would imply that the dredging operation creates a disturbance which does cause entrainment of oxygen into the liquid and thus raises the dissolved oxygen level. Whether this observation would be true with deeper dredging operations (i.e., more depth of water over sediment) is unknown.

The in-situ measurements collected for dredging and non-dredging operations were "favorable" relative to natural occurring conditions. This particular pilot operation did not show any significant adverse affects or changes to the estuarine aquatic environment. Further investigations in other locations may necessitate more detailed monitoring of turbidity,

TABLE 3-1

IN-SITU MEASUREMENTS
NON-DREDGE AND DREDGE OPERATION
RIBAULT RIVER SEDIMENT STUDY

PARAMETER	BEFORE AND BETWEEN DREDGING				DREDGING			
	NUMBER OF OBSERVATIONS	RANGE	MEDIAN	MEAN	NUMBER OF OBSERVATIONS	RANGE	MEDIAN	MEAN
Temperature (°C)	78	19.0-23.0	21.0	21.0	17	19.0-23.0	21.2	21.3
Salinity (parts/1,000)	79	5.8-12.0	8.0	8.1	33	5.6-10.0	8.0	7.7
pH	15	7.2-7.9	7.6	7.6	5	7.3-7.8	7.5	7.5
Conductivity (umhos/cm)	85	8500-18200	12000	12203.5	76	8500-15000	10000	11167.0
DO (mg/l)								
control	69	3.8-12.5	5.0	5.8				
dredge	83	2.2-13.6	5.4	5.6	100	1.4-14.4	6.2	7.4

nutrients, and metals in the water column to verify these preliminary quantitative results.

SECTION FOUR

4.0 CENTRIFUGE DEWATERING OPERATION

4.1 INTRODUCTION

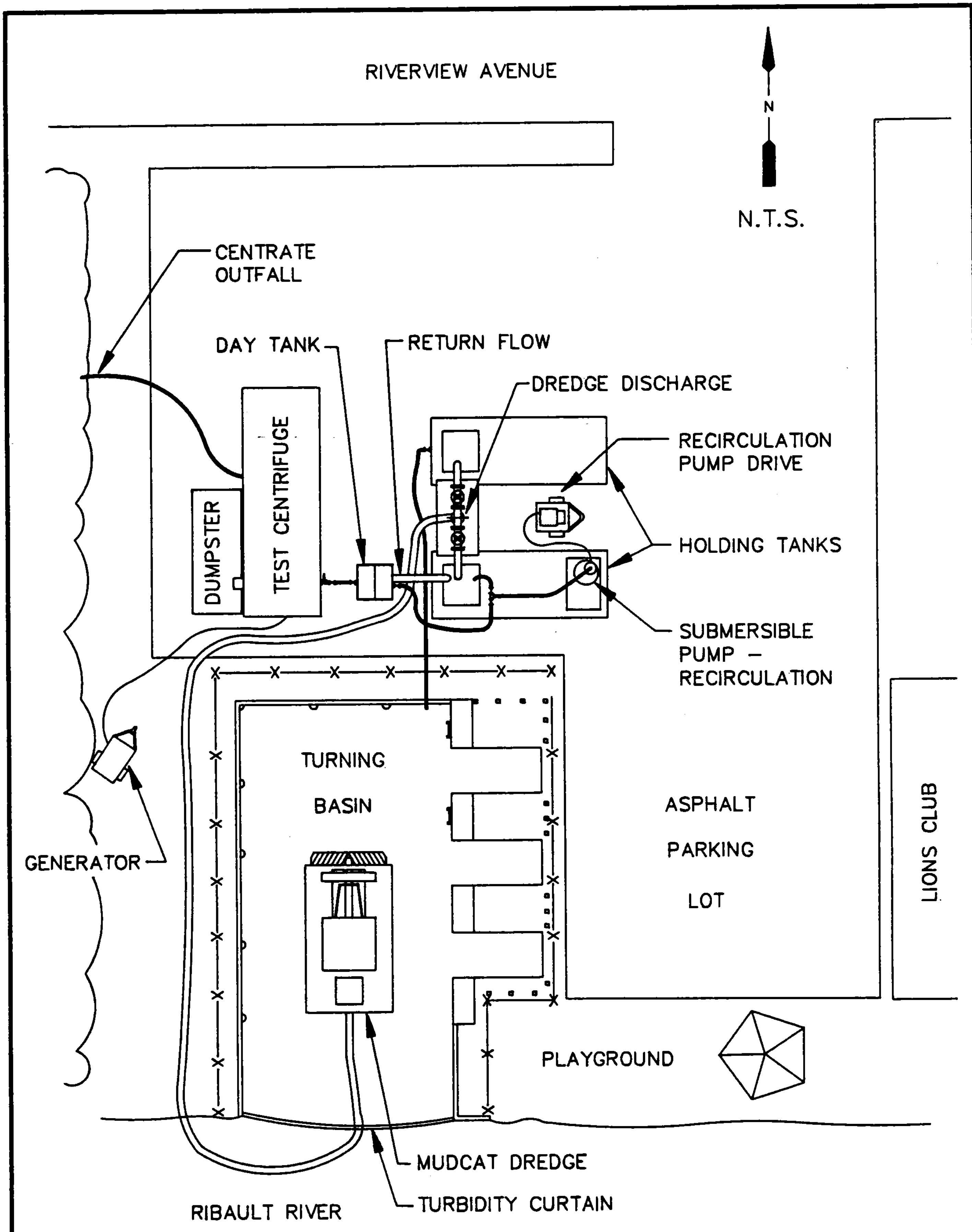
The dewatering operation necessary for concentrating sediment material removed from a river must be commensurate with full-scale sediment projects. The dredge operation, storage facilities, feed systems, dewatering equipment, and ultimate disposal characteristics must be representative of full-scale applications. In this regard, all equipment obtained for the dewatering operation is typically used in sludge process studies since the characteristics obtained with the test centrifuge operation can be applied to the full-scale conditions. Years of experience with centrifuge design has clearly demonstrated the reliability of test unit geometry and the scale-up accuracy.

Sediment material removed from the boat basin was placed in storage tanks to allow continuous feed to the pilot dewatering system. Each process component was necessary to allow a uniform and continuous flow of sediment material to the dewatering system under varying test conditions. As the material was supplied to the centrifuge, dewatered, and residual streams collected, samples were obtained to represent feed material, dewatered solids, and remaining liquid (centrate). The operation, sampling procedure, and analyses techniques are presented.

4.2 DEWATERING TEST EQUIPMENT

As presented on Figure 4-1, the principal test components consisted of:

- o Two converted semi-trailer water tight trucks functioning as storage tanks,
- o Recirculation system containing self-priming pump and piping,
- o Feed tank "day-tank" with screen,
- o Sludge feed pump with alternative polymer injection points,



PILOT PLANT EQUIPMENT ARRANGEMENT

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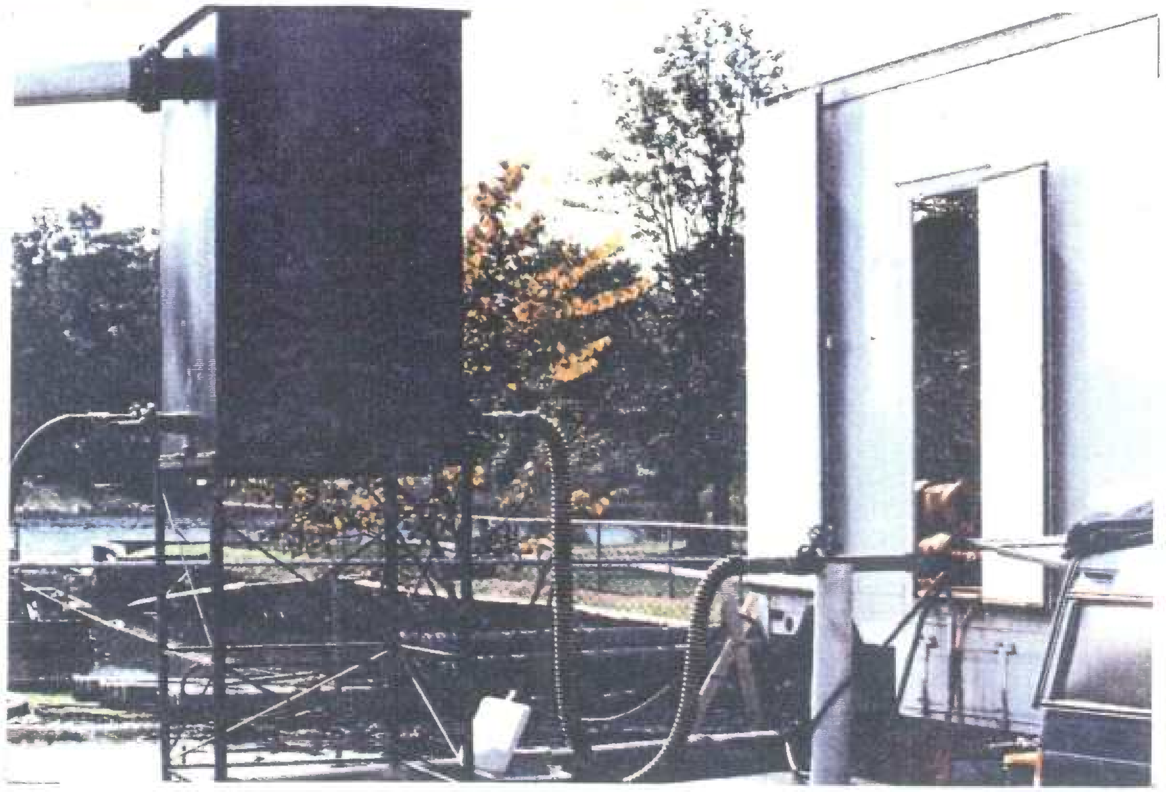
FIGURE 4-1

- Humbolt Model S2-1 centrifuge,
- Screw conveyor to discharge dewatered cake,
- Polymer make-up system and polymer feed pumps, and
- Centrate discharge line.

The dewatering system operation primarily involved pumping sediment material from the "day-tank" through the centrifuge, discharging dewatered sediment material to a dumpster, and discharging the clean centrate to a swale/wetlands area. Figure 4-2 represents the specific equipment used to dewater the sediment material. In order to accomplish each one of these functions, constant maintenance was required of each process operation. The recirculation system maintained between the storage tanks and the "day-tank" presented the most difficulty in providing continuous sediment material. Due to the heterogeneous nature of the sediment material removed from the boat basin, large diameter (in excess of 5/8" diameter) items had to be retained from transfer to the centrifuge. Through placement of a 1/2" maximum opening screen in the "day-tank," the material fed to the centrifuge was uniform enough to avoid further mechanical problems. A similar situation would be considered with respect to sludge conveyance equipment and dewatering system in a full-scale operation.

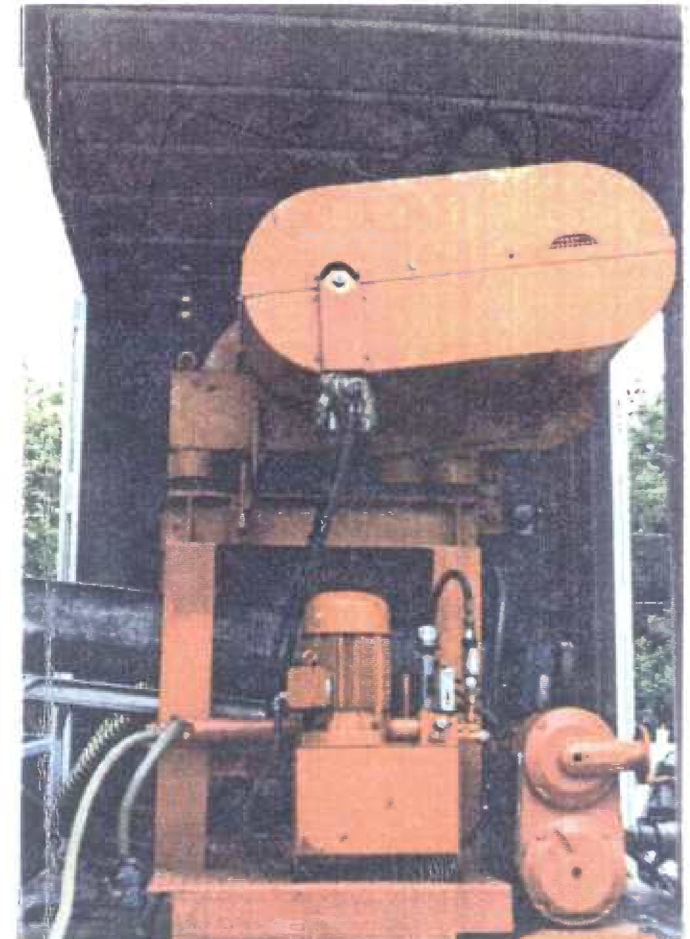
The material removed from the "day-tank" was continuously fed at the established uniform rate through the centrifuge by using a sludge feed pump. This progressive cavity sludge feed pump and associated pipe contained multiple injection points for polymer feed prior to the centrifuge. Although differing injection points were attempted in this investigation, a specific location for optimum performance was not defined.

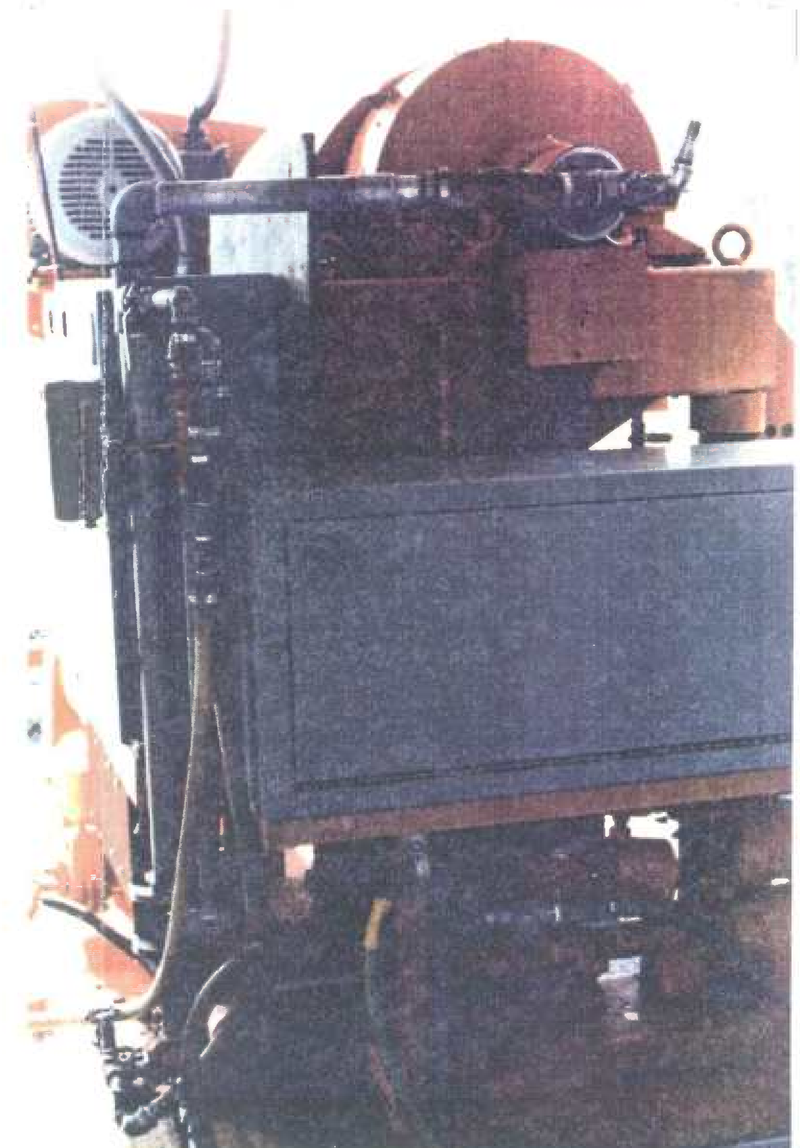
Centrifuge operation was maintained on a continuous basis except when centrate conveyance tubes clogged during testing when high solids concentrations remained in the centrate. As various test conditions were modified, excess or extreme solids concentrations (greater than 5,000 mg/l) would occur and decrease the longevity of centrifuge run times. This

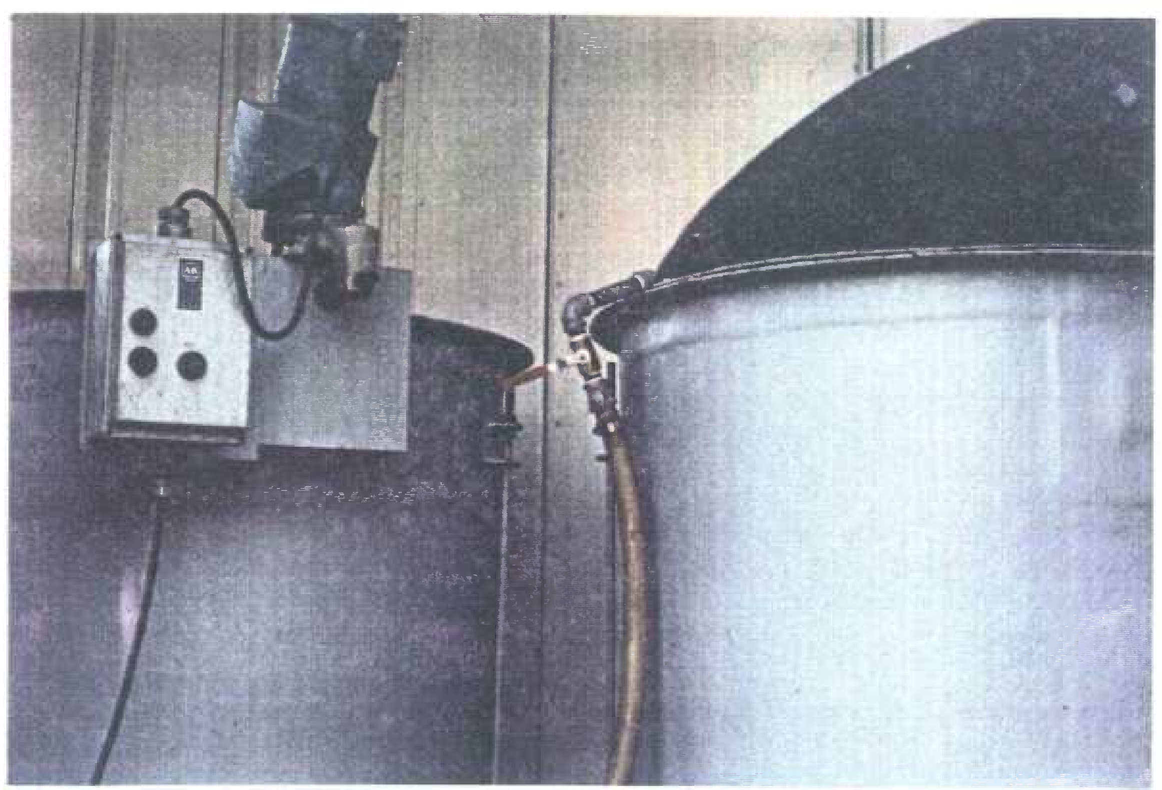


DAY TANK

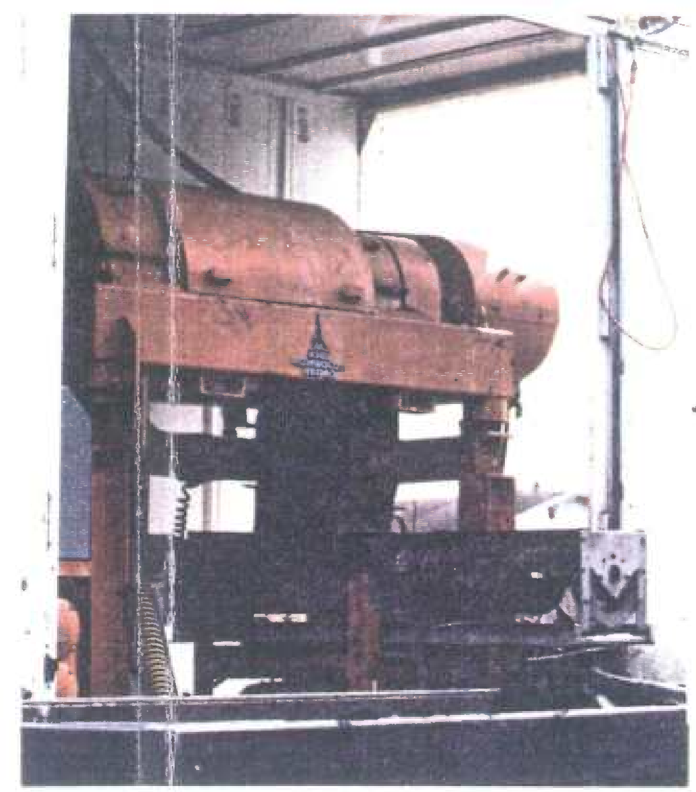
SEDIMENT FEED PUMP







POLYMER STORAGE TANKS



CENTRIFUGE, FEED PUMP, CONVEYOR

SEDIMENT FEED SYSTEM
CENTRIFUGE DEWATERING SYSTEM

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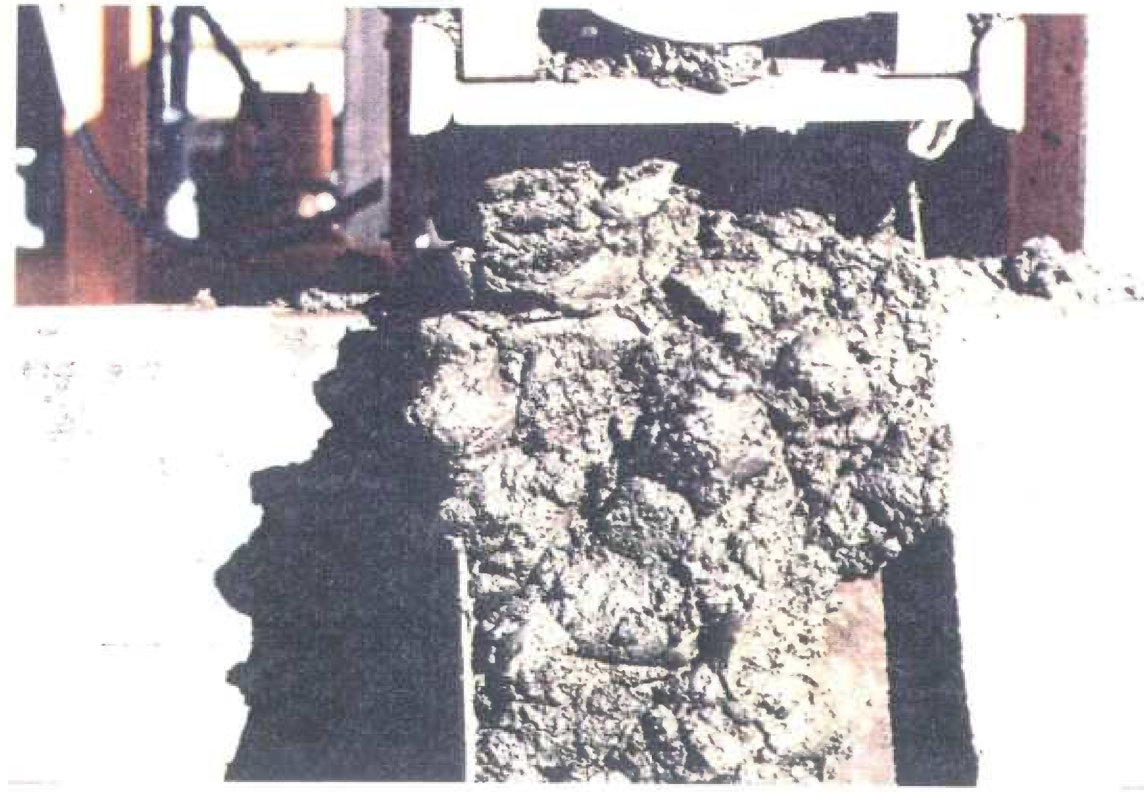
FIGURE 4-2

clogging phenomena necessitated the routine dismantling and cleaning of these centrate tubes. As full-scale operations are considered for centrifuge dewatering, the design of the conveyance system for centrate must assure that high enough velocities can be maintained to avoid this routine maintenance problem.

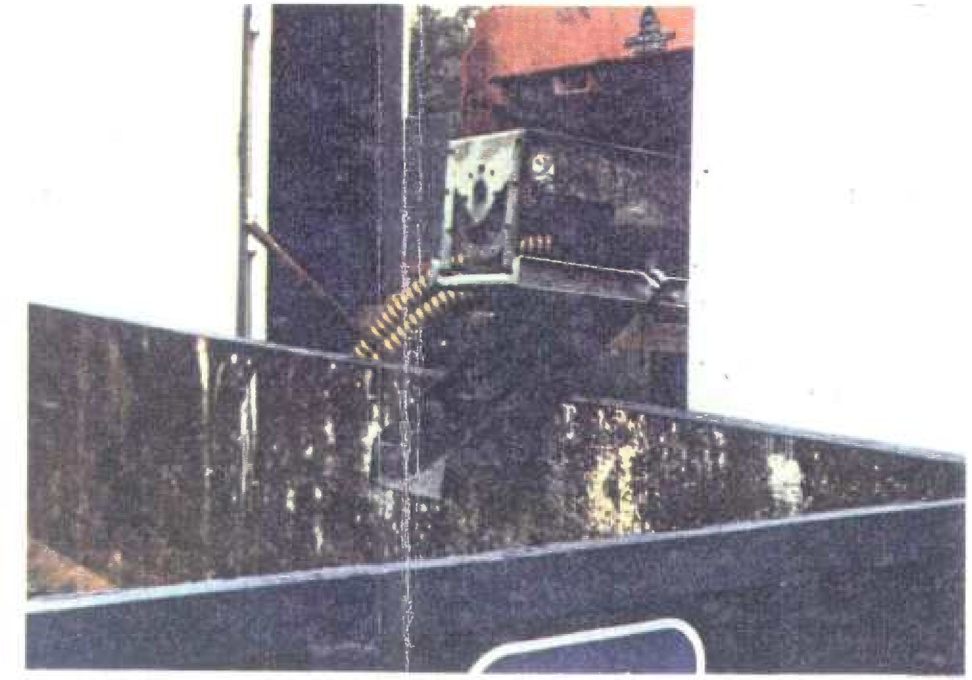
The dewatered sediment material was conveyed from the centrifuge to a dumpster. Figure 4-3 displays the representative "good" dewatered sediment and the relative clean centrate. As the feed rates and polymer dosages were varied, the cake would vary in consistency. The conveyor had to be manned to assure continuous discharge of this dewatered material into the dumpster. However, with optimum operating characteristics, the principal concern would be directed toward an appropriate angle of repose for installation of the conveyor system. Naturally, ultimate disposal characteristics would need to be confirmed for the dewatered cake.

Improved solids concentrations can normally be obtained through polymer additions. Representative sediment muck had been transmitted to three different polymer companies to determine the best polymers for the pilot test program. Each company investigated cationic, anionic, and non-ionic polymers. The results of these investigations indicated that anionic polymers should be used for the pilot testing. Three different anionic polymers were used during these pilot testings.

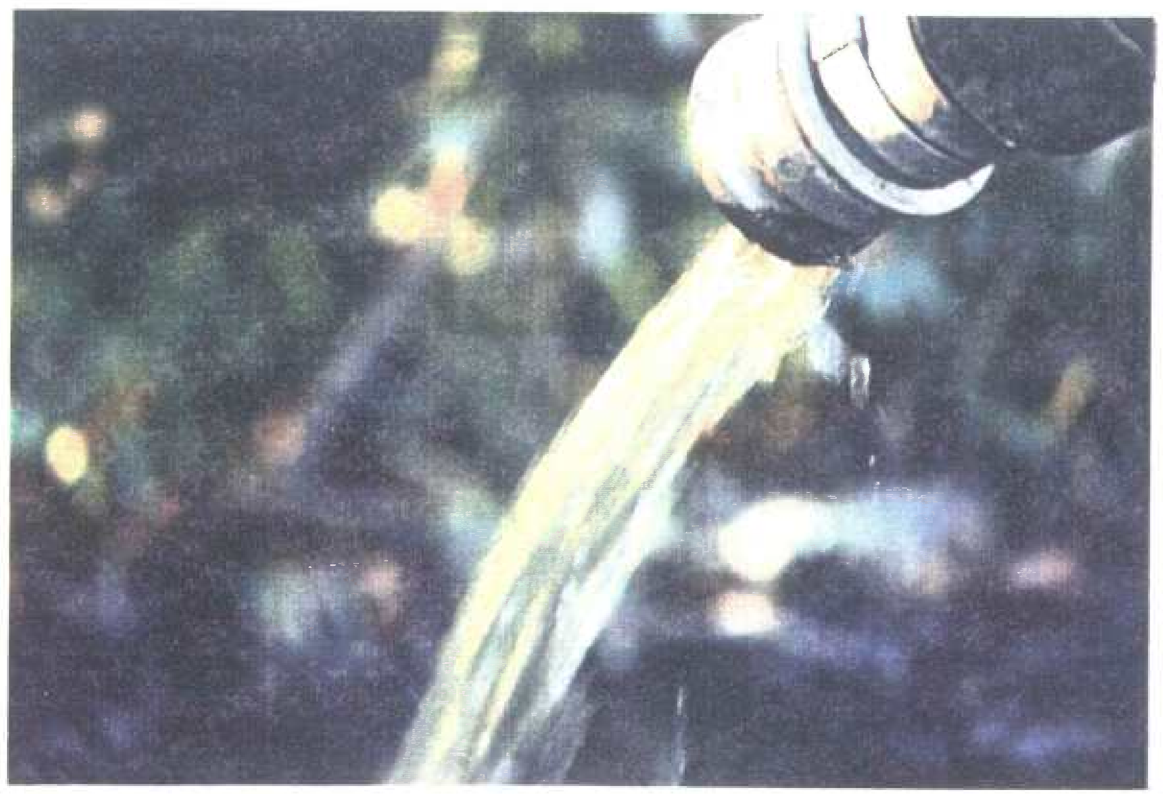
In order to validate the technical feasibility of dewatering river sediments, the pilot tests needed to be operated at a variety of conditions. During the 2-week testing program, the following ranges of variables were investigated:



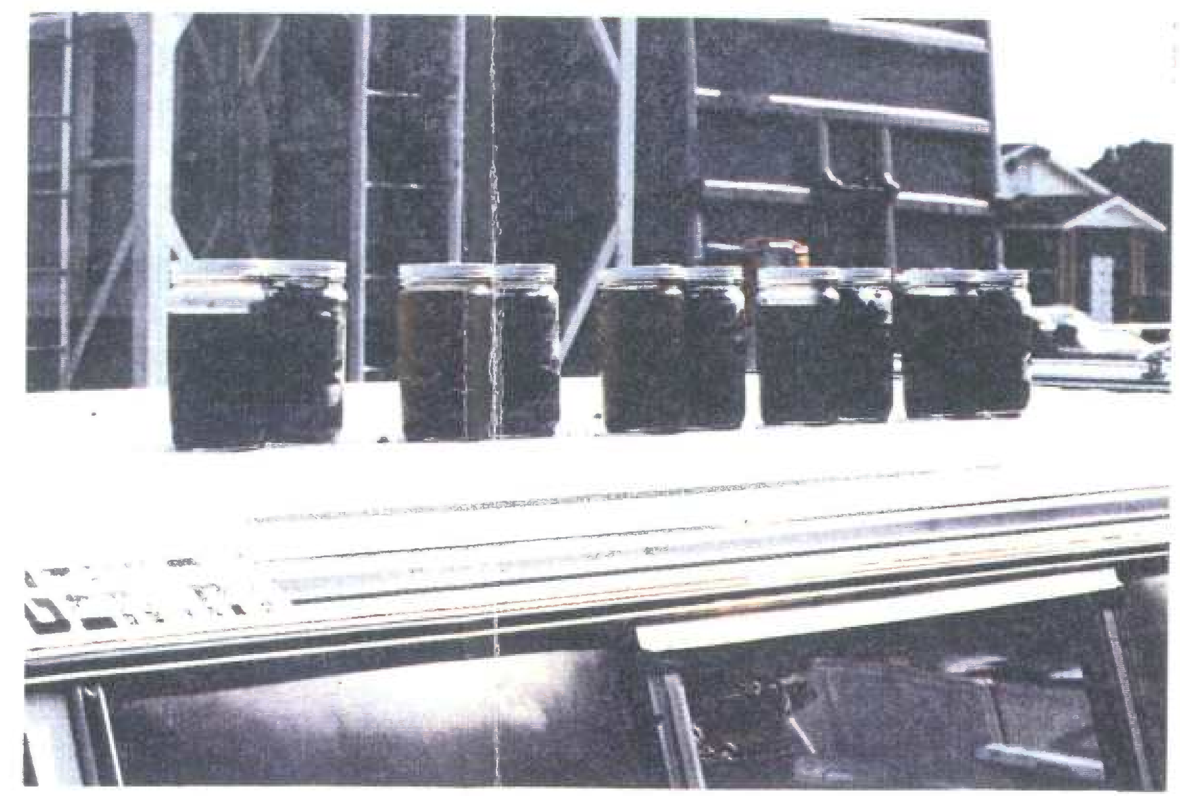
DEWATERED SEDIMENT



DEWATERED SEDIMENT



CENTRATE WITH POLYMER ADDITION



CENTRATE SAMPLE ON LEFT
DEWATERED SEDIMENT ON RIGHT

DEWATERED SEDIMENT
CLARIFIED CENTRATE

environmental engineers, scientists, planners, & management consultants

CDM

FIGURE 4-3

Variable	Operating Range
Solids Feed Rate:	10.6 - 32.4 gpm
Gravitational Force:	501 - 2617 x G
Differential:	2.4 - 9.4 rpm
Polymer Feed:	3.7 - 4.7 gpm
Polymer Concentration:	0.1 - 0.3 percent

By only changing one variable at a time and keeping the others constant, experimental runs could be completed to identify the affect of that variable on centrifuge operation. As with any pilot testing program, the exact range and impact of variables were unknown as the testing procedure was initiated. As the testing process continued, however, certain variables that had little impact upon operation were maintained constant.

According to discussions with the Humbolt Decantur, Inc. personnel before this pilot testing program was planned, each of the identified variables can be related to a prototype centrifuge. The capability to design a full-scale operation around these results has been proven to be valid with respect to other solids dewatering operations. Naturally, utilizing river sediment as a feed material to a centrifuge is not a proven application. However, based upon other site-specific operations in Europe, this is not a unique application. Each installation or application location would have to be evaluated prior to full-scale operation to assure success.

4.3 SAMPLING/TESTING PROCEDURES

Because a uniform sediment material feed was maintained in the storage tanks, recirculation system, and day tank, continuous sampling was not necessary. Therefore, a sampling procedure capable of identifying the uniformity of feed material, dewatered cake, and centrate quality was developed based on a sequence of standardized run times. The testing procedure was delineated as follows:

- Sediment Material Samples:

  Following 20-30 minutes of run stabilization time, the following samples were collected:

  At time 0, a sample was collected for total solids and total suspended solids.

  At time 0+15 minutes, a sample was collected for total solids, total suspended solids, and a equivalent sample for a composite sample for later analysis.

  At time 0+30 minutes, a sample was collected for total solids and total suspended solids.

- Dewatered Solids Cake Samples:

  After the 30-minute stabilization period, the following test samples were collected:

  At time 0, a sample was collected was collected for total solids and total suspended solids.

  At time 0+15 minutes, a sample for total solids and total suspended solids plus an equal volume sample was retained for a composite sample.

  At time 0+30 minutes, a sample was collected for total solids and total suspended solids.

- Centrate Samples:

  After the initial 30-minute stabilization period, the following samples were collected:

  At time 0, a sample was collected for total solids and total suspended solids.

  At time 0+15 minutes, a sample was collected for total solids and total suspended solids, plus an equal volume sample was retained to form a composite sample.

  At time 0+30 minutes, a sample was collected for total solids and total suspended solids.

As a result of the above sample collection process, each test period consisted of 30 minutes stabilization time, 30 minutes run time, and a downloading time following that run. Each series of three samples adequately characterized the input, dewatered solids output, and liquid output. Through collecting these samples, a true characterization of the impact of principal variables and the solids capture from the runs was obtained. Furthermore, the sample collected at the mid-point of each run was composited in the morning and afternoon to provide representative characteristics relative to nitrogen, phosphorus, and heavy metals content.

Operating characteristics obtained from these multiple test runs provide a better understanding of full-scale application. Not only the specific data collected from the sampling program, but the operating characteristics and problems associated with sediment material dewatering can be better understood. In performing the 47 runs, a broad spectrum of operating characteristics was experienced. These results provide valuable information in determining the capabilities for removing sediment material and dewatering the solids.

SECTION FIVE

5.0 DEWATERING TEST RESULTS

5.1 INTRODUCTION

The purpose of the pilot plant investigation was to evaluate the performance of a test scale centrifuge when utilized for dewatering nutrient-rich river sediments. The investigation successfully removed the sediment material from the test area utilizing the mudcat dredge and provided a uniform feed of sediment material to the centrifuge equipment with the assistance of the recirculating pump/pipe arrangement. Laboratory analyses were completed to identify suspended solids, heavy metals concentrations, and nutrient concentrations for the various flow streams. Laboratory support for this pilot study was provided by FDER (Jacksonville and Tallahassee) and the City of Jacksonville Bio-Environmental Division.

As with most solids related test procedures, meaningful results can only be obtained when the quality characteristics are expressed in terms of representative units. Results of the analyses performed on sediment material, sediment material dewatered cake, and centrate were converted to common units for equivalent comparisons. Specifically, values reported as mg/l, ug/l, and concentration per wet sample were converted to mg/kg of dry solids.

Since the objective of the testing program was the applicability of test results to full-scale operation, the results were developed to reflect both pilot operations and applicability to river sediment removal. The following subsections define the sediment material concentration, the heavy metals removal/recovery, and the nutrient removal/recovery. Each of these categories is presented relative to raw material application and raw sediment material injected with polymer feed.

5.2 SEDIMENT SOLIDS RESULTS

5.2.1 WITHOUT POLYMER ADDITION

Ten tests were conducted with three runs per test to identify the centrifuge performance characteristics without polymer addition. In each of these runs, solids feed rates varied between 15 gallons per minute and 25 gallons per minute with respective gravitational forces varying between 501 and 2617 Gs. Table 5-1 displays the results for total suspended solids in the sediment material, total suspended solids in the dewatered cake, total suspended solids in the centrate, and total percent solids recovery.

Analyses performed for the 30 samples collected without polymer addition indicated very satisfactory results. As the centrifuge gravitational force was reduced for the feed rate of 15 gallons per minute, reductions in percent solids in the dewatered cake were reported. As the gravitational force was reduced, the total suspended solids observed in the centrate also increased. In both instances, the recovery rate for suspended solids remained in excess of 50 percent, while the dewatered cake exceeded 33 percent solids, and the centrate contained less than 5.5 percent suspended solids.

The results obtained from the pilot test runs for total suspended solids without polymer addition indicate the following:

- Fifty to 60 percent of the total suspended solids applied to the centrifuge can be recovered in the cake.
- Total suspended solids in the dewatered cake averaged 37 percent solids, with a 33-48 percent range.
- Solids feed rates equivalent to 0.5 tons per hour can be accomplished with gravitational forces equalling 1127 Gs.
- Centrate total suspended solids cannot be reduced below approximately 4.5 percent, with 5.5 percent being realistic for full-scale application.

TABLE 5-1

SUSPENDED SOLIDS MEASUREMENTS
CENTRIFUGE DEWATERING WITHOUT POLYMER
RIBAULT RIVER SEDIMENT STUDY

FEED NUMBER	RUN NUMBER	TOTAL SUSPENDED SOLIDS FEED (%)	TOTAL SUSPENDED SOLIDS CAKE (%)	TOTAL SUSPENDED SOLIDS CENTRATE (%)	SUSPENDED SOLIDS RECOVERY (%)	DIFFERENTIAL (RPM)	BOWL SPEED (RPM)	FEED FLOW RATE (GPM)
1	1-3	8.7	37.7	4.9	50.5	2.00	3200	25
2	4-6	10.0	33.1	4.6	62.4	1.25	3200	25
3	7-8	9.6	34.5	4.5	60.7	3.00	3200	25
4	9-11	9.1	33.4	4.4	60.1	3.00	3200	15
5	12-14	10.8	37.1	5.7	55.8	1.25	3200	15
6	15-17	10.0	33.1	5.5	53.7	1.25	2000	15
7	18-20	11.0	24.7	5.3	66.1	3.00	2000	15
39	111-113	12.1	47.9	7.6	44.3	1.00	1400	15
41	115-117	10.4	32.7	5.9	52.8	1.50	1720	15
42	118-120	9.7	48.0	6.1	42.5	1.50	1720	25

5.2.2 WITH POLYMER ADDITION

Thirty-three test periods consisting of 93 runs were conducted with various polymer feed rates. In each of these instances, polymer flow rate and polymer dosage were varied singularly to identify the impacts relative to the solids feed rate, centrifuge G force, and centrifuge differential. Table 5-2 displays the results obtained from all tests conducted with multiple polymer feed rates. With the addition of polymer, each sediment material feed rate had to be adjusted to reflect the total flow going to the centrifuge for calculations regarding solids recovery.

