Walker Process Equipment

PHILLIPS WWTP - BIOLOGICAL NUTRIENT REMOVAL PROCESS EVALUATION

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CITY OF PHILLIPS, WISCONSIN
BIOLOGICAL NUTRIENT REMOVAL PROCESS EVALUATION

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ACRONYMS, SYMBOLS, and ABBREVIATIONS

BNR = biological nutrient removal
BOD_5 = biochemical oxygen demand

$CaCO_3$ = calcium carbonate
$CBOD_5$ = carbonaceous biochemical oxygen demand
COD = chemical oxygen demand

°C = degrees Centigrade
°F = degrees Fahrenheit
DAFT = dissolved air flotation thickener

EBPR = enhanced biological phosphorus removal

gpm = gallons per minute

K = potassium

mg = milligrams
Mg = magnesium
mgd = million gallons per day
mg/l = milligrams per liter
MLSS = mixed liquor suspended solids
MLVSS = mixed liquor volatile suspended solids

NOx = nitrite-nitrate

ppd = pounds per day

RBC = rotating biological contactor
RSS = return secondary sludge

$SBOD_5$ = soluble BOD_5
$SCBOD_5$ = soluble carbonaceous biochemical oxygen demand
SCT = sludge contact tank
SCOD = soluble chemical oxygen demand
SR = sludge recirculation
SWD = sidewater depth

TDH = total dynamic head
TKN = total Kjeldahl nitrogen
TSS = total suspended solids

UV = ultraviolet

VFA = volatile fatty acids
VSS = volatile suspended solids

WPDES = Wisconsin Pollutant Discharge Elimination System
WWTP = Wastewater Treatment Plant

PHILLIPS WWTP – BNR PROCESS EVALUATION

A biological nutrient removal (BNR) process evaluation was performed at the wastewater treatment plant (WWTP) in the City of Phillips, Wisconsin. The BNR process evaluation at the City of Phillips WWTP is being performed in three phases. This report describes the results of the first phase (Phase 1) of the BNR process evaluation.

DESCRIPTION OF PROJECT

A BNR demonstration project was performed to determine the capability of the rotating biological contactor (RBC) secondary treatment process to remove nitrogen and phosphorus. The RBC fixed film secondary treatment process has been commonly used for removal of soluble biochemical oxygen demand and to convert ammonia to nitrite and nitrate. Biological phosphorus removal and denitrification using an RBC process has been achieved by the addition of a sludge recirculation (SR) system and anoxic/anaerobic reactors.

Objectives of Project

The project was performed to document the performance of the existing process, and identify modifications to improve the operation and performance of a RBC/SR process for the removal of nitrogen and phosphorus. The work was performed at the existing WWTP in the City of Phillips, Wisconsin. The City of Phillips WWTP was selected to evaluate the BNR process using an RBC since the treatment plant was designed for ammonia removal using the fixed film RBC portion of the secondary treatment process and phosphorus removal using the SR portion of the secondary treatment process.

Description of Program

A BNR demonstration program was developed to evaluate and identify modifications to improve BNR with the RBC/SR process. The program is separated in to three phases. Phase 1 includes documentation of existing conditions, and identification and selection of modifications to augment the operation and performance of the BNR process. Phase 2 includes design of modifications to augment the operation and performance of the BNR process, developing a sampling and testing program to monitor and document the modifications to improve cold weather operation, and implementation and testing of process modifications to augment the BNR process during cold weather operation. Phase 3 includes documentation and analysis of the results of the BNR demonstration program.

EXISTING WWTP

The WWTP site is located in the northern portion of the City of Phillips. The site is bordered on the east by Elk Lake. Elk Lake is an artificial lake created by damming the Elk River. This location has been the site of the Phillips WWTP since the first facility was constructed prior to 1950.

The existing WWTP was upgraded with an SR system designed to achieve enhanced biological phosphorus removal (EBPR) in 2001. The biological phosphorus removal process was designed to meet a monthly average total phosphorus (TP) effluent limit of 1.6 milligrams per liter (mg/l). The 1.6 mg/l effluent limit became effective on June 1, 2002. The 1.6 mg/l monthly average TP effluent limit was replaced by a 1.0 mg/l monthly average TP effluent limit on January 1, 2013 when the Wisconsin Pollutant Discharge Elimination System (WPDES) permit was reissued. The reissued permit also contained a 0.7 mg/l six-month average TP effluent limit that was effective for May through October of each year.

The WWTP was designed in 2001 for an average annual flow of 0.374 million gallons per day (mgd) and a peak flow of 1.4 mgd. The WWTP was designed for an average annual biochemical oxygen demand (BOD_5) loading of 530 pounds per day (ppd), average annual suspended solids loading of 445 ppd, average annual total Kjedahl nitrogen (TKN) loading of 82 ppd, average annual ammonia loading of 48 ppd, and an average annual phosphorus loading of 18 ppd.

The WWTP is required to provide secondary treatment of influent wastewater to meet WPDES permit requirement for carbonaceous BOD_5 ($CBOD_5$), suspended solids, pH, fecal coliforms, and TP. The effluent limits contained in the permit are summarized in Table 1. Future permit requirements for effluent TP may be as low as 0.04 mg/l. Additional tertiary treatment would be required to meet an effluent TP limit of 0.04 mg/l.

Table 1 Present Discharge Requirements

Effluent Parameter	Concentration, mg/l
$CBOD_5$	
Weekly Average	40
Monthly Average	25
Suspended Solids	
Weekly Average	45
Monthly Average	30
TP	
Six-Month Average(a)	0.7
Monthly Average	1.0
pH, s.u.	
Daily Minimum	6.0
Daily Maximum	9.0
Fecal Coliform, colonies/100 ml(b)	400

(a)May – October
(b)Disinfection is required from May 1 through September 30

Description of WWTP Facilities

The WWTP secondary treatment system is presently operated as a RBC/SR process preceded by shredding, screening, grit removal, primary clarification, and followed by disinfection with ultraviolet (UV) light. Sludge is anaerobically digested and transferred to sludge storage tanks. Sludge is applied to agricultural land for disposal. A schematic flow diagram of the process is included in Appendix "A". Design data for the WWTP is included in Appendix "B".

Headworks. Raw wastewater from the City flows by gravity through 21-inch diameter and 15-inch diameter sewers on the WWTP site to a junction manhole located on the southeast portion of the WWTP site. The wastewater flows from the junction manhole through 10 feet of 21-inch diameter sewer to the WWTP headworks.

The wastewater passes through a sewage shredder that grinds the solid matter into smaller pieces. The shredding helps minimize pump and pipeline plugging. Grinding is accomplished by a pair of revolving cutter heads located within a stationary housing.

Raw Sewage Pumping. After passing through the sewage shredder, the wastewater flows through a 6-inch Parshall flume into the raw sewage wet well. The level in the Parshall flume is measured by an ultrasonic level/flow transmitter. The level/flow transmitter calculates the flow through the Parshall flume using the measured level. Time composite samples of the raw wastewater are taken after the influent Parshall flume.

Wastewater flows by gravity to a 3,300-gallon concrete wet well. Three centrifugal non-clog raw sewage pumps are used to pump raw sewage from the wet well to the influent channel of the Preliminary Treatment area. The raw sewage pumps are equipped with variable speed drives. Each raw sewage pump is rated for 500 gallons per minute (gpm) at a total dynamic head (TDH) of 35 feet.

Preliminary Treatment. The raw sewage flows by gravity through a mechanically cleaned cylindrical bar screen where solids are collected and automatically removed by a mechanical rake arm. The operation of the mechanical rake arm is controlled by an ultrasonic level transmitter. The debris removed from the cylindrical bar screen by the mechanical rake arm is deposited in a collection hopper where it is washed to remove any organic material. After the debris passes through the wash zone, it travels into a compression zone. The compression zone compacts the screenings and deposits them in a dumpster. The compacted screenings in the dumpster are taken off site for disposal.

Wastewater flows through the mechanical bar screen and enters an aerated grit chamber. The grit chamber is equipped with coarse bubble diffusers that introduce low pressure air to the wastewater for separation of the inorganics from the organics. The detention time in the grit chamber is 10 minutes at the average annual design flow of 0.374 mgd. The settled grit is removed from the aerated grit chamber with a grit dewatering screw. The dewatered grit is discharged into a dumpster and taken off site for disposal.