The results obtained from the 33 testing periods indicate remarkable suspended solids recovery throughout the range of operating parameters. Analyses collected from 24 of the testing periods achieved total suspended solids concentrations in the dewatered cake ranging from 25.57 percent to 36.40 percent, with an average value of 32.3 percent. Within this operating range, the total polymer concentration only varied between 0.1 and 0.2 percent, with a maximum feed rate of 4.7 gallons per minute (2.0 to 10.4 pounds per ton) utilized with the sediment material. The corresponding percent recovery of solids averaged 97.8 percent with the exception of one test having only 89.9 percent recovery. For each of these testing periods, the centrate solids concentration exceeded 1.0 three times with values of 1.34, 1.87, and 1.93 percent.

As with most solids dewatering investigations, the objectives are to have the least solids in the centrate and the highest percentage solids in the dewatered cake. As indicated for the results obtained with the sediment material injected with polymer, both of these objectives were obtained with remarkable results. When the gravitational force and sediment material feed rate are reviewed, the only distinct difference that can be drawn is relative to the centrate quality. With the lower sediment material feed rates (approximately 15 gallons per minute), the centrate values approached 0.05 percent solids and still maintained the nearly 99 percent total suspended solids recovery. Within the spectrum of variables

TABLE 5-2

SUSPENDED SOLIDS MEASUREMENTS
CENTRIFUGE DEWATERING WITH POLYMER
RIBAULT RIVER SEDIMENT STUDY

TEST NUMBER	RUN NUMBER	POLYMER TYPE	POLYMER CONCENTRATION (%)	POLYMER FLOW RATE (GPM)	FEED PUMP RATE (GPM)	TOTAL SUSPENDED SOLIDS FEED (%)	TOTAL SUSPENDED SOLIDS CAKE (%)	TOTAL SUSPENDED SOLIDS CENTRATE (%)	SUSPENDED SOLIDS RECOVERY (%)	DIFFERENTIAL (RPM)	BOWL SPEED (RPM)
8	21-23	7182	0.1	3.7	25	8.94	26.07	4.19	56.6	3	2000
9	24-26	7182	0.1	3.8	25	8.77	29.13	3.86	58.2	3	2500
10	27-29	7182	0.1	3.7	25	8.42	33.67	3.72	56.5	3	3200
11	30-32	7182	0.2	3.6	25	8.90	29.53	3.90	58.7	3	3200
12	33-35	726	0.2	3.7	25	9.15	31.27	0.84	92.3	3	3200
13	36-38	727	0.2	3.7	25	9.42	34.27	0.22	98.1	3	3200
14	39-41	727	0.2	4.7	25	9.44	36.20	0.72	93.1	3	3200
15	42-44	726	0.2	4.6	15	10.90	30.53	0.09	99.3	3	3200
16	45-47	727	0.2	4.6	15	10.91	33.20	0.04	99.6	3	3200
17	48-50	726	0.2	4.6	10	11.83	33.20	0.13	99.0	3	3200
18	51	727	0.2	4.7	10	11.82	31.40	0.06	99.6	3	3200
19	52-54	727	0.2	4.6	10	12.11	33.60	0.07	99.5	3	3200
25	70-72	726	0.1	4.6	25	7.48	34.57	0.24	97.0	3	1720
26	73-75	727	0.1	4.6	25	8.77	38.23	0.85	90.9	3	1720
40	114	727	0.05	4.6	15	9.96	25.20	0.02	99.8	3.75	1400
20	55-57	726	0.2	4.6	25	11.99	34.13	1.93	86.7	4	3200
21	58-60	727	0.2	4.6	25	12.56	32.33	1.87	88.4	4	3200
22	61-63	726	0.3	4.7	15	11.63	23.90	0.18	99.0	4	3200
23	64-66	727	0.3	4.6	15	11.29	31.60	0.06	99.5	4	3200
24	67-69	727	0.1	4.6	15	13.18	30.33	0.04	99.8	4	3200
27	76-78	726	0.1	4.6	25	11.33	36.40	1.34	89.9	4	2100
28	79-81	727	0.2	4.6	15	10.67	27.50	0.02	99.8	4	1720

TABLE 5-2 (CONTINUED)

SUSPENDED SOLIDS MEASUREMENTS
CENTRIFUGE DEWATERING WITH POLYMER
RIBAULT RIVER SEDIMENT STUDY

TEST NUMBER	RUN NUMBER	POLYMER TYPE	POLYMER CONCENTRATION (%)	POLYMER FLOW RATE (GPM)	FEED PUMP RATE (GPM)	TOTAL SUSPENDED SOLIDS FEED (%)	TOTAL SUSPENDED SOLIDS CAKE (%)	TOTAL SUSPENDED SOLIDS CENTRATE (%)	SUSPENDED SOLIDS RECOVERY (%)	DIFFERENTIAL (RPM)	BOWL SPEED (RPM)
29	82-84	727	0.2	4.6	20	9.58	26.53	0.02	99.8	4	1720
30	85-87	727	0.2	3.6	15	13.99	32.00	0.02	99.9	4	1720
31	88-90	727	0.1	4.6	15	12.84	22.67	0.02	99.9	4	1720
32	91-92	727	0.2	4.6	20	12.10	30.20	0.02	99.9	4	2100
33	93-95	727	0.2	3.7	20	11.13	29.20	0.71	95.2	4	2100
34	96-98	727	0.1	4.6	15	9.98	28.87	0.02	99.8	4	2100
35	99-101	727	0.1	4.6	20	11.63	32.27	0.29	98.0	4	2100
36	102-104	727	0.2	4.6	15	11.89	28.53	0.03	99.8	4	1400
37	105-107	727	0.2	4.6	20	11.35	28.50	0.05	99.7	4	1400
38	108-110	727	0.1	4.6	15	10.87	25.57	0.02	99.9	4	1400
43	121-123	727	0.05	4.6	15	8.52	22.01	0.01	99.9	4	1400

which were reviewed, the impact of differential upon these results was negligible.

The analytical results obtained for centrifuge dewatering with polymer feed indicate the following:

- Total suspended solids capture or recovery can exceed 95 percent with polymer addition.
- Total suspended solids in the centrate can remain below 1.0 percent and possibly 0.5 percent.
- Total suspended solids in the dewatered cake can achieve 30.0 percent, and possibly with further refinements during start-up, 35 percent total suspended solids can be achieved.
- A centrifuge operating in the range between 700-1,000 Gs is feasible to accomplish the identified solids removal.

5.3 HEAVY METALS RESULTS

Due to the laboratory constraints and the quantity of samples required to identify the centrifuge operating characteristics, the number of samples for heavy metals and nutrient analyses were limited. During the first 5 days of operation, sampling was confined to determining the removal of suspended solids in the centrifuge operation. Once the dewatering operation was better understood, the sample collection during the second week of operation was directed toward verifying impacts upon secondary (heavy metals and nutrients) constituents.

Each series of three tests was used to form a composite sample. For example, when three tests were conducted during a morning period, equivalent quantities of sample were collected from each of the three runs for each test. Therefore, a composite sample representing nine individual samples formed the composite for that specific sample. In each instance, a sample was collected of the sediment feed material, dewatered cake material, and centrate for each of the tests. The composite sample resulting from each of these three sampling locations was analyzed for heavy metals and nutrients.

The dewatering test was not designed to achieve optimum reduction of any heavy metal, but only to identify the heavy metals removed/recovered. The results are summarized in Table 5-3. Due to the hydraulics of the test unit, the performance of the centrifuge is keyed to the measurement of the feed concentration as it compares to the concentration in the centrate, or percent recovery. The metals concentrations remaining in the centrate exceeded the water column values by ratios of approximately 20 to 50 times the values reported for Ribault River samples. In these instances, all values are relative to mg/kg relationships and naturally would have to be reduced by the relationship of volume of centrate to volume of Ribault River into which the centrate would be returned.

Table 5-4 lists the percent recovery of an element for a given sample identification number. The sample identification number sequence has been reduced from 6000, 7000, and 8000, to Sample ID Number 000. Likewise the 6001, 7001, and 8001 sequence is reported as Sample ID Number 001. The negative values indicate an error in the field or laboratory procedures, data analysis, or any combination of the preceding. The negative values listed in Table 5-4 will not be used in calculating average values. An analysis for the element cadmium was also performed. Due to the number of negative values calculated for percent recovery, the values for cadmium were not reported in Table 5-3.

The average percent recovery for the reported elements was calculated by two different methods. In Table 5-5, the range was restricted by omitting the highest and lowest values from the calculation scheme for each element, while in Table 5-6 the range was not restricted and all values were used.

The average percent recovery in Table 5-5 ranged from 56 percent for copper to 89 percent for mercury. Using the calculation method in

TABLE 5-3

HEAVY METALS MEASUREMENTS
CENTRIFUGE DEWATERING RESULTS
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	DATE COLLECTED	TOTAL SUSPENDED SOLIDS (mg/Kg)	CHROMIUM (mg/Kg)	CHROMIUM METAL RECOVERY (%)	LEAD (mg/Kg)	LEAD METAL RECOVERY (%)	COPPER (mg/Kg)	COPPER METAL RECOVERY (%)	IRON (mg/Kg)	IRON METAL RECOVERY (%)	MERCURY (mg/Kg)	MERCURY METAL RECOVERY (%)	NICKEL (mg/Kg)	NICKEL METAL RECOVERY (%)
6000	11/07/88	123,100	89.4		113.7		59.3		29,878		0.29		17.06	
7000	11/07/88	10,100	13.9	84.5	45.5	60.0	21.2	64.3	3,277	89.0	1.14	-289.3	3.47	79.7
8000	11/07/88	326,000	101.2		135.0		70.6		35,337		0.40		22.70	
6001	11/07/88	121,500	98.8		123.5		70.0		30,551		0.40		17.28	
7001	11/07/88	6,150	17.9	81.9	35.8	71.0	29.6	57.7	2,293	92.5	0.05	88.3	4.39	74.6
8001	11/07/88	320,000	90.6		115.6		81.3		35,213		0.45		21.25	
6002	11/08/88	66,950	98.6		115.0		64.2		32,278		0.39		17.92	
7002	11/08/88	3,120	33.3	66.2	60.9	47.1	59.0	8.2	6,442	80.0	0.04	90.1	8.33	53.5
8002	11/08/88	314,000	105.1		156.1		66.9		31,981		0.43		17.83	
6003	11/08/88	123,350	81.1		113.5		67.3		28,480		0.41		16.21	
7003	11/08/88	9,700	25.8	68.2	66.5	41.4	17.9	73.3	4,330	84.8	0.29	27.5	7.11	56.1
8003	11/08/88	295,000	98.3		128.8		78.0		32,773		0.39		18.31	

NOTES:

1. 6000 series represents feed comp.
2. 7000 series represents centrate comp.
3. 8000 series represents cake comp.

TABLE 5-3 (CONTINUED)

HEAVY METALS MEASUREMENTS
CENTRIFUGE DEWATERING RESULTS
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	DATE COLLECTED	TOTAL SUSPENDED SOLIDS (mg/Kg)	CHROMIUM (mg/Kg)	CHROMIUM METAL RECOVERY (%)	LEAD (mg/Kg)	LEAD METAL RECOVERY (%)	COPPER (mg/Kg)	COPPER METAL RECOVERY (%)	IRON (mg/Kg)	IRON METAL RECOVERY (%)	MERCURY (mg/Kg)	MERCURY METAL RECOVERY (%)	NICKEL (mg/Kg)	NICKEL METAL RECOVERY (%)
6004	11/09/88	99,600	99.4		130.5		76.3		31,958		0.38		17.07	
7004	11/09/88	233	82.0	17.5	142.1	-8.8	128.8	-68.7	6,567	79.5	0.00	100.0	12.45	27.1
8004	11/09/88	304,000	85.5		118.4		69.1		29,464		0.37		16.45	
6005	11/09/88	133,000	90.2		112.8		67.7		28,902		0.32		15.79	
7005	11/09/88	185	87.0	3.5	119.5	-5.9	97.3	-43.8	10,757	62.8	0.00	100.0	5.41	65.8
8005	11/09/88	320,000	87.5		125.0		68.8		29,744		0.42		17.50	
6006	11/10/88	102,600	92.6		117.0		64.3		31,296		0.34		16.57	
7006	11/10/88	3,050	27.5	70.3	65.6	43.9	45.9	28.6	11,115	64.5	0.03	92.3	6.56	60.4
8006	11/10/88	2,400	10833.3		14583.3		7916.7		3,905,000		46.67		2208.33	
6007	11/10/88	116,700	94.3		111.4		60.8		30,368		0.30		17.14	
7007	11/10/88	800	31.6	66.4	36.3	67.5	95.0	-56.1	11,125	63.4	0.00	100.0	9.38	45.3
8007	11/10/88	2,520	7936.5		11111.1		6349.2		3,111,905		50.40		1746.03	
6008	11/11/88	98,000	87.8		112.2		60.2		28,327		0.42		15.31	
7008	11/11/88	41,500	12.5	85.7	4.2	96.2	0.9	98.5	4,048	85.7	0.16	62.4	3.66	76.1
8008	11/11/88	366,000	60.1		98.4		46.4		28,309		0.36		16.94	

NOTES:

1. 6000 series represents feed comp.
2. 7000 series represents centrate comp.
3. 8000 series represents cake comp.

TABLE 5-4

HEAVY METALS RECOVERY
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	CHROMIUM METAL RECOVERY (%)	LEAD METAL RECOVERY (%)	COPPER METAL RECOVERY (%)	IRON METAL RECOVERY (%)	MERCURY METAL RECOVERY (%)	NICKEL METAL RECOVERY (%)
000	84.5	60	64.3	89	-289.3	79.7
001	81.9	71	57.7	92.5	88.3	74.6
002	66.2	47.1	8.2	80	90.1	53.5
003	68.2	41.4	73.3	84.8	27.5	56.1
004	17.5	-8.8	-68.7	79.5	100	27.1
005	3.5	-5.9	-43.8	62.8	100	65.8
006	70.3	43.9	28.6	64.5	92.3	60.4
007	66.4	67.5	-56.1	63.4	100	45.3
008	85.7	96.2	98.5	85.7	62.4	76.1

TABLE 5-5

HEAVY METALS RECOVERY
AVERAGES BASED ON RESTRICTED RANGE
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	CHROMIUM METAL RECOVERY (%)	LEAD METAL RECOVERY (%)	COPPER METAL RECOVERY (%)	IRON METAL RECOVERY (%)	MERCURY METAL RECOVERY (%)	NICKEL METAL RECOVERY (%)
000	85	60	64	89		
001	82	71	58		88	75
002	66	42		80	90	54
003	68		73	85		56
004	18			80	100	
005						66
006	70	44	29	65	92	60
007	66	68		63	100	45
008	—	—	—	86	62	76
Average	65	58	56	78	89	62

TABLE 5-6

HEAVY METALS RECOVERY
AVERAGES BASED ON UNRESTRICTED RANGE
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	CHROMIUM METAL RECOVERY (%)	LEAD METAL RECOVERY (%)	COPPER METAL RECOVERY (%)	IRON METAL RECOVERY (%)	MERCURY METAL RECOVERY (%)	NICKEL METAL RECOVERY (%)
000	85	60	64	89		80
001	82	71	58	93	88	75
002	66	47	8	80	90	54
003	68	41	73	85	28	56
004	18			80	100	27
005	4			63	100	66
006	70	44	29	65	92	60
007	66	68		63	100	45
008	86	96	99	86	62	76
Average	60	61	55	78	83	60

Table 5-6, the recoveries ranged from 55 percent for copper to 83 percent for mercury. The rankings based on percent recovery, from lowest to highest, were the same for both Table 5-5 and Table 5-6 for all of the elements except lead. In Table 5-5, was in the second lowest position between copper and nickel while in Table 5-6 feed became the fourth lowest position between chromium and iron. The other elements ranked from lowest to highest recoveries were copper, nickel, chromium, iron and mercury.

With the operating parameters confined to specific testing, only the last days sampling contained results for heavy metals associated with dewatering river sediment material without polymer addition. For each of the parameters analyzed, the analyses indicated that the heavy metals results were as good if not better than the previous results reported for testing with polymer addition. Specifically, lead, copper, chromium, and iron reductions all exceeded 85 percent while mercury and nickel each exceeded 62 and 75 percent, respectively. Although further testing and analyses should be performed for identifying heavy metals impacts, the results from these preliminary testings indicate entrainment of these specific metals within the dewatered cake and quantities of metals in the centrate compatible with naturally occurring concentrations with minimal dilution in those waters.

5.4 NUTRIENT REMOVALS FROM RIVER SEDIMENT

The same composite samples utilized for heavy metals analyses were analyzed for nutrient analyses. The sediment feed material, the dewatered sediment cake, and the centrate were analyzed for ammonia-N, nitrite-N, nitrate-N, total kjehdal nitrogen, sulfate, and total phosphorus. The results from these analyses are reported in Table 5-7.

As predicted from Dr. Trefry's previous findings, the nitrite and nitrate states of nitrogen are minimal, if nonexistent, and the brief transition from anaerobic to oxic states had no impact upon these constituents. Relative to sulfate, large quantities were observed, but minimal

TABLE 5-7

NUTRIENT MEASUREMENTS
CENTRIFUGE DEWATERING RESULTS
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	DATE	AMMONIA NH3-N	AMMONIA PERCENT RECOVERY (%)	NITRITE NO2-N	NITRITE PERCENT RECOVERY (%)	NITRATE NO3-N	NITRATE PERCENT RECOVERY (%)	SULPHATE S04	SULPHATE PERCENT RECOVERY (%)	TOTAL KJELDAHL NITROGEN TKN-N	TKN PERCENT RECOVERY (%)	TOTAL PHOSPHORUS TP-P	TP PERCENT RECOVERY (%)
6000	11/07/88 AM	24 mg/l		0.015 mg/l		0.015 mg/l		468 mg/l		7500 mg/Kg		44.7 mg/l	
7000	11/07/88 AM	21 mg/l	12.5	0.015 mg/l	0.0	0.015 mg/l	0.0	462 mg/l	1.3	151 mg/l	98.0	2.79 mg/l	93.8
8000	11/07/88 AM	181 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		798 mg/Kg		18038 mg/Kg		842 mg/Kg	
6001	11/07/88 PM	7.37 mg/l		0.015 mg/l		0.015 mg/l		383 mg/l		6900 mg/Kg		35.8 mg/l	
7001	11/07/88 PM	6.09 mg/l	17.4	0.015 mg/l	0.0	0.015 mg/l	0.0	354 mg/l	7.6	84.4 mg/l	98.8	1.88 mg/l	94.7
8001	11/07/88 PM	27 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		1767 mg/Kg		27075 mg/Kg		799 mg/Kg	
6002	11/08/88 AM	12.2 mg/l		0.015 mg/l		0.015 mg/l		469 mg/l		3143 mg/Kg		26.1 mg/l	
7002	11/08/88 AM	10.1 mg/l	17.2	0.015 mg/l	0.0	0.015 mg/l	0.0	403 mg/l	14.1	66.4 mg/l	97.9	1.93 mg/l	92.6
8002	11/08/88 AM	73.4 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		1236 mg/Kg		17475 mg/Kg		710 mg/Kg	
6003	11/08/88 PM	10.1 mg/l		0.015 mg/l		0.117 mg/l		643 mg/l		6480 mg/Kg		32.3 mg/l	
7003	11/08/88 PM	8.63 mg/l	14.6	0.015 mg/l	0.0	0.583 mg/l	-398.3	392 mg/l	39.0	93.5 mg/l	98.6	2.42 mg/l	92.5
8003	11/08/88 PM	47.8 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		877 mg/Kg		13275 mg/Kg		731 mg/Kg	

NOTES:

1. 6000 series represents feed comp.
2. 7000 series represents centrate comp.
3. 8000 series represents cake comp.

TABLE 5-7 (CONTINUED)

NUTRIENT MEASUREMENTS
CENTRIFUGE DEWATERING RESULTS
RIBAULT RIVER SEDIMENT STUDY

SAMPLE ID NUMBER	DATE	AMMONIA NH3-N	AMMONIA PERCENT RECOVERY (%)	NITRITE NO2-N	NITRITE PERCENT RECOVERY (%)	NITRATE NO3-N	NITRATE PERCENT RECOVERY (%)	SULPHATE S04	SULPHATE PERCENT RECOVERY (%)	TOTAL KJELDAHL NITROGEN TKN-N	TOTAL KJELDAHL NITROGEN PERCENT RECOVERY (%)	TOTAL PHOSPHORUS TP-P	TOTAL PHOSPHORUS PERCENT RECOVERY (%)
6004	11/09/88 AM	7.14 mg/l		0.015 mg/l		0.015 mg/l		505 mg/l		5625 mg/Kg		37.6 mg/l	
7004	11/09/88 AM	5.87 mg/l	17.8	0.015 mg/l	0.0	0.015 mg/l	0.0	369 mg/l	26.9	50.9 mg/l	99.1	1.29 mg/l	96.6
8004	11/09/88 AM	62.5 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		864 mg/Kg		9000 mg/Kg		731 mg/Kg	
6005	11/09/88 PM	10.4 mg/l		0.015 mg/l		0.015 mg/l		335 mg/l		6690 mg/Kg		42.9 mg/l	
7005	11/09/88 PM	6.4 mg/l	38.5	0.015 mg/l	0.0	0.015 mg/l	0.0	323 mg/l	3.6	25.1 mg/l	99.6	1.96 mg/l	95.4
8005	11/09/88 PM	93.2 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		1270 mg/Kg		13275 mg/Kg		754 mg/Kg	
6006	11/10/88 AM	8.22 mg/l		0.015 mg/l		0.015 mg/l		335 mg/l		5625 mg/Kg		36.7 mg/l	
7006	11/10/88 AM	6.95 mg/l	15.5	0.015 mg/l	0.0	0.015 mg/l	0.0	218 mg/l	34.9	48.3 mg/l	99.1	2.78 mg/l	92.4
8006	11/10/88 AM	31 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		956 mg/Kg		18525 mg/Kg		599 mg/Kg	
6007	11/10/88 PM	9.5 mg/l		0.015 mg/l		0.015 mg/l		262 mg/l		5835 mg/Kg		39.4 mg/l	
7007	11/10/88 PM	8.11 mg/l	14.6	0.015 mg/l	0.0	0.055 mg/l	-266.7	225 mg/l	14.1	30.3 mg/l	99.5	0.934 mg/l	97.6
8007	11/10/88 PM	27 mg/Kg		0.378 mg/Kg		0.375 mg/Kg		1902 mg/Kg		19650 mg/Kg		754 mg/Kg	
6008	11/11/88 AM	6 mg/l		0.015 mg/l		0.015 mg/l		261 mg/l		4350 mg/Kg		39.4 mg/l	
7008	11/11/88 AM	5.84 mg/l	2.7	0.015 mg/l	0.0	0.015 mg/l	0.0	243 mg/l	6.9	451 mg/Kg	89.6	25.2 mg/l	[illegible]
8008	11/11/88 AM	25 mg/Kg		0.375 mg/Kg		0.375 mg/Kg		1360 mg/Kg		28125 mg/Kg		820 mg/Kg	

NOTES:

1. 6000 series represents feed comp.
2. 7000 series represents centrate comp.
3. 8000 series represents cake comp.

precipitation was exhibited through the dewatering process. If the total sulphur content would have been measured in this sediment material and then analyzed relative to conversion states, a different and more complete picture would have possibly been obtained.

When the results for ammonia retention, total kjehdal retention, and total phosphorus are reviewed, a significant impact is reported. Since ammonia represents an intermediate state of nitrogen from the totally reduced to totally oxidized state, these results are not surprising. However, when the quantities of total nitrogen and total phosphorus retained in the dewatered cake are reviewed, the significance of removing river sediment is quantified.

In all of the analyses performed with and without polymer addition, total nitrogen was almost totally entrained in the dewatered cake (values ranging between 98 and 99.5 percent) and total phosphorus was retained in excess of 92 percent on all dewatered cake. The only two instances when the values dropped below these reported ranges were the last series of tests when no polymer feed was used and testing difficulty was encountered relative to centrate clarity. Even with these decreased operating conditions, 89.6 percent of nitrogen and 36 percent of phosphorus were retained.

Beyond the significance of the percent retainage in the dewatered cake, the absolute quantities of total nitrogen and total phosphorus are significant. With respect to the samples collected, total nitrogen exceeded 19,650 mg/kg of solid in all of the samples analyzed. This quantity of nitrogen removed from the riverine environment is significant as a nutrient load with long-term impact upon the water column. Commensurately, phosphorus in excess of 700 mg/kg of sediment was also retained in the dewatered cake. These quantities of nutrients removed from the sensitive riverine/estuarine environments can have long-term impacts upon improved water quality.

5.5 ENVIRONMENTAL CONSEQUENCES

As a portion of the pilot test investigation, Dr. John Trefry developed an independent review of the heavy metals and nutrients encountered during the dewatering program (Appendix A). A key observation proposed by Dr. Trefry focuses on the amount of metals remobilized and placed in solution during the dredging/dewatering process. For the samples taken from the sediment material fed to the centrifuge and samples collected of the centrate, the heavy metal content is essentially 100 percent associated with the solid phase. In the typical river system, quantities of heavy metals vary primarily as a function of the amount of suspended sediment in the water column. Thus, one of the best tests for metal release during the dewatering operation is the quantity of metal concentrations in solution. For the pilot test project, no significant heavy metal releases were detected for all heavy metals analyzed.

Relative to the interstitial waters, the solution phase of the centrate was very low in dissolved phosphate, iron, and copper. Although high quantities were anticipated, the difference was the large quantity of river water mixed with the sediment in transporting the material to the holding tanks. Another more technical explanation for this observation is that iron and phosphate precipitated under oxic conditions during the well-aerated centrifuge process. Such behavior was anticipated and the removal of iron and phosphorus from solution by precipitation of iron oxides and phosphates under oxic conditions is reasonable. Therefore, the capturing of these constituents in the dewatered sediment cake would be anticipated in other locations.

In summary, the chemistry of the centrate solution was very similar to the surrounding river waters in every aspect except for the suspended solids. Naturally, the suspended solids concentration will be minimal when optimum conditions are utilized for centrifuge dewatering as indicated for most of the samples exceeding 98 percent solids capture.

5.6 SUMMARY OF RESULTS

The following results are reported based upon the evaluations conducted October 30 and November 11, 1988:

- Solids dewatering without polymer can achieve 50-60 percent recovery of solids fed to a centrifuge, will contain 37-38 percent total suspended solids in the cake, and discharge approximately 4-6 percent total suspended solids in the centrate.
- Centrifuge dewatering operations with polymer feed can achieve 94-97 percent recovery of solids fed, can obtain 28-32 percent solids in the dewatered cake, and contain 0.05-0.1 percent total suspended solids in the centrate with polymer dosages ranging between 1.1 pounds/ton and 5.2 pounds/ton.
- Heavy metal reductions can range between 50-70 percent for chromium, lead, copper, iron, mercury, nickel, selenium, and sodium.
- Total nutrient removals for nitrogen and phosphorus can range between 93-97 percent in the dewatered cake from the total feed solids fed to a centrifuge.

SECTION SIX

6.0 REPRESENTATIVE SEDIMENT REMOVAL PLAN

6.1 INTRODUCTION

As a result of the preliminary findings of the pilot scale testing, the next logical step is to extrapolate the applicability of these results to a full-scale operation. During water quality investigations performed within the Miami River and Biscayne Bay zone, the impact of sediment upon water quality was well documented. In response to inquiries from local government officials, the U.S. Army Corps of Engineers, Jacksonville District, was requested to identify solutions and evaluate the feasibility of various options to remove sediment from the Miami River. The draft report entitled "DRAFT FEASIBILITY REPORT MIAMI RIVER, FLORIDA," April, 1986, was prepared to address the feasibility of removing and disposing of materials contained in the Miami River.

Preliminary investigations indicated that along the 6 miles of river between the salinity dam at 36th Street and the discharge of the river into Biscayne Bay, approximately 521,000 cubic yards of sediment exist on the bottom channel. The sediment material contained heavy metals in similar concentrations to those identified in the present investigation. Bioassay and bioaccumulation results did not indicate detrimental impacts upon marine organisms from any heavy metals present in the sediment. Furthermore, results obtained from elutriate tests performed for the Corps on both the sediment and liquid phases and subsequent bioassays indicated that the impact from resuspension would be minimal if noticeable in the water column.

The basic alternatives evaluated by the Corps were:

- o No action plan
- o Dredge with offshore disposal

- o Dredge with drying
- o Dredge with incineration of material

The initial recommendation indicated that dredging with offshore disposal would be the most acceptable alternative for this operation. The material would be removed utilizing two clam shell dredges with 2-cubic yard capacity and would take approximately 12 months to accomplish the dredging and disposal operation. The total 1986 cost was estimated to be $7.8 million with no annual maintenance required. When this value is escalated to January 1989 dollars, the total cost becomes approximately $8.4 million.

This alternative was recommended over the other removal techniques because of two principal drawbacks to the other options, i.e.: 1) no proven technology to dewater the material, and 2) difficulty with ultimate disposal of the dewatered material. The following focus on the preliminary identification of an alternative solution using the dewatering technique tested in the study. The application presented herein is offered as an illustration. Site specific details will have to be addressed prior to any consideration of this option.

6.2 SEDIMENT REMOVAL PROGRAM AND ASSUMPTIONS

The initial extraction portion of this option is identical to the alternative identified by the Corps of Engineers. Barges outfitted with clam shell dredges would remove the 521,000 cubic yards of material within the Miami River. This material would be removed and placed in barges to be hauled to a convenient location for dewatering. A possible site identified for a dewatering operation with centrifuges would be the Virginia Key Wastewater Treatment Plant operated by the Miami-Dade Water and Sewer Authority. All material conveyed by the barges to this location would be be off-loaded utilizing hydraulic pumps into holding tanks placed near the treatment facility. Once the materials are transported to the holding tanks, sludge feed pumps would feed the material into the centrifuge dewatering operation.

Similar to the Corps alternative, this operation would be carried out within a 12-month period. Therefore, temporary shelter consisting of an economically constructed roofed facility large enough to protect the equipment and workers during operation would need to be constructed. Operating components would primarily involve sediment material feed pumps, chemical feed pumps/system, centrifuges, conveyor systems for dryed cake, potable water supply, centrate transfer pumps, and associated electrical control panels. Once the sediment has been dewatered into a cake form, all cake would be transported in 10-15 cubic yard trucks to approved agricultural lands (approximately 20 miles from the site). When the trucks were unloaded, the material would be disced into the soil to serve as a soil conditioner, returning the lands to return to a usable form for further agricultural production.

Centrate generated by the dewatering centrifuges would be pumped to the Virginia Key plant for processing with the normal wastewater influent stream. The characteristics of the centrate must be monitored and representative samples collected to assure no detrimental impact on the treatment facility. Results from the pilot test indicate that the centrate characteristics should be quite compatible with the plant's influent wastewaters. Based upon preliminary calculations, dewatering the 521,000 cubic yards of sediment material would generate approximately 105 million gallons of centrate to be handled over the entire processing period, or approximately 400 gpm.

The principal assumptions inherent in this alternative are:

- o The 521,000 cubic yards of sediment will be representative of the feed material to the centrifuge. This assumes that any carrying liquid removed by the clam shells will be lost when the material is off-loaded into the holding tanks at Virginia Key or be displaced as material is loaded onto the barges. As indicated by the pilot testing, the in-situ solids concentration of 8-12 percent was replicated by the sampling performed on material fed to the centrifuge.

- The efficiencies obtained by the pilot plant investigation on the Ribault River sediments will be similar to those accomplished by a full-scale operation.

- The dewatered sludge cake will not contain constituents which will be detrimental to the future use of agricultural lands.

- The centrate applied to the wastewater treatment plant will not contain any constituents which will cause difficulty in the treatment process or disposal techniques utilized for the treatment plant's sludge.

- Cost estimates are based upon preliminary information from dredge contractors and equipment suppliers.

- Either the 12 hours per day, 7 days per week or the 24-hours per day, 7 days per week operation could be maintained through contract operations performed adjacent to the Virginia Key Wastewater Plant. All services would be performed by a general contractor through a competitive bid process.

6.3 PRELIMINARY COST EVALUATION

Based upon the sediment quantity identified by the Corps of Engineers, the 521,000 cubic yards represents approximately 105.2 million gallons of material. This material can be removed from the Miami River utilizing clam shell dredges and transported to a holding tank area at the Virginia Key Wastewater Treatment Plant using hydraulic pumps. Although a longer work period would be possible, a 9-month operating program is assumed for cost purposes. This option requires dredges to operate approximately 12 hours per day, 7 days per week, and 26-weeks continuously. The material off-loaded at the Virginia Key plant site will then be available to the dewatering operation on a continuous basis either 12 or 24 hours per day.

In order to fully accommodate the dewatering operation, the 105.2 million gallons must be processed through the dewatering centrifuges at a uniform rate of flow. Based upon a potential six month dewatering operation, the average feed rate through the centrifuges would be 400 gallons per minute operating 24 hours per day, 7 days per week, for 26 weeks. If 12 hours per day were anticipated for the same time span, 800 gallons per minute would need to be fed through the system for 12 hours continuously. Based upon utilizing the 12 hours per day operation (this allows for maintenance down time and mechanical failures), two centrifuges would be provided, each with a capacity of 400 gallons per minute. Along with these centrifuges, the necessary sludge pumps, polymer feed system, conveyor transport system, electrical control panels, building, access road, centrate pump system, potable water supply, and miscellaneous items would be provided.

The additional cost for manpower to operate the centrifuges, trucks to convey the dewatered material to agricultural lands, polymer feed cost (if required), and electrical usage were estimated. Based upon the above assumptions, the total estimated cost to accomplish the removal of the 521,000 cubic yards, dewater the sediment, and transport the sediment to the agricultural land for use as a soil conditioner would be approximately $6,700,000.

GLOSSARY

GLOSSARY OF TERMS

Backdrive - A device which permits adjustment of the differential speed between the bowl and scroll conveyor. Available in a variety of forms including hydraulic, electrical or mechanical. May be either manual or automatic adjustment type.

Beach - A part of the conical bowl section defined as the distance from the top of the pool to the point of cake discharge. The non-submerged portion of the bowl across which settled solids are conveyed for further de-watering after leaving the pool and prior to discharge from the centrifuge.

Bowl - A cylindrical-conical rotating drum or basket.

Cake - The thickened and or dewatered product discharged from the conical end of the centrifuge bowl.

Centrate - The liquid discharged from the cylindrical end of the centrifuge bowl.

Ceramic - A material sometimes used at certain locations of the centrifuge to minimize wear due to abrasion. An extremely hard, abrasion resistant clay material comprised of a very high alumina content, prepared by baking.

Centrifuge - A device which separates by the application of centrifugal force.

Centrifugal Force - The force which tends to impel a thing, or parts of a thing outward from a center of rotation.

Classification - The selective separation of various solids phases based upon particle size or density variations, resulting in different settling rates.

Concurrent Flow - Centrifuge design configuration whereby both liquid and solids travel along the bowl in the same direction.

Conveyor (Scroll) - A helical screw contoured to the shape of the centrifuge bowl; used to transport the settled solids to the point of discharge.

Differential Speed -	The difference in rotational speed between the rotating bowl and scroll.
Countercurrent Flow -	Centrifuge design configuration whereby both liquid and solids travel in opposite directions to their respective discharge points.
Decanter -	A vessel used to decant liquid, sediment solids.
Dewatering -	The separation of liquids from solids; the concentration/drying of solids to the extent possible.
Drainage Deck -	Same as "Beach"
Effluent -	Same as "Centrate"
Fenwal Switch -	A switch located in the main bearing pillow blocks which senses bearing temperature and initiates shutdown in the event of excessive bearing temperature (optional)
Hardsurfacing -	Any of a group of materials used to protect parts of the centrifuge from wear due to abrasion.
Hopper -	A receptacle or chute for collecting and directing either solids or liquids discharged from a centrifuge.
Polymer -	Any of a group of high molecular weight, synthetic polyelectrolytes used to condition sludge prior to thickening and or dewatering to promote high solids recovery efficiency.
Pool -	The liquid/solids volume retained in the centrifuge during operation.
Pool Depth -	The distance from the inner diameter of the bowl wall to the top of the pool.
Recovery -	The efficiency of the centrifuge to separate suspended solids from liquids and subsequently discharge separated solids as cake; the removal efficiency of solids as cake expressed as a percentage of the total influent suspended solids.
Sintered -	The fusing together of particles.

Sintered Tungsten Carbide -	Fused tungsten carbide used as a hard-surfacing material by Sharples.
Sludge -	The precipitated solid matter produced by clarification/sedimentation processes.
Slurry -	A blend of liquid and solids.
Thickening -	The process of concentrating from a dilute stream to a more heavily solids laden stream.
Vibration Isolator -	A device located under each corner of the centrifuge to dampen vibrations created during centrifuge operation; may be comprised of a rubber buffer or springs.
Vibration Switch -	A switch located on the base of the centrifuge which initiates centrifuge shutdown in the event of excessive vibration during operation.
Weir (Overflow) -	A series of plates or dams located at the cylindrical end of the bowl which are adjustable to permit variation of internal pool level.

APPENDICES

APPENDIX A

BACKGROUND CHARACTERISTICS

Muck Removal by Dredging/Centrifugation - - Chemical Results

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Introduction

Deposition of fine-grained, organic-rich, black sediments, sometimes referred to as muck, can greatly alter water quality and biological communities in estuarine systems. Muck is not the natural bottom in many areas of Florida. Where present, muck can be easily resuspended and greatly increase turbidity in the water column. Increased turbidity leads to decreased growth of seagrasses as has been observed in a variety of Florida locations including Tampa Bay and the Indian River Lagoon (Haddad, 1985). These organic-rich sediments also support massive bacterial activity and thereby promote decomposition of organic matter and depletion of oxygen in sediments and bottom water. In addition to oxygen depletion, the decomposition process leads to production of noxious toxic species such as hydrogen sulfide and ammonia. As the normal, perhaps sandy, sediment of an estuary is covered with muck, habitats for benthic organisms are also changed. This process can completely alter biological community structure. Furthermore, muck can serve as a significant depository for many contaminants.

In some cases, removal of muck sediments is the best form of remediation. However, the high water content of these deposits (typically about 80% by weight and 90% by volume) makes disposal and subsequent drying complicated because of the need for large land areas. Removal of some of the water by a technique such as centrifugation limits the volume of the deposit and thus makes the economics of disposal more favorable. The concerns during a dredging/centrifugation operation focus on environmental disturbance due to the dredging process and return of the centrate waters to the system.

During a test program in the Ribault River, Jacksonville, we made a few chemical measurements to augment the more extensive program carried out by the State of Florida Department of Environmental Regulation. These include the following: (1) determination of concentrations of dissolved and particulate trace metals in river water, the intake sediment/water mixture and the centrate, and (2) determination of concentrations of selected components in the sediment interstitial water. This information will be used to make a preliminary assessment of the muck centrifugation program.

Dissolved and Particulate Trace Metals

Samples of water from the dredged channel and the main river, along with the intake sediment and centrate were filtered through 0.4 μm pore-size membrane filters and analyzed for dissolved Cu, Cr, Fe and Pb. The solid phase in each case was also analyzed following complete digestion with $HF-HNO_3-HClO_4$. All analyses were carried out by atomic absorption spectrophotometry using flame or heated graphite atomizer techniques.

Concentrations of total suspended matter (TSM) were 2-7 mg/L in the water column of the channel and river. Values for the intake sediment and resultant centrate were, of course, much higher (Table 1 and appendices) because these samples were composed of large amounts of bottom sediment. However, the concentrations of dissolved trace metals in all 5 samples (Table 1) were generally similar. Figure 1 shows that dissolved Cu concentrations ranged from 0.1-0.8 μg/L (parts per billion) for all samples. In effect no difference is observed between the centrate waters and background concentrations in the Ribault River. A similar situation is observed for Pb where the centrate waters have slightly lower Pb concentrations than the receiving river water (Figure 1). The case for Fe is more dramatic, yet somewhat similar to that found for Pb and will be discussed with the interstitial water data.

The observed trace metal concentrations are reasonably low in both the river water and the centrate water. Thus, from this very preliminary perspective, we do not find a change in dissolved concentrations for the metals analyzed in the centrate waters relative to the ambient river water. This result is partially due to the high percentage of river water included in the intake material as will be discussed in the next section.

When concentrations of particulate metals are expressed as μg metal/L water, a large difference is observed between ambient river samples and the intake and centrate samples. This difference is completely a function of the mass of suspended sediment per liter of sample and does not influence dissolved metal concentrations as described above.