Primary Treatment. The effluent from the preliminary treatment area flows by gravity to the primary treatment channel and is distributed to two rectangular primary clarifiers. Each primary clarifier is 30 feet long, 10 feet wide, and has a sidewater depth (SWD) of 7.25 feet. Solids settle out and form a sludge blanket on the bottom while scum and floating debris float to the surface. Each primary clarifier is equipped with a longitudinal chain and flight collector that operates continuously. The settled sludge is scraped to hoppers at the inlet end of the primary clarifiers for collection and removal, and the scum and floating debris is conveyed to the effluent end of the primary clarifiers for removal by rotating scum skimmers. The sludge blanket depth is typically three feet at the inlet end, and less than one-foot at the effluent end. The effluent from the primary clarifiers flows over weirs and flows by gravity to the sludge contact tank (SCT).

Secondary Treatment. Secondary treatment of wastewater for removal of BOD_5, suspended solids, and phosphorus is achieved using an RBC/SR process. The RBC/SR process consists of an SCT (anoxic/anaerobic reactor), a two stage RBC system, an SR system, and secondary clarifiers. The effluent from the primary clarifiers flows by gravity through a 12-inch diameter pipeline to the SCT. The SCT contains four compartments. The SCT is designed to allow return secondary sludge (RSS) to be added to any compartment and allow primary effluent to enter either half of the tank. The effluent from the primary clarifiers presently mixes with RSS in the first compartment which acts as an anoxic reactor when nitrification is occurring in the RBC system. The anoxic compartment creates conditions favorable for denitrification of the RSS and soluble BOD_5 ($SBOD_5$) removal.

The wastewater then passes into anaerobic compartments of the SCT that create conditions favorable for the development of phosphorus accumulating organisms. Phosphorus release and $SBOD_5$ removal occurs in the anaerobic compartments. The anoxic/anaerobic reactor compartments are mixed with turbine mixers that operate continuously. A mechanical aerator is provided to allow any compartment of the SCT to be aerated if additional aerobic treatment is needed. Each compartment is provided with a mounting bracket for the mechanical aerator. The mechanical aerator is not typically used.

The effluent from the SCT flows by gravity through a channel to the RBC process. The RBC units provide aerobic conditions to allow phosphorus uptake, BOD_5 removal, and oxidation of ammonia to nitrite and nitrate. Two RBC units are operated in series. The piping is arranged to allow the SCT to be bypassed, the first-stage RBC unit to be bypassed, or the second-stage RBC unit to be bypassed.

Typically, mixed liquor from the SCT flows to RBC Unit No. 1. The wastewater flows through the RBC Unit No. 1 in a transverse direction. RBC Unit No. 1 is a single-stage unit. The wastewater flows by gravity from RBC Unit No. 1 through a 12-inch diameter pipeline to RBC Unit No. 2. The wastewater flows through RBC Unit No. 2 in a longitudinal direction. RBC Unit No. 2 is a two compartment unit.

Supplemental aeration is provided for each RBC unit using a diffused aeration system. The rotation of the RBC units and the aeration provided by the diffused aeration system maintains an aerobic environment in the RBC units and maintains the solids in the wastewater in suspension. Two positive displacement blowers provide air to the RBC units through an 8-inch diameter header. A 4-inch diameter air header with 24 course bubble diffusers provides aeration beneath each RBC unit. The amount of air to each RBC unit is manually regulated by a 4-inch diameter butterfly valve.

The mixed liquor from the RBC Unit No. 2 effluent channel flows by gravity through a 12-inch diameter pipeline to the secondary clarifier influent channel where it is distributed to two rectangular secondary clarifiers. Each secondary clarifier is 40 feet long, 12 feet wide, and has an SWD of 10 feet. Each secondary clarifier is equipped with a longitudinal chain and flight collector that operates continuously. The settled sludge is scraped to sludge hoppers at the inlet end of the secondary clarifiers by the longitudinal collectors. The sludge blanket depth is typically maintained less than two feet. Secondary sludge is pumped from the secondary clarifiers and is presently discharged to the first compartment of the SCT through a 4-inch diameter pipeline. The RSS flow is measured with a 4-inch diameter magnetic flow meter. The RSS flow rate is typically 210 to 220 gpm, and is approximately 230 gpm when sludge is wasted. The effluent from the secondary clarifiers flows over rectangular weirs and is collected in steel troughs where the effluent flow by gravity to an effluent box. Final effluent flows by gravity through a 12-inch diameter pipeline to the former chorine contact tank for disinfection with UV light.

Disinfection. The effluent from the secondary clarifiers flows into an effluent box. Effluent from the secondary clarifier effluent box flows by gravity through 12-inch diameter pipelines to the former chlorine contact tank. The effluent is disinfected with UV light. The UV disinfection equipment is in the north channel of the north compartment of the former chlorine contact tank. Composite samples of disinfected effluent are collected from the channel after the UV disinfection equipment. Final effluent flows by gravity over a weir to an outfall chamber. The final effluent flows from the outfall chamber through a 16-inch diameter outfall sewer to a manhole east of the former chlorine contact tank. Effluent from Phillips Plating Company is combined with the municipal WWTP final effluent in the manhole. The combined wastewater is discharged through the 16-inch diameter outfall sewer to Elk Lake.

The former chlorine contact tank has two compartments. The south compartment may be used for disinfection with chlorine solution when the UV disinfection equipment is out of service. The flow into each chlorine contact compartment is controlled by plug valves. Sulfur dioxide is used for dechlorination when chlorination is used. The sulfur dioxide is added in the last channel in the north compartment of the chlorine contact tank prior to flowing over the weir to the outfall chamber.

Sludge Treatment. Primary sludge is collected in each primary clarifier sludge hopper. The primary sludge is removed from the primary clarifiers and pumped to the anaerobic digester for stabilization. There are two (2) primary sludge pumps located in the primary sludge pump room in the Preliminary Treatment Building. Each pump is rated for 30 gpm. Sludge removal from the hoppers in each clarifier is controlled by diaphragm-type control valves. The frequency of sludge removal from the clarifier has been reduced to increase the solids retention time in the primary clarifiers to allow fermentation of the primary sludge to generate volatile fatty acids (VFA). Sludge is typically pumped from the primary clarifiers twice a month. In the spring, approximately 400 gallons are pumped from each clarifier, and the remainder of the year approximately 200 gallons of primary sludge is pumped from each primary clarifier when sludge is pumped to the anaerobic digester.

Secondary sludge is collected in each secondary clarifier sludge hopper. The secondary sludge is removed from the secondary clarifiers and returned to the SCT or wasted to a dissolved air flotation thickener (DAFT). The secondary sludge may also be returned to the grit aeration channel so that it may be co-settled with the primary sludge in the primary clarifiers. The secondary sludge is pumped continuously by two RSS pumps. Each secondary clarifier is equipped with a RSS pump located in the sludge hopper of each clarifier.

The thickener sludge pumps are used to discharge waste secondary sludge from the RSS pipeline to the DAFT in the Sludge Thickener Building. Sludge is typically wasted to the DAFT for one (1) to two (2) hours, five days per week. During the spring when sloughing occurs on the RBC units, sludge may be wasted to the DAFT for six to seven hours per day. Polymer is added to the waste secondary sludge to enhance solids flotation. In the DAFT, microscopic air bubbles attach themselves to the solids in the waste secondary sludge and float the solids to the surface. The solids that float to the surface are collected by a rotating scoop and discharged to the sludge wet well in the Sludge Thickener Building. The thickened secondary sludge in the sludge well is pumped by a thickener sludge pump to the anaerobic digester for stabilization.

Thickened secondary sludge and the primary sludge, (or a combination of the two types of sludge from the treatment processes) are pumped to the Sludge Treatment Area. The WWTP uses a single stage anaerobic sludge digestion process. The anaerobic digester is 25 feet in diameter and has an SWD of 19 feet. The anaerobically digested sludge is heated and mixed. The anaerobic digester is mixed using a mechanical draft tube mixing system and the sludge recirculation pumps. The recirculation pumps are used to circulate the contents of the digester through the boiler/heat exchanger for heating the contents of the digester. Sludge gas produced in the digester is used as a supplemental fuel source for the boiler/heat exchanger. Excess sludge gas not used by the boiler/heat exchanger is flared at the waste gas burners. Supernatant is not decanted from the anaerobic digester. This prevents recycling phosphorus and ammonia to the liquid treatment process.