A more useful way of looking at particulate metal concentrations is as μg metal/g sediment or suspended sediment. These values can then be compared with those for surrounding natural soils, average continental crust

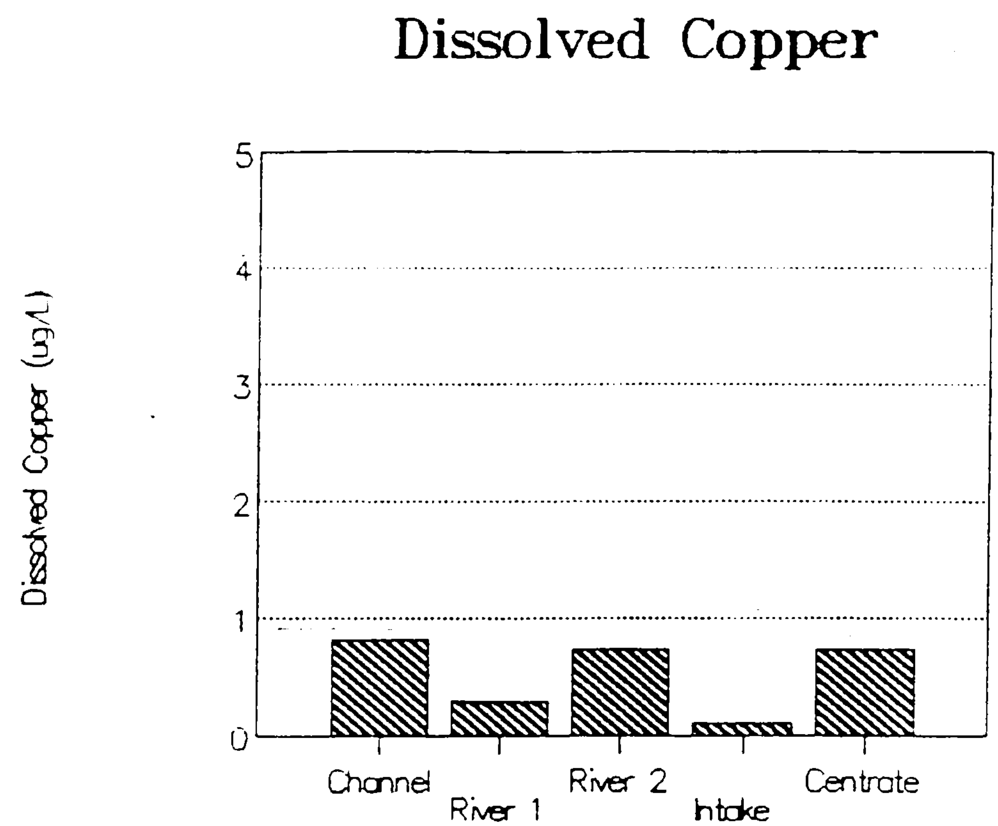
Sample ID	TSM (mg/L)	Dis Cu (ug/L)	Dis Cr (ug/L)	Dis Fe (ug/L)	Dis Pb (ug/L)
Channel	7.37	0.82	<0.2	15.9	1.1
River 1	2.56	0.29	<0.2	18.4	1.2
River 2	2.3	0.74	<0.2	21.6	1
Intake	84600	0.1	<0.2	1.2	0.59
Centrate	48000	0.74	<0.2	0.5	0.59

Sample ID	TSM (mg/L)	Part. Cu (ug/L)	Part. Cr (ug/L)	Part. Fe (ug/L)	Part. Pb (ug/L)
Channel	7.37	0.52	0.69	207	0.46
River 1	2.56	0.16	0.16	82	0.11
River 2	2.3	0.14	0.15	75	0.11
Intake	84600	9800	xx	3900000	16600
Centrate	48000	6700	xx	2400000	10800

Sample ID	TSM (mg/L)	Tot Cu (ug/L)	Tot Cr (ug/L)	Tot Fe (ug/L)	Tot Pb (ug/L)
Channel	7.37	1.3	0.69	223	1.6
River 1	2.56	0.45	0.16	100	1.3
River 2	2.3	0.88	0.15	97	1.1
Intake	84600	9800	xx	3900000	16600
Centrate	48000	6700	xx	2400000	10800

Sample ID	Al (%)	Fe (%)	Cu (ug/g)	Cr (ug/g)	Pb (ug/g)	Zn (ug/g)
Channel	5.77	2.81	71	94	62	xx
River 1	4.2	3.21	64	61	43	xx
River 2	4.4	3.27	63	66	47	xx
Intake	7.58	4.57	116	xx	196	408
Centrate	9.44	5.09	139	xx	226	512
River Sed.	6.8	4.18	76	xx	145	340
River base	3.73	1.92	<3	xx	<15	19

Table 1. Concentrations of total suspended matter and trace metals from study area.



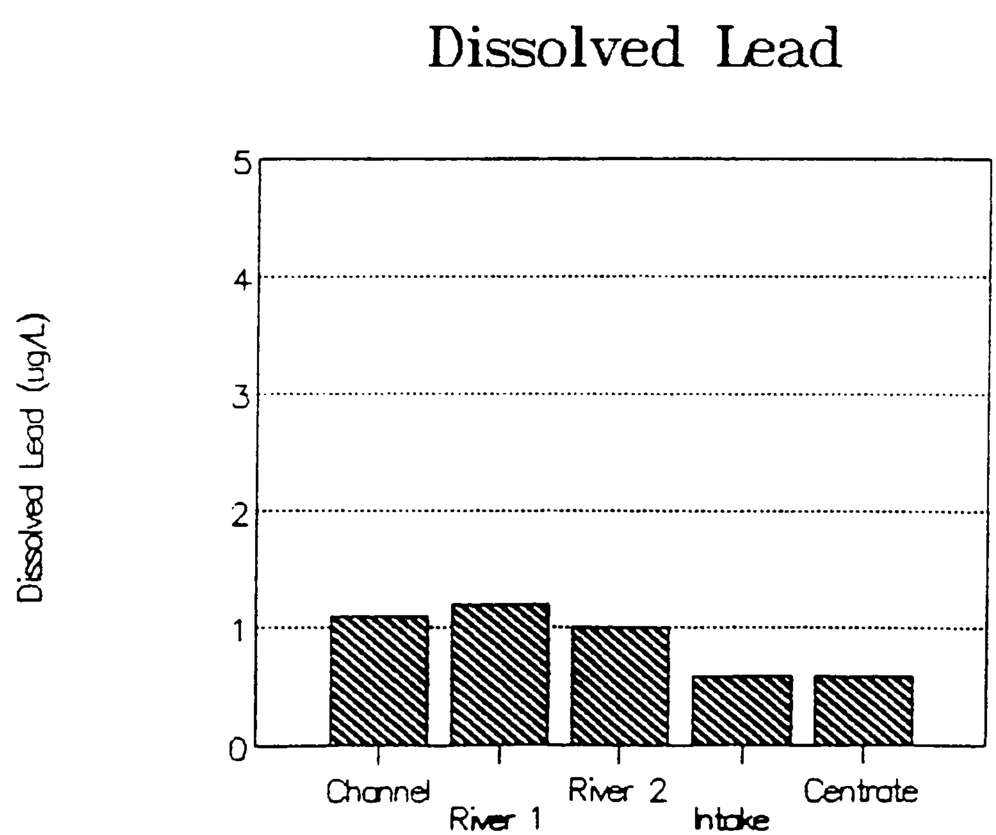


Figure 1. Dissolved copper and lead concentrations for water column and centrifuge samples.

or average marine seidments to determine the degree of contamination. Figure 2 shows that solid-phase Cu content ranges from <3-139 μg/g, where typical values for normal soil or sediment are predicted to be about 10-50 μg/g. The very low value for the deep layer of sediment is skewed because of the abundance of low-metal bearing quartz sand in that "river base sediment". Copper values for the river suspended matter show little evidence of contamination; however, the samples of sediment analyzed (including dredged material) have Cu contents of about twice natural levels. The scenario for Pb is similar; however, the degree of contamination for the sediments is significantly higher. This is most likely related to run-off of Pb from roadways via gasoline Pb additives. The degree of contamination in the sediments will always be a factor in deciding whether muck disposal requires any special precautions and must be considered on a case-by-case basis.

One of the key points of this discussion focuses on the amount of metal remobilized and put into solution during the dredging/centrifugation process. Figure 3 shows the percent of total metal that is dissolved and particulate for each sample. In the case of the intake and centrate samples, the metal content is essentially 100% associated with the solid phase. In the normal river system, the percentages vary, primarily as a function of the amount of suspended sediment in the river (Table 1). Thus, one of the best tests of metal release during the operation is in the dissolved metal data. In this case, no significant releases were detected for the chemical species studied.

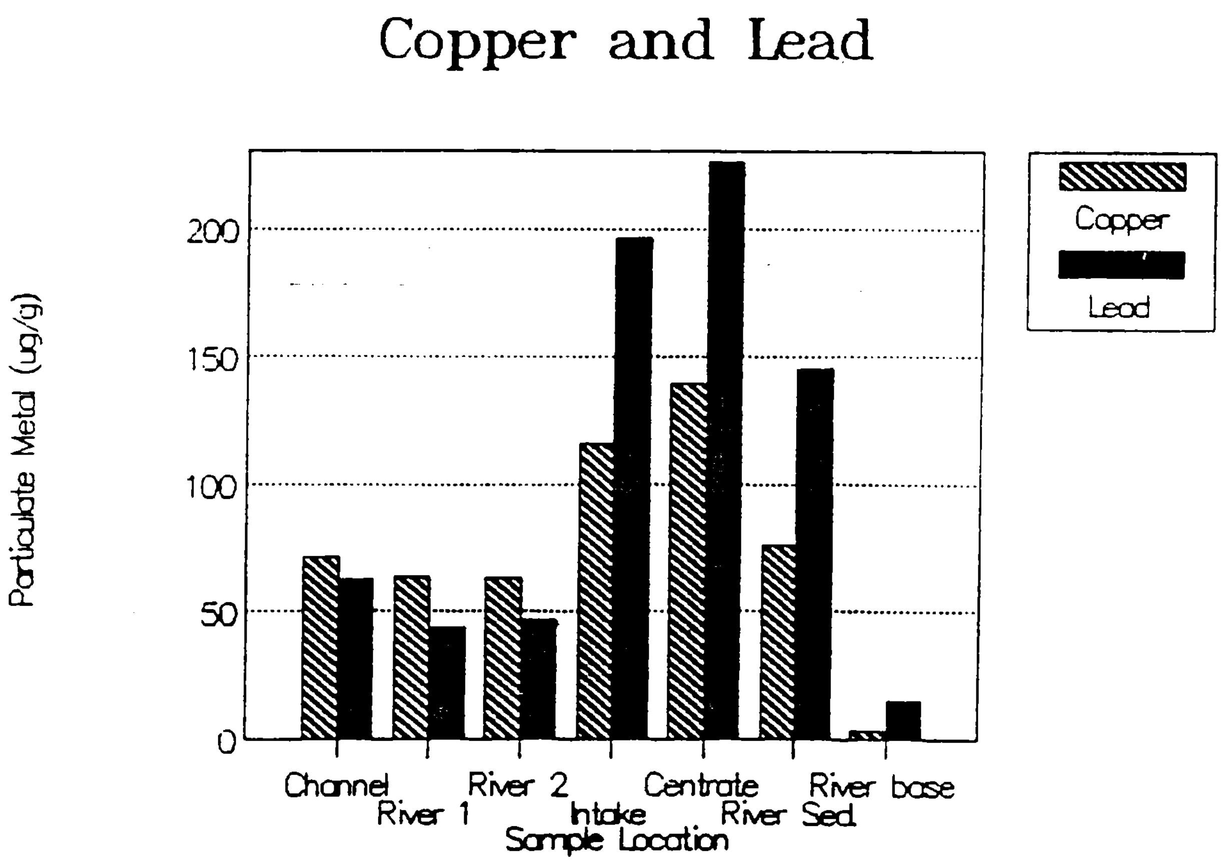
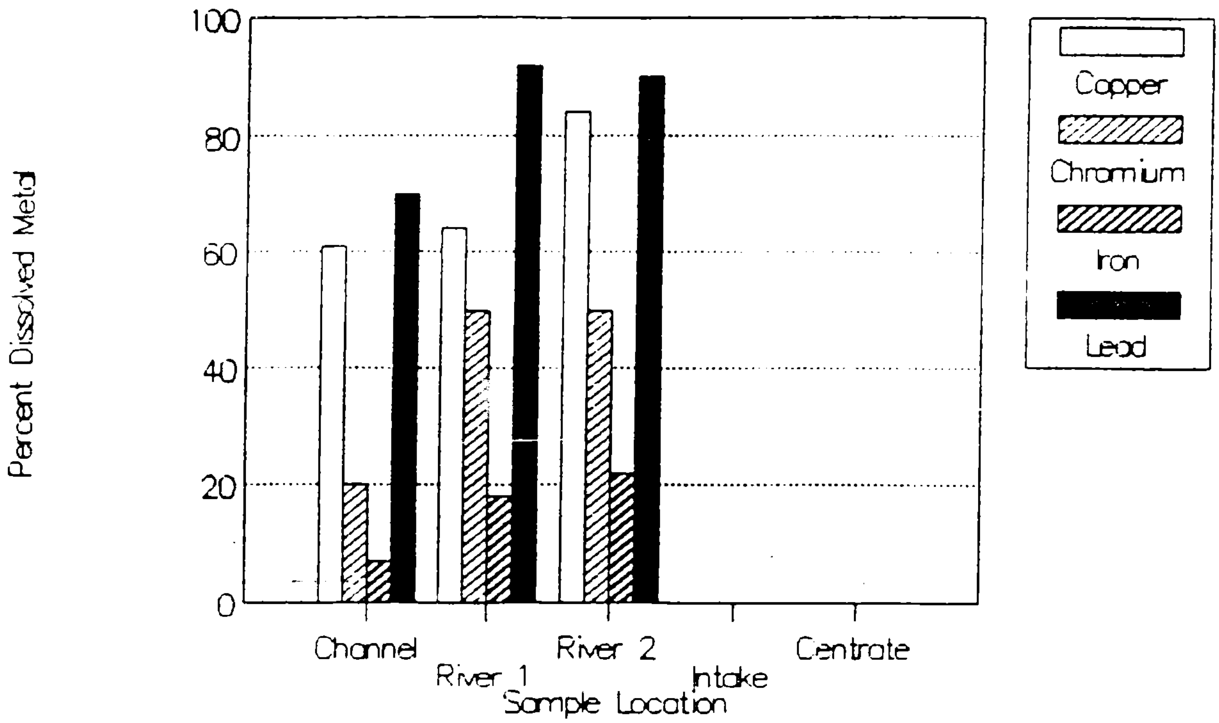


Figure 2. Concentrations of copper and lead in samples of river suspended sediment, centrifuge solids, and river bottom sediment.



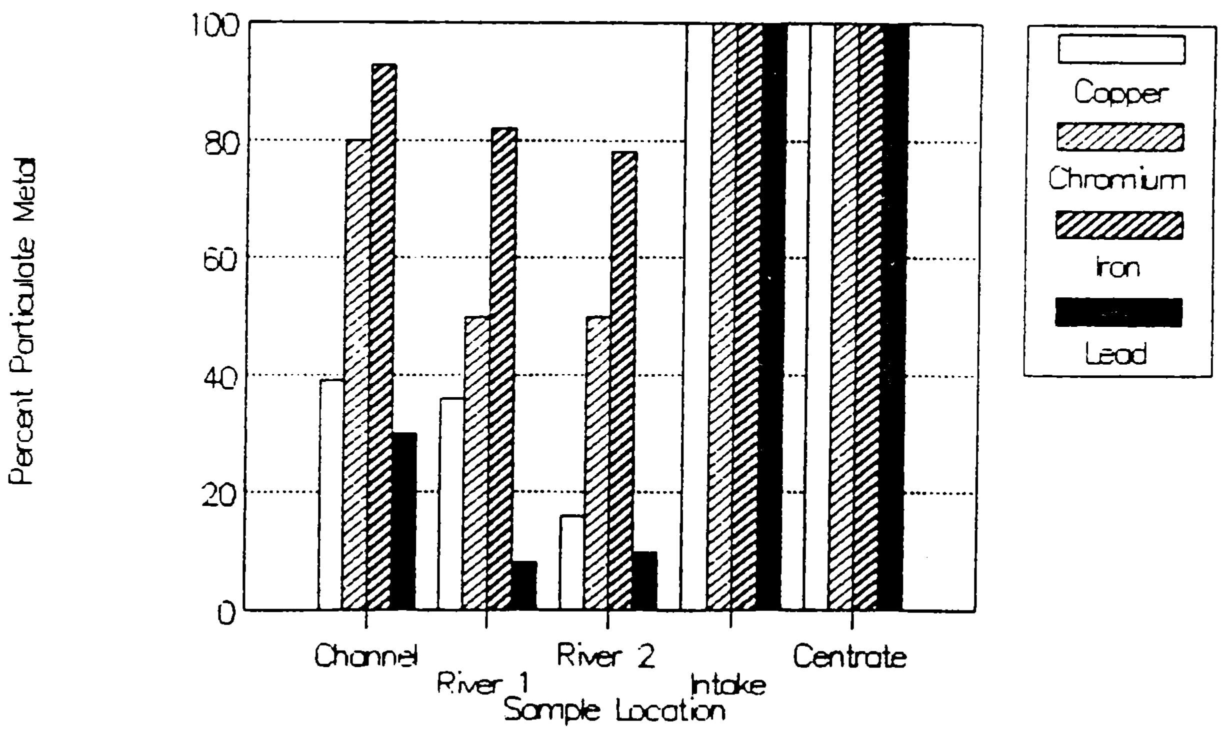


Figure 3. Percent of total metal in dissolved and particulate phases.

Interstitial Water

The chemistry of sediment interstitial water results from the sum of a variety of decomposition, dissolution and precipitation reactions between the sediment and the water buried with it. Interstitial water is typically enriched with phosphate, ammonia and dissolved carbon dioxide, the products of organic matter degradation. Dissolution of iron and manganese oxides under conditions of no oxygen and lower pH can greatly enrich interstitial waters in Fe, Mn and other metals relative to the overlying water. When oxygen is depleted in the interstitial water, chemical reduction of sulfate can lead to production of hydrogen sulfide. One concern during the dredging/centrifugation operation, is release of selected chemical species to the overlying water via the centrate liquid.

To help identify potential releases from the sediments, two cores were collected and the interstitial water obtained by laboratory centrifugation at 20,000 rpm for 20 minutes. From separate drying measurements of wet sediment, we determined that the sediment averaged about 80% water by weight and 90% water by volume (Table 2). This represents about 200,000 mg solids/kg, a value to keep in mind with respect to the engineering data for feed, centrate and cake. The typical centrifuge cake contained 300,000-400,000 mg solids/kg, showing the net efficiency of the centrifuge relative to in situ sediment. The water content of the sediment was relatively uniform throughout the muck layer.

The Loss on Ignition (LOI) at 550°C provides an approximation of the organic matter content of the sediment and values of 15-24% were observed (Table 2). These levels are typical for muck sediment and high for most

Table 2. Jacksonville Sediment and Interstitial Water Analysis

Date started: 27-Nov-88

Updated: 07-Dec-88

Sediment Depth (cm)	Core	Beaker Weight (g)	Beaker + Wet Sediment (g)	Beaker + Dry Sediment (g)	Salinity (°/oo)	% Wt Water	% Wt Sediment	Water Volume (cm3)	Sediment Volume (cm3)	Salt Corr.	Total Volume (cm3)	Porosity
0 - 25	S	30.144	43.330	32.510	7.3	0.821	0.179	0.601	0.065	0.006	0.865	0.924
25 - 50	S	22.341	53.780	28.920	2.6	0.791	0.209	0.771	0.078	0.002	0.850	0.908
50 - 75	S	8.087	15.002	11.244	1.1	0.711	0.289	0.693	0.109	0.001	0.802	0.864
0 - 25	L	8.422	18.954	10.331	6.8	0.919	0.181	0.799	0.066	0.005	0.865	0.923
25 - 50	L	8.394	18.818	10.681	2.9	0.790	0.210	0.771	0.078	0.002	0.849	0.908
50 - 75	L	7.872	16.961	9.782	1.1	0.790	0.210	0.771	0.079	0.001	0.850	0.907

Sediment Depth (cm)	Core	Beaker Weight (g)	Beaker + Dry Sediment (g)	Beaker + Sediment (LOI) (g)	% LOI	Interstitial Phosphate (μM)	Interstitial Manganese (μM)	Interstitial Iron (μM)	Interstitial Copper (nM)	Mid-Point Sediment (cm)
0 - 25	S	30.144	32.510	31.960	23.25	940	10.4	22.9	354	-12.5
25 - 50	S	22.341	28.920	27.610	19.91	384	11.3	46.7	350	-37.5
50 - 75	S	8.087	11.244	10.770	15.01	109	6.3	43.6	285	-62.5
0 - 25	L	8.422	10.331	9.910	22.05	750	3.6	4.[illegible]	249	-12.5
25 - 50	L	8.394	10.581	10.200	21.03	470	9.0	17.8	91	-37.5
50 - 75	L	7.372	9.782	9.330	23.66	366	4.1	6.4	161	-62.5
Intake	--	-----	-----	-----	-----	1.2	-----	-----	-----	-----
Centrate	--	-----	-----	-----	-----	4.3	-----	-----	-----	-----

natural estuarine sediments. Such organic-rich sediments provide abundant food for bacterial activity and resultant oxygen depletion. This parameter was also relatively uniform throughout the core (Figure 4).

The salinity of the interstitial water often shows the seasonal changes in the salinity of the overlying water. At the study site, the interstitial water in the surficial sediment had a salinity of about 7 °/₀₀, in close agreement with water column values of about 6 °/₀₀. However, salinity values downcore (Figure 4) decreased to 2 and then 1 °/₀₀. This trend can result from mixing with upwardly advecting, shallow ground water or can reflect the time-averaged salinity of the Ribault River. If the latter case is true, then the salinity of the river was anomalously high during the study period.

Interstitial phosphate concentrations are generally high, and values of 3-30 mg P/L are at least two orders of magnitude above ambient values for the water column. A decrease in concentrations of interstitial water phosphate with increasing depth in the sediment (Figure 4) is most likely related to precipitation of phosphate with iron as both species increse to very high levels. Interestingly enough, the concentrations of dissolved phosphate in the centrate liquid do not reflect the high values of the interstitial water, a point to be discussed momentarily.

Concentrations of Fe and Mn in the interstitial water (Figure 5) are typical for anoxic estuarine sediments. Dissolved iron and manganese build up to high levels under conditions of no oxygen because the chemically reduced form of each metal (Fe^{2+} and Mn^{2+}) are more soluble than the corresponding oxidized forms. The interstitial water concentrations for Fe are at least 100 times higher than those in the overlying water.

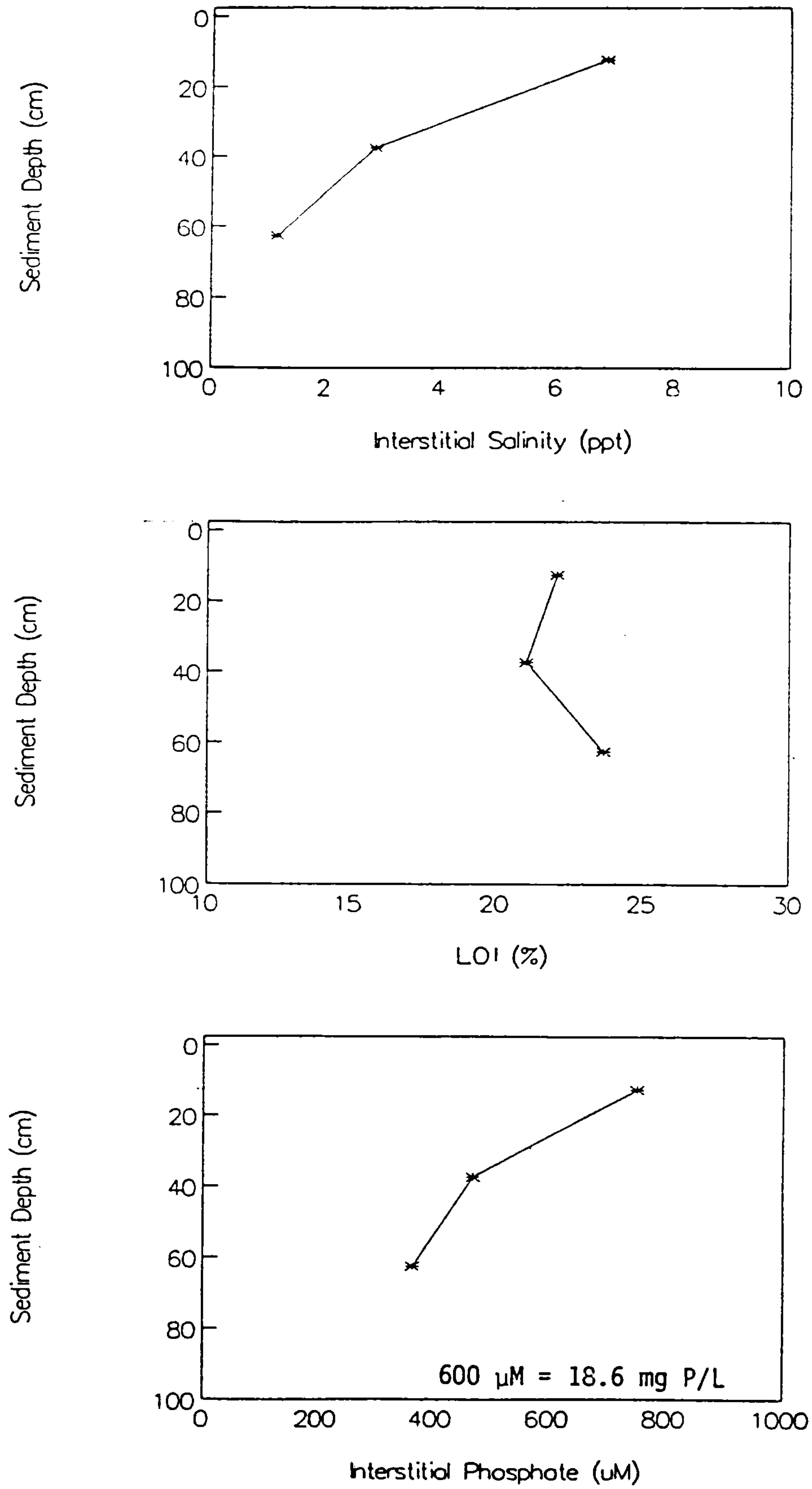


Figure 4. Vertical profiles of sediment interstitial water salinity and phosphate as well as sediment loss of ignition (LOI) at 550°C.

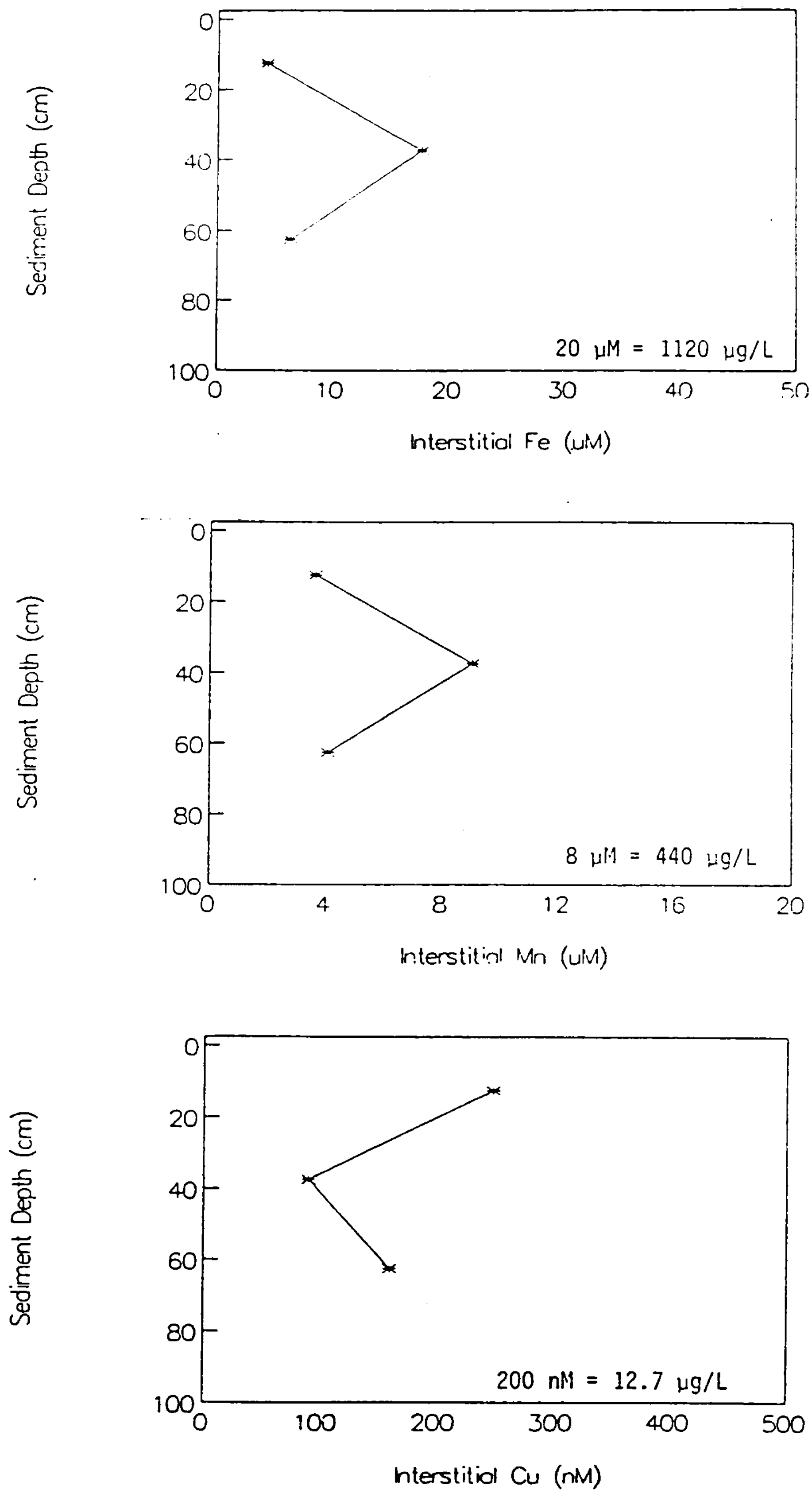


Figure 5. Vertical profiles of sediment interstitial water iron, manganese and copper.

Concentrations of Cu in the interstitial water are higher than expected for sulfide-rich interstitial water and the only logical explanation for this observation is that the Cu has been complexed with the abundant dissolved organic matter in the interstitial water and thereby stayed in solution. Interstitial water Cu concentrations are about 20 times higher than found in the ambient river water.

In comparison with the interstitial water, the solution phase of the centrate we collected was very low in dissolved phosphate, iron and copper. Part of this discrepancy results from the large amount of river water entrained with the intake material. From the available data, the intake sample that we collected contained about 40% channel sediment with its interstitial water and 60% river water. Assuming a 20-25% dewatering by centrifugation relative to the original sediment, as much as a 10-fold dilution of the interstitial water with river water in the centrate solution is estimated. This is consistent with the observed dissolved Cu data but not the Fe and phosphate values. The predicted concentrations of Fe and phosphate in the centrate solution phase should still have been considerably higher. One possible explanation for this observation is that Fe and phosphate precipitated under oxic conditions during the well-aerated centrifugation process. Such behavior was anticipated and the removal of Fe and phosphorus from solution by precipitation of iron oxides and phosphates under oxic conditions is reasonable.

Thus, the chemistry of the centrate solution was very similar to the river water to which it was being returned in every aspect except the burden of total suspended sediment. The main option available to minimize this condition is to increase the amount of polymer used.

APPENDIX B

OPERATING IN-SITU CHARACTERISTICS

WATER QUALITY MONITORING

ORGANIC DREDGING

DEMONSTRATION PROJECT

T.K. STOKES PARK
RIBAULT RIVER
JACKSONVILLE, FLORIDA
OCTOBER 31 - NOVEMBER 11, 1988

Submitted to:

Camp Dresser & McKee Inc.
6650 Southpoint Parkway, Suite 330
Jacksonville, Florida 32216

Submitted by:

Environmental Services & Permitting, Inc.
P.O. Box 5489
Gainesville, Florida 32602-5489

March 7, 1989

1.0 INTRODUCTION

Environmental Services and Permitting, Inc. (ESP) was subcontracted by Camp Dresser & McKee (CDM) to assist in monitoring water quality parameters during the Florida Department of Environmental Regulation (FDER) Organic Dredging Demonstration Project at T. K. Stokes Park boat-launching ramp on the Ribault River, Jacksonville, Florida.

The purpose of ESP's assistance was to monitor and observe water quality parameters during dredging and non-dredging operations. The water quality parameters monitored were dissolved oxygen (DO), conductivity, salinity, pH, and temperature. The adjacent wetland receiving the centrate discharge was visually evaluated for any direct impacts to the wetland vegetation.

2.0 METHODS AND MATERIALS

In-situ water quality parameter measurements were taken for temperature, salinity, pH (limited monitoring), conductivity, and dissolved oxygen (DO) at the city of Jacksonville's T. K. Stokes Park boat-launching ramp. These water quality parameter measurements were taken from October 31 to November 7, 1988 at the dredge and turbidity barrier, and from the dredge only November 10 and 11. A visual evaluation of the adjacent wetlands was made periodically to observe the centrate discharge impacts to the wetlands (i.e., coverage of wetland by centrate flow).

Instruments used for the monitoring were two DO meters; salinity, conductivity, temperature meter; and a pH meter. Meters were calibrated daily according to the manufacturers' directions. A strip chart recorder charted DO measurements at the dredge October 31 and November 1 and 2.

The sampling stations from October 31 to November 7 were located on the starboard side of the dredge, just behind the cutterhead and on the west bulkhead between the dredge and the turbidity barrier. During November 10 and 11 measurements were only taken at the dredge because the dredge was operating near the boat basin entrance to the Ribault River.

3.0 RESULTS

1. Water Quality Parameters

Water quality parameters measured during the demonstration are displayed in Tables 1 and 2. The following statistics compare non-dredging to dredging operations.

PARAMETER	NON-DREDGING N	RANGE	MEDIAN	MEAN	DREDGING N	RANGE	MEDIAN	MEAN
Temperature	78	19.0-23.0	21.0	21.0	17	19.0-23.0	21.2	21.3
Salinity	79	5.8-12.0	8.0	8.1	33	5.6-10.0	8.0	7.7
pH	15	7.2-7.9	7.6	7.6	5	7.3-7.8	7.5	7.5
Conductivity	85	8500-18200	12000	12203.5	76	8500-15000	10000	11167.0
DO								
control	69	3.8-12.5	5.0	5.8				
dredge	83	2.2-13.6	5.4	5.6	100	1.4-14.4	6.2	7.4

These water quality parameters do not differ significantly between non-dredging and dredging values. The percent variation between non-dredging and dredging mean values is:

	% Variation
Temperature	1.4
Salinity	4.9
pH	1.3
Conductivity	8.4
DO (at dredge)	24.3

The greatest variation is seen in DO non-dredging and dredging values. The range and median values for non-dredging parameters are fairly consistent and similar.

2. Wetland Discharge Area

A visual inspection and evaluation of the wetland receiving the centrate discharge was made in the morning and afternoon. The wetland is comprised of a salt marsh zone and a transitional zone located behind the salt marsh. The salt marsh vegetation is Juncus roemerianus (black needle rush) and the transitional wetland is dominated by Acer rubrum (red maple), Quercus nigra (water oak), Myrica cerifera (wax myrtle), Juniperus virginiana (southern red cedar), and Melia azedarach (Chinaberry or Chinese tallow tree). Understory is comprised of vines, shrubs, and grasses. Over the two-week demonstration project, the centrate discharge spread slowly through the transitional wetland towards a tidal opening in the Juncus marsh. This opening is connected with the Ribault River only during high tide periods. Because of the topography of the transitional wetland there are natural berms across the wetland which detained the centrate flow and allowed it to settle out some before reaching the Juncus marsh.

4.0 DISCUSSION

The following paragraphs briefly discuss the functions and values of the water quality parameters monitored during the demonstration project.

Dissolved Oxygen (DO). Oxygen dissolves freely in water as a result of photosynthesis, aquatic community respiration, air-water interface diffusion, and wind-driven mixing. Temperature, pressure, and salinity determine the amount of DO water can hold, i.e., its saturation level. DO levels below 4.0 mg/l are generally considered detrimental to aquatic life. Requirements vary according to species, life stage, temperature, activity, and concentration of dissolved substances in the water.

pH. The pH value is a measurement of hydrogen ion activity. A change of one pH unit indicates a tenfold change in hydrogen ion concentration. Factors affecting pH are mineral content, water-air interface diffusion, pollution, and photosynthetic activity. In stagnant basins where large amounts of hydrogen sulfide may be present, pH values may range between four and six. Although variations in salinity affect pH, the predominant factor is the total carbon dioxide content or partial pressure. The favorable pH range for aquatic organisms is between five and nine.

Salinity. The salinity of a water body is the amount of total solids in the water column after all carbonates have been converted to oxides, all bromide and iodide have been replaced by chloride, and all organic matter has been oxidized. It is the sum of the cations and anions. The salinity of oceanic waters is 33 to 37 parts per thousand.

<u>Conductivity.</u> Electrical conductivity is a measurement of the water column to carry a current and depends on the total concentration of ionized dissolved substances. Conductivity increases almost linearly with increasing salinity and is a function of salinity and temperature.

Comparing dredging and non-dredging parameters both to each other and in relation to the natural "favorable" range of values, the values observed during the demonstration project do not show any significant adverse effects or changes to the estuarine aquatic environment. Although there were wide variations in DO readings, there were also corresponding natural and man-induced factors that may have influenced these readings. Such variations in the dredge operation (up-and-down motion plus cutterhead action) and tide and current fluctuations in the dead-end boat basin may have influenced the wide range of DO readings.

Because of the demonstration nature of the project, a sampling protocol was not initiated to collect preproject baseline conditions for comparison purposes.

Table 1.

WATER QUALITY PARAMETERS
DREDGING OPERATIONS

		T °C	S ppt	pH pH unit	C µmhos/cm	DO mg/l	COMMENTS
10/31/88							
	1530	23	8.9		14300	6.0	
	1533	22.5	8.5		14500	5.8	
	1535		8.9		14200	5.6	
stop	1536						
11/01/88							
	0836	20	9.0		9800	4.2	
	0844				10800	3.6	
	0845		8.0		11000	3.2	
stop	0846					1.4	
start	0847					3.2	
	0849				11000	4.4	
	0850				11200	4.5	
	0851				11300	4.2	
stop	0852				11500	4.0	
start	1320	21	8.2		12000	5.0	
	1322				12200	5.1	
	1324				12200	4.8	
stop	1325				12200	4.7	
11/02/88							
start	0904	19	9.0		13800	5.4	
	0906				13900	4.4	
stop	0907				13800	4.4	

WATER QUALITY PARAMETERS
DREDGING OPERATIONS

		T °C	S ppt	pH pH unit	C µmhos/cm	DO mg/l	COMMENTS
start	0909				14000	4.2	
	0910				13700	4.1	
	0911				14000	4.8	
	0912				13500	5.2	
	0914				14000	5.2	
	0915				14000	4.8	
stop	0916				14000	4.6	
start	1335	22	8.3		13300	6.2	
	1336				13000	6.4	
	1338				13000	6.3	
stop	1339						
start	1340				13000	6.4	
	1342				13000	7.2	
stop	1343						
11/03/88							
start	0941	19	9.9		15000	4.1	
	0943					4.2	
	0944		9.9		15000	4.5	
	0945		10.0		15000	4.1	
	0946		10.0		15000	4.0	
	0947		8.5		13000	5.0	
	0948					5.1	
stop	0949		8.0		12100	5.0	
start	1440		8.0		12000	5.3	
	1441		8.0			7.0	

WATER QUALITY PARAMETERS
DREDGING OPERATIONS

		T °C	S ppt	pH pH unit	C µmhos/cm	DO mg/l	COMMENTS
	1442					7.2	
	1443					7.4	
	1444					6.8	
	1445					6.4	
	1446					6.6	
	1447					6.2	
stop	1448		8.0		12500	6.0	
start	1645	21	9.0		13500	5.9	
	1647					5.8	
	1648					6.2	
	1649					6.4	
stop	1650		8.5		13100	6.4	
11/04/88							
start	1315	22.5	6.5		10000	8.0	
	1316					8.6	
	1317					10.0	
	1318					10.2	
	1319					10.2	
	1320					9.8	
stop	1321	22.5	6.5		10000	8.8	
start	1542	22.0	6.0		9900	13.2	
	1543					11.4	
	1544					14.4	
stop	1545	22.0	6.2		9900	12.0	

WATER QUALITY PARAMETERS
DREDGING OPERATIONS

		T °C	S ppt	pH pH unit	C μmhos/cm	DO mg/l	COMMENTS
start	1547					13.8	
	1548					13.0	
	1549					12.2	
stop	1550	22.0	6.4		10000	14.0	

11/07/88 WEEK OF NOVEMBER 7 = NEW MOON PRODUCING VERY LOW TIDES. MEASUREMENTS WERE LIMITED TO TIME BEFORE LOW TIDE WHEN BASIN WOULD HAVE LITTLE OR NO WATER IN IT. TWO READINGS 11/7 (Table 2); NONE 11/8, 11/9.

		T °C	S ppt	pH pH unit	C μmhos/cm	DO mg/l	COMMENTS
11/10/88							
start	1137	21.0	6.5	7.3	9500	7.2	
	1138				9800	8.2	
	1139				9800	8.5	
	1140				9800	7.2	
	1141		6.5		9800	8.4	
	1142		6.5		9800	8.5	
	1143				9800	8.1	
	1144				9800	8.0	
	1145				9600	8.1	
	1146				9800	7.8	
	1147		6.2		9800	7.2	
stop	1148		6.2	7.3	9800	6.2	

WATER QUALITY PARAMETERS
DREDGING OPERATIONS

		T °C	S ppt	pH pH unit	C µmhos/cm	DO mg/l	COMMENTS
start	1455	23.0	6.1	7.7	9000	5.1	Only a few
	1456				9000	5.2	inches of
1457					7000	5.6	water in
	1458				8500	4.4	basin
	1459				8500	3.7	
stop	1500				8500	1.5	
start	1502				9000	2.6	
	1503				9000	3.7	
stop	1504		5.6	7.8	9000	1.7	
11\11\88							
start	0945	20.0	5.8		8500	6.5	High tide
	0946				8800	6.5	
	0947				8500	6.5	
	0948				8500	6.8	
	0949				8500	6.9	
	0950				8500	6.9	
	0951				8500	7.1	
stop	0952				8500	7.0	
				(1400)			
start	1518	21.2	6.2	7.5	9200	6.0	Tide
	1519				9200	6.4	falling
stop	1520				9200	6.2	

Table 2.

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

	T °C at dredge	S ppt at dredge	pH pH unit at dredge	C $\frac{\mu mhos}{cm}$ at dredge	DO $\frac{mg}{l}$ control	DO $\frac{mg}{l}$ at dredge	COMMENTS Control is located away from dredging.
10/31/88							
1400		8.0	7.2	14500	4.5		
1520	22.0	8.9		14800	5.0		
1555					4.6		
1620					4.3		
1645					4.3		
1700					4.3		
11/01/88							
0900				12200	4.1	3.8	
0930	20.3	9.0		13500	4.1	3.6	
1000	20.2	9.0		13200	4.0	2.6	
1030	20.4	8.5		13000	4.1	2.6	
1100	20.2	8.5		13000	4.3	2.6	
1140	20.5	8.0		12000	4.7	4.2	
1200	20.5	8.0		12000	4.5	3.7	
before1300	21.0	8.2		13000	4.7	4.4	
after 1330				12800	5.1	4.8	
1400	21.2	9.9		15000	5.4	4.8	Tide rising
1430	21.3	11.0		16900	5.2	5.2	

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

	T at dredge	S at dredge	pH at dredge	C at dredge	DO control	DO at dredge	COMMENTS
1500	21.5	11.2		17000	5.0	4.6	
1530	21.5	11.1		17000	5.0	4.9	
1600	21.3	11.0		17000	4.6	4.2	
1630	21.5	11.0		16800	4.4	4.4	
1700	21.5	10.8		16300	4.7	4.1	
11/2/88							Low tide
0830	19.0	9.1		14000	3.8	4.8	
before0900					3.8	4.9	
after 0921					4.2		
1000	19.5	9.1		14000	4.2	2.2	
1030	19.5	9.1		14000	4.5	2.2	
1100	19.5	9.1		13700	5.0	2.3	
1130	19.9	9.1		13800	4.7	2.2	
1200	20.0	9.1		13500	4.9	2.7	
1230	20.2	9.0		13500	4.7	2.7	
1300	21.5	8.9		12900	5.3	4.2	
before1330	22.0	8.3		12500	5.0	5.2	
after 1345				13000	5.7	5.8	
1400	2'	11.0		16200	7.1		Ribault River
	5'	12.0		17500	6.4		Ribault River
1430	21.0	9.8		14800	5.5	5.6	
1500	21.0	10.5		16500	5.5	5.5	

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

	T at dredge	S at dredge	pH at dredge	C at dredge	DO control	DO at dredge	COMMENTS
1530	21.0	11.5		18000	5.2	5.4	
1630	21.0	12.0		18200	5.6	5.4	
1700	21.2	12.0		18000	5.6	5.8	
1730	21.3	11.5		16500	5.5	5.0	
11/03/88							
0830	19.0	10.5		16000	4.7	4.1	
0900	19.0	10.9		13500	4.0	4.5	
before0930					4.5		
after 1030	20.0	8.0		12000	4.5	3.4	
1100	20.0	8.0		12000	4.2	3.1	
1130	20.0	8.9		11000	4.5	5.0	
1200	20.0	8.0		12000	7.4	2.7	
1230	21.0	8.0		12000	8.0	2.8	
1300	22.0	8.0		12000	7.0	4.0	
1330	23.0	8.0		12900	6.0	5.8	
before1400	22.0	8.0		12000	5.8	5.9	
after 1530	21.0	8.2		13000	7.0	5.2	
before1600	21.0	8.5		13000	8.4	9.6	

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

		T at dredge	S at dredge	pH at dredge	C at dredge	DO control	DO at dredge	COMMENTS
11/04/88								
	0900	21.0	7.5		11200	8.0	8.8	
	1000	21.0	7.5		11200	10.6	10.4	
	1030	21.0	7.5		11200	8.2	9.6	
	1100	21.0	7.5		11200	8.2	9.8	
	1130	21.5	7.0		11000	7.0	7.2	
	1200	21.5	7.0		11000	8.3	5.5	
	1230	21.8	7.0		11000	7.0	6.4	
before	1311	22.8	6.5		10000		10.0	
after	1400	23.0	6.0		10000	6.2	4.2	
	1430	23.0	6.5		10000	7.4	5.6	
	1500	23.0	6.5		9900	6.4	8.4	
before	1530	22.0	6.0		9900	9.8	13.6	
after	1630	21.5	7.0		10500	9.0	9.0	
	1700	21.5	7.0		11000	9.2	10.0	
	1730	21.5	7.0		11000	7.8	11.8	
11/07/88								
apx.	0800	21.0	9.5		15000	8.5	7.8	
	1120	20.0	6.8		11000	12.5	7.9	Within 6" bottom

11/08 and 11/09-NO MEASUREMENTS

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

	T at dredge	S at dredge	pH at dredge	C at dredge	DO control	DO at dredge	COMMENTS
11/10/88							
0930	20.0	6.5	7.4	10000	*	6.2	*Control DO Station removed due to dredging at entrance of basin.
1030	20.0	6.5	7.4	9500		6.6	
before1100	22.0	6.5	7.3	9600		6.5	
after 1230	22.0	6.2	7.7	9800		6.2	
1300	21.0	6.2	7.9	9800		6.6	
1330	21.0	6.0	7.8	9200		5.1	Falling tide
1400	21.0	6.2	7.8	9500		5.3	
before1430	21.5	6.1	7.7	9000			Only a few inches of H_2O
11/11/88							
0830	20.0	5.8		8800		6.7	Tide rising
before0930	20.0	5.8		8500		6.3	
after 0953				8500		6.6	
0954				9000		6.5	
0955	20.0	6.0		8800		5.8	
1030	20.0	6.0	7.5	9000		5.9	
1100	20.3	6.2	7.6	9300		6.5	
1200	20.5	6.2	7.6	9300		5.9	Tide falling

WATER QUALITY PARAMETERS
NON-DREDGING OPERATIONS

	T at dredge	S at dredge	pH at dredge	C at dredge	control	DO at dredge	COMMENTS
1230	20.5	6.2	7.7	9200		5.7	
1300	20.5	6.2	7.5	9300		5.8	
1400	20.5	6.0	7.5	9200		5.3	
1455	21.2	6.2		9200		5.6	
before1500	21.2	6.2		9200		5.4	
after 1521				9200		5.7	

APPENDIX C

DEWATERED TEST RESULTS WITHOUT POLYMER

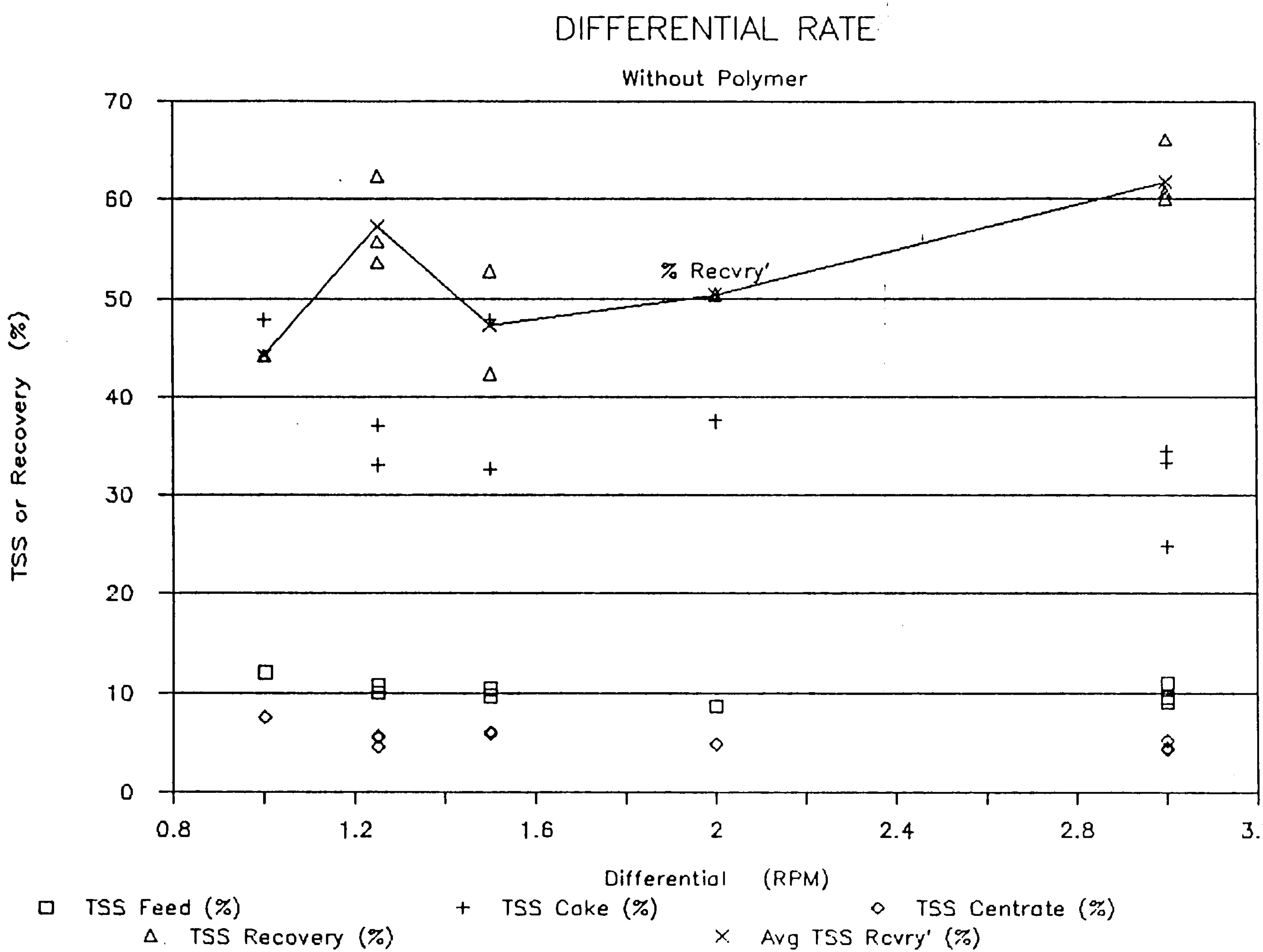
TEST NUMBER	RUN NUMBER	VARIABLES: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	TEST AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	DIFFERENTIAL AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	FIXED: DIFFERENTIAL (RPM)
39	111	12.2	51.3	7.7	43.1									
39	112	12.1	47.3	7.5	45.2									
39	113	11.9	45.2	7.5	44.6	12.1	47.9	7.6	44.3	12.1	47.9	7.6	44.3	1.00
2	4	9.7	38.0	4.7	58.8									
2	5	10.4	38.8	4.7	62.7									
2	6	9.8	22.6	4.5	67.7	10.0	33.1	4.6	62.4					1.25
5	12	11.2	37.0	5.9	56.0									
5	13	10.7	35.4	5.6	56.0									
5	14	10.4	39.0	5.4	55.5	10.8	37.1	5.7	55.8					1.25
6	15	10.1	31.2	5.8	52.4									
6	16	9.9	36.0	5.9	48.7									
6	17	10.0	32.0	4.9	60.0	10.0	33.1	5.5	53.7	10.3	34.4	5.3	57.3	1.25
41	115	10.3	34.5	6.1	49.6									
41	116	10.8	32.4	5.7	57.5									
41	117	10.2	31.2	6.0	51.1	10.4	32.7	5.9	52.8					1.50
42	118	10.1	44.4	6.4	43.2									
42	119	10.0	48.5	6.2	43.6									
42	120	9.1	51.0	5.9	40.7	9.7	48.0	6.1	42.5	10.1	40.3	6.0	47.3	1.50
1	1	9.1	36.4	4.9	53.6									
1	2	9.2	37.8	4.8	54.2									
1	3	7.8	38.8	4.9	42.4	8.7	37.7	4.9	50.5	8.7	37.7	4.9	50.5	2.00
3	7	9.9	37.6	4.5	61.8									
3	8	9.2	31.4	4.5	59.5	9.6	34.5	4.5	60.7					3.00
4	9	8.2	32.8	4.2	56.1									
4	10	9.4	35.4	4.5	60.4									
4	11	9.7	32.0	4.4	63.4	9.1	33.4	4.4	60.1					3.00
7	18	13.1	15.6	5.3	90.1									
7	19	10.1	28.0	5.3	58.2									
7	20	9.7	30.4	5.1	56.7	11.0	24.7	5.3	66.1	9.9	30.9	4.7	61.8	3.00

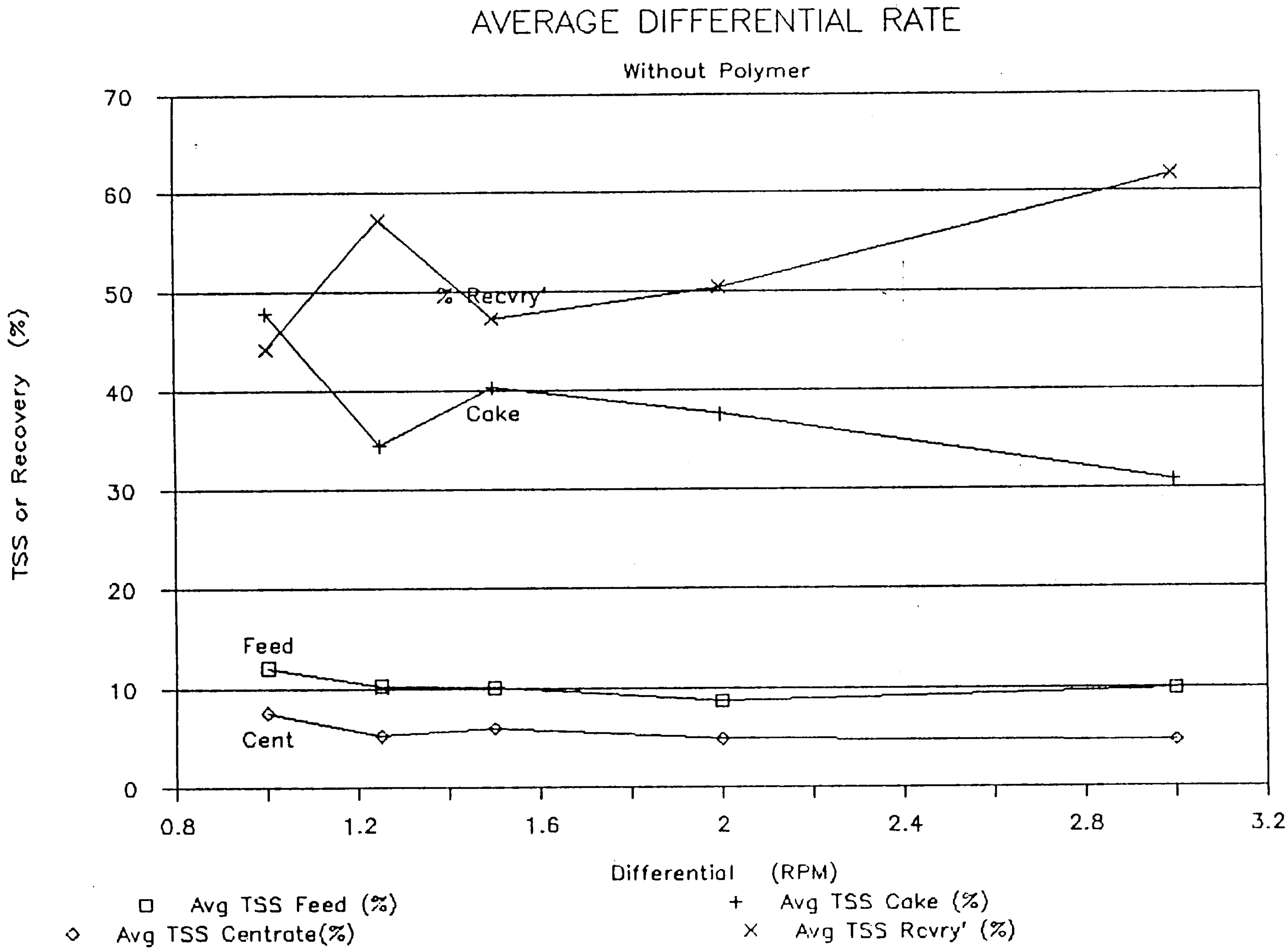
Difrnt'l Rate (RPM)	Avg TSS Feed (%)	Avg TSS Cake (%)	Avg TSS Cent (%)	Avg % Recovery @ Difrnt'l (%)
0.90				
1.00	12.1	47.9	7.6	44.3
1.25	10.3	34.4	5.3	57.3
1.50	10.1	40.3	6.0	47.3
2.00	8.7	37.7	4.9	50.5
3.00	9.9	30.9	4.7	61.8
3.10				

Cake

% Recvry'

TSS Feed (%)	TSS Cake (%)	Y Range: TSS Centrate (%)	% Recovery per Test (%)	Average % Recovery @ Difrnt'l (%)	X Range: Difrnt'l Rate (RPM)
					0.90
12.1	47.9	7.6	44.3	44.3	1.00
10.0	33.1	5.5	53.7	57.3	1.25
9.7	48.0	6.1	42.5	47.3	1.50
8.7	37.7	4.9	50.5	50.5	2.00
11.0	24.7	5.3	66.1	61.8	3.00
10.0	33.1	4.6	62.4		1.25
10.8	37.1	5.7	55.8		1.25
10.4	32.7	5.9	52.8		1.50
9.6	34.5	4.5	60.7		3.00
9.1	33.4	4.4	60.1		3.00
					3.10

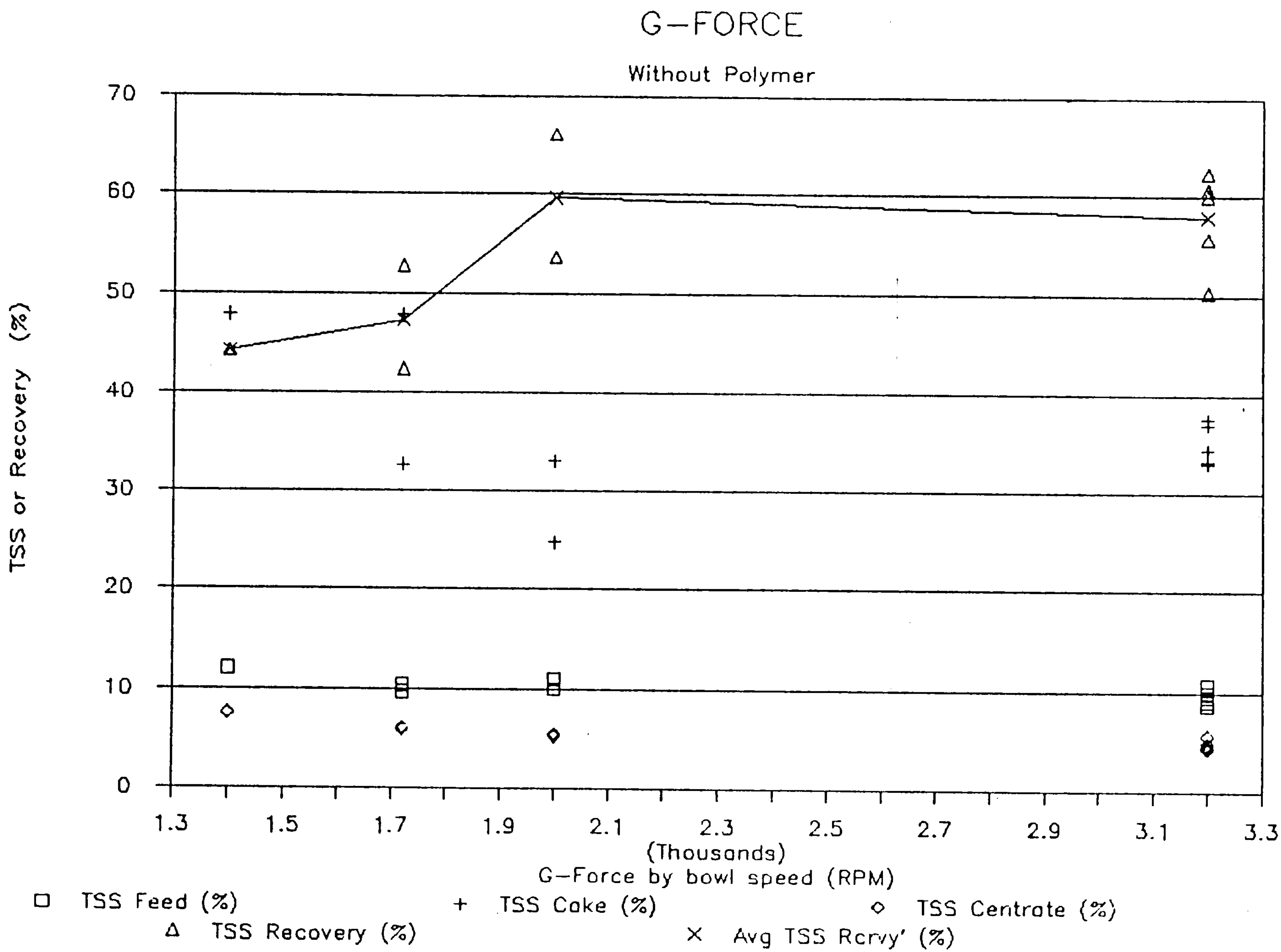

DIFFERENTIAL RATE
Without Polymer
70
60
50
40
30
20
10
0
TSS or Recovery (%)
% Recvry'
0.8
1.2
1.6
2
2.4
2.8
3.2
Differential (RPM)
TSS Feed (%)
TSS Coke (%)
TSS Centrate (%)
TSS Recovery (%)
Avg TSS Rcvry' (%)


AVERAGE DIFFERENTIAL RATE
Without Polymer
70
60
50
40
30
20
10
0
TSS or Recovery (%)
% Recvry'
Cake
Feed
Cent
0.8
1.2
1.6
2
2.4
2.8
3.2
Differential (RPM)
Avg TSS Feed (%)
Avg TSS Cake (%)
Avg TSS Centrate(%)
Avg TSS Rcvry' (%)

TEST NUMBER	RUN NUMBER	VARIABLES: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	TEST AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	G-FORCE AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	FIXED: G-Force
1	1	9.1	36.4	4.9	53.6									
1	2	9.2	37.8	4.8	54.2									
1	3	7.8	38.8	4.9	42.4	8.7	37.7	4.9	50.5					3,200
2	4	9.7	38.0	4.7	58.8									
2	5	10.4	38.8	4.7	62.7									
2	6	9.8	22.6	4.5	67.7	10.0	33.1	4.6	62.4					3,200
3	7	9.9	37.6	4.5	61.8									
3	8	9.2	31.4	4.5	59.5	9.6	34.5	4.5	60.7					3,200
4	9	8.2	32.8	4.2	56.1									
4	10	9.4	35.4	4.5	60.4									
4	11	9.7	32.0	4.4	63.4	9.1	33.4	4.4	60.1					3,200
5	12	11.2	37.0	5.9	56.0									
5	13	10.7	35.4	5.6	56.0									
5	14	10.4	39.0	5.4	55.5	10.8	37.1	5.7	55.8	9.6	35.2	4.8	58.0	3,200
6	15	10.1	31.2	5.8	52.4									
6	16	9.9	36.0	5.9	48.7									
6	17	10.0	32.0	4.9	60.0	10.0	33.1	5.5	53.7					2,000
7	18	13.1	15.6	5.3	90.1									
7	19	10.1	28.0	5.3	58.2									
7	20	9.7	30.4	5.1	56.7	11.0	24.7	5.3	66.1	10.5	28.9	5.4	59.7	2,000
39	111	12.2	51.3	7.7	43.1									
39	112	12.1	47.3	7.5	45.2									
39	113	11.9	45.2	7.5	44.6	12.1	47.9	7.6	44.3	12.1	47.9	7.6	44.3	1,400
41	115	10.3	34.5	6.1	49.6									
41	116	10.8	32.4	5.7	57.5									
41	117	10.2	31.2	6.0	51.1	10.4	32.7	5.9	52.8					1,720
42	118	10.1	44.4	6.4	43.2									
42	119	10.0	48.5	6.2	43.6									
42	120	9.1	51.0	5.9	40.7	9.7	48.0	6.1	42.5	10.1	40.3	6.0	47.3	1,720

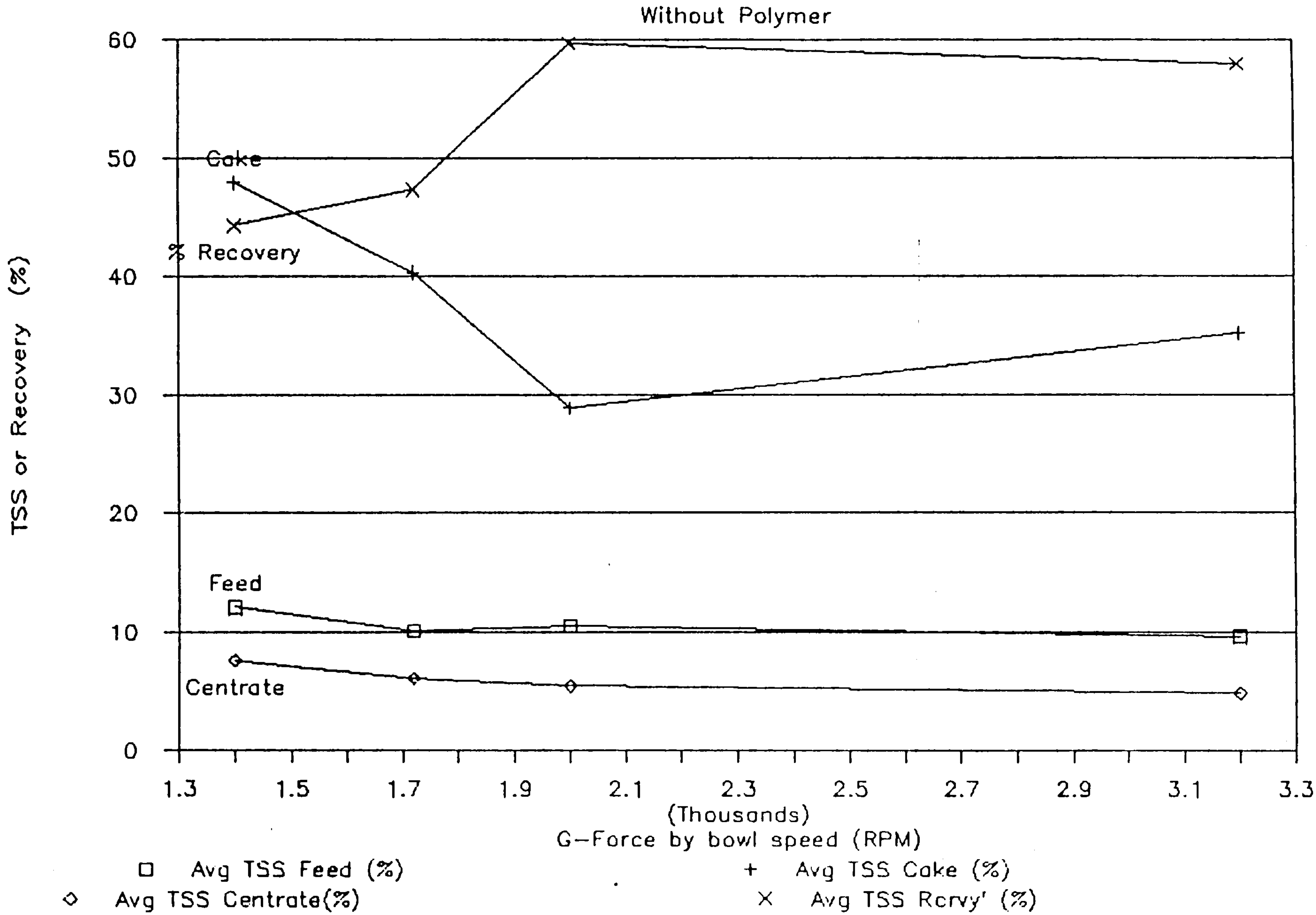
G-Force (RPM)	Avg TSS Feed (%)	Avg TSS Cake (%)	Avg TSS Centrate (%)	Avg % Recovery @ G-Force (%)
1,375				
1,400	12.1	47.9	7.6	44.3
1,720	10.1	40.3	6.0	47.3
2,000	10.5	28.9	5.4	59.7
3,200	9.6	35.2	4.8	58.0
3,225				

		Y Range			X Range
TSS Feed (%)	TSS Cake (%)	TSS Centrate (%)	% Recovery per Test (%)	Average % Recovery @ G-Force (%)	G-Force (RPM)
					1,375
12.1	47.9	7.6	44.3	44.3	1,400
9.7	48.0	6.1	42.5	47.3	1,720
11.0	24.7	5.3	66.1	59.7	2,000
10.8	37.1	5.7	55.8	58.0	3,200
10.4	32.7	5.9	52.8		1,720
10.0	33.1	5.5	53.7		2,000
8.7	37.7	4.9	50.5		3,200
10.0	33.1	4.6	62.4		3,200
9.6	34.5	4.5	60.7		3,200
9.1	33.4	4.4	60.1		3,200
					3,225



G-FORCE
Without Polymer
TSS or Recovery (%)
70
60
50
40
30
20
10
0
1.3
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
(Thousands)
G-Force by bowl speed (RPM)
TSS Feed (%)
TSS Cake (%)
TSS Centrate (%)
TSS Recovery (%)
Avg TSS Rcrvy' (%)

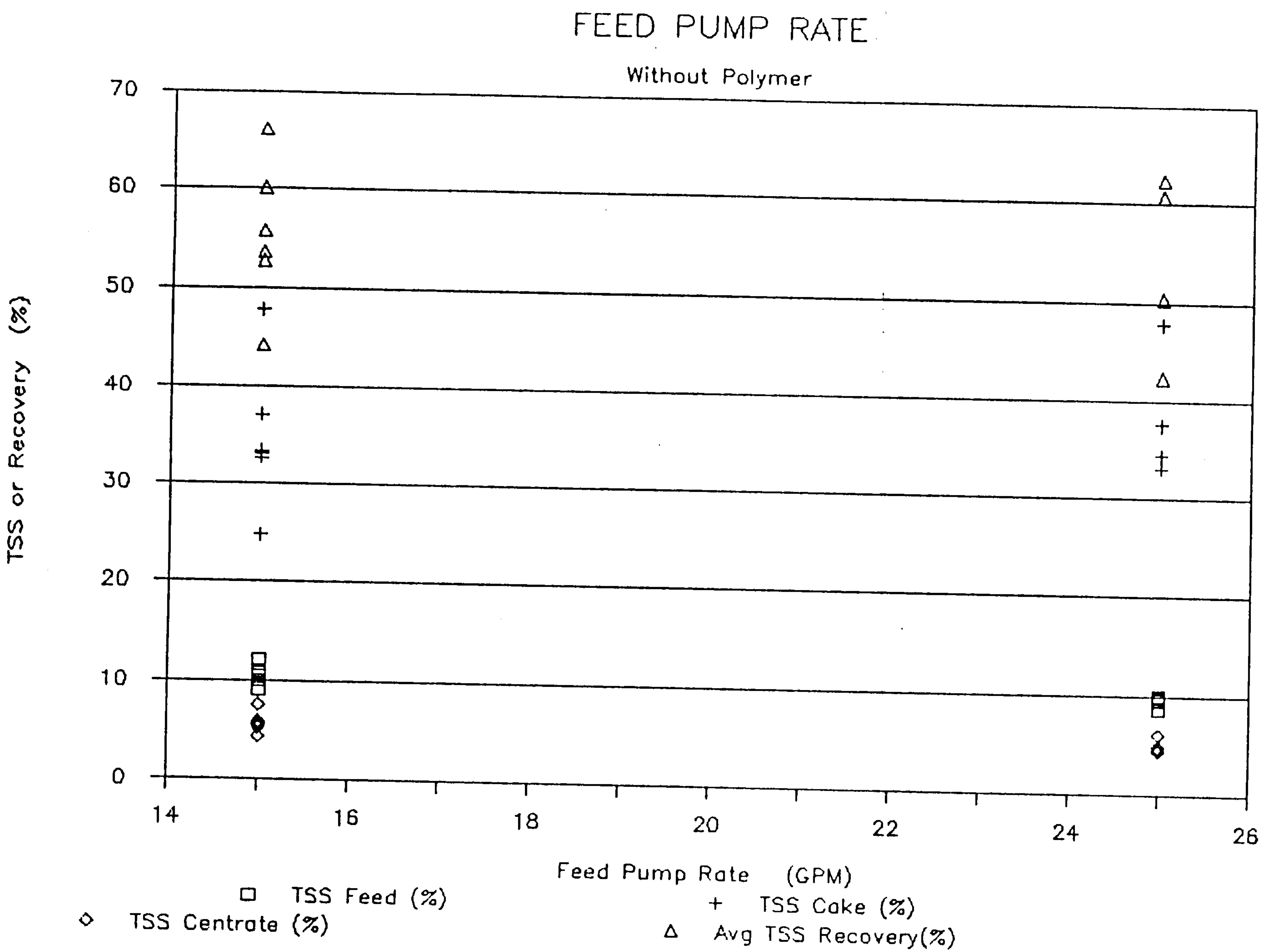
AVERAGE G-FORCE

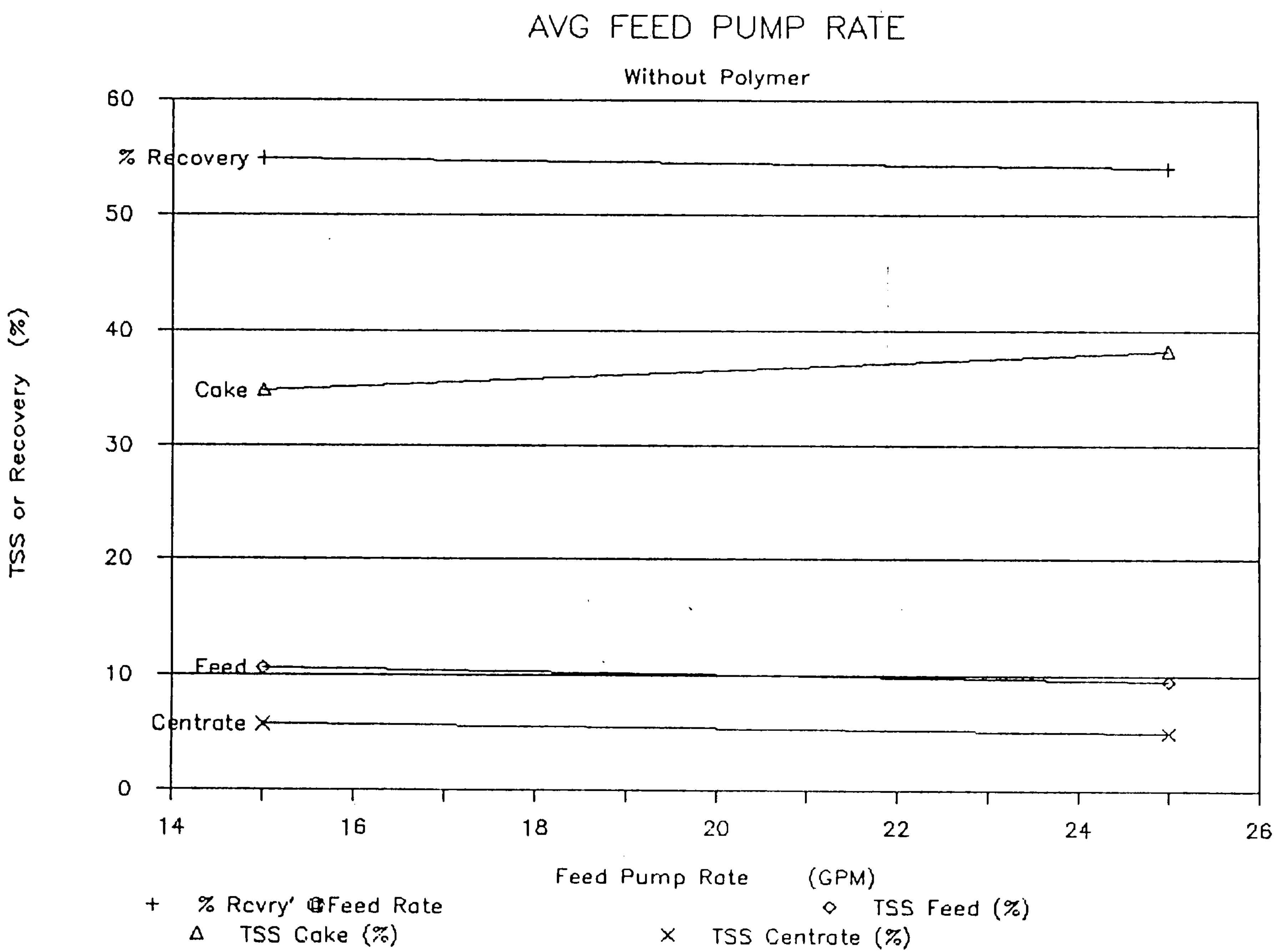


TEST NUMBER	RUN NUMBER	VARIABLES: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	TEST AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	FEED PUMP AVERAGED: TOTAL SUSPENDED SOLIDS FEED	TOTAL SUSPENDED SOLIDS CAKE	TOTAL SUSPENDED SOLIDS CENTRATE	% RECOVERY	FIXED: FEED PUMP RATE (GPM)
1	1	9.1	36.4	4.9	53.6									
1	2	9.2	37.8	4.8	54.2									
1	3	7.8	38.8	4.9	42.4	8.7	37.7	4.9	50.5					25
2	4	9.7	38.0	4.7	58.8									
2	5	10.4	38.8	4.7	62.7									
2	6	9.8	22.6	4.5	67.7	10.0	33.1	4.6	62.4					25
3	7	9.9	37.6	4.5	61.8									
3	8	9.2	31.4	4.5	59.5	9.6	34.5	4.5	60.7					25
42	118	10.1	44.4	6.4	43.2									
42	119	10.0	48.5	6.2	43.6									
42	120	9.1	51.0	5.9	40.7	9.7	48.0	6.1	42.5	9.5	38.3	5.0	54.1	25
4	9	8.2	32.8	4.2	56.1									
4	10	9.4	35.4	4.5	60.4									
4	11	9.7	32.0	4.4	63.4	9.1	33.4	4.4	60.1					15
5	12	11.2	37.0	5.9	56.0									
5	13	10.7	35.4	5.6	56.0									
5	14	10.4	39.0	5.4	55.5	10.8	37.1	5.7	55.8					15
6	15	10.1	31.2	5.8	52.4									
6	16	9.9	36.0	5.9	48.7									
6	17	10.0	32.0	4.9	60.0	10.0	33.1	5.5	53.7					15
7	18	13.1	15.6	5.3	90.1									
7	19	10.1	28.0	5.3	58.2									
7	20	9.7	30.4	5.1	56.7	11.0	24.7	5.3	66.1					15
39	111	12.2	51.3	7.7	43.1									
39	112	12.1	47.3	7.5	45.2									
39	113	11.9	45.2	7.5	44.6	12.1	47.9	7.6	44.3					15
41	115	10.3	34.5	6.1	49.6									
41	116	10.8	32.4	5.7	57.5									
41	117	10.2	31.2	6.0	51.1	10.4	32.7	5.9	52.8	10.6	34.8	5.7	54.9	15

Feed Pump Rate (GPM)	TSS Feed (%)	TSS Cake (%)	TSS Centrate (%)	Average % Recovery @Feed Rate (%)
14.0				
15.0	10.6	34.8	5.7	54.9
25.0	9.5	38.3	5.0	54.1
26.0				

Y Range: TSS Feed	TSS Cake	TSS Centrate	% Recovery per Test	Average % Recovery @Feed Rate	X Range: Feed Pump Rate
					14.0
10.4	32.7	5.9	52.8	54.9	15.0
9.7	48.0	6.1	42.5	54.1	25.0
8.7	37.7	4.9	50.5		25.0
10.0	33.1	4.6	62.4		25.0
9.6	34.5	4.5	60.7		25.0
9.1	33.4	4.4	60.1		15.0
10.8	37.1	5.7	55.8		15.0
10.0	33.1	5.5	53.7		15.0
11.0	24.7	5.3	66.1		15.0
12.1	47.9	7.6	44.3		15.0
					26.0


FEED PUMP RATE
Without Polymer
70
60
50
40
30
20
10
0
TSS or Recovery (%)
14
16
18
20
22
24
26
Feed Pump Rate (GPM)
TSS Feed (%)
TSS Centrate (%)
TSS Cake (%)
Avg TSS Recovery(%)


AVG FEED PUMP RATE
Without Polymer
TSS or Recovery (%)
% Recovery
Cake
Feed
Centrate
60
50
40
30
20
10
0
14
16
18
20
22
24
26
Feed Pump Rate (GPM)
+ % Rcvry' @Feed Rate
◇ TSS Feed (%)
Δ TSS Cake (%)
× TSS Centrate (%)