Sludge Storage. Digested sludge is transferred from the anaerobic digester to the sludge storage tanks. Sludge Storage Tank No. 1 is 28 feet in diameter, has an SWD of 17 feet, and a volume of 83,775 gallons. Sludge Storage Tank No. 2 is 36 feet in diameter, has an SWD of 20 feet, and a volume of 152,600 gallons. The tanks are designed to provide approximately 180 days of sludge storage at the average annual loading conditions. Supernatant is not decanted from the storage tanks.

Each tank is equipped with a sludge loading pump rated for 600 gpm. The sludge that is stored in the storage tanks is circulated and mixed within the tank by sludge loading pumps. The sludge loading pumps are used to fill sludge hauling trucks at the sludge loading station. The sludge hauling trucks take the sludge off site for disposal by land application.

Performance of WWTP

A summary of the influent and effluent wastewater characteristics in tabular and graphical format is included in Appendix "C". The EBPR process was placed in service in the spring of 2002. The EBPR process has had difficulty in producing an effluent that meets the effluent TP requirements of the WPDES permit during the cold weather months. In January of 2008 the staff at the WWTP began adding ferric chloride to the mixed liquor in the second stage RBC to meet TP effluent requirements. Ferric chloride addition was used when the primary effluent wastewater temperature was below 45 degrees Fahrenheit (°F).

In March of 2014, the shaft of the first stage RBC unit failed. In June of 2014, the shaft of the second stage RBC unit failed. The failure of the RBC unit shafts resulted in very poor performance of the WWTP for removal of $CBOD_5$, total suspended solids (TSS), and TP. Ferric chloride was added to the wastewater during the period the RBC units were out of service. Ferric chloride addition was continued through the summer of 2015 as a pilot program to determine the level of TP removal that could be achieved by phosphorus precipitation.

BNR PROCESS EVALUATION – PHASE 1

The first phase of the BNR process evaluation, included identification and documentation of the present process configuration and existing equipment operating conditions; and identification of the wastewater characteristics in each liquid treatment process of the WWTP without the addition of ferric chloride to supplement the biological phosphorus removal process.

Objectives of Phase 1

The objectives of Phase 1 include documentation of existing operating conditions, and identification and selection of modifications to augment the operation and performance of the BNR process to improve cold weather BNR performance. Documentation of the existing conditions included a sampling and testing program to characterize the wastewater in each liquid treatment process.

Description of Testing Program

A sampling and testing program was performed during a two-week period in the beginning of August of 2016. The routine testing performed by the staff of the WWTP was supplemented with additional sampling and testing. A summary of the sampling locations and characteristic testing performed during the Phase 1 Testing Program is included in Appendix "D".

The routine sampling and testing performed by the staff of the WWTP includes collection of time composite samples of influent and effluent wastewater. The influent and effluent samples were removed from the sample for shipment to a commercial laboratory between 7:00 a.m. and 8:00 a.m. three days per week. The composite samplers are programmed to collect samples every 15 minutes.

The sampling and testing program used to supplement the routine sampling and testing included obtaining grab samples of primary effluent, grab samples of mixed liquor in each of the four compartments of the SCT, grab samples of the effluent from each RBC unit, grab samples of return sludge, and grab samples of final effluent collected after the UV disinfection equipment during the same three days that routine composite samples are collected. Grab samples were collected by the staff between 8:00 a.m. and 12:00 p.m. and placed in five gallon containers.

Testing of the composite and grab samples was performed by two commercial laboratories. The commercial laboratories supplied sample containers for the characteristic testing. The WWTP staff filled the sample containers with the grab samples stored in the five gallon containers and composite samples from the influent and effluent samplers. Specific samples were filtered during sample preparation to remove biological solids and to obtain the soluble fraction of chemical oxygen demand (COD), $CBOD_5$, or orthophosphate. Samples of mixed liquor were pre-filtered with a basket type coffee filter to remove larger biological solids. The pre-filtered samples were then passed through a 4.25-centimeter diameter, 1.5-micron retention, glass fiber filter in a magnetic filter holder and vacuum suction flask. The filtrate collected in the flask was then placed in the sample containers provided by the commercial laboratory.