APPENDIX D

DEWATERED TEST RESULTS WITH POLYMER

SAVED :POLY.WR1 ORTEGA RIVER (RIBAULT RIVER) ORGANIC SEDIMENT DREDGE PROJECT
DATE :12/12/88

With polymer

TEST NUMBER	RUN NUMBER	POLYMER TYPE	CONCENTRATION (%)	POLYMER FLOW RATE (GPM)	POLYMER CORRECTION FACTOR	FEED PUMP RATE (GPM)	POLYMER FLOW RATE (GPM)	CENTRATE CORRECTION FACTOR	AVERAGE TOTAL SUSPENDED SOLIDS FEED (%)	AVERAGE TOTAL SUSPENDED SOLIDS CAKE (%)	AVERAGE TOTAL SUSPENDED SOLIDS CENTRATE (%)	RECOVERY (%)	DIFFERENTIAL (RPM)	G-FORCE (RPM)	FEED FLOW RATE (GPM)
8	21-23	7182	0.1	3.7	0.37	25	3.7	1.1	8.94	26.07	4.19	56.6	3	2000	25
9	24-26	7182	0.1	3.8	0.38	25	3.8	1.2	8.77	29.13	3.86	58.2	3	2500	25
10	27-29	7182	0.1	3.7	0.37	25	3.7	1.1	8.42	33.67	3.72	56.5	3	3200	25
11	30-32	7182	0.2	3.6	0.72	25	3.6	1.1	8.90	29.53	3.90	58.7	3	3200	25
12	33-35	726	0.2	3.7	0.74	25	3.7	1.1	9.15	31.27	0.84	92.3	3	3200	25
13	36-38	727	0.2	3.7	0.74	25	3.7	1.1	9.42	34.27	0.22	98.1	3	3200	25
14	39-41	727	0.2	4.7	0.94	25	4.7	1.2	9.44	36.20	0.72	93.1	3	3200	25
15	42-44	726	0.2	4.6	0.92	15	4.6	1.3	10.90	30.53	0.09	99.3	3	3200	15
16	45-47	727	0.2	4.6	0.92	15	4.6	1.3	10.91	33.20	0.04	99.6	3	3200	15
17	48-50	726	0.2	4.6	0.92	10	4.6	1.5	11.83	33.20	0.13	99.0	3	3200	10
18	51	727	0.2	4.7	0.94	10	4.7	1.5	11.82	31.40	0.06	99.6	3	3200	10
19	52-54	727	0.2	4.6	0.92	10	4.6	1.5	12.11	33.60	0.07	99.5	3	3200	10
20	55-57	726	0.2	4.6	0.92	25	4.6	1.2	11.99	34.13	1.93	86.7	4	3200	25
21	58-60	727	0.2	4.6	0.92	25	4.6	1.2	12.56	32.33	1.87	88.4	4	3200	25
22	61-63	726	0.3	4.7	1.41	15	4.7	1.3	11.63	23.90	0.18	99.0	4	3200	15
23	64-66	727	0.3	4.6	1.38	15	4.6	1.3	11.29	31.60	0.06	99.5	4	3200	15
24	67-69	727	0.1	4.6	0.46	15	4.6	1.3	13.18	30.33	0.04	99.8	4	3200	15
25	70-72	726	0.1	4.6	0.46	25	4.6	1.2	7.48	34.57	0.24	97.0	3	1720	25
26	73-75	727	0.1	4.6	0.46	25	4.6	1.2	8.77	38.23	0.85	90.9	3	1720	25
27	76-78	726	0.1	4.6	0.46	25	4.6	1.2	11.33	36.40	1.34	89.9	4	2100	25
28	79-81	727	0.2	4.6	0.92	15	4.6	1.3	10.67	27.50	0.02	99.8	4	1720	15
29	82-84	727	0.2	4.6	0.92	20	4.6	1.2	9.58	26.53	0.02	99.8	4	1720	20
30	85-87	727	0.2	3.6	0.72	15	3.6	1.2	13.99	32.00	0.02	99.9	4	1720	15
31	88-90	727	0.1	4.6	0.46	15	4.6	1.3	12.84	22.67	0.02	99.9	4	1720	15
32	91-92	727	0.2	4.6	0.92	20	4.6	1.2	12.10	30.20	0.02	99.9	4	2100	20
33	93-95	727	0.2	3.7	0.74	20	3.7	1.2	11.13	29.20	0.71	95.2	4	2100	20
34	96-98	727	0.1	4.6	0.46	15	4.6	1.3	9.98	28.87	0.02	99.8	4	2100	15
35	99-101	727	0.1	4.6	0.46	20	4.6	1.2	11.63	32.27	0.29	98.0	4	2100	20
36	102-104	727	0.2	4.6	0.92	15	4.6	1.3	11.89	28.53	0.03	99.8	4	1400	15
37	105-107	727	0.2	4.6	0.92	20	4.6	1.2	11.35	28.50	0.05	99.7	4	1400	20
38	108-110	727	0.1	4.6	0.46	15	4.6	1.3	10.87	25.57	0.02	99.9	4	1400	15
40	114	727	0.05	4.6	0.23	15	4.6	1.3	9.96	25.20	0.02	99.8	3.75	1400	15
43	121-123	727	0.05	4.6	0.23	15	4.6	1.3	8.52	22.01	0.01	99.9	4	1400	15

SAVED :WCONCN.WR1 ORTEGA RIVER (RIBAULT RIVER) ORGANIC SEDIMENT DREDGE PROJECT
DATE :12/13/88

GRAPHS:
WCONCN: All tests at given polymer correction factors
WACONCN: Averages of correction factors

With polymer
Variable: Polymer Correction Factor

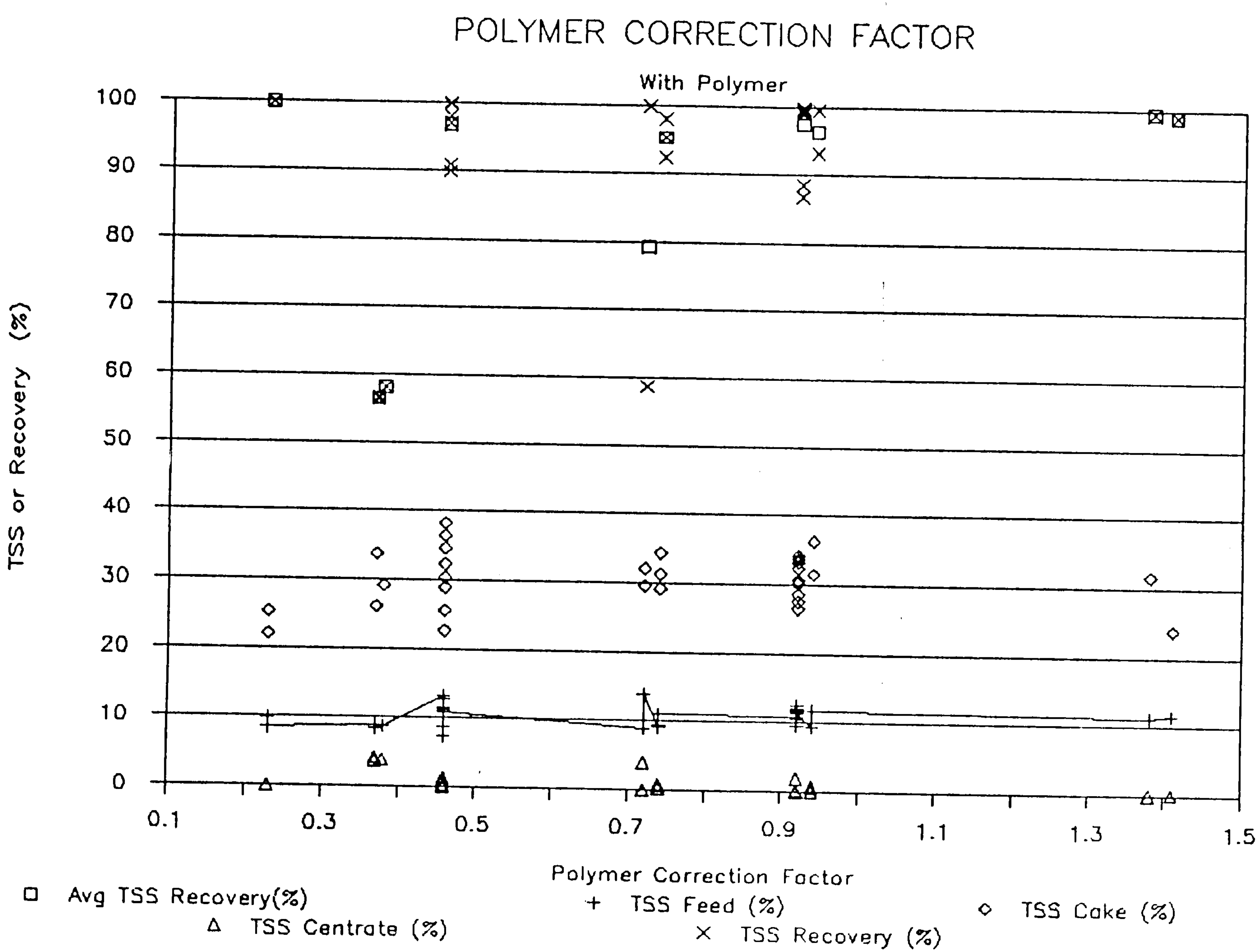
TEST NUMBER	RUN NUMBER	POLYMER TYPE	CONCEN-TRATION (%)	POLYMER FLOW RATE (GPM)	POLYMER COR-RECTION FACTOR	FEED PUMP RATE (GPM)	POLYMER FLOW RATE (GPM)	CENTRATE COR-RECTION FACTOR	AVERAGE TOTAL SUSPENDED SOLIDS FEED (%)	AVERAGE TOTAL SUSPENDED SOLIDS CAKE (%)	AVERAGE TOTAL SUSPENDED SOLIDS CENTRATE (%)	RECOVERY (%)	DIFFER-ENTIAL (RPM)	G-FORCE (RPM)	FEED FLOW RATE (GPM)
40	114	727	0.05	4.6	0.23	15	4.6	1.3	9.96	25.20	0.02	99.8	3.75	1400	15
43	121-123	727	0.05	4.6	0.23	15	4.6	1.3	8.52	22.01	0.01	99.9	4	1400	15
8	21-23	7182	0.1	3.7	0.37	25	3.7	1.1	8.94	26.07	4.19	56.6	3	2000	25
10	27-29	7182	0.1	3.7	0.37	25	3.7	1.1	8.42	33.67	3.72	56.5	3	3200	25
9	24-26	7182	0.1	3.8	0.38	25	3.8	1.2	8.77	29.13	3.86	58.2	3	2500	25
24	67-69	727	0.1	4.6	0.46	15	4.6	1.3	13.18	30.33	0.04	99.8	4	3200	15
25	70-72	726	0.1	4.6	0.46	25	4.6	1.2	7.48	34.57	0.24	97.0	3	1720	25
26	73-75	727	0.1	4.6	0.46	25	4.6	1.2	8.77	38.23	0.85	90.9	3	1720	25
27	76-78	726	0.1	4.6	0.46	25	4.6	1.2	11.33	36.40	1.34	89.9	4	2100	25
31	88-90	727	0.1	4.6	0.46	15	4.6	1.3	12.84	22.67	0.02	99.9	4	1720	15
34	96-98	727	0.1	4.6	0.46	15	4.6	1.3	9.98	28.87	0.02	99.8	4	2100	15
35	99-101	727	0.1	4.6	0.46	20	4.6	1.2	11.63	32.27	0.29	98.0	4	2100	20
38	108-110	727	0.1	4.6	0.46	15	4.6	1.3	10.87	25.57	0.02	99.9	4	1400	15
11	30-32	7182	0.2	3.6	0.72	25	3.6	1.1	8.90	29.53	3.90	58.7	3	3200	25
30	85-87	727	0.2	3.6	0.72	15	3.6	1.2	13.99	32.00	0.02	99.9	4	1720	15
12	33-35	726	0.2	3.7	0.74	25	3.7	1.1	9.15	31.27	0.84	92.3	3	3200	25
13	36-38	727	0.2	3.7	0.74	25	3.7	1.1	9.42	34.27	0.22	98.1	3	3200	25
33	93-95	727	0.2	3.7	0.74	20	3.7	1.2	11.13	29.20	0.71	95.2	4	2100	20
15	42-44	726	0.2	4.6	0.92	15	4.6	1.3	10.90	30.53	0.09	99.3	3	3200	15
16	45-47	727	0.2	4.6	0.92	15	4.6	1.3	10.91	33.20	0.04	99.6	3	3200	15
17	48-50	726	0.2	4.6	0.92	10	4.6	1.5	11.83	33.20	0.13	99.0	3	3200	10
19	52-54	727	0.2	4.6	0.92	10	4.6	1.5	12.11	33.60	0.07	99.5	3	3200	10
20	55-57	726	0.2	4.6	0.92	25	4.6	1.2	11.99	34.13	1.93	86.7	4	3200	25
21	58-60	727	0.2	4.6	0.92	25	4.6	1.2	12.56	32.33	1.87	88.4	4	3200	25
28	79-81	727	0.2	4.6	0.92	15	4.6	1.3	10.67	27.50	0.02	99.8	4	1720	15
29	82-84	727	0.2	4.6	0.92	20	4.6	1.2	9.58	26.53	0.02	99.8	4	1720	20
32	91-92	727	0.2	4.6	0.92	20	4.6	1.2	12.10	30.20	0.02	99.9	4	2100	20
36	102-104	727	0.2	4.6	0.92	15	4.6	1.3	11.89	28.53	0.03	99.8	4	1400	15
37	105-107	727	0.2	4.6	0.92	20	4.6	1.2	11.35	28.50	0.05	99.7	4	1400	20
14	39-41	727	0.2	4.7	0.94	25	4.7	1.2	9.44	36.20	0.72	93.1	3	3200	25
18	51	727	0.2	4.7	0.94	10	4.7	1.5	11.82	31.40	0.06	99.6	3	3200	10
23	64-66	727	0.3	4.6	1.38	15	4.6	1.3	11.29	31.60	0.06	99.5	4	3200	15
22	61-63	726	0.3	4.7	1.41	15	4.7	1.3	11.63	23.90	0.18	99.0	4	3200	15

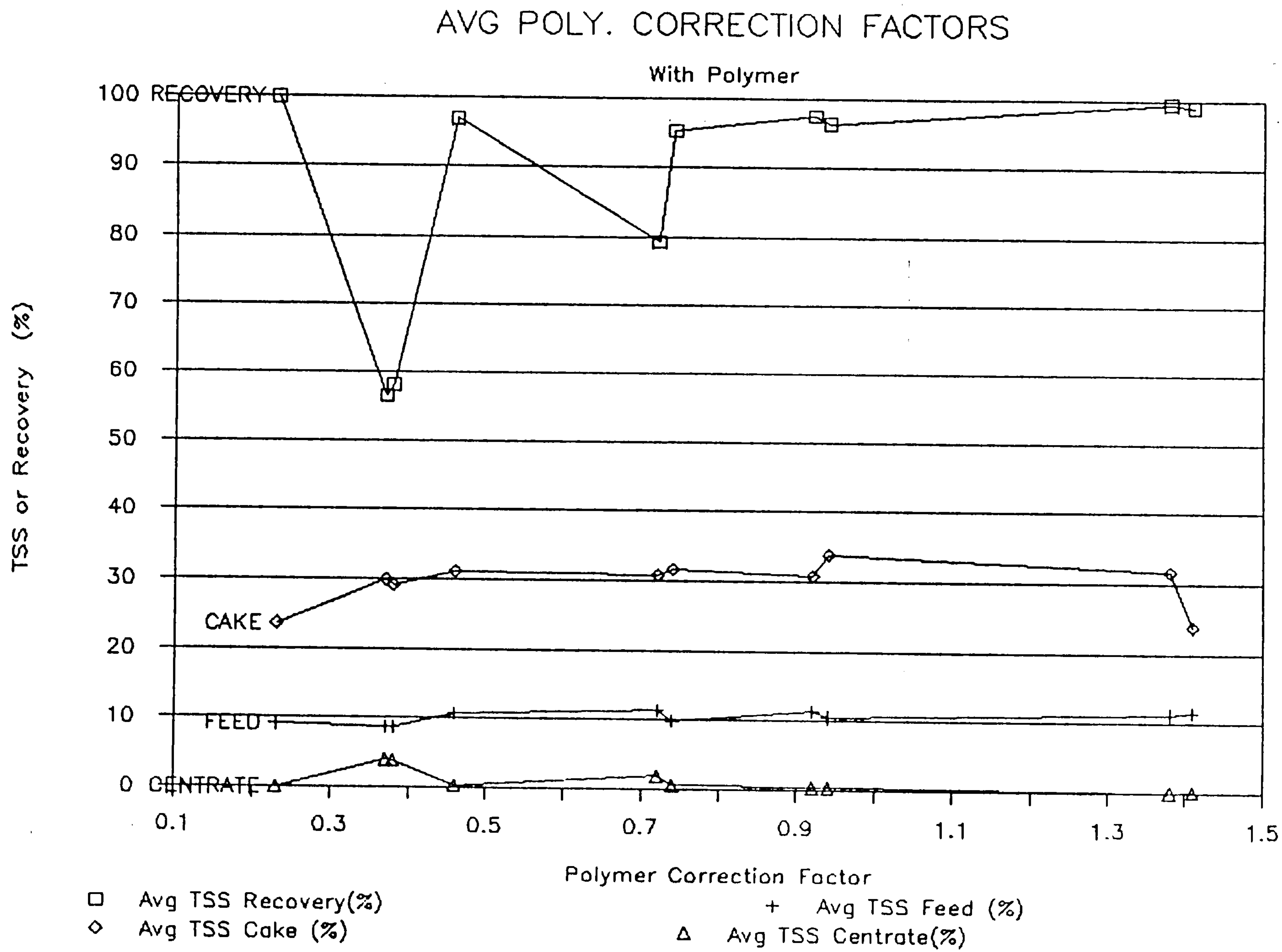
TEST

TEST NUMBER	AVG RECOVERY @ GIVEN CONCNTRA. (%)	Y-RANGE (Variables) AVG TSS FEED (%)	AVG TSS CAKE (%)	AVG TSS CENTRATE (%)	AVG RECOVERY PER TEST (%)	X-RANGE (Fixed) POLYMER CONCNTRA. FACTOR
						0.10
40		9.96	25.20	0.02	99.83	0.23
43	99.87	8.52	22.01	0.01	99.91	0.23
8		8.94	26.07	4.19	56.61	0.37
10	56.53	8.42	33.67	3.72	56.46	0.37
9	58.16	8.77	29.13	3.86	58.16	0.38
24		13.18	30.33	0.04	99.78	0.46
25		7.48	34.57	0.24	96.95	0.46
26		8.77	38.23	0.85	90.86	0.46
27		11.33	36.40	1.34	89.88	0.46
31		12.84	22.67	0.02	99.92	0.46
34		9.98	28.87	0.02	99.82	0.46
35		11.63	32.27	0.29	98.04	0.46
38	96.89	10.87	25.57	0.02	99.86	0.46
11		8.90	29.53	3.90	58.70	0.72
30	79.30	13.99	32.00	0.02	99.91	0.72
12		9.15	31.27	0.84	92.31	0.74
13		9.42	34.27	0.22	98.06	0.74
33	95.19	11.13	29.20	0.71	95.18	0.74
15		10.90	30.53	0.09	99.28	0.92
16		10.91	33.20	0.04	99.65	0.92
17		11.83	33.20	0.13	98.98	0.92
19		12.11	33.60	0.07	99.47	0.92
20		11.99	34.13	1.93	86.73	0.92
21		12.56	32.33	1.87	88.43	0.92
28		10.67	27.50	0.02	99.83	0.92
29		9.58	26.53	0.02	99.81	0.92
32		12.10	30.20	0.02	99.88	0.92
36		11.89	28.53	0.03	99.82	0.92
37	97.41	11.35	28.50	0.05	99.66	0.92
14		9.44	36.20	0.72	93.15	0.94
18	96.35	11.82	31.40	0.06	99.55	0.94
23	99.52	11.29	31.60	0.06	99.52	1.38
22	98.98	11.63	23.90	0.18	98.98	1.41
						1.45

AVERAGE

AVG RECOVERY @ GIVEN CONCNTRA. (%)	Y-RANGE (Variables) AVG TSS FEED @ GIVEN CONCNTRA. (%)	AVG TSS CAKE @ GIVEN CONCNTRA. (%)	AVG TSS CENTRATE @ GIVEN CONCNTRA. (%)	X-RANGE (Fixed) POLYMER CONCNTRA. FACTOR
				0.10
99.87	9.24	23.61	0.02	0.23
56.53	8.68	29.87	3.96	0.37
58.16	8.77	29.13	3.86	0.38
96.89	10.76	31.11	0.35	0.46
79.30	11.44	30.77	1.96	0.72
95.19	9.90	31.58	0.59	0.74
97.41	11.45	30.75	0.39	0.92
96.35	10.63	33.80	0.39	0.94
99.52	11.29	31.60	0.06	1.38
98.98	11.63	23.90	0.18	1.41
				1.45


POLYMER CORRECTION FACTOR
With Polymer
100
90
80
70
60
50
40
30
20
10
0
TSS or Recovery (%)
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
Polymer Correction Factor
Avg TSS Recovery(%)
TSS Centrate (%)
TSS Feed (%)
TSS Recovery (%)
TSS Cake (%)



AVG POLY. CORRECTION FACTORS
With Polymer
TSS or Recovery (%)
100
90
80
70
60
50
40
30
20
10
0
RECOVERY
CAKE
FEED
CENTRATE
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
Polymer Correction Factor
Avg TSS Recovery(%)
Avg TSS Cake (%)
Avg TSS Feed (%)
Avg TSS Centrate(%)

SAVED :WDIF.WR1 ORTEGA RIVER (RIBAULT RIVER) ORGANIC SEDIMENT DREDGE PROJECT

DATE :12/13/88

GRAPHS

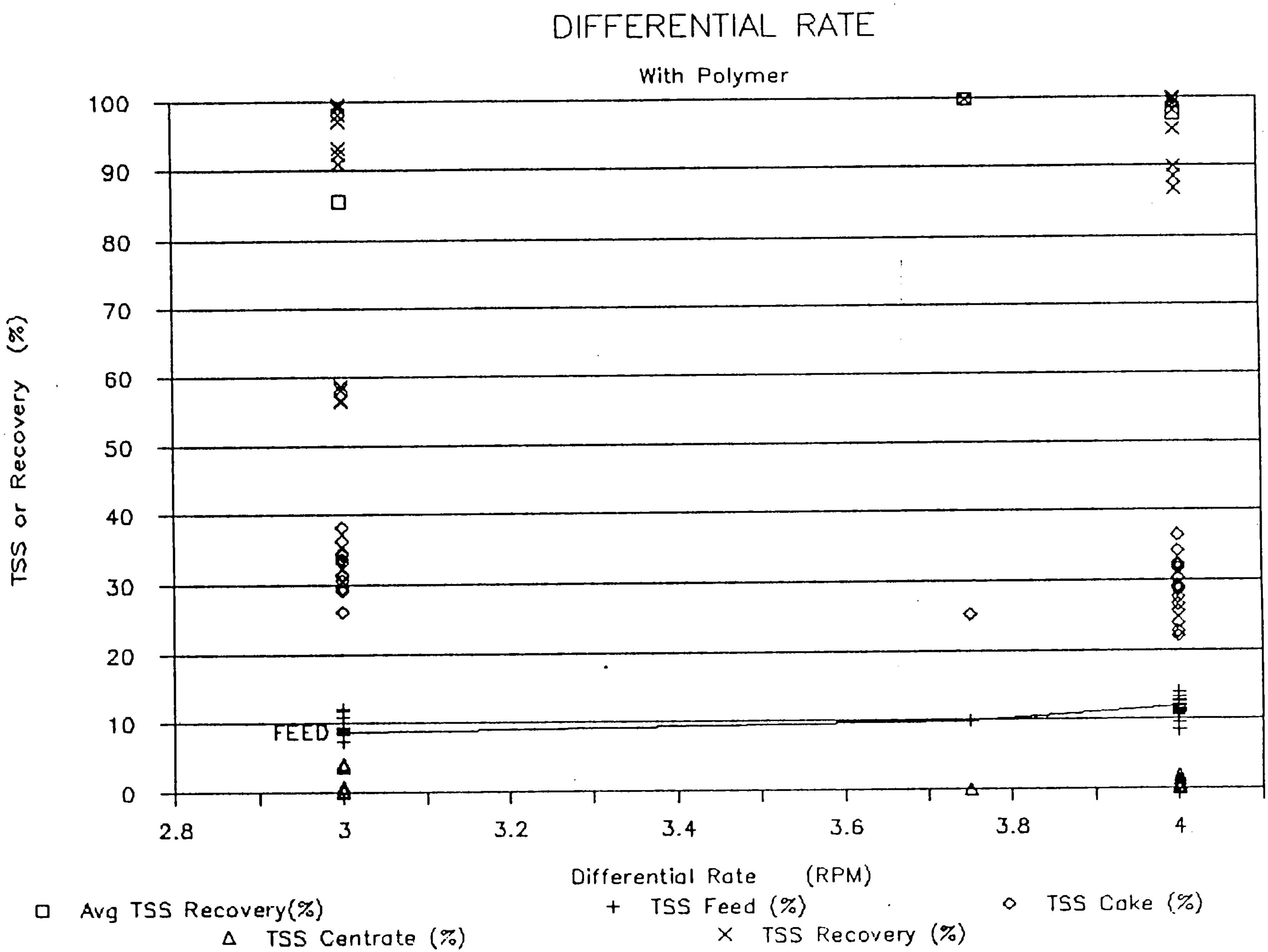
With polymer WDIF :All tests at given differential rates

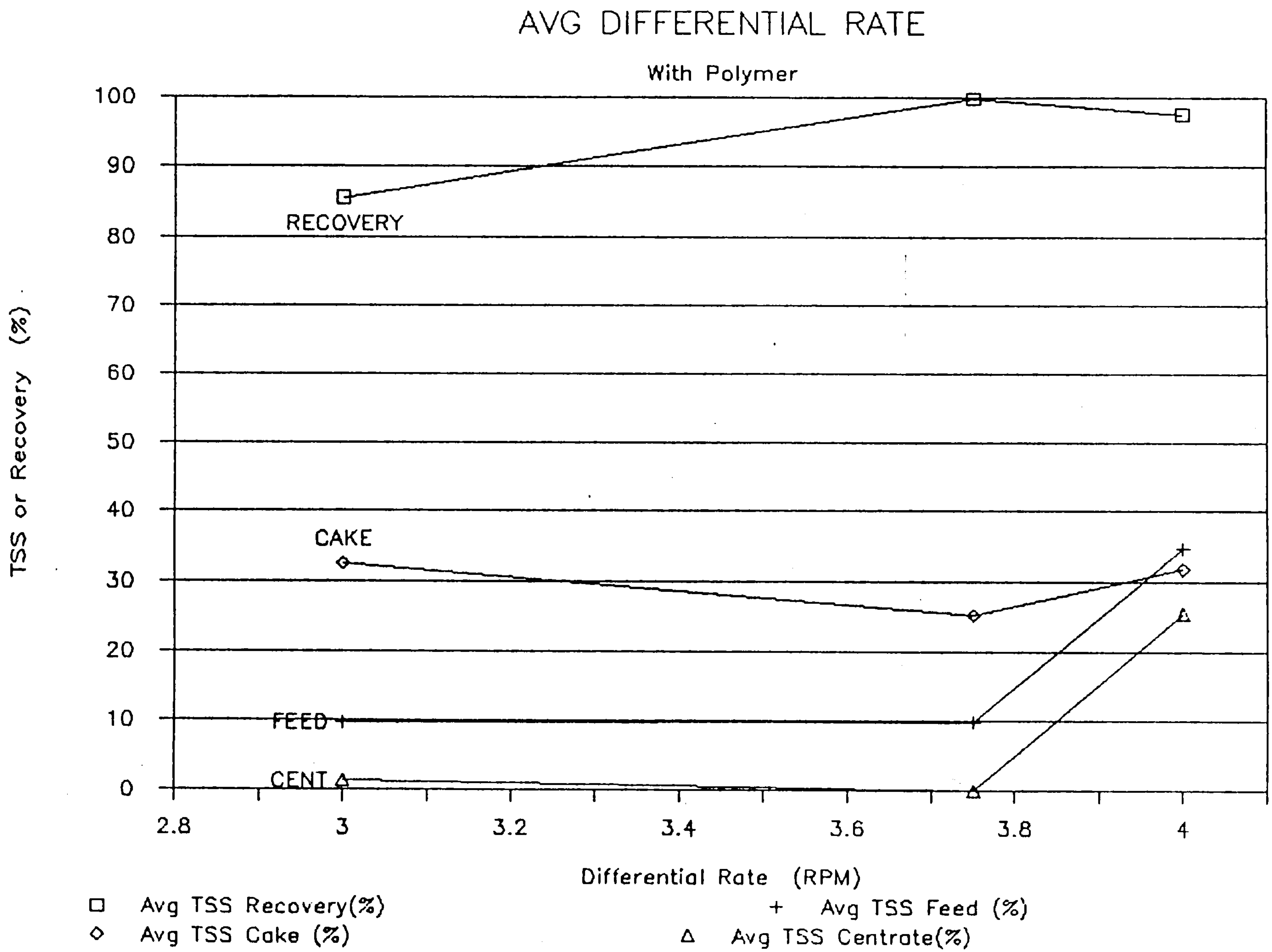
Variable: Differential Rate WADIF :Averages of differential rates

TEST NUMBER	RUN NUMBER	POLYMER TYPE	CONCENTRATION (%)	POLYMER FLOW RATE (GPM)	POLYMER CORRECTION FACTOR	FEED PUMP RATE (GPM)	POLYMER FLOW RATE (GPM)	CENTRATE CORRECTION FACTOR	AVERAGE TOTAL SUSPENDED SOLIDS FEED (%)	AVERAGE TOTAL SUSPENDED SOLIDS CAKE (%)	AVERAGE TOTAL SUSPENDED SOLIDS CENTRATE (%)	RECOVERY (%)	DIFFERENTIAL (RPM)	G-FORCE (RPM)	FEED FLOW RATE (GPM)
8	21-23	7182	0.1	3.7	0.37	25	3.7	1.1	8.94	26.07	4.19	56.6	3	2000	25
9	24-26	7182	0.1	3.8	0.38	25	3.8	1.2	8.77	29.13	3.86	58.2	3	2500	25
10	27-29	7182	0.1	3.7	0.37	25	3.7	1.1	8.42	33.67	3.72	56.5	3	3200	25
11	30-32	7182	0.2	3.6	0.72	25	3.6	1.1	8.90	29.53	3.90	58.7	3	3200	25
12	33-35	726	0.2	3.7	0.74	25	3.7	1.1	9.15	31.27	0.84	92.3	3	3200	25
13	36-38	727	0.2	3.7	0.74	25	3.7	1.1	9.42	34.27	0.22	98.1	3	3200	25
14	39-41	727	0.2	4.7	0.94	25	4.7	1.2	9.44	36.20	0.72	93.1	3	3200	25
15	42-44	726	0.2	4.6	0.92	15	4.6	1.3	10.90	30.53	0.09	99.3	3	3200	15
16	45-47	727	0.2	4.6	0.92	15	4.6	1.3	10.91	33.20	0.04	99.6	3	3200	15
17	48-50	726	0.2	4.6	0.92	10	4.6	1.5	11.83	33.20	0.13	99.0	3	3200	10
18	51	727	0.2	4.7	0.94	10	4.7	1.5	11.82	31.40	0.06	99.6	3	3200	10
19	52-54	727	0.2	4.6	0.92	10	4.6	1.5	12.11	33.60	0.07	99.5	3	3200	10
25	70-72	726	0.1	4.6	0.46	25	4.6	1.2	7.48	34.57	0.24	97.0	3	1720	25
26	73-75	727	0.1	4.6	0.46	25	4.6	1.2	8.77	38.23	0.85	90.9	3	1720	25
40	114	727	0.05	4.6	0.23	15	4.6	1.3	9.96	25.20	0.02	99.8	3.75	1400	15
20	55-57	726	0.2	4.6	0.92	25	4.6	1.2	11.99	34.13	1.93	86.7	4	3200	25
21	58-60	727	0.2	4.6	0.92	25	4.6	1.2	12.56	32.33	1.87	88.4	4	3200	25
22	61-63	726	0.3	4.7	1.41	15	4.7	1.3	11.63	23.90	0.18	99.0	4	3200	15
23	64-66	727	0.3	4.6	1.38	15	4.6	1.3	11.29	31.60	0.06	99.5	4	3200	15
24	67-69	727	0.1	4.6	0.46	15	4.6	1.3	13.18	30.33	0.04	99.8	4	3200	15
27	76-78	726	0.1	4.6	0.46	25	4.6	1.2	11.33	36.40	1.34	89.9	4	2100	25
28	79-81	727	0.2	4.6	0.92	15	4.6	1.3	10.67	27.50	0.02	99.8	4	1720	15
29	82-84	727	0.2	4.6	0.92	20	4.6	1.2	9.58	26.53	0.02	99.8	4	1720	20
30	85-87	727	0.2	3.6	0.72	15	3.6	1.2	13.99	32.00	0.02	99.9	4	1720	15
31	88-90	727	0.1	4.6	0.46	15	4.6	1.3	12.84	22.67	0.02	99.9	4	1720	15
32	91-92	727	0.2	4.6	0.92	20	4.6	1.2	12.10	30.20	0.02	99.9	4	2100	20
33	93-95	727	0.2	3.7	0.74	20	3.7	1.2	11.13	29.20	0.71	95.2	4	2100	20
34	96-98	727	0.1	4.6	0.46	15	4.6	1.3	9.98	28.87	0.02	99.8	4	2100	15
35	99-101	727	0.1	4.6	0.46	20	4.6	1.2	11.63	32.27	0.29	98.0	4	2100	20
36	102-104	727	0.2	4.6	0.92	15	4.6	1.3	11.89	28.53	0.03	99.8	4	1400	15
37	105-107	727	0.2	4.6	0.92	20	4.6	1.2	11.35	28.50	0.05	99.7	4	1400	20
38	108-110	727	0.1	4.6	0.46	15	4.6	1.3	10.87	25.57	0.02	99.9	4	1400	15
43	121-123	727	0.05	4.6	0.23	15	4.6	1.3	8.52	22.01	0.01	99.9	4	1400	15

TEST						
		Y-RANGE (Variables)				X-RANGE
TEST NUMBER	AVG RECOVERY @ GIVEN DIFERN'L (%)	AVG TSS FEED (%)	AVG TSS CAKE (%)	AVG TSS CENTRATE (%)	AVG RECOVERY PER TEST (%)	(Fixed) DIFERN'L (RPM)
						2.8
8		8.94	26.07	4.19	56.61	3
9		8.77	29.13	3.86	58.16	3
10		8.42	33.67	3.72	56.46	3
11		8.90	29.53	3.90	58.70	3
12		9.15	31.27	0.84	92.31	3
13		9.42	34.27	0.22	98.06	3
14		9.44	36.20	0.72	93.15	3
15		10.90	30.53	0.09	99.28	3
16		10.91	33.20	0.04	99.65	3
17		11.83	33.20	0.13	98.98	3
18		11.82	31.40	0.06	99.55	3
19		12.11	33.60	0.07	99.47	3
25		7.48	34.57	0.24	96.95	3
26	85.59	8.77	38.23	0.85	90.86	3
40	99.83	9.96	25.20	0.02	99.83	3.75
20		11.99	34.13	1.93	86.73	4
21		12.56	32.33	1.87	88.43	4
22		11.63	23.90	0.18	98.98	4
23		11.29	31.60	0.06	99.52	4
24		13.18	30.33	0.04	99.78	4
27		11.33	36.40	1.34	89.88	4
28		10.67	27.50	0.02	99.83	4
29		9.58	26.53	0.02	99.81	4
30		13.99	32.00	0.02	99.91	4
31		12.84	22.67	0.02	99.92	4
32		12.10	30.20	0.02	99.88	4
33		11.13	29.20	0.71	95.18	4
34		9.98	28.87	0.02	99.82	4
35		11.63	32.27	0.29	98.04	4
36		11.89	28.53	0.03	99.82	4
37		11.35	28.50	0.05	99.66	4
38		10.87	25.57	0.02	99.86	4
43	97.50	8.52	22.01	0.01	99.91	4
						4.1

AVERAGE				
	Y-RANGE (Variables)			X-RANGE
AVG RECOVERY @ GIVEN DIFERN'L (%)	AVG TSS FEED @ GIVEN DIFERN'L (%)	AVG TSS CAKE @ GIVEN DIFERN'L (%)	AVG TSS CENT @ GIVEN DIFERN'L (%)	(Fixed) DIFERN'L (RPM)
				2.8
85.59	9.78	32.49	1.35	3.0
99.83	9.96	25.20	0.02	3.8
97.50	34.59	31.72	25.47	4.0
				4.1


DIFFERENTIAL RATE
With Polymer
TSS or Recovery (%)
100
90
80
70
60
50
40
30
20
10
0
FEED
2.8
3
3.2
3.4
3.6
3.8
4
Differential Rate (RPM)
Avg TSS Recovery(%)
TSS Centrate (%)
TSS Feed (%)
TSS Recovery (%)
TSS Cake (%)


AVG DIFFERENTIAL RATE
With Polymer
TSS or Recovery (%)
100
90
80
70
60
50
40
30
20
10
0
RECOVERY
CAKE
FEED
CENT
2.8
3
3.2
3.4
3.6
3.8
4
Differential Rate (RPM)
Avg TSS Recovery(%)
Avg TSS Cake (%)
Avg TSS Feed (%)
Avg TSS Centrate(%)

SAVED :WFEED.WR1 ORTEGA RIVER (RIBAULT RIVER) ORGANIC SEDIMENT DREDGE PROJECT
DATE :12/13/88

GRAPHS:
With polymer WFEED: All tests at given feed pump rates
Variable: Feed Pump Rate WAFEED: Averages of feed pump rates

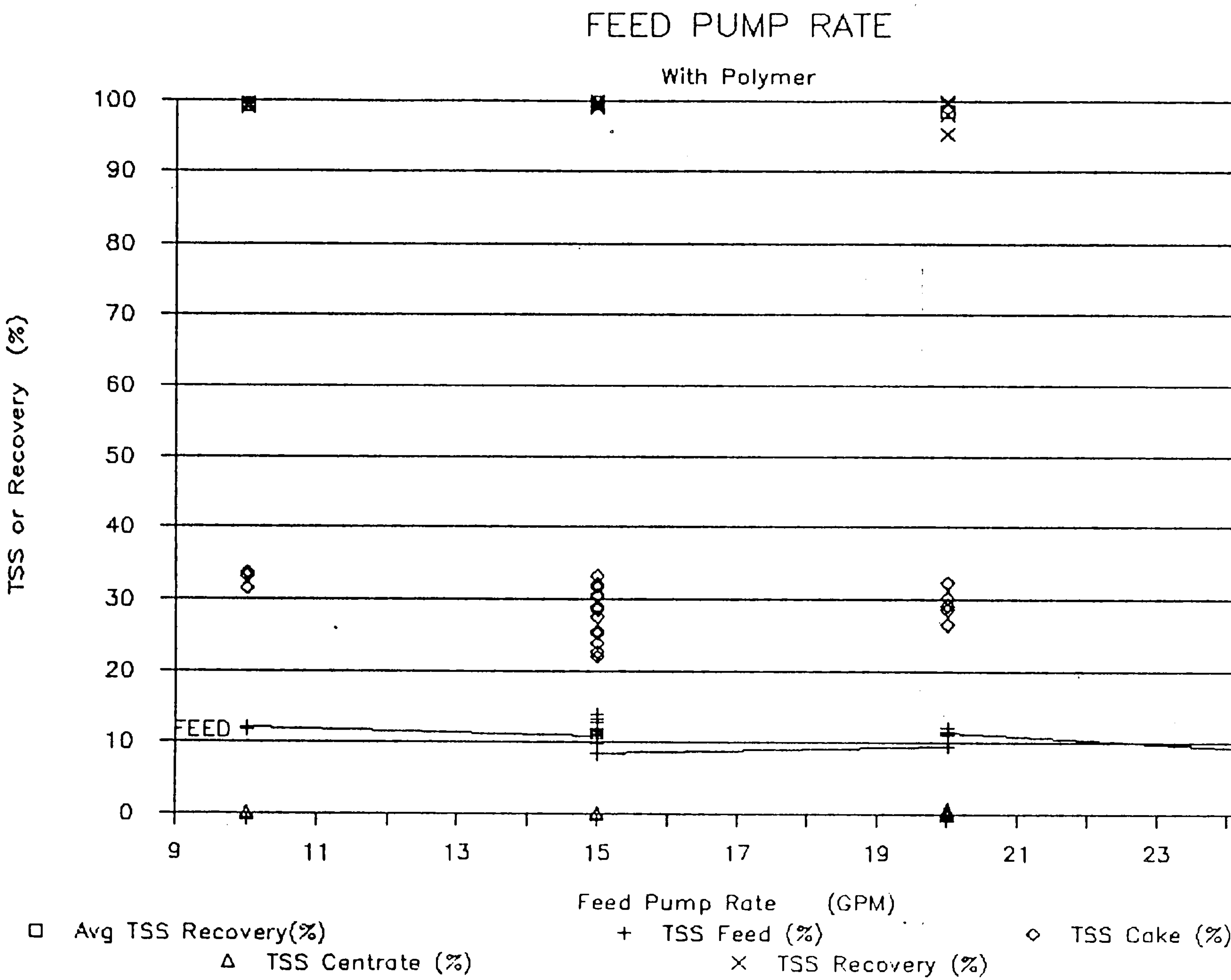
TEST NUMBER	RUN NUMBER	POLYMER TYPE	CONCENTRATION (%)	POLYMER FLOW RATE (GPM)	POLYMER CORRECTION FACTOR	FEED PUMP RATE (GPM)	POLYMER FLOW RATE (GPM)	CENTRATE CORRECTION FACTOR	AVERAGE TOTAL SUSPENDED SOLIDS FEED (%)	AVERAGE TOTAL SUSPENDED SOLIDS CAKE (%)	AVERAGE TOTAL SUSPENDED SOLIDS CENTRATE (%)	RECOVERY (%)	DIFFERENTIAL (RPM)	G-FORCE (RPM)	FEED FLOW RATE (GPM)
17	48-50	726	0.2	4.6	0.92	10	4.6	1.5	11.83	33.20	0.13	99.0	3	3200	10
18	51	727	0.2	4.7	0.94	10	4.7	1.5	11.82	31.40	0.06	99.6	3	3200	10
19	52-54	727	0.2	4.6	0.92	10	4.6	1.5	12.11	33.60	0.07	99.5	3	3200	10
15	42-44	726	0.2	4.6	0.92	15	4.6	1.3	10.90	30.53	0.09	99.3	3	3200	15
16	45-47	727	0.2	4.6	0.92	15	4.6	1.3	10.91	33.20	0.04	99.6	3	3200	15
22	61-63	726	0.3	4.7	1.41	15	4.7	1.3	11.63	23.90	0.18	99.0	4	3200	15
23	64-66	727	0.3	4.6	1.38	15	4.6	1.3	11.29	31.60	0.06	99.5	4	3200	15
24	67-69	727	0.1	4.6	0.46	15	4.6	1.3	13.18	30.33	0.04	99.8	4	3200	15
28	79-81	727	0.2	4.6	0.92	15	4.6	1.3	10.67	27.50	0.02	99.8	4	1720	15
30	85-87	727	0.2	3.6	0.72	15	3.6	1.2	13.99	32.00	0.02	99.9	4	1720	15
31	88-90	727	0.1	4.6	0.46	15	4.6	1.3	12.84	22.67	0.02	99.9	4	1720	15
34	96-98	727	0.1	4.6	0.46	15	4.6	1.3	9.98	28.87	0.02	99.8	4	2100	15
36	102-104	727	0.2	4.6	0.92	15	4.6	1.3	11.89	28.53	0.03	99.8	4	1400	15
38	108-110	727	0.1	4.6	0.46	15	4.6	1.3	10.87	25.57	0.02	99.9	4	1400	15
40	114	727	0.05	4.6	0.23	15	4.6	1.3	9.96	25.20	0.02	99.8	3.75	1400	15
43	121-123	727	0.05	4.6	0.23	15	4.6	1.3	8.52	22.01	0.01	99.9	4	1400	15
29	82-84	727	0.2	4.6	0.92	20	4.6	1.2	9.58	26.53	0.02	99.8	4	1720	20
32	91-92	727	0.2	4.6	0.92	20	4.6	1.2	12.10	30.20	0.02	99.9	4	2100	20
33	93-95	727	0.2	3.7	0.74	20	3.7	1.2	11.13	29.20	0.71	95.2	4	2100	20
35	99-101	727	0.1	4.6	0.46	20	4.6	1.2	11.63	32.27	0.29	98.0	4	2100	20
37	105-107	727	0.2	4.6	0.92	20	4.6	1.2	11.35	28.50	0.05	99.7	4	1400	20
8	21-23	7182	0.1	3.7	0.37	25	3.7	1.1	8.94	26.07	4.19	56.6	3	2000	25
9	24-26	7182	0.1	3.8	0.38	25	3.8	1.2	8.77	29.13	3.86	58.2	3	2500	25
10	27-29	7182	0.1	3.7	0.37	25	3.7	1.1	8.42	33.67	3.72	56.5	3	3200	25
11	30-32	7182	0.2	3.6	0.72	25	3.6	1.1	8.90	29.53	3.90	58.7	3	3200	25
12	33-35	726	0.2	3.7	0.74	25	3.7	1.1	9.15	31.27	0.84	92.3	3	3200	25
13	36-38	727	0.2	3.7	0.74	25	3.7	1.1	9.42	34.27	0.22	98.1	3	3200	25
14	39-41	727	0.2	4.7	0.94	25	4.7	1.2	9.44	36.20	0.72	93.1	3	3200	25
20	55-57	726	0.2	4.6	0.92	25	4.6	1.2	11.99	34.13	1.93	86.7	4	3200	25
21	58-60	727	0.2	4.6	0.92	25	4.6	1.2	12.56	32.33	1.87	88.4	4	3200	25
25	70-72	726	0.1	4.6	0.46	25	4.6	1.2	7.48	34.57	0.24	97.0	3	1720	25
26	73-75	727	0.1	4.6	0.46	25	4.6	1.2	8.77	38.23	0.85	90.9	3	1720	25
27	76-78	726	0.1	4.6	0.46	25	4.6	1.2	11.33	36.40	1.34	89.9	4	2100	25

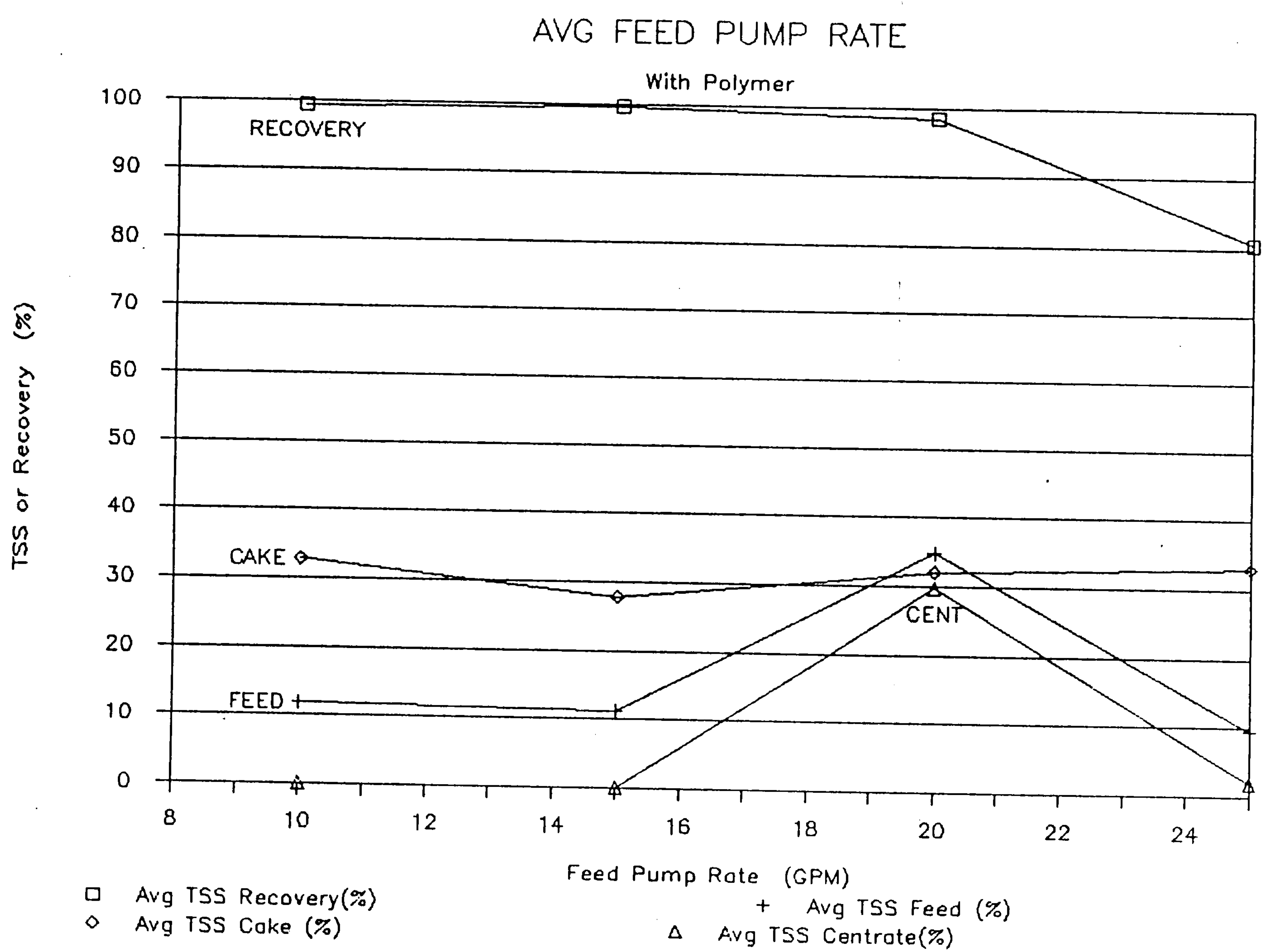
TEST

TEST NUMBER	AVG RECOVERY @ GIVEN FEED RATE (%)	Y-RANGE (Variables) AVG TSS FEED (%)	AVG TSS CAKE (%)	AVG TSS CENTRATE (%)	AVG RECOVERY PER TEST (%)	X-RANGE (Fixed) FEED RATE (GPM)
						9
17		11.83	33.20	0.13	98.98	10
18		11.82	31.40	0.06	99.55	10
19	99.33	12.11	33.60	0.07	99.47	10
15		10.90	30.53	0.09	99.28	15
16		10.91	33.20	0.04	99.65	15
22		11.63	23.90	0.18	98.98	15
23		11.29	31.60	0.06	99.52	15
24		13.18	30.33	0.04	99.78	15
28		10.67	27.50	0.02	99.83	15
30		13.99	32.00	0.02	99.91	15
31		12.84	22.67	0.02	99.92	15
34		9.98	28.87	0.02	99.82	15
36		11.89	28.53	0.03	99.82	15
38		10.87	25.57	0.02	99.86	15
40		9.96	25.20	0.02	99.83	15
43	99.70	8.52	22.01	0.01	99.91	15
29		9.58	26.53	0.02	99.81	20
32		12.10	30.20	0.02	99.88	20
33		11.13	29.20	0.71	95.18	20
35		11.63	32.27	0.29	98.04	20
37	98.51	11.35	28.50	0.05	99.66	20
8		8.94	26.07	4.19	56.61	25
9		8.77	29.13	3.86	58.16	25
10		8.42	33.67	3.72	56.46	25
11		8.90	29.53	3.90	58.70	25
12		9.15	31.27	0.84	92.31	25
13		9.42	34.27	0.22	98.06	25
14		9.44	36.20	0.72	93.15	25
20		11.99	34.13	1.93	86.73	25
21		12.56	32.33	1.87	88.43	25
25		7.48	34.57	0.24	96.95	25
26		8.77	38.23	0.85	90.86	25
27	80.53	11.33	36.40	1.34	89.88	25
						25

AVERAGE

AVG RECOVERY @ GIVEN FEED RATE (%)	Y-RANGE (Variables) AVG TSS FEED @ GIVEN FEED RATE (%)	AVG TSS CAKE @ GIVEN FEED RATE (%)	AVG TSS CENTRATE @ GIVEN FEED RATE (%)	X-RANGE (Fixed) FEED RATE (GPM)
				8
99.33	11.92	32.73	0.08	10
99.70	11.28	27.84	0.04	15
98.51	34.81	32.02	29.68	20
80.53	9.60	32.98	1.98	25
				25


FEED PUMP RATE
With Polymer
TSS or Recovery (%)
100
90
80
70
60
50
40
30
20
10
0
FEED
9
11
13
15
17
19
21
23
25
Feed Pump Rate (GPM)
Avg TSS Recovery(%)
TSS Feed (%)
TSS Cake (%)
TSS Centrate (%)
TSS Recovery (%)


AVG FEED PUMP RATE
With Polymer
RECOVERY
CAKE
FEED
CENT
100
90
80
70
60
50
40
30
20
10
0
8
10
12
14
16
18
20
22
24
TSS or Recovery (%)
Feed Pump Rate (GPM)
Avg TSS Recovery(%)
Avg TSS Cake (%)
Avg TSS Feed (%)
Avg TSS Centrate(%)

SAVED :WGFOR.WR1 ORTEGA RIVER (RIBAULT RIVER) ORGANIC SEDIMENT DREDGE PROJECT
DATE :12/12/88

GRAPHS:
With polymer WGFOR: G-Force at all test
Variable: G-Force WAGFOR: G-Force at averages

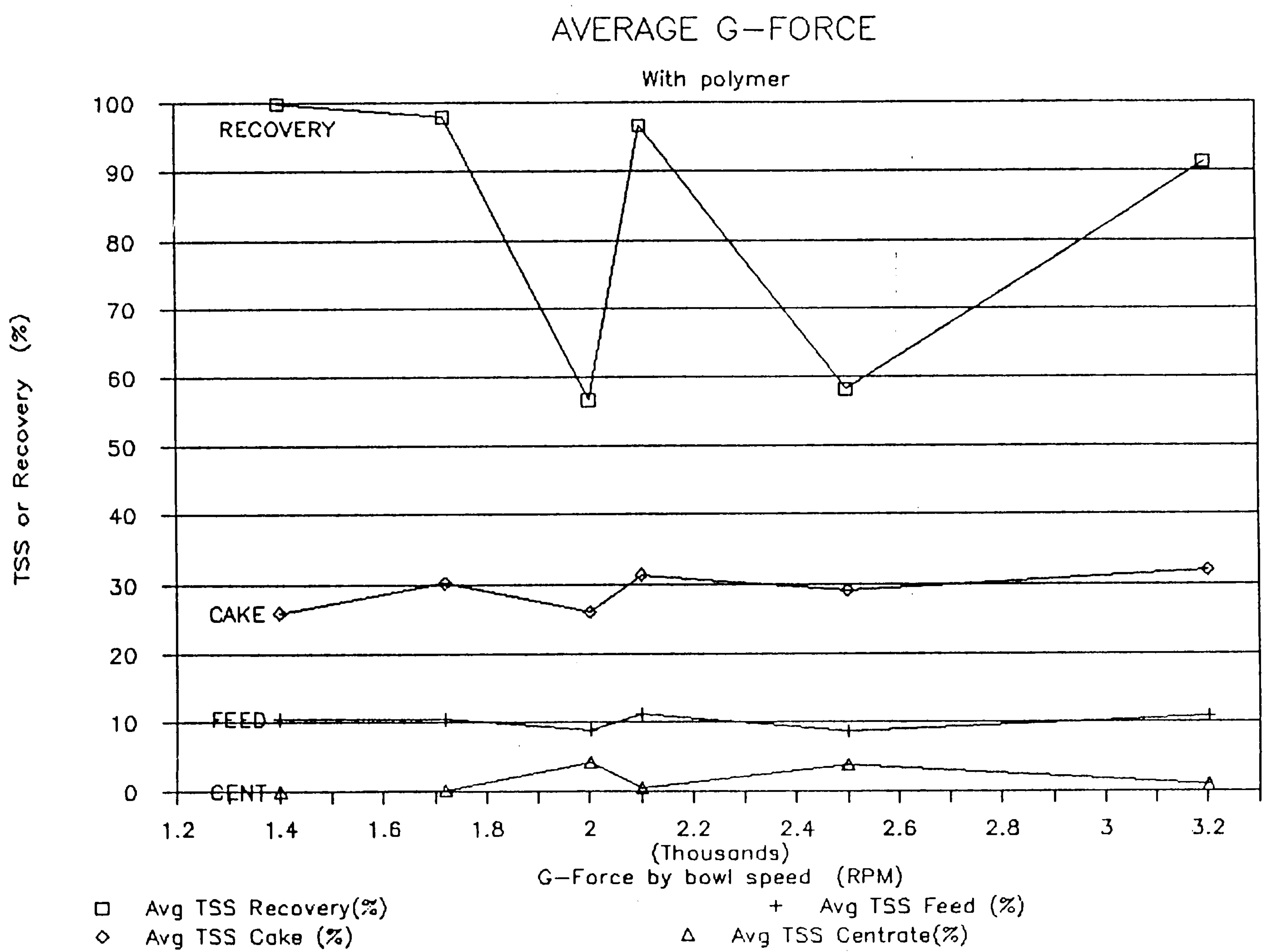
TEST NUMBER	RUN NUMBER	POLYMER TYPE	CONCEN-TRATION (%)	POLYMER FLOW RATE (GPM)	POLYMER COR-RECTION FACTOR	FEED PUMP RATE (GPM)	POLYMER FLOW RATE (GPM)	CENTRATE COR-RECTION FACTOR	AVERAGE TOTAL SUSPENDED SOLIDS FEED (%)	AVERAGE TOTAL SUSPENDED SOLIDS CAKE (%)	AVERAGE TOTAL SUSPENDED SOLIDS CENTRATE (%)	RECOVERY (%)	DIFFER-ENTIAL (RPM)	G-FORCE (RPM)	FEED FLOW RATE (GPM)
36	102-104	727	0.2	4.6	0.92	15	4.6	1.3	11.89	28.53	0.03	99.8	4	1400	15
37	105-107	727	0.2	4.6	0.92	20	4.6	1.2	11.35	28.50	0.05	99.7	4	1400	20
38	108-110	727	0.1	4.6	0.46	15	4.6	1.3	10.87	25.57	0.02	99.9	4	1400	15
40	114	727	0.05	4.6	0.23	15	4.6	1.3	9.96	25.20	0.02	99.8	3.75	1400	15
43	121-123	727	0.05	4.6	0.23	15	4.6	1.3	8.52	22.01	0.01	99.9	4	1400	15
25	70-72	726	0.1	4.6	0.46	25	4.6	1.2	7.48	34.57	0.24	97.0	3	1720	25
26	73-75	727	0.1	4.6	0.46	25	4.6	1.2	8.77	38.23	0.85	90.9	3	1720	25
28	79-81	727	0.2	4.6	0.92	15	4.6	1.3	10.67	27.50	0.02	99.8	4	1720	15
29	82-84	727	0.2	4.6	0.92	20	4.6	1.2	9.58	26.53	0.02	99.8	4	1720	20
30	85-87	727	0.2	3.6	0.72	15	3.6	1.2	13.99	32.00	0.02	99.9	4	1720	15
31	88-90	727	0.1	4.6	0.46	15	4.6	1.3	12.84	22.67	0.02	99.9	4	1720	15
8	21-23	7182	0.1	3.7	0.37	25	3.7	1.1	8.94	26.07	4.19	56.6	3	2000	25
27	76-78	726	0.1	4.6	0.46	25	4.6	1.2	11.33	36.40	1.34	89.9	4	2100	25
32	91-92	727	0.2	4.6	0.92	20	4.6	1.2	12.10	30.20	0.02	99.9	4	2100	20
33	93-95	727	0.2	3.7	0.74	20	3.7	1.2	11.13	29.20	0.71	95.2	4	2100	20
34	96-98	727	0.1	4.6	0.46	15	4.6	1.3	9.98	28.87	0.02	99.8	4	2100	15
35	99-101	727	0.1	4.6	0.46	20	4.6	1.2	11.63	32.27	0.29	98.0	4	2100	20
9	24-26	7182	0.1	3.8	0.38	25	3.8	1.2	8.77	29.13	3.86	58.2	3	2500	25
10	27-29	7182	0.1	3.7	0.37	25	3.7	1.1	8.42	33.67	3.72	56.5	3	3200	25
11	30-32	7182	0.2	3.6	0.72	25	3.6	1.1	8.90	29.53	3.90	58.7	3	3200	25
12	33-35	726	0.2	3.7	0.74	25	3.7	1.1	9.15	31.27	0.84	92.3	3	3200	25
13	36-38	727	0.2	3.7	0.74	25	3.7	1.1	9.42	34.27	0.22	98.1	3	3200	25
14	39-41	727	0.2	4.7	0.94	25	4.7	1.2	9.44	36.20	0.72	93.1	3	3200	25
15	42-44	726	0.2	4.6	0.92	15	4.6	1.3	10.90	30.53	0.09	99.3	3	3200	15
16	45-47	727	0.2	4.6	0.92	15	4.6	1.3	10.91	33.20	0.04	99.6	3	3200	15
17	48-50	726	0.2	4.6	0.92	10	4.6	1.5	11.83	33.20	0.13	99.0	3	3200	10
18	51	727	0.2	4.7	0.94	10	4.7	1.5	11.82	31.40	0.06	99.6	3	3200	10
19	52-54	727	0.2	4.6	0.92	10	4.6	1.5	12.11	33.60	0.07	99.5	3	3200	10
20	55-57	726	0.2	4.6	0.92	25	4.6	1.2	11.99	34.13	1.93	86.7	4	3200	25
21	58-60	727	0.2	4.6	0.92	25	4.6	1.2	12.56	32.33	1.87	88.4	4	3200	25
22	61-63	726	0.3	4.7	1.41	15	4.7	1.3	11.63	23.90	0.18	99.0	4	3200	15
23	64-66	727	0.3	4.6	1.38	15	4.6	1.3	11.29	31.60	0.06	99.5	4	3200	15
24	67-69	727	0.1	4.6	0.46	15	4.6	1.3	13.18	30.33	0.04	99.8	4	3200	15

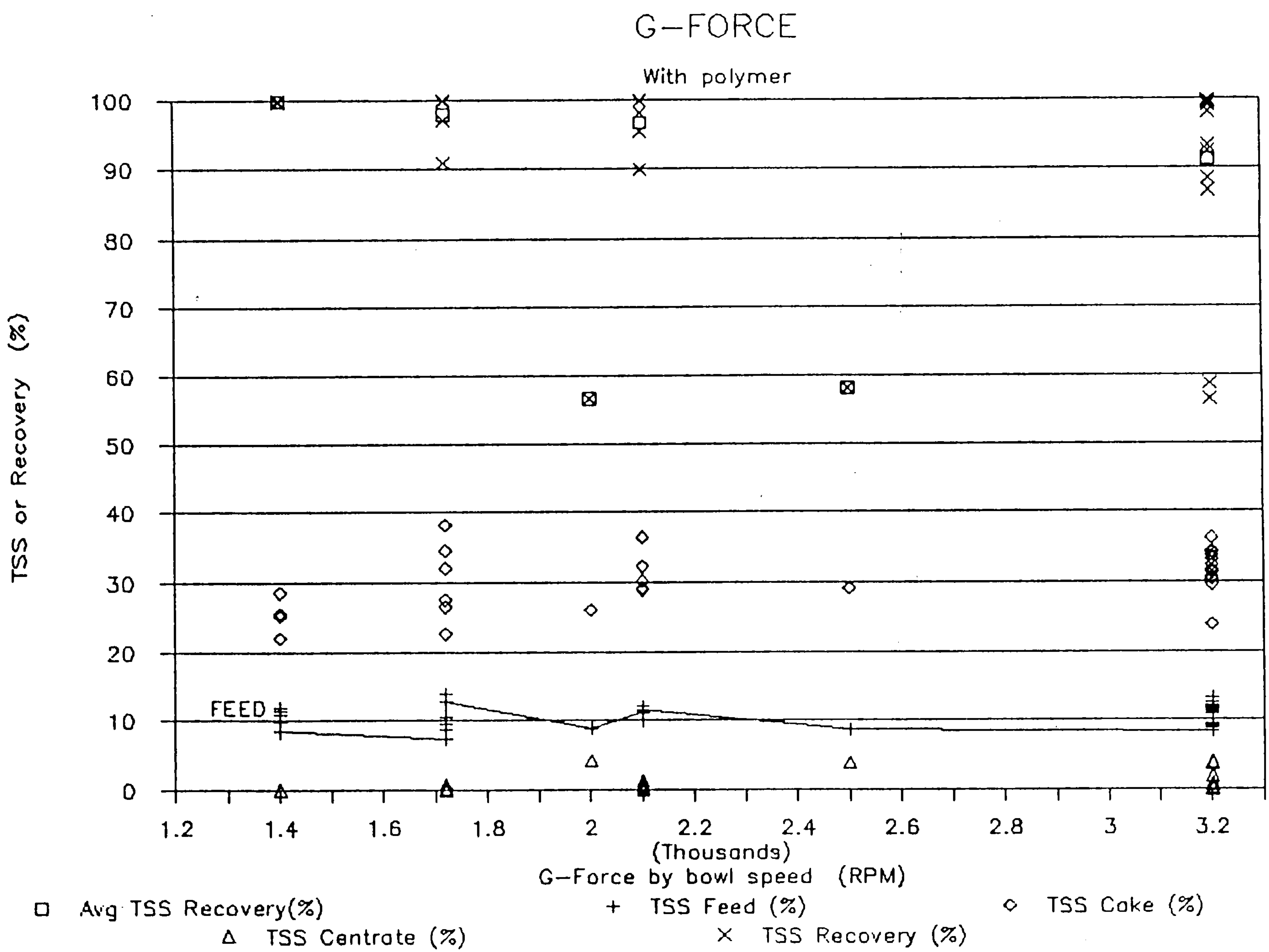
TEST

TEST NUMBER	AVG RECOVERY @ GIVEN G-FORCE (%)	Y-RANGE (Variables) AVG TSS FEED (%)	AVG TSS CAKE (%)	AVG TSS CENTRATE (%)	AVG RECOVERY PER TEST (%)	X-RANGE G-FORCE (RPM)
						1200
36		11.89	28.53	0.03	99.82	1400
37		11.35	28.50	0.05	99.66	1400
38		10.87	25.57	0.02	99.86	1400
40		9.96	25.20	0.02	99.83	1400
43	99.81	8.52	22.01	0.01	99.91	1400
25		7.48	34.57	0.24	96.95	1720
26		8.77	38.23	0.85	90.86	1720
28		10.67	27.50	0.02	99.83	1720
29		9.58	26.53	0.02	99.81	1720
30		13.99	32.00	0.02	99.91	1720
31	97.88	12.84	22.67	0.02	99.92	1720
8	56.61	8.94	26.07	4.19	56.61	2000
27		11.33	36.40	1.34	89.88	2100
32		12.10	30.20	0.02	99.88	2100
33		11.13	29.20	0.71	95.18	2100
34		9.98	28.87	0.02	99.82	2100
35	96.56	11.63	32.27	0.29	98.04	2100
9	58.16	8.77	29.13	3.86	58.16	2500
10		8.42	33.67	3.72	56.46	3200
11		8.90	29.53	3.90	58.70	3200
12		9.15	31.27	0.84	92.31	3200
13		9.42	34.27	0.22	98.06	3200
14		9.44	36.20	0.72	93.15	3200
15		10.90	30.53	0.09	99.28	3200
16		10.91	33.20	0.04	99.65	3200
17		11.83	33.20	0.13	98.98	3200
18		11.82	31.40	0.06	99.55	3200
19		12.11	33.60	0.07	99.47	3200
20		11.99	34.13	1.93	86.73	3200
21		12.56	32.33	1.87	88.43	3200
22		11.63	23.90	0.18	98.98	3200
23		11.29	31.60	0.06	99.52	3200
24	91.27	13.18	30.33	0.04	99.78	3200
						3300

AVERAGE

AVG RECOVERY @ GIVEN G-FORCE (%)	Y-RANGE (Variables) AVG TSS FEED @ GIVEN G-FORCE (%)	AVG TSS CAKE @ GIVEN G-FORCE (%)	AVG TSS CENTRATE @ GIVEN G-FORCE (%)	X-RANGE (Fixed) G-FORCE (RPM)
				1200
99.81	10.52	25.96	0.03	1400
97.88	10.55	30.25	0.20	1720
56.61	8.94	26.07	4.19	2000
96.56	11.23	31.39	0.48	2100
58.16	8.77	29.13	3.86	2500
91.27	10.90	31.94	0.92	3200
				3300


AVERAGE G-FORCE
With polymer
100
90
80
70
60
50
40
30
20
10
0
TSS or Recovery (%)
RECOVERY
CAKE
FEED
CENT
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
(Thousands)
G-Force by bowl speed (RPM)
Avg TSS Recovery(%)
Avg TSS Cake (%)
Avg TSS Feed (%)
Avg TSS Centrate(%)



G-FORCE
With polymer
TSS or Recovery (%)
100
90
80
70
60
50
40
30
20
10
0
FEED
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
(Thousands)
G-Force by bowl speed (RPM)
Avg TSS Recovery(%)
TSS Feed (%)
TSS Coke (%)
TSS Centrote (%)
TSS Recovery (%)

APPENDIX E

DEWATERING TEST RESULTS
HUMBOLDT DECANTER, INC.

HUMBOLDT DECANTER INC.

Originally Sent via Telefax

January 27, 1989

Camp, Dresser & McKee
6650 Southpoint Parkway
Jacksonville, Florida 32216

FEB 2

Attention: Mr. Stephen R. Sedgwick, P.E.

Reference: River Bottom Sludge Dewatering Program

Dear Steve:

This letter will serve to confirm our telephone conversation of January 25 when we briefly discussed the results of the test program which was conducted in Jacksonville last November.

I am enclosing herewith the test report prepared by our Mr. Jerry Kanney who conducted the test program on our behalf. Also enclosed you will find our invoice for expenses incurred in connection with that test program. We would greatly appreciate it if you would arrange for prompt remittance of the amount due.

At the outset I would like to apologize for providing this report so late. Mr. Kanney originally sent his report to our Atlanta office in mid - December; however, it was not until after the first of the year that it actually arrived here. We sincerely hope that this delay has not caused you any undue hardship.

As you know, given the relatively short time-frame which was available for the test program, an ambitious program was nevertheless completed. Testing encompassed a fairly broad range of operating conditions and spanned a total of 123 test runs. Likewise, as might be expected given the type of feed material processed, the feed material appears to have fluctuated in quality during the test program (even during a given 3 - run series of tests), all of which makes interpretation of the data difficult. In his cover note which accompanied his report to our office Mr. Kanney requested that I review the data and provide you with my interpretation which I am pleased to do here.

I would also like to point out that the nature of the centrifuge feed material turned out to be much different than I originally anticipated when we first discussed Humboldt's participation in this program. Going into the test program I had what now appears to have been an erroneous, pre-conceived notion that the feed sludge would contain a high percentage of light, organic materials instead of the high percentage of inorganic solids which was found to exist.

AUTHORIZED REPRESENTATIVE KHD CENTRIFUGES
3200 POINTE PARKWAY, ATLANTA (NORCROSS), GEORGIA 30092-USA
TELEPHONE 404/448-4748 FAX 404/448-1391
TWX 810-766-4531 HUMDAG NRCS

Test Observations & Results

1. Centrifuge performance without polymer flocculant addition resulted in the development of the driest cake products but would not be recommended for full-scale operation when processing similiar materials for the reasons presented below:

   a. The recovery efficiency of the centrifuge (ability to recover as cake product suspended solids in feed) was considered by us to be unacceptably low without polymer addition and was generally in the range of only 50 - 65%.

   b. The higher cake solids reported during testing without polymer flocculant addition may likely be attributed to selective classification having occurred such that the centrifuge only captured as cake product heavy inorganic materials present in feed (ie, sand, silt, etc.). Interestingly, if classification did in fact occur as is suspected, the centrifuge would have captured primarily that fraction of the feed solids which could possibly be returned to the river bed while likely rejecting the vast majority of lighter, organic materials which, per our understanding, are the target of this program.

2. Of the various polymer flocculant products tested, Allied Colloids Percol 727 (anionic powder) is judged to have been the most effective. Generally speaking, a dosage of 3 - 4 pounds of this product per ton of suspended solids in feed resulted in recovery efficiencies of 99+%. Purchased in sufficient quantity the cost of this product is approximately $1.35 - 1.50 per pound such that the polymer cost would be in the range of $4.00 - 6.00 per ton of feed solids when processing similar material to that tested.

   Further to this subject are the following points for your consideration as regards a full-scale installation:

   a. The test program clearly demonstrated that 99+% recovery is achievable. A question to be resolved is whether or not such a high degree of solids recovery would be required in full-scale operation.

   b. The variable nature of the feed material suggests that regular screening of polymer products and a full compliment of polymer products would likely have to be maintained on site to ensure optimum performance and cost-effectiveness.

3. Based upon laboratory analysis of the material tested it is now known that the feed solids typically contained 80 - 85% inorganic materials; which materials are assumed to have been largely comprised of sand and silt. Given the highly abrasive characteristics of such materials and in the interest of minimizing wear on internal surfaces and maximizing on-line reliability, we would strongly recommend that the lowest possible bowl speed consistent with your performance objectives be utilized in any

3. (Continued)
full-scale operation. Accordingly, you will note in the enclosed data that, as the test program progressed, the operating bowl speed was significantly reduced (from 2,617 x Gravity to 500 x Gravity).

4. With proper polymer flocculant product selection a dewatered cake product containing 28 - 34% solids appears to be readily achievable in combination with a very high recovery level. Comparative cake dryness appears to have been somewhat better at the highest bowl speed tested; however, based upon our experience, it is our belief that the potential negative impact of high speed operation in this abrasive service (ie, higher electrical power and maintenance cost, lower reliability, etc.) would likely offset any benefit offerred by a somewhat drier cake product.

Summarizing all of the above, when processing a material of similar quality to that tested we would estimate the following performance for one of the larger Humboldt Centrifuges available and equipped with an automatically regulating hydraulic scroll drive:

Centrifuge Model No.:	S6-1
Centrifuge Bowl Diameter x Length:	56" x 165"
Centrifuge Bowl Speed:	1,000 RPM Maximum
Centrifuge Force x Gravity:	782 x G Maximum
Slurry Concentration:	9 - 12% Solids (T.S.S.)
Slurry Specific Gravity:	1.05 (Estimated)
Slurry Hydraulic Feed Rate:	325 - 450 GPM
Slurry Solids Feed Rate:	8.5 - 10 Tons Per Hour
% Solids Cake:	28 - 34% T.S.
% Recovery:	95 - 99+%
Polymer - Lbs. Per Ton:	Four (4)
Centrifuge Connected HP:	300
Centrifuge Gross Weight:	48,500 Lbs.

Please note as a point of information that the low-speed Humboldt Model S6-1 centrifuge generally described above can handle much higher hydraulic and solids capacities than listed above and has successfully processed more than 800 gpm in sewage sludge service. The specific capacity listed above is based on a conservative estimate of expected performance when processing a material similar to that tested.

Full - Scale Evaluation

During our recent telephone conversation you inquired as to our participation in a possible full-scale demonstration which would be carried out at a location in Miami, Florida. It is our understanding that this program would commence in June or July of this year and would require approximately six (6) months to complete. After having considered this subject I can propose the following for your consideration.

Humboldt Decanter, Inc. (hereafter "HDI") would be very much interested to participate in such a program. Please note that we would require a minimum of four (4) months advance notice of your intent to conduct this program to provide us with ample preparation time to locate all required ancillary equipment to be provided by us which is not already in our possession. Our participation would be based on the following concept:

1. HDI's participation would be based upon a minimum rental period of six (6) months for the equipment furnished by us. In the event that the demonstration program ultimately requires a longer timeframe than originally foreseen, the Lease could be extended on a month-to-month basis to suit your specific needs.

2. HDI could furnish the following equipment for this demonstration program:

   a. One (1) - Humboldt Model S6-1 Centrifuge with wetted parts of carbon steel construction and Humboldt standard abrasion protection features; complete with rubber buffer vibration isolators, 300 HP main drive motor and Viscotherm Analog (automatic regulation) Hydraulic Scroll Drive System

   b. One (1)- Electric Control Panel, free-standing

   c. One (1)- Set Discharge Hoppers of carbon steel construction

   d. One (1)- Set Flexible Connections

   e. Ten (10)- Days Service at Site to inspect installation by others; instruct your operating personnel in equipment operation, optimization and maintenance; and place the equipment into operation; in no more than three (3) trips to site.

   f. Two (2) - Lots freight (to site and return)

   g. One (1) - Lot normal spare parts on a consignment basis; parts to be paid for by the Lessee as used.

3. Lessee's responsibilities would include the following:

   a. Supply all required ancillary equipment, utilities and materials necessary to make-up a complete installation which is not included in HDI's scope of supply (ie, pumps, polymer makeup and metering system, polymer, cake conveying system, overhead hoists, lubricants, etc.).

   b. Install the equipment and upon completion of the demonstration program, dismantle the site.

   c. Provide operating and maintenance personnel; provide regular maintenance for the HDI equipment on an as-needed basis.

   d. Provide all necessary permits and assume all responsibility for safeguarding the equipment and for disposal of centrifuge discharged material (cake and centrate).

   e. Provide HDI with regular access to its equipment as well as all records as to the operation, maintenance and process performance of the equipment throughout the term of the Lease as HDI may reasonably request;

   f. Ensure that the HDI equipment is not modified, tampered with or relocated without the express written consent of HDI.

   g. Permit HDI to establish its ownership of and security interest in the HDI equipment furnished under this agreement via a UCC-1 filing (Uniform Commercial Code) filed with the Secretary of State of the State of Florida.

4. Upon completion of the Lease period (demonstration program);

   a. HDI would have no use for some of the accessories furnished in connection with the demonstration program such that their cost would have to be fully written off during the Lease period.

   b. The Lessee would additionally pay the one-time cost of refurbishing the centrifuge and hydraulic scroll drive system.

5. Assuming that HDI's participation as summarized above is acceptable, the estimated rental cost for the equipment and services listed above would be approximately $37,500 per month; excluding any applicable taxes or spare parts consumed during the demonstration period as well as the one-time expense for refurbishing the centrifuge, etc.

5. <u>(Continued)</u>

Please note that HDI would also be pleased to provide information relative to;

a. A longer Lease period, or;

b. A Lease - Purchase option, or;

c. An Outright Purchase of the equipment proposed.

Please let us know if you have interest in any of the alternative programs summarized above.

During our telephone conversation on January 25 you requested that I also provide you with information relative to the supply of two (2) smaller centrifuges and related ancillary equipment, which system would provide you with greater operational flexibility and potential standby capacity. Please be advised that I have requested information from Humboldt Wedag at it's headquarters as to the availability of two (2) Humboldt model S5-1 centrifuges (bowl diameter x length - 44" x 132") and will provide that information as soon as it become available. For your information, based upon present conditions it is doubtful that we could supply two of the smaller units complete with all required ancillary equipment within the timeframe you are contemplating. Second, the cost of such a system would undoubtedly be considerably higher than estimated above for the S6-1 system as proposed.

I trust that you will find the information contained in this letter to be self-explanatory and sufficient to meet your present needs. Should you have any questions which I may be able to answer, please do not hesitate to be in contact with us as necessary.

Very truly yours,
Humboldt Decanter, Inc.

Stephen H. Silverman

Stephen H. Silverman
General Manager

Enclosures

CAMP DRESSER & McKEE INC.

RIVER SEDIMENT PROJECT

PILOT PLANT INVESTIGATION

TEST SITE: T.J. STOKES PARK
JACKSONVILLE, FLORIDA

TEST REPORT

DEWATERING OF RIVER BOTTOM DREDGE MATERIAL

Prepared by: Humboldt Decanter, Inc.

INTRODUCTION

CAMP DRESSER & McKEE INC., initiated a pilot plant investigation to determine the feasibility of using a centrifuge for dewatering river bottom sediment in an attempt to clean up polluted water ways. Humboldt Decanter was invited to demonstrate the Centripress with the expectation of the driest possible cake and removal of the metals and nutrients.

A pilot study of this type has not been investigated before, thus all of the acquired test results will need to be analyzed for many different strategies. This particular report will explain the functions of the centrifuge and how different test results were obtained. It must be kept in mind that due to economics, any one of the test results could be the best for this application.

OBJECTIVES

Going into the test, the objectives were defined as follows:

1) Obtain the driest possible cake.

2) Minimize polymer usage.

3) Produce a series of tests without the use of polymer.

4) Demonstrate the best possible recovery of suspended solids.

5) Obtain the highest possible sludge flow rate.

TEST EQUIPMENT

The dewatering unit provided by Humboldt Decanter was the Centripress 2-1 with automatic analog hydraulic drive mounted on a standard 35 ft. enclosed trailer. Ancillary equipment consisted of sludge and polymer feed pumps, a polymer mixing station with dual stirred tanks, dewatered cake conveyer, and controls.

TEST PROCEDURES

CDM set the sample testing procedure to run the centrifuge at a particular setting for 30 minutes and then take the first set of samples. The equipment settings would not be changed until a second and third set of samples were taken, at 15 minutes intervals after the first. These three sets of samples constitutes one series of tests. Following the initial series of tests, one variable of the centrifuge would be changed and the second series of tests started.

The laboratory contracted by CDM allowed a total of 18 samples per day to be analyzed. This limited our tests to 6 series per day since each test included samples taken of the feed material, centrate and, cake.

Sludge (river sediment) was provided to Humbolt's regulated pump by CDM from a day tank. The test was divided into several parts utilizing as many different centrifuge variables as time permitted. At the beginning of each series of tests I explained the variables of the centrifuge and the the theoretical results. A decision was then made as to the direction to proceed.

Initial tests using polymer were run at identical equipment settings but using the three different polymers. These tests were used as comparisons to select the best polymer to use during more extensive testing.

During the testing period the variables that were changed to produce different results were the G-force, sludge flow rate, differential speed of the conveyor, polymer dose rate and, polymer concentration. Due to the restricted time limit of this test the pond depth in the bowl was changed but, not used as a comparison test.

RESULTS

All of the results obtained are recorded in the attached tables. All calculations are based on total suspended solids (TSS) except cake solids which are reported as total solids (TS).

Before we can interrupt the test results I must explain a few of the "test series." The reason for running a series of three tests at identical equipment settings was to allow for inconsistencies in laboratory analysis, feed material or, mechanical problems. This would allow at least two comparable results for plotting graphs. The few "test series" that should be explained are as follows:

Series # 3 and 32

Includes test numbers 7 & 8 and 91 & 92 and, due to the strainer in the day tank being plugged a third set of samples was unattainable. These series should be included in all analysis.