BNR PROCESS EVALUATION – PHASE 1 RESULTS

The testing results from the commercial laboratories were reviewed and summarized to identify wastewater characteristics for each liquid treatment unit process, and to calculate loadings to the WWTP, the secondary treatment system, and the mass discharge to Elk Lake during the two-week testing program. The following sections describe the testing results for the wastewater flow and loadings, summarize the testing results, and describe the significance of the testing results related to BNR at the Phillips WWTP.

Laboratory testing results for values reported for influent and effluent are from composite wastewater samples. The date indicated for test results for composite wastewater samples is representative of the wastewater characteristics from approximately 7:00 a.m. the previous day to approximately 7:00 a.m. of the date indicated for the test result. Grab samples were collected within five hours of the influent and effluent samples being removed from the samplers.

Supplemental testing samples collected for the influent on August 3, 2016, primary effluent on August 2, 2016 and August 3, 2016, Solids Contact Tank No. 3 on August 2, 2016 and August 3, 2016, Solids Contact Tank No. 1 on August 3, 2016, Solids Contact Tank No. 2 on August 3, 2016, Solids Contact Tank No. 4 on August 2, 2016 and August 3, 2016, RBC Unit No. 1 on August 3, 2016, RBC Unit No. 2 on August 3, 2016, and effluent on August 3, 2016 were received at the commercial laboratory at temperatures ranging from 7 degrees Centigrade (°C) to 17.7°C which is greater than maximum recommended temperature of 6°C. Routine testing samples collected by the staff of the WWTP arrived at the commercial laboratory at a satisfactory temperature.

Flows and Loadings

The flows and loadings to the treatment plant, primary effluent, and the final effluent were recorded and calculated for the two-week testing period. Influent flow data is recorded at 6:00 a.m. each day. Influent flow data represents the total flow measured from 6:00 a.m. the previous day to 6:00 a.m. of the date indicated with the measured flow. The Phillips WWTP does not have a flow meter to measure primary effluent or final effluent flow. The measured influent flow is used to calculate the primary effluent and final effluent loadings. The RSS flow for the RBC/SR process is measured with a magnetic flow meter. The RSS flow during the Phase 1 testing period was 210 gpm. The flow to the RBC/SR secondary treatment process is the sum of the influent flow and the RSS flow. A summary of the influent flow, RSS flow, and RBC/SR secondary treatment biological process flow, and return sludge flow ratio is presented in Table 2. The influent flow ranged from 0.150 mgd to 0.203 mgd and averaged 0.170 mgd. The RBC/SR secondary treatment process flow ranged from 0.452 mgd to 0.505 mgd, and averaged 0.472 mgd. The return sludge ratio to influent flow ranged from 1.49:1 to 2.01:1, and averaged 1.80:1.

Table 2 Influent and Process Flows

Characteristic	Date						Minimum	Average	Maximum
	8/2/16	8/3/16	8/4/16	8/9/16	8/10/16	8/11/16			
Influent flow, mgd	0.163	0.203	0.187	0.163	0.154	0.150	0.150	0.170	0.203
Return Sludge flow, mgd	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302
Biological Process flow, mgd	0.465	0.505	0.489	0.465	0.456	0.452	0.452	0.472	0.505
Return Sludge Flow ratio(a)	1.85	1.49	1.61	1.85	1.96	2.01	1.49	1.80	2.01

(a)Ratio of Return Sludge flow to Influent flow

The hydraulic detention time was calculated for the secondary treatment process for the Phase 1 testing program. The hydraulic detention time in the SCT ranged from 133 minutes to 149 minutes, and averaged 143 minutes. The hydraulic detention time for RBC Unit No. 1 ranged from 39 minutes to 44 minutes, and averaged 42 minutes. The hydraulic detention time of RBC Unit No. 2 ranged from 39 minutes to 43 minutes, and averaged 41 minutes. A summary of the hydraulic detention time is included in Appendix "F", Page F-1.