Series # 18

Includes test number 51 and should be omitted from any analysis. The remaining two samples were unattainable since the feed material had been exhausted.

Series # 40 and 43

Includes test numbers 114 and 121,122 &, 123. Series number 40 is incomplete due to the centrate tubes in the centrifuge being plugged. But, test number 114 can be used to replace test number 123 since all equipment settings are identical. The results of test number 123 fall out of line due to the polymer tank being empty.

The data tables are compiled in the order the tests were run but, for an easier interpretation they can be sub-divided into three groups as follows:

Series # 1 - 8 and 39 - 42

These series of tests were conducted with many of the variables but, all of them were run without polymer.

Series # 9 - 27

The underlying reason for these series was for the comparison of the three polymers. The three polymers used were a Nalco - 7182, Allied Colloids - Percol 726 and 727. The test results show that the recovery levels using the Nalco - 7182 were consistently lower than either of the Allied Colloids products. The % cake dryness was also consistently lower. When comparing the two Percol products the results were much closer, with the Percol 727 performing slightly better than the 726. The analysis of these initial tests allowed us to run more extensive tests the second week by using only the Percol 727 polymer.

Series # 28 - 38 and 43

These tests were run using as many variables as time would permit after determining that Allied Colloids, Percol 727 polymer produced the best results.

Series # 13,14,16,19,21,23,24 and,26

Although these series of tests were initially used for comparison of polymers, they should also be used for the analysis of tests involving Allied Colloids 727 polymer.

1. <u>Effect of G-force on recovery without polymer:</u>

While performing the tests it was visually impossible to determine if the centrate would be acceptable. But, as the test analysis prove, the recovery level increases with the G-force. The recovery levels went from a low of 42% to a high of almost 68%. Tests were run at four different G levels with an approximate 25% increase in recovery between the 500 G's and 2600 G's.

2. <u>Effect of G-force on recovery using .05% concentration of polymer:</u>

Due to the limited time structure for this test only one series of tests was run using the .05% concentration of polymer. These three tests were also run at the 500 G level. The results were very consistent at over 99.8% recovery for all three tests.

3. <u>Effect of G-force on recovery using .1% concentration of polymer:</u>

While looking at the results of just the Percol 727 polymer the analysis show that virtually all of the recovery levels are over 99%. Even, the three tests run at 500 G's are over 99%.

4. <u>Effect of G-force on recovery using .2% concentration of polymer:</u>

Again, looking at just the 727 polymer we consistently achieved recovery levels in the high 90% range. At the 500 G level we had six test results over 99% recovery.

5. <u>Effect of G-force on cake, without polymer:</u>

Surprisingly higher cake solids were achieved at the lower G levels. The results prove that at 1000 and 2600 G's we averaged cakes between 27% and 37%. At the lower G levels of 500 and 750 cake solids results were between 43% to over 50%.

6. <u>Effect of G-force on cake, .05% concentration polymer:</u>

Using only the one series of three tests the cake solids results were consistent, averaging 25.4%. The three tests were run at the 500 G force.

7. <u>Effect of G-force on cake, .1% concentration polymer:</u>

Several series of tests were performed at the .1% concentration of polymer using four different G-forces. At the higher G levels of 1100 and 2600 all of the cake solids were between 27% and 33%. At 500G's the results were slightly lower averaging 25.6% cake solids. The best results were at 750 G's with two of the three tests averaging 43.6%.

8. <u>Effect of G-force on cake, .2% concentration polymer:</u>

The effect of a stronger polymer solution did not show significantly better results at 1100 and 2600 G's. At the 2600 G level fifteen tests were run and only three cake solids placed higher than the same G's using a .1% concentration. While running 1100 G's the results were virtually the same as the lighter .1% solution. At 500 and 750 G's the cake solids averaged 28.6%.

9. <u>Effect of polymer lbs/ton on recovery:</u>

When reviewing the results it becomes obvious that at any of the four G-forces tested and at any of the polymer concentrations tried a 99%+ recovery level can be obtained. But, the results also show that at the lighter polymer concentrations of .1% and .05%, less polymer lbs/ton are needed to reach the 99%+ recovery level. We also found that using the lighter concentrations and, 750 or 500 G's the lbs/ton of polymer used can be lowered to around 3 lbs/ton and still obtain a 99%+ recovery level.

10. Hydraulic pressure / Differential speed:

Due to the extremely high solids content of the feed stream the differential speed was run at higher RPM's for the majority of the tests. The high differential was essential for an acceptable recovery level. It was also noted that lowering the differential did not improve the cake dryness but, did lower the percentage of recovery. While performing the tests with polymer there was a distinct cut-off point, where if the differential speed was set to low, the centrate went totally black. For the period of time allowed for these tests I was unable to run a grayish or translucent centrate. It was either a very clear centrate or totally black.

Explanation of PHOTOGRAPHS

1) The small dredger used to supply the sediment. The photo was taken during the ebb tide, concequntly the dredge was immobile at the time. The surrounding river bottom is the sediment that the dredger sucked up, down to approximately six feet.

2) A view of the Centripress CP -2 through the trailer doors.

3) The feed material being pumped from the dredger into the holding tank.

4) An overview of the project site. From right to left:

   Two sealed trailers used as holding tanks.

   Above the trailers is the valve and pumping station.

   In the center is the day tank that was continually recirculated to the holding tank.

   Humboldt's test trailer.

5) The dried cake as it is discharged from the centrifuge. The cake shown in the photo is over 35% TS.

6) The centrate as it is discharged from the centrifuge. The centrate shown is over a 99% recovery level.

7) A view inside the day tank. On the right side is the suction screen that did cause problems with

plugging from time to time.

8) A photograph of the dumpster having been overloaded with the dried cake material

CONCLUSION

SUMMARY

We must realize that as extensive as the tests performed for this report seem, that only the surface has been touched. Many conclusions can be drawn from these tests but, they also tell us that better results might be obtained with a more economical approach. This means if we had more time for this test or future testing, we might be able to obtain acceptable results at low G-forces and minimum amounts of polymer or no polymer used at all.

The majority of statements in this report about "results" lean toward the 500 G force. There are two basic reasons for emphasizing the results at the lowest possible G force. The first being, the test results themselves. In most cases we obtained equal or better cakes, recovery levels and, less polymer lb/ton used. The second being economics. This meaning, maintenance and wear of the centrifuge and peripheral equipment. River bottom sediment usually contains high amounts of sand and other abrasives that will cause premature were of internal parts of the centrifuge and pumps. Two methods of prolonging the wear due to abrasives are first; use a hydrocyclone ahead of the centrifuge and second; operate the centrifuge at the lowest possible G-force with acceptable results.

ACKNOWLEDGMENTS

Humboldt Decanter Inc., gratefully acknowledges the cooperation and assistance of the Camp Dresser & McKee Inc. staff, who were associated with the test, in insuring that the test ran smoothly and reached a successful conclusion. The personnel involved with this pilot study were by far the most knowledgable and energetic that this writer has ever worked with.

CAMP DRESSER & McKEE INC.

TEST SERIES NUMBER	1			2			3		4	
TEST NUMBER	1	2	3	4	5	6	7	8	9	10
DATE	11/1	11/1	11/1	11/1	11/1	11/1	11/1	11/1	11/1	11/1
TIME	10:15	10:30	10:45	12:00	12:15	12:30	1:00	1:15	4:30	4:45
MACHINE TYPE	CENTRIPRESS CP 2-1									
BOWL SIZE	18 x 54									
BOWL SPEED	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200
G-FORCE	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617
DIFFERENTIAL (RPM)	4.7	4.7	4.7	2.9	2.9	2.9	7.1	7.1	7.1	7.1
POOL (MM)	274	274	274	274	274	274	274	274	274	274
HYD. PRESSURE (BAR)	30	30	30	60	70	65	30	30	20	20
SLUDGE TYPE	RIVER SEDIMENT									
FLOW RATE (GPM)	28.92	28.78	27.33	29.39	30.07	35.43	29.88	30.30	29.07	29.79
SOLIDS CONC'N (%)	9.065	9.160	7.800	9.660	10.430	9.830	9.930	9.220	8.190	9.430
VOLATILE SOLIDS (%)	17.540	20.633	16.282	16.149	16.107	18.006	16.717	18.330	14.652	13.680
INORGANICS (%)	82.460	79.367	83.718	83.851	83.893	81.994	83.283	81.670	85.348	86.320
POLYMER TYPE										
RATE (GPM)	0.0									
CONCENTRATION (%)	0.00									
ADDITION PT. (FT)										
LB/HOUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RATE (LB/HR D.S.)	1311.79	1319.16	1066.75	1420.82	1569.25	1743.00	1484.68	1397.84	1191.51	1405.91
CAKE (%TS)	35.70	37.80	38.80	38.00	38.80	22.60	37.60	31.40	32.80	35.40
CENTRATE (%TSS)	4.890	4.830	4.910	4.680	4.680	4.500	4.530	4.520	4.180	4.450
CAKE VOLATILES (%)	13.45	13.76	16.49	15.26	15.98	15.93	14.36	15.29	15.24	14.69
CAKE INORGANICS (%)	86.55	86.24	83.51	84.74	84.02	84.07	85.64	84.71	84.76	85.31
CENT. VOLATILES (%)	23.52	25.05	24.64	25.43	24.57	20.67	21.19	22.35	22.97	22.25
CENT. INORGANICS (%)	76.48	74.95	75.36	74.57	75.43	79.33	78.81	77.65	77.03	77.75
RECOVERY (%)	53.37	54.20	42.42	58.79	62.69	67.70	61.83	59.55	56.11	60.40
POLYMER (LB/TON)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	5			6			7			8		
11	12	13	14	15	16	17	18	19	20	21	22	23
11/1 5:00	11/2 10:15	11/2 10:30	11/2 10:45	11/2 11:30	11/2 11:45	11/2 12:00	11/2 12:30	11/2 12:45	11/2 1:00	11/2 2:15	11/2 2:30	11/2 2:45
3200	3200	3200	3200	2000	2000	2000	2000	2000	2000	2000	2000	2000
2617	2617	2617	2617	1022	1022	1022	1022	1022	1022	1022	1022	1022
7.1	2.9	2.9	2.9	2.9	2.9	2.9	7.1	7.1	7.1	7.1	7.1	7.1
274	274	274	274	274	274	274	274	274	274	274	274	274
20	55	50	50	20	20	20	10	10	10	10	10	10
30.97	18.42	17.75	17.61	18.08	17.32	18.47	61.62	18.98	18.31	26.86	27.55	26.67
9.740	11.200	10.255	10.420	10.130	9.920	10.020	13.100	10.090	9.700	8.790	9.130	8.900
13.758	13.304	17.065	15.835	16.288	13.911	17.465	14.122	19.524	20.000	21.388	20.920	20.225
86.242	86.696	82.935	84.165	83.712	86.089	82.535	85.878	80.476	80.000	78.612	79.080	79.775
										7182	7182	7182
										3.7	3.7	3.7
										.10	.10	.10
										6	6	6
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	1.85	1.85
1509.68	1032.52	911.01	918.41	916.25	859.94	926.27	4039.34	958.22	888.82	1181.46	1258.74	1187.72
32.00	34.60	35.40	39.00	31.20	36.00	32.00	15.60	28.00	30.40	25.20	26.20	26.80
4.420	5.860	5.640	5.440	5.810	5.880	4.930	5.330	5.340	5.130	4.320	4.010	4.250
16.25	16.47	17.51	17.44	19.23	17.22	18.13	17.95	16.43	15.13	16.67	16.03	19.40
83.75	83.53	82.49	82.56	80.77	82.78	81.88	82.05	83.57	84.87	83.33	83.97	80.60
24.21	23.72	23.58	24.26	23.24	26.02	21.70	22.33	22.85	22.61	22.45	22.69	23.29
75.79	76.28	76.42	75.74	76.76	73.98	78.30	77.67	77.15	77.39	77.55	77.31	76.71
63.37	57.40	53.53	55.54	52.40	48.68	60.05	90.10	58.17	56.68	54.26	60.15	55.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.13	2.94	3.12

TEST SERIES NUMBER	9			10			11			12	
TEST NUMBER	24	25	26	27	28	29	30	31	32	33	34
DATE	11/2	11/2	11/2	11/2	11/2	11/2	11/3	11/3	11/3	11/3	11/3
TIME	3:30	3:45	4:00	4:30	4:45	5:00	1:15	1:30	1:45	2:40	2:55
MACHINE TYPE	CENTRIPRESS CP 2-1										
BOWL SIZE	18 x 54										
BOWL SPEED	2500	2500	2500	3200	3200	3200	3200	3200	3200	3200	3200
G-FORCE	1598	1598	1598	2617	2617	2617	2617	2617	2617	2617	2617
DIFFERENTIAL (RPM)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
POOL (MM)	274	274	274	274	274	274	262	262	262	262	262
HYD. PRESSURE (BAR)	20	20	20	35	35	40	40	40	40	90	95
SLUDGE TYPE	RIVER SEDIMENT										
FLOW RATE (GPM)	25.95	26.23	26.73	25.47	24.94	25.58	27.24	25.94	26.61	30.20	29.72
SOLIDS CONC'N (%)	8.830	8.600	8.890	9.050	8.100	8.120	8.775	8.530	9.350	9.390	9.130
VOLATILE SOLIDS (%)	19.819	15.698	15.523	14.917	16.049	16.995	17.151	18.406	18.289	15.868	15.991
INORGANICS (%)	80.181	84.302	84.477	85.083	83.951	83.005	82.849	81.594	81.711	84.132	84.009
POLYMER TYPE	7182	7182	7182	7182	7182	7182	7182	7182	7182	726	726
RATE (GPM)	3.8	3.8	3.8	3.8	3.7	3.7	3.6	3.6	3.6	3.7	3.7
CONCENTRATION (%)	.10	.10	.10	.10	.10	.10	.20	.20	.20	.20	.20
ADDITION PT. (FT)	6	6	6	6	6	6	6	6	6	6	6
LB/HOUR	1.90	1.90	1.90	1.90	1.85	1.85	3.60	3.60	3.60	3.70	3.70
RATE (LB/HR D.S.)	1146.45	1128.59	1189.17	1153.65	1010.83	1039.33	1196.17	1107.31	1244.90	1418.95	1357.92
CAKE (%TS)	29.00	28.80	29.60	34.20	34.00	32.80	27.80	31.10	29.40	31.00	30.00
CENTRATE (%TSS)	4.240	3.810	3.550	4.060	3.780	3.320	3.570	3.765	4.360	.900	1.320
CAKE VOLATILES (%)	22.07	16.67	19.59	19.88	18.82	20.12	17.27	17.04	17.01	20.65	22.00
CAKE INORGANICS (%)	77.93	83.33	80.41	80.12	81.18	79.88	82.73	82.96	82.99	79.35	78.00
CENT. VOLATILES (%)	23.11	23.62	23.10	23.65	21.96	23.19	22.13	22.58	22.71	23.33	23.48
CENT. INORGANICS (%)	76.89	76.38	76.90	76.35	78.04	76.81	77.87	77.42	77.29	76.67	76.52
RECOVERY (%)	53.73	57.77	62.65	55.97	53.22	60.04	62.66	57.46	56.19	92.07	87.84
POLYMER (LB/TON)	3.32	3.37	3.20	3.30	3.66	3.56	6.02	6.51	5.79	5.22	5.45

	13			14			15			16		
35	36	37	38	39	40	41	42	43	44	45	46	47
11/3	11/3	11/3	11/3	11/3	11/3	11/3	11/4	11/4	11/4	11/4	11/4	11/4
3:10	4:25	4:40	4:55	5:40	5:55	6:10	2:00	2:15	2:30	3:00	3:15	3:30
3200	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200
2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617
7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
262	262	262	262	262	262	262	262	262	262	262	262	262
95	105	110	105	120	120	120	55	55	55	50	50	50
29.62	29.71	27.56	34.02	26.38	28.85	28.65	18.15	17.95	17.33	16.61	17.01	17.67
8.940	8.970	9.010	10.290	9.140	9.470	9.700	10.750	11.035	10.910	10.610	11.160	10.960
16.443	15.273	17.203	15.938	17.505	17.318	15.361	13.488	14.952	15.215	15.834	17.832	17.336
83.557	84.727	82.797	84.062	82.495	82.682	84.639	86.512	85.048	84.785	84.166	82.168	82.664
726	727	727	727	727	727	727	726	726	726	727	727	727
3.7	3.7	3.7	3.7	4.7	4.7	4.7	4.6	4.6	4.6	4.6	4.6	4.6
.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
6	6	6	6	6	6	6	6	6	6	6	6	6
3.70	3.70	3.70	3.70	4.70	4.70	4.70	4.60	4.60	4.60	4.60	4.60	4.60
1325.17	1333.65	1242.68	1751.63	1206.73	1366.93	1390.79	976.23	990.92	946.29	881.85	949.99	969.04
32.80	32.80	41.60	28.40	41.40	31.20	36.00	29.00	30.40	32.10	34.20	34.20	31.20
.300	.250	.307	.096	.802	1.190	.160	.114	.098	.080	.052	.044	.036
19.51	21.95	19.71	17.61	18.84	19.23	18.33	27.59	25.66	23.36	18.71	18.13	18.59
80.49	78.05	80.29	82.39	81.16	80.77	81.67	72.41	74.34	76.64	81.29	81.87	81.41
33.33	28.00	26.08	27.08	20.70	19.33	23.13	35.09	36.73	47.50	40.38	63.64	55.56
66.67	72.00	73.92	72.92	79.30	80.67	76.88	64.91	63.27	52.50	59.62	36.36	44.44
97.17	97.65	96.91	99.31	91.69	89.11	98.56	99.12	99.26	99.37	99.56	99.65	99.72
5.59	5.55	5.96	4.23	7.80	6.88	6.76	9.43	9.29	9.73	10.44	9.69	9.50

17			18	TEST SERIES NUMBER
48	49	50	51	TEST NUMBER
11/4	11/4	11/4	11/4	DATE
4:15	4:30	4:45	5:15	TIME
				MACHINE TYPE
				BOWL SIZE
3200	3200	3200	3200	BOWL SPEED
2617	2617	2617	2617	G-FORCE
7.1	7.1	7.1	7.1	DIFFERENTIAL (RPM)
262	262	262	262	POOL (MM)
35	35	35	35	HYD. PRESSURE (BAR)
				SLUDGE TYPE
10.96	10.51	10.34	10.88	FLOW RATE (GPM)
11.730	11.830	11.940	11.820	SOLIDS CONC'N (%)
18.500	20.034	19.682	20.558	VOLATILE SOLIDS (%)
81.500	79.966	80.318	79.442	INORGANICS (%)
726	726	726	727	POLYMER TYPE
4.6	4.6	4.6	4.7	RATE (GPM)
.20	.20	.20	.20	CONCENTRATION (%)
6	6	6	6	ADDITION PT. (FT)
4.60	4.60	4.60	4.70	LB/HOUR
643.48	622.12	617.50	643.52	RATE (LB/HR D.S.)
31.00	33.60	35.00	31.40	CAKE (%TS)
.108	.135	.140	.058	CENTRATE (%TSS)
18.71	20.83	21.14	21.66	CAKE VOLATILES (%)
81.29	79.17	78.86	78.34	CAKE INORGANICS (%)
46.51	38.89	39.29	56.52	CENT. VOLATILES (%)
53.49	61.11	60.71	43.48	CENT. INORGANICS (%)
99.16	98.91	98.87	99.55	RECOVERY (%)
14.31	14.80	14.91	14.62	POLYMER (LB/TON)

CAMP DRESSER & McKEE INC.

TEST SERIES NUMBER	19			20			21			22
TEST NUMBER	52	53	54	55	56	57	58	59	60	61
DATE	11/7	11/7	11/7	11/7	11/7	11/7	11/7	11/7	11/7	11/7
TIME	10:35	10:50	11:05	11:45	12:00	12:15	2:45	4:00	4:15	4:50
MACHINE TYPE	CENTRIPRESS CP 2-1									
BOWL SIZE	18 x 54									
BOWL SPEED	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200
G-FORCE	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617
DIFFERENTIAL (RPM)	7.1	7.1	7.1	9.4	9.4	9.4	9.4	9.4	9.4	9.4
POOL (MM)	262	262	262	262	262	262	262	262	262	262
HYD. PRESSURE (BAR)	55	50	50	110	110	110	90	95	100	50
SLUDGE TYPE	RIVER SEDIMENT									
FLOW RATE (GPM)	10.81	10.54	10.95	32.91	28.83	30.19	34.10	30.56	32.38	20.05
SOLIDS CONC'N (%)	12.44	12.18	11.91	11.94	12.37	11.67	13.35	12.16	12.18	12.00
VOLATILE SOLIDS (%)	13.59	15.27	15.20	15.49	16.33	16.54	17.30	18.83	18.64	19.42
INORGANICS (%)	86.41	84.73	84.80	84.51	83.67	83.46	82.70	81.17	81.36	80.58
POLYMER TYPE	727	727	727	726	726	726	727	727	727	726
RATE (GPM)	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7
CONCENTRATION (%)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.30
ADDITION PT. (FT)	6	6	6	6	6	6	6	6	6	6
LB/HOUR	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	7.06
RATE (LB/HR D.S.)	672.94	642.24	652.77	1966.50	1784.53	1763.20	2278.11	1859.69	1973.58	1203.86
CAKE (%TS)	33.80	34.60	31.61	29.60	39.00	33.80	29.80	34.60	32.60	27.60
CENTRATE (%TSS)	.060	.074	.073	1.750	2.230	1.820	2.730	1.790	1.085	.165
CAKE VOLATILES (%)	15.98	16.18	16.77	16.89	15.90	17.75	16.78	17.34	16.56	17.39
CAKE INORGANICS (%)	84.02	83.82	83.23	83.11	84.10	82.25	83.22	82.66	83.44	82.61
CENT. VOLATILES (%)	11.42	18.92	22.78	21.71	22.87	21.43	19.05	19.55	15.67	15.15
CENT. INORGANICS (%)	88.58	81.08	77.22	78.29	77.13	78.57	80.95	80.45	84.33	84.85
RECOVERY (%)	99.55	99.42	99.44	88.87	84.37	87.09	85.01	87.96	93.12	98.97
POLYMER (LB/TON)	13.68	14.34	14.11	4.68	5.16	5.22	4.04	4.95	4.67	11.72

		23			24		
62	63	64	65	66	67	68	69
11/7 5:05	11/7 5:20	11/7 6:00	11/7 6:15	11/7 6:30	11/7 7:05	11/7 7:20	11/7 7:35
3200	3200	3200	3200	3200	3200	3200	3200
2617	2617	2617	2617	2617	2617	2617	2617
9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
262	262	262	262	262	262	262	262
50	50	50	50	50	50	50	60
19.06	44.92	18.28	17.22	18.01	19.65	20.12	20.11
12.01	10.87	11.52	11.05	11.29	12.34	13.60	12.99
19.40	18.49	18.49	14.03	13.20	12.64	11.47	13.55
80.60	81.51	81.51	85.97	86.80	87.36	88.53	86.45
726	726	727	727	727	727	727	727
4.7	4.7	4.6	4.6	4.6	4.6	4.6	4.6
.30	.30	.30	.30	.30	.10	.10	.10
6	6	6	6	6	6	6	6
7.06	7.06	6.91	6.91	6.91	2.30	2.30	2.30
1145.32	2443.35	1054.02	952.03	1017.36	1213.58	1369.12	1307.27
29.60	14.50	30.80	33.00	31.00	29.60	31.60	30.20
.190	.170	.070	.060	.062	.039	.042	.038
16.89	33.10	16.88	16.97	17.42	18.24	17.72	16.56
83.11	66.90	83.12	83.03	82.58	81.76	82.28	83.44
13.16	11.76	14.29	16.67	12.90	25.84	26.19	26.32
86.84	88.24	85.71	83.33	87.10	74.16	73.81	73.68
98.75	99.48	99.50	99.53	99.54	99.76	99.77	99.78
12.32	5.78	13.10	14.51	13.58	3.79	3.36	3.52

TEST SERIES NUMBER	25			26			27		
TEST NUMBER	70	71	72	73	74	75	76	77	78
DATE	11/8	11/8	11/8	11/8	11/8	11/8	11/8	11/8	11/8
TIME	1:30	1:45	2:00	2:45	3:00	3:15	8:15	8:30	8:45
MACHINE TYPE									
BOWL SIZE									CENTRIPRESS (
BOWL SPEED	1720	1720	1720	1720	1720	1720	2100	2100	2100
G-FORCE	756	756	756	756	756	756	1127	1127	1127
DIFFERENTIAL (RPM)	7.1	7.1	7.1	7.1	7.1	7.1	9.4	9.4	9.4
POOL (MM)	256	256	256	256	256	256	262	262	262
HYD. PRESSURE (BAR)	40	40	35	40	40	40	45	40	45
SLUDGE TYPE									RIVER
FLOW RATE (GPM)	27.66	26.66	26.08	28.89	26.66	25.44	30.13	28.42	30.43
SOLIDS CONC'N (%)	8.65	8.03	6.01	7.49	9.92	8.89	11.25	11.25	11.48
VOLATILE SOLIDS (%)	13.64	14.45	15.88	15.75	15.32	16.76	15.47	16.18	17.68
INORGANICS (%)	86.36	85.55	84.12	84.25	84.68	83.24	84.53	83.82	82.32
POLYMER TYPE	726	726	726	727	727	727	726	726	726
RATE (GPM)	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
CONCENTRATION (%)	.10	.10	.10	.10	.10	.10	.10	.10	.10
ADDITION PT. (FT)	25	25	25	25	25	25	25	25	25
LB/HOUR	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
RATE (LB/HR D.S.)	1197.33	1071.20	784.64	1082.74	1323.39	1131.73	1696.15	1599.06	1747.81
CAKE (%TS)	35.70	37.00	31.00	27.50	42.60	44.60	33.20	38.60	35.00
CENTRATE (%TSS)	.2220	.3580	.1160	.1040	1.1300	1.3300	1.5867	1.5067	.9367
CAKE VOLATILES (%)	15.97	17.03	19.35	13.09	15.02	10.76	13.86	13.08	14.86
CAKE INORGANICS (%)	84.03	82.97	80.65	86.91	84.98	89.24	86.14	86.92	85.14
CENT. VOLATILES (%)	19.82	20.11	18.97	23.08	20.13	21.05	21.01	21.24	20.28
CENT. INORGANICS (%)	80.18	79.89	81.03	76.92	79.87	78.95	78.99	78.76	79.72
RECOVERY (%)	97.68	95.82	98.15	98.80	89.32	85.30	88.30	88.21	93.30
POLYMER (LB/TON)	3.84	4.30	5.87	4.25	3.48	4.07	2.71	2.88	2.63

28			29			30			31		
79	80	81	82	83	84	85	86	87	88	89	90
11/8	11/9	11/9	11/9	11/9	11/9	11/9	11/9	11/9	11/9	11/9	11/9
10:45	11:00	11:15	11:45	12:00	12:15	3:10	3:25	3:40	6:00	6:15	6:30
P 2-1											
		18 x 54									
1720	1720	1720	1720	1720	1720	1720	1720	1720	1720	1720	1720
756	756	756	756	756	756	756	756	756	756	756	756
9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
262	262	262	262	262	262	262	262	262	262	262	262
20	20	20	20	20	20	35	30	30	25	25	25
SEDIMENT											
19.92	18.59	19.12	28.24	24.93	25.18	17.67	20.74	21.23	24.51	24.14	21.39
10.88	10.69	11.57	10.45	9.86	9.47	9.42	13.85	14.21	13.09	12.91	12.52
15.63	16.28	15.99	16.75	18.76	18.80	26.54	18.77	17.87	19.86	19.60	19.33
84.38	83.72	84.01	83.25	81.24	81.20	73.46	81.23	82.13	80.14	80.40	80.67
727	727	727	727	727	727	727	727	727	727	727	727
4.6	4.6	4.6	4.6	4.6	4.6	3.6	3.6	3.6	4.6	4.6	4.6
.20	.20	.20	.20	.20	.20	.20	.20	.20	.10	.10	.10
25	25	25	25	25	25	25	25	25	25	25	25
4.60	4.60	4.60	4.60	4.60	4.60	3.60	3.60	3.60	2.30	2.30	2.30
1084.27	994.33	1107.20	1476.49	1230.00	1192.99	833.10	1437.51	1509.59	1605.69	1559.23	1339.91
25.65	27.90	28.90	24.60	28.30	26.70	29.80	33.20	33.00	24.60	24.60	27.00
.0200	.0253	.0230	.0233	.0233	.0190	.0195	.0175	.0190	.0165	.0165	.0175
17.93	17.56	19.72	19.51	19.79	21.72	20.13	20.48	21.21	13.01	24.39	22.22
82.07	82.44	80.28	80.49	80.21	78.28	79.87	79.52	78.79	86.99	75.61	77.78
26.25	31.62	30.43	28.76	28.76	35.26	30.77	40.00	28.95	45.45	33.33	37.14
73.75	68.38	69.57	71.24	71.24	64.74	69.23	60.00	71.05	54.55	66.67	62.86
99.86	99.81	99.84	99.84	99.81	99.84	99.82	99.91	99.91	99.92	99.92	99.90
8.49	9.26	8.32	6.24	7.49	7.72	8.65	5.01	4.77	2.87	2.95	3.44

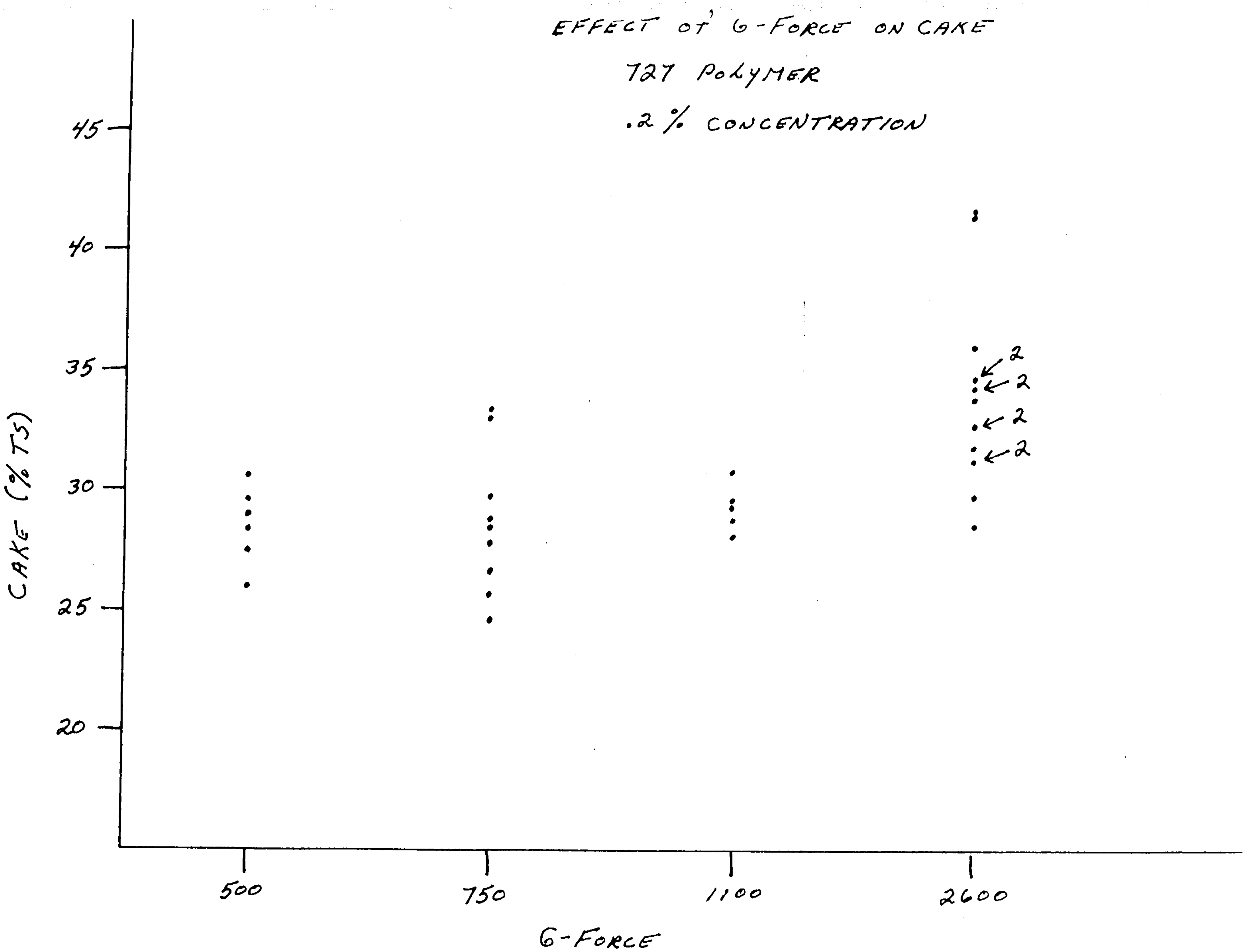
TEST SERIES NUMBER	32		33			34			35		
TEST NUMBER	91	92	93	94	95	96	97	98	99	100	101
DATE	11/9	11/9	11/10	11/10	11/10	11/10	11/10	11/10	11/10	11/10	11/10
TIME	8:15	8:30	11:50	12:05	12:20	2:05	2:20	2:35	3:05	3:20	3:35
-MACHINE TYPE	CENTRIPRESS CP 2-1										
-BOWL SIZE	18 X 54										
BOWL SPEED	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
G-FORCE	1127	1127	1127	1127	1127	1127	1127	1127	1127	1127	1127
DIFFERENTIAL (RPM)	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
POOL (MM)	262	262	262	262	262	262	262	262	262	262	262
HYD. PRESSURE (BAR)	40	40	50	50	50	20	20	20	30	30	35
-SLUDGE TYPE	RIVER SEDIMENT										
FLOW RATE (GPM)	27.08	27.32	26.09	26.41	27.16	17.88	17.35	17.38	23.73	26.19	25.81
SOLIDS CONC'N (%)	12.32	12.00	11.21	10.63	11.19	10.11	9.96	9.86	10.66	12.00	12.25
VOLATILE SOLIDS (%)	19.07	15.13	15.52	15.80	16.80	15.73	16.97	18.05	17.26	17.04	17.71
INORGANICS (%)	80.93	84.87	84.48	84.20	83.20	84.27	83.03	81.95	82.74	82.96	82.29
POLYMER TYPE	727	727	727	727	727	727	727	727	727	727	727
RATE (GPM)	4.6	4.6	3.7	3.7	3.7	4.6	4.6	4.6	4.6	4.6	4.6
CONCENTRATION (%)	.20	.20	.20	.20	.20	.10	.10	.10	.10	.10	.10
ADDITION PT. (FT)	25	25	25	25	25	25	25	25	25	25	25
LB/HOUR	4.60	4.60	3.70	3.70	3.70	2.30	2.30	2.30	2.30	2.30	2.30
RATE (LB/HR D.S.)	1669.41	1639.60	1463.26	1404.83	1520.88	904.49	864.54	857.29	1265.99	1572.59	1582.15
CAKE (%TS)	30.80	29.60	28.00	28.80	29.40	28.20	29.40	29.00	33.80	31.60	31.40
CENTRATE (%TSS)	.0195	.0200	1.7300	.3100	.0800	.0200	.0190	.0230	.0205	.0260	.8150
CAKE VOLATILES (%)	20.78	19.59	18.21	19.44	19.05	17.73	17.69	16.55	16.57	15.82	17.20
CAKE INORGANICS (%)	79.22	80.41	81.79	80.56	80.95	82.27	82.31	83.45	83.43	84.18	82.80
CENT. VOLATILES (%)	35.90	35.00	19.94	20.42	25.00	30.00	31.58	30.43	31.71	35.77	24.54
CENT. INORGANICS (%)	64.10	65.00	80.06	79.58	75.00	70.00	68.42	69.57	68.29	64.23	75.46
RECOVERY (%)	99.88	99.88	88.17	97.79	99.47	99.83	99.84	99.80	99.84	99.83	94.84
POLYMER (LB/TON)	5.52	5.62	5.06	5.27	4.87	5.09	5.32	5.37	3.64	2.93	2.91

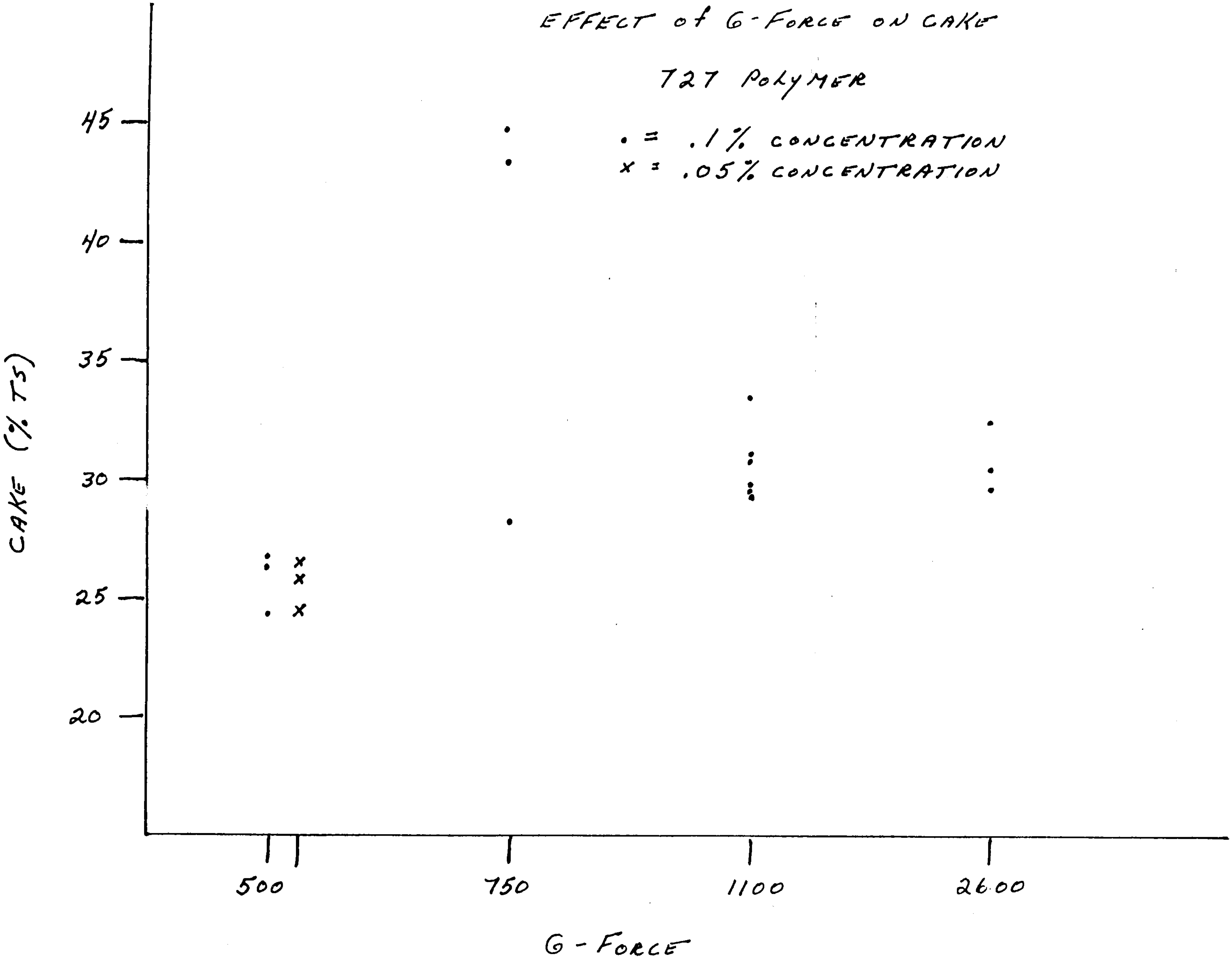
CAMP DRESSER & McKEE INC.

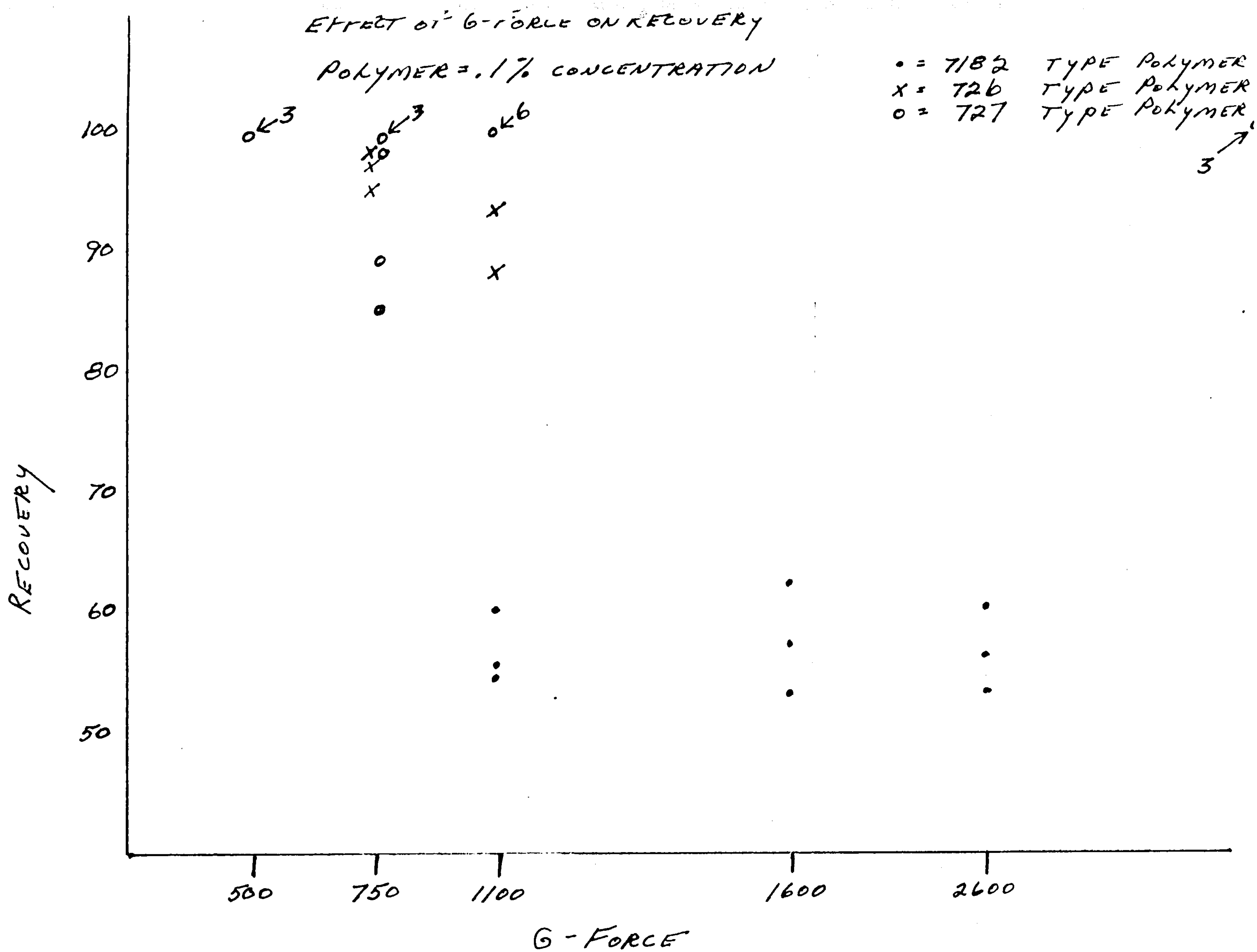
TEST SERIES NUMBER	36			37			38			39
TEST NUMBER	102	103	104	105	106	107	108	109	110	111
DATE	11/10	11/10	11/10	11/10	11/10	11/10	11/10	11/10	11/10	11/11
TIME	4:20	4:35	4:50	5:35	5:50	6:05	6:40	6:55	7:10	12:40
MACHINE TYPE	CENTRIPRESS CP 2-1									
BOWL SIZE	18 x 54									
BOWL SPEED	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
G-FORCE	501	501	501	501	501	501	501	501	501	501
DIFFERENTIAL (RPM)	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	2.4
POOL (MM)	262	262	262	262	262	262	262	262	262	256
HYD. PRESSURE (BAR)	20	20	20	25	25	25	20	20	20	15
SLUDGE TYPE	RIVER SEDIMENT									
FLOW RATE (GPM)	21.26	19.94	18.25	28.19	26.28	26.54	20.60	19.82	19.51	16.70
SOLIDS CONC'N (%)	11.98	12.33	11.37	11.66	11.39	10.99	10.82	11.08	10.72	12.15
VOLATILE SOLIDS (%)	16.94	16.71	14.86	14.67	15.19	16.47	16.17	16.52	17.44	15.39
INORGANICS (%)	83.06	83.29	85.14	85.33	84.81	83.53	83.83	83.48	82.56	84.[illegible]
POLYMER TYPE	727	727	727	727	727	727	727	727	727	
RATE (GPM)	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	
CONCENTRATION (%)	.20	.20	.20	.20	.20	.20	.10	.10	.10	
ADDITION PT. (FT)	25	25	25	25	25	25	25	25	25	
LB/HOUR	4.60	4.60	4.60	4.60	4.60	4.60	2.30	2.30	2.30	0.00
RATE (LB/HR D.S.)	1274.51	1230.46	1038.14	1644.93	1497.66	1459.59	1115.57	1098.70	1046.67	1015.64
CAKE (%TS)	26.00	29.00	30.60	27.50	29.70	28.30	24.40	26.30	26.00	51.30
CENTRATE (%TSS)	.0266	.0307	.0264	.0293	.0900	.0370	.0200	.0207	.0220	7.7000
CAKE VOLATILES (%)	19.23	18.62	18.30	17.45	18.52	18.73	18.85	20.15	20.00	11.89
CAKE INORGANICS (%)	80.77	81.38	81.70	82.55	81.48	81.27	81.15	79.85	80.00	88.11
CENT. VOLATILES (%)	32.71	32.57	30.36	31.74	26.67	35.14	23.50	22.71	24.09	19.35
CENT. INORGANICS (%)	67.29	67.43	69.64	68.26	73.33	64.86	76.50	77.29	75.91	80.65
RECOVERY (%)	99.84	99.81	99.81	99.82	99.40	99.75	99.87	99.86	99.84	43.09
POLYMER (LB/TON)	7.22	7.48	8.87	5.60	6.15	6.31	4.13	4.19	4.40	0.00

		40	TEST SERIES NUMBER	41			42			43	
112	113	114	TEST NUMBER	115	116	117	118	119	120	121	122
11/11	11/11	11/11	DATE	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11
12:55	1:10	2:50	TIME	6:30	6:45	7:00	7:30	7:45	8:00	8:55	9:10
---	---	---	MACHINE TYPE	---	---	---	---	---	---	---	---
---	---	---	BOWL SIZE	---	---	---	---	---	---	---	---
1400	1400	1400	BOWL SPEED	1720	1720	1720	1720	1720	1720	1400	1400
501	501	501	G-FORCE	756	756	756	756	756	756	501	501
2.4	2.4	8.8	DIFFERENTIAL (RPM)	3.5	3.5	3.5	3.5	3.5	3.5	9.4	9.4
256	256	256	POOL (MM)	256	256	256	256	256	256	256	256
15	15	15	HYD. PRESSURE (BAR)	15	15	15	25	25	25	15	15
---	---	---	SLUDGE TYPE	---	---	---	---	---	---	---	---
16.97	17.06	18.83	FLOW RATE (GPM)	17.58	18.56	18.01	27.72	27.46	26.96	17.79	16.80
12.13	11.93	10.01	SOLIDS CONC'N (%)	10.31	10.80	10.19	10.08	9.96	9.14	8.73	8.27
15.91	17.27	14.79	VOLATILE SOLIDS (%)	14.35	13.70	14.62	15.97	15.86	16.96	18.44	17.65
84.09	82.73	85.21	INORGANICS (%)	85.65	86.30	85.38	84.03	84.14	83.04	81.56	82.35
		727	POLYMER TYPE							727	727
		4.6	RATE (GPM)							4.6	4.6
		.05	CONCENTRATION (%)							.05	.05
		25	ADDITION PT. (FT)							25	25
0.00	0.00	1.15	LB/HOUR	0.00	0.00	0.00	0.00	0.00	0.00	1.15	1.15
1029.82	1018.48	943.16	RATE (LB/HR D.S.)	906.79	1002.80	918.12	1398.06	1368.53	1233.28	776.94	695.06
47.30	44.25	25.60	CAKE (%TS)	34.50	32.40	31.20	44.40	48.50	51.00	24.60	26.10
7.5200	7.4900	.0220	CENTRATE (%TSS)	6.1550	5.6800	5.9800	6.3500	6.1700	5.8500	.0100	.0100
15.64	11.30	17.97	CAKE VOLATILES (%)	11.59	11.73	14.74	8.33	9.07	9.41	16.67	16.86
84.36	88.70	82.03	CAKE INORGANICS (%)	88.41	88.27	85.26	91.67	90.93	90.59	83.33	83.14
20.08	20.83	22.73	CENT. VOLATILES (%)	21.53	24.47	23.75	24.72	24.47	23.76	23.00	17.00
79.92	79.17	77.27	CENT. INORGANICS (%)	78.47	75.53	76.25	75.28	75.53	76.24	77.00	83.00
45.19	44.80	99.82	RECOVERY (%)	49.05	57.49	51.11	43.18	43.60	40.66	99.90	99.89
0.00	0.00	2.44	POLYMER (LB/TON)	0.00	0.00	0.00	0.00	0.00	0.00	2.96	3.31

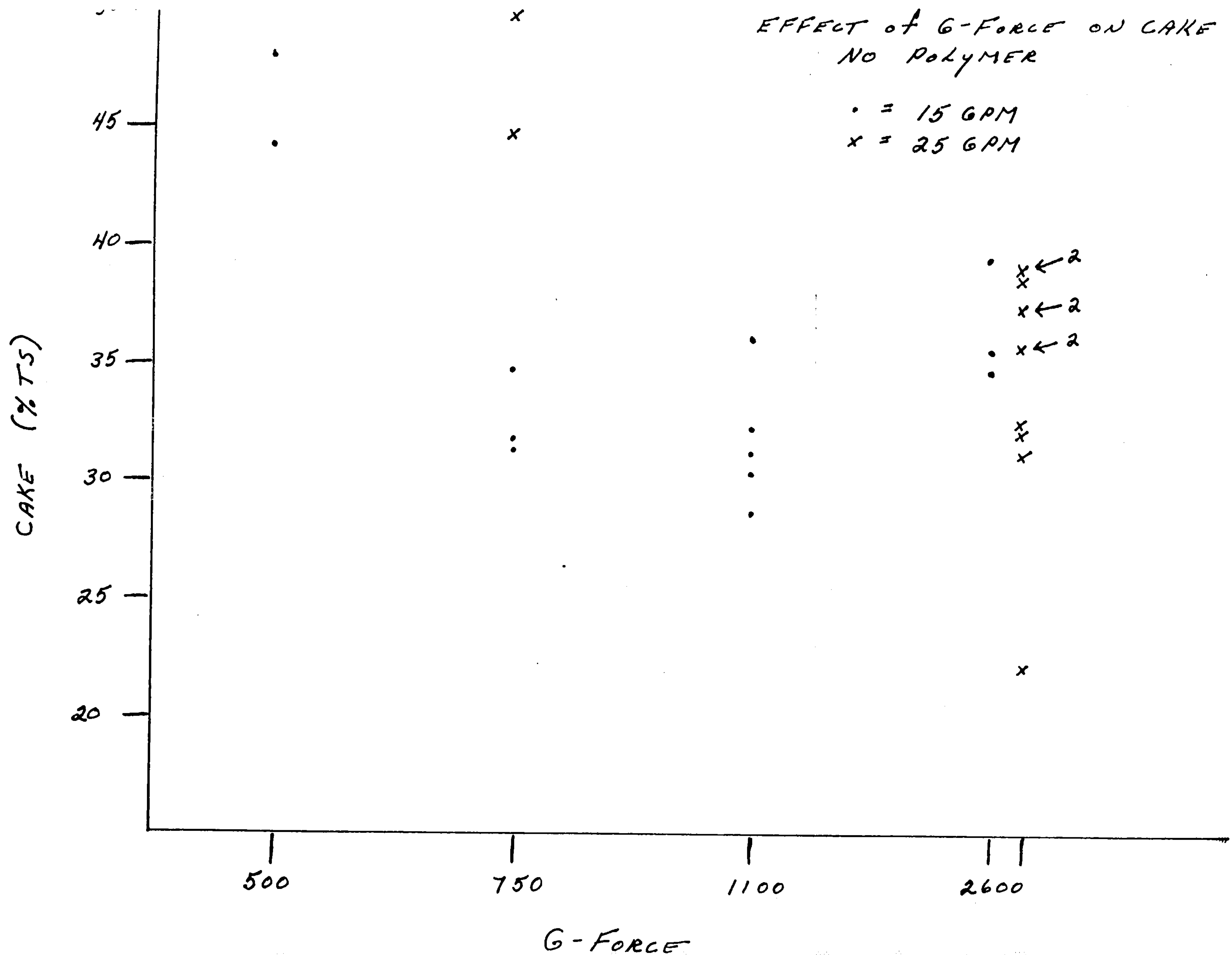
	TEST SERIES NUMBER
123	TEST NUMBER
11/11	DATE
9:25	TIME
---------	MACHINE TYPE
---------	BOWL SIZE
1400	BOWL SPEED
501	G-FORCE
9.4	DIFFERENTIAL (RPM)
256	POOL (MM)
15	HYD. PRESSURE (BAR)
---------	SLUDGE TYPE
25.93	FLOW RATE (GPM)
8.55	SOLIDS CONC'N (%)
17.89	VOLATILE SOLIDS (%)
82.11	INORGANICS (%)
727	POLYMER TYPE
4.6	RATE (GPM)
.05	CONCENTRATION (%)
25	ADDITION PT. (FT)
1.15	LB/HOUR
1109.29	RATE (LB/HR D.S.)
15.33	CAKE (%TS)
.0100	CENTRATE (%TSS)
17.83	CAKE VOLATILES (%)
82.17	CAKE INORGANICS (%)
16.00	CENT. VOLATILES (%)
84.00	CENT. INORGANICS (%)
99.93	RECOVERY (%)
2.08	POLYMER (LB/TON)

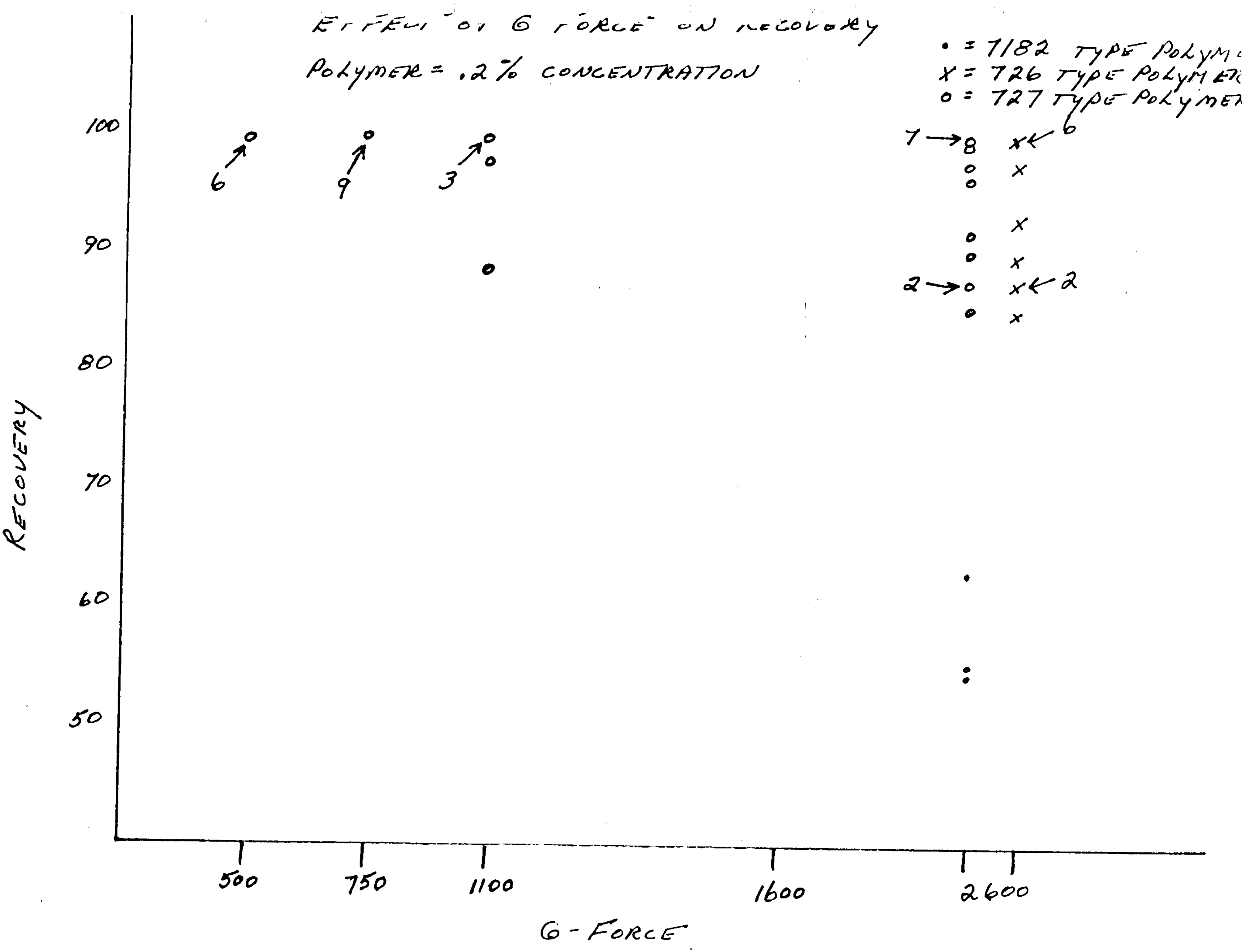

EFFECT OF G-FORCE ON CAKE
727 POLYMER
.2 % CONCENTRATION
45
40
35
30
25
20
CAKE (% TS)
2
2
2
2
500
750
1100
2600
G-FORCE

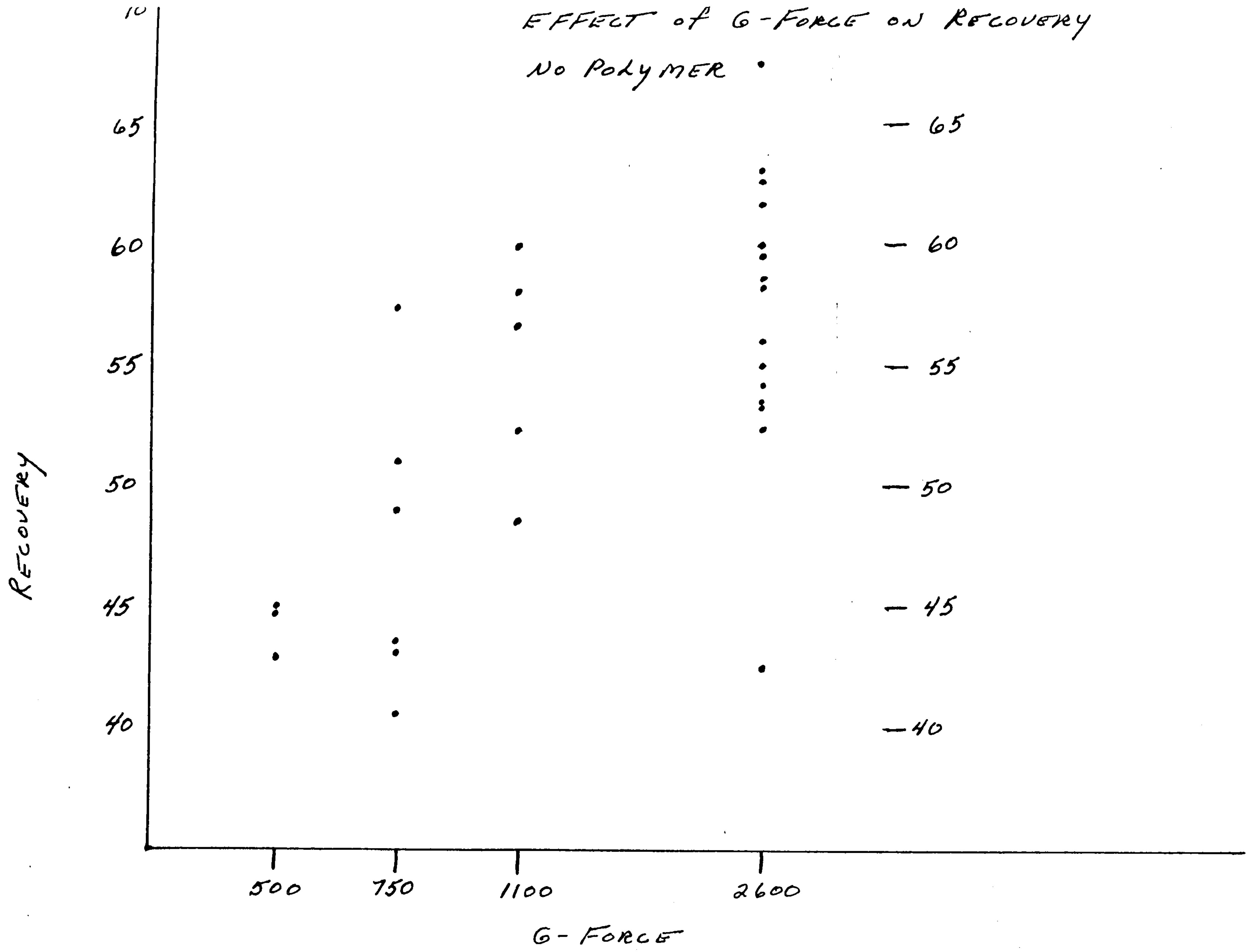

EFFECT of G-FORCE ON CAKE
727 POLYMER
• = .1% CONCENTRATION
x = .05% CONCENTRATION
45
40
35
30
25
20
CAKE (% TS)
500
750
1100
2600
G-FORCE

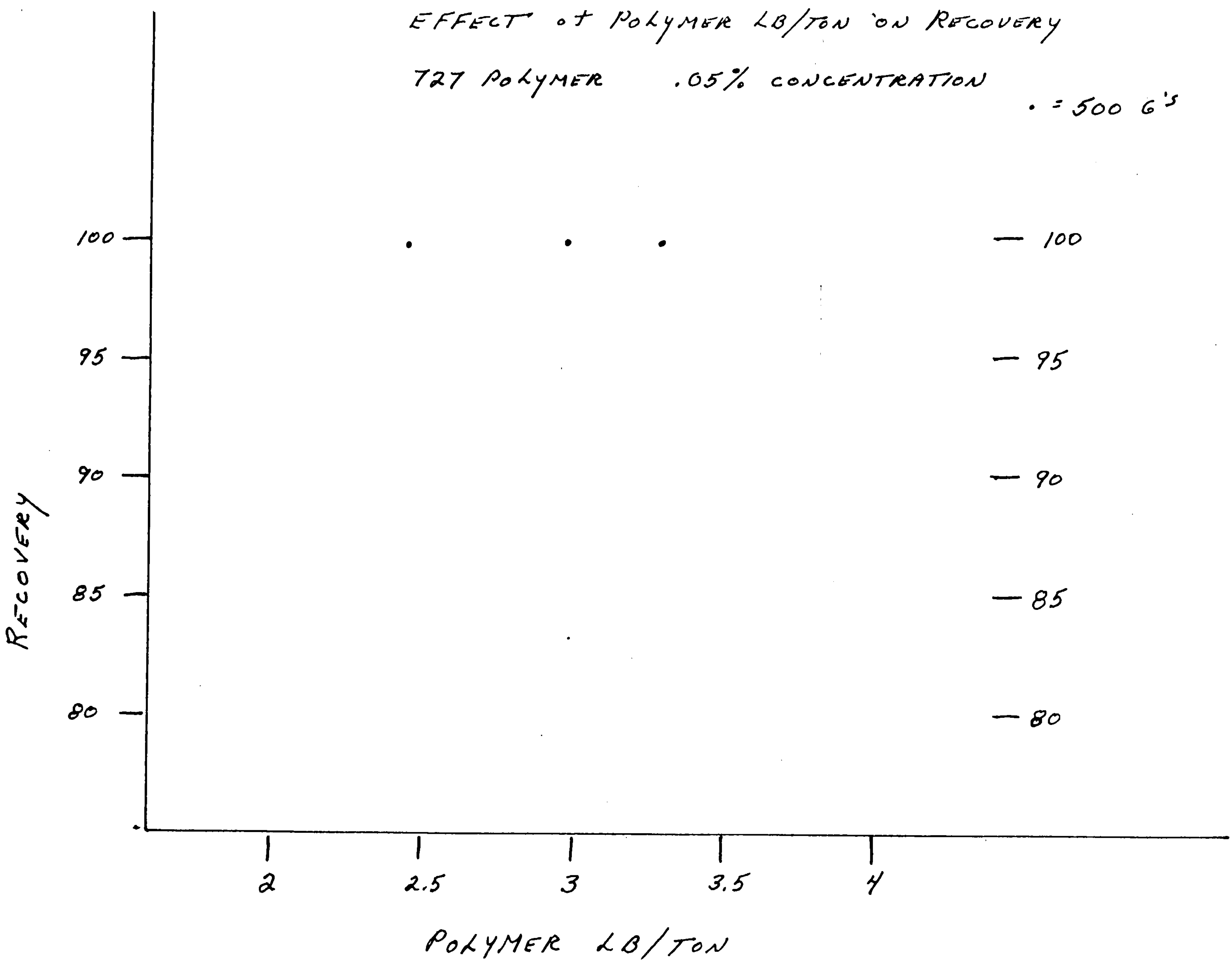


EFFECT OF G-FORCE ON RECOVERY
POLYMER = .1% CONCENTRATION
• = 7182 TYPE POLYMER
X = 726 TYPE POLYMER
O = 727 TYPE POLYMER
3
6
100
90
80
70
60
50
RECOVERY
500
750
1100
1600
2600
G-FORCE

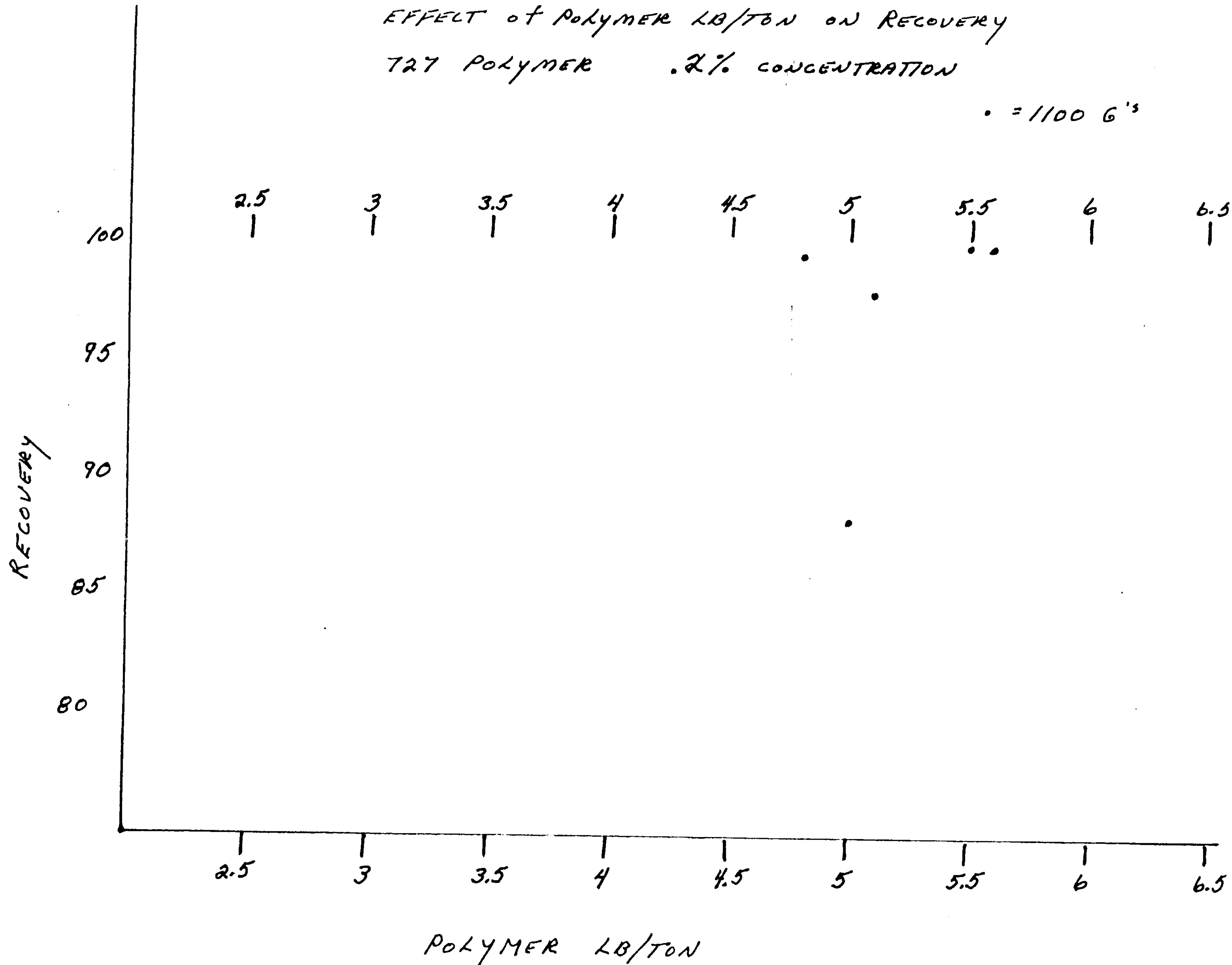

EFFECT of G-FORCE ON CAKE
NO POLYMER
• = 15 GPM
x = 25 GPM
45
40
35
30
25
20
CAKE (% TS)
2
2
2
500
750
1100
2600
G-FORCE

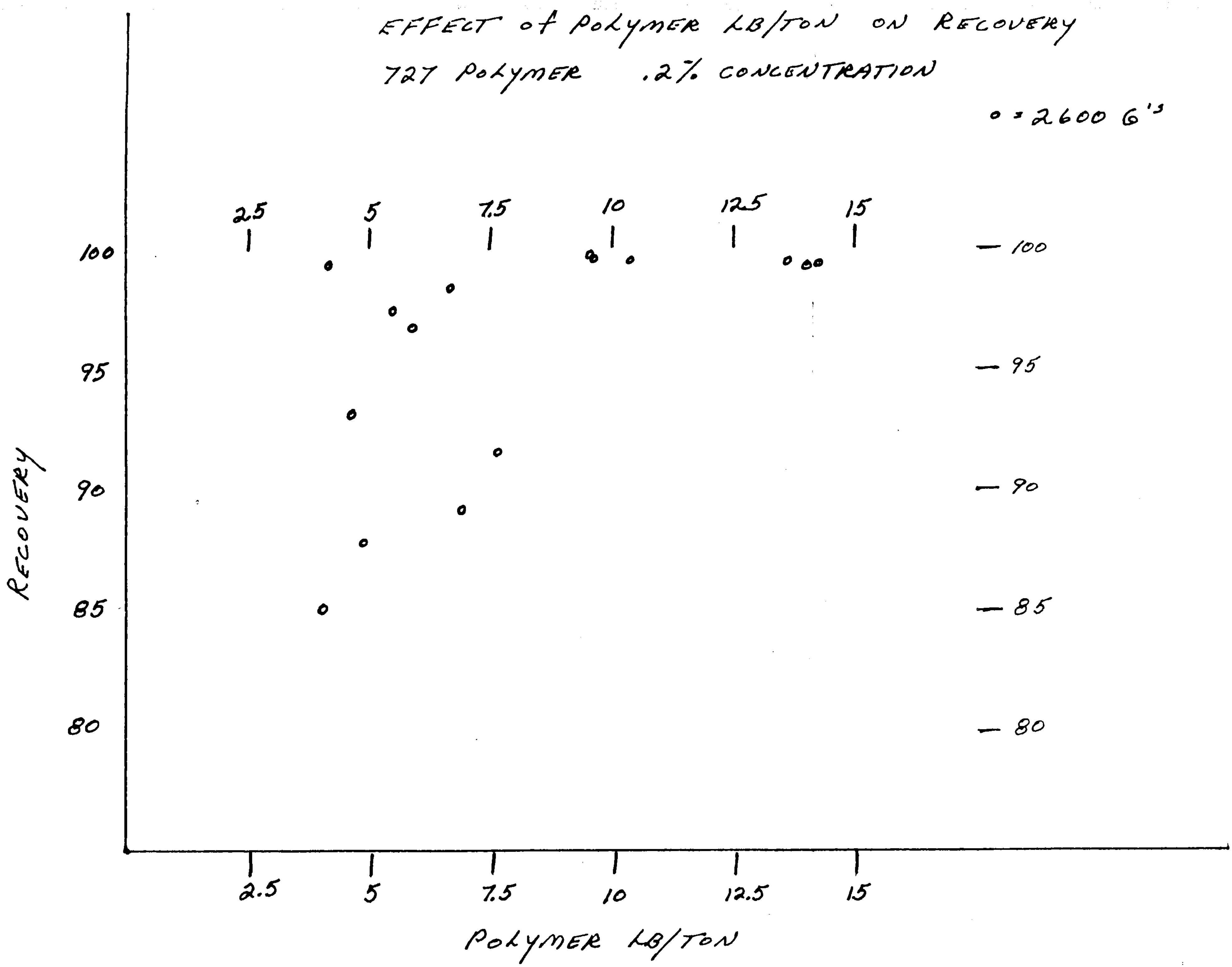

EFFECT OF G FORCE ON RECOVERY
POLYMER = .2% CONCENTRATION
• = 7182 TYPE POLYM
X = 726 TYPE POLYMER
o = 727 TYPE POLYMER
100
90
80
70
60
50
RECOVERY
500
750
1100
1600
2600
G - FORCE


EFFECT of G-FORCE ON RECOVERY
NO POLYMER
RECOVERY
G-FORCE
500
750
1100
2600
40
45
50
55
60
65
70



EFFECT OF POLYMER LB/TON ON RECOVERY
727 POLYMER .05% CONCENTRATION
• = 500 G's
RECOVERY
100
95
90
85
80
2
2.5
3
3.5
4
POLYMER LB/TON

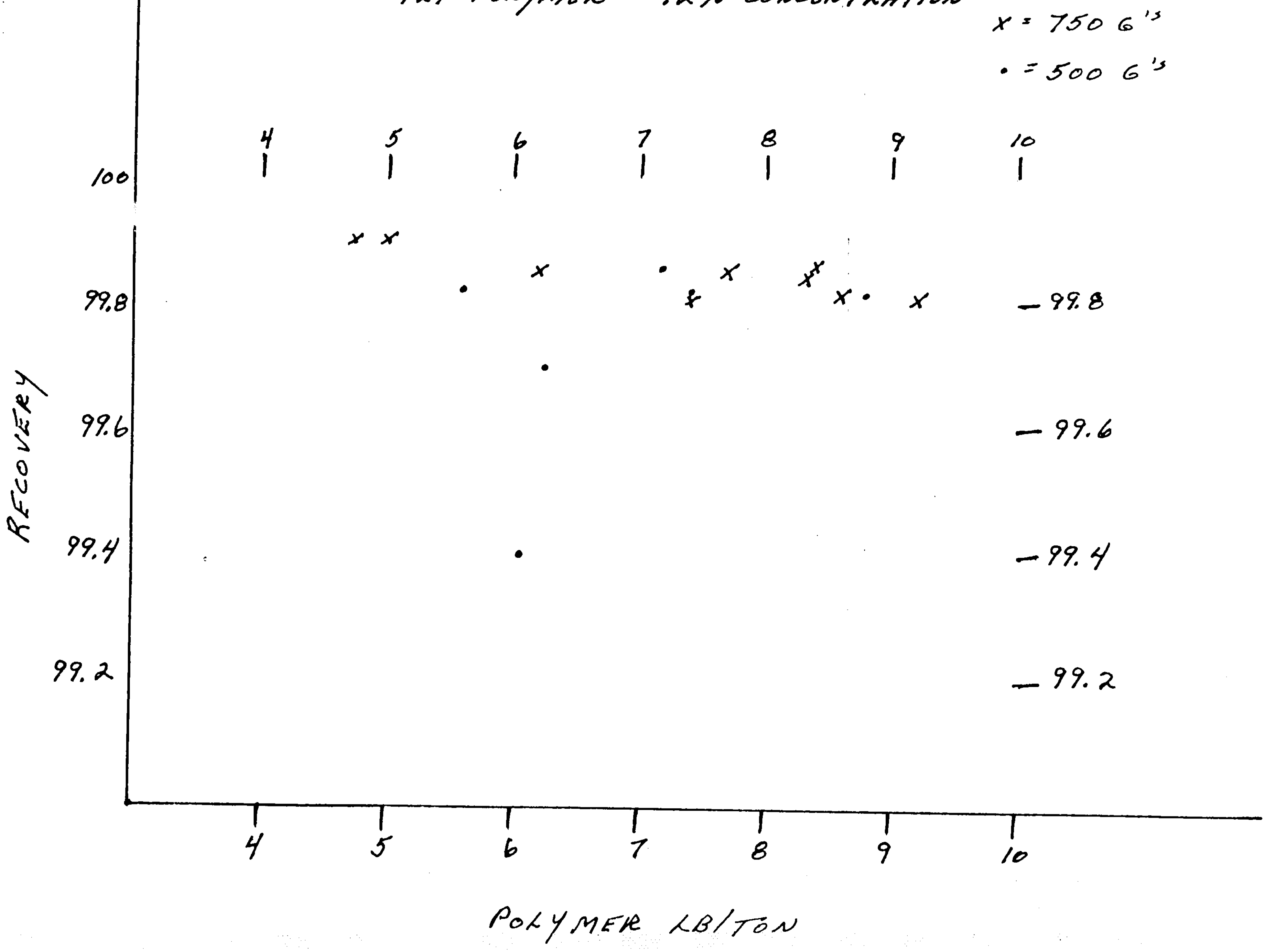

EFFECT of POLYMER LB/TON ON RECOVERY
727 POLYMER .2% CONCENTRATION
• = 1100 G's
RECOVERY
100
95
90
85
80
2.5
3
3.5
4
4.5
5
5.5
6
6.5
POLYMER LB/TON

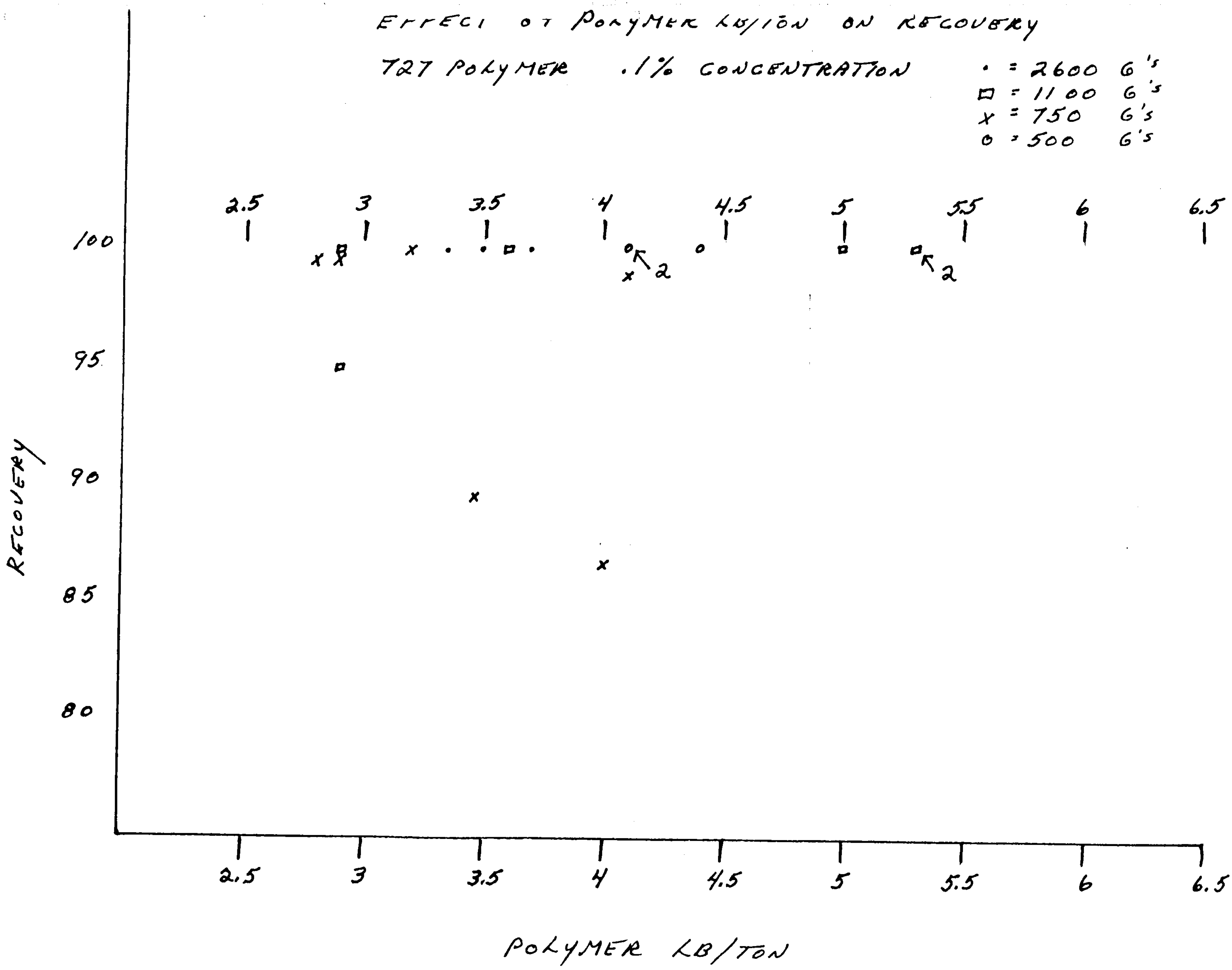


EFFECT of POLYMER LB/TON ON RECOVERY
727 POLYMER .2% CONCENTRATION
o = 2600 G's
RECOVERY
POLYMER LB/TON
2.5
5
7.5
10
12.5
15
100
95
90
85
80

EFFECT OF POLYMER LB/TON ON RECOVERY

727 POLYMER .2% CONCENTRATION




EFFECT OF POLYMER ADDITION ON RECOVERY
727 POLYMER .1% CONCENTRATION
• = 2600 G's
□ = 1100 G's
x = 750 G's
o = 500 G's
2.5
3
3.5
4
4.5
5
5.5
6
6.5
100
95
90
85
80
2
2
RECOVERY
POLYMER LB/TON