Influent. Influent loadings during the Phase 1 testing period are presented in Table 3. The influent BOD_5 loadings ranged from 225 ppd to 265 ppd, and averaged 236 ppd. The influent COD loadings ranged from 438 ppd to 849 ppd, and averaged 618 ppd. The influent TSS loadings ranged from 247 ppd to 356 ppd, and averaged 314 ppd. The influent volatile suspended solids (VSS) loadings ranged from 88 ppd to 349 ppd, and averaged 222 ppd. The influent TP loadings ranged from 7.4 ppd to 8.9 ppd, and averaged 7.8 ppd. The influent orthophosphate loadings ranged from 4.5 ppd to 4.8 ppd, and averaged 4.6 ppd. The influent TKN loadings ranged from 58 ppd to 63 ppd, and averaged 59 ppd. The influent ammonia loadings ranged from 35 ppd to 37 ppd and averaged 36 ppd. The influent nitrite-nitrate (NO_x) loadings ranged from 1.0 ppd to 1.8 ppd, and averaged 1.3 ppd.

Table 3 Influent Flows and Loadings

	Loadings, ppd								
	Date								
Characteristic	8/2/16	8/3/16	8/4/16	8/9/16	8/10/16	8/11/16	Minimum	Average	Maximum
Flow	0.163	0.203	0.187	0.163	0.154	0.150	0.150	0.170	0.203
BOD_5	243	225	225	234	265	225	225	236	265
COD	438	639	639	506	849	639	438	618	849
TSS	343	312	312	247	356	312	247	314	356
VSS	88	224	224	223	349	224	88	222	349
TP	7.4	7.5	7.5	7.8	8.9	7.5	7.4	7.8	8.9
Orthophosphate	4.6	4.5	4.5	4.6	4.8	4.5	4.5	4.6	4.8
TKN	59	58	58	56	63	58	56	59	63
Ammonia-N	37	35	35	37	37	35	35	36	37
NO_x	1.8	1.2	1.2	1.1	1.0	1.2	1.0	1.3	1.8

Primary Effluent. The primary effluent loadings represent the mass entering the RBC/SR secondary treatment system without the mass from RSS recycle. Primary effluent loadings during the Phase 1 testing period are presented in Table 4. Primary effluent $CBOD_5$ loadings ranged from 126 ppd to 186 ppd, and averaged 155 ppd. Primary effluent Soluble $CBOD_5$ ($SCBOD_5$) loadings ranged from 52 ppd to 129 ppd, and averaged 85 ppd. Primary effluent COD loadings ranged from 370 ppd to 576 ppd, and averaged 484 ppd. Primary effluent Soluble COD (SCOD) loadings ranged from 159 ppd to 265 ppd, and averaged 210 ppd. Primary effluent TSS loadings ranged from 144 ppd to 256 ppd, and averaged 174 ppd. Primary effluent VSS loadings ranged from 114 ppd to 201 ppd, and averaged 143 ppd. Primary effluent TP loadings ranged from 4.7 ppd to 7.6 ppd, and averaged 6.2 ppd. Primary effluent orthophosphate loadings ranged from 2.8 ppd to 4.5 ppd, and averaged 3.8 ppd. Primary effluent TKN loadings ranged from 36 ppd to 54 ppd, and averaged 45 ppd. Primary effluent ammonia loadings ranged from 21ppd to 32 ppd, and averaged 26 ppd. Primary effluent NO_x loadings ranged from 0.3 ppd to 2.9 ppd, and averaged 1.7 ppd. Primary effluent VFA loadings ranged from 13 ppd to 64 ppd, and averaged 40 ppd. VFA loadings were equal to approximately 50 percent of the $SCBOD_5$ loadings. Primary effluent potassium (K) loadings ranged from 12 ppd to 20 ppd, and averaged 17 ppd. Primary effluent magnesium (Mg) loadings ranged from 9 ppd to 19 ppd, and averaged 16 ppd. Primary effluent hardness loadings ranged from 131 ppd to 259 ppd, and averaged 205 ppd.

Final Effluent. Final effluent loading to Elk Lake during the Phase 1 testing period are presented in Table 5. Final effluent $CBOD_5$ loadings ranged from 4.1 ppd to 14.0 ppd, and averaged 7.2 ppd. Final effluent $SCBOD_5$ loadings ranged from 2.5 ppd to 5.1 ppd, and averaged 3.1 ppd. Final effluent COD loadings ranged from 74 ppd to 114 ppd, and averaged 91 ppd. Final effluent SCOD loadings ranged from 60 ppd to 95 ppd, and averaged 75 ppd. Final effluent TSS loadings ranged from 9 ppd to 24 ppd, and averaged 14 ppd. Final effluent TP loadings ranged from 0.4 ppd to 1.0 ppd, and averaged 0.6 ppd. Final effluent orthophosphate loadings ranged from 0.3 ppd to 0.5 ppd, and average 0.4 ppd. Final effluent TKN loadings ranged from 7.2 ppd to 16.8 ppd, and averaged 10.9 ppd. Final effluent ammonia loadings ranged from 2.4 ppd to 11.2 ppd, and averaged 6.0 ppd. Final effluent NO_x loadings ranged from 9.4 ppd to 16.2 ppd, and averaged 13.1 ppd.

Table 4 Primary Effluent Loadings

Characteristic	Loadings, ppd								
	Date						Minimum	Average	Maximum
	8/2/16	8/3/16	8/4/16	8/9/16	8/10/16	8/11/16			
$CBOD_5$	186	151	173	151	145	126	126	155	186
$SCBOD_5$	109	52	129	101	64	56	52	85	129
COD	491	576	516	500	452	370	370	484	576
SCOD	234	159	265	226	195	183	159	210	265
TSS	144	256	156	190	154	145	144	174	256
VSS	114	201	126	150	148	120	114	143	201
TP	6.5	6.8	6.6	7.6	5.1	4.7	4.7	6.2	7.6
Orthophosphate	4.2	4.2	4.1	4.5	3.2	2.8	2.8	3.8	4.5
TKN	54	54	45	45	39	36	36	45	54
Ammonia-N	32	28	27	25	23	21	21	26	32
NO_x	1.8	2.2	0.3	2.9	1.8	1.1	0.3	1.7	2.9
VFA	61	13	64	36	48	17	13	40	64
K	18	20	18	19	16	12	12	17	20
Mg	16	19	18	17	14	9	9	16	19
Hardness	200	259	243	212	184	131	131	205	259

Table 5 Final Effluent Loadings

Characteristic	Loadings, ppd								
	Date						Minimum	Average	Maximum
	8/2/16	8/3/16	8/4/16	8/9/16	8/10/16	8/11/16			
$CBOD_5$	5.4	8.5	14.0	4.1	5.1	6.3	4.1	7.2	14.0
$SCBOD_5$	2.7	5.1	3.1	2.7	2.6	2.5	2.5	3.1	5.1
COD	79	108	114	98	76	74	74	91	114
SCOD	60	90	62	95	76	69	60	75	95
TSS	24	15	14	14	9	9	9	14	24
TP	1.0	0.7	0.7	0.5	0.6	0.4	0.4	0.6	1.0
Orthophosphate	0.3	0.4	0.5	0.4	0.3	0.4	0.3	0.4	0.5
TKN	7.2	16.8	8.9	9.1	11.0	12.4	7.2	10.9	16.8
Ammonia-N	2.4	11.2	2.7	4.2	6.7	8.6	2.4	6.0	11.2
NOx	12.1	13.5	16.2	15.1	12.5	9.4	9.4	13.1	16.2

<u>Summary of Testing Results</u>

The testing results for the samples of influent, primary effluent, RSS, Solids Contact Tanks No. 1 through No. 4, RBC Units No. 1 and No. 2, and final effluent collected during the Phase 1 testing period are included in Appendix "E". The following sections provide a detailed description of the testing results and summarize the change in wastewater characteristics as the treatment process progresses.

<u>BOD_5/$CBOD_5$</u>. The WPDES permit requires testing the WWTP influent for BOD_5 three times a week. The concentration of BOD_5 during the Phase 1 testing period ranged from 144 mg/l to 206 mg/l and averaged 172 mg/l. The WPDES permit requires treatment plant to meet $CBOD_5$ effluent limits. Testing for $CBOD_5$ was performed for final effluent to provide information on total BOD_5 removal from the WWTP process. Testing for $SCBOD_5$ was performed for primary effluent, Solids Contact Tanks No. 1 through No. 4 mixed liquor, and RBC Units No. 1 and No. 2 effluent, to provide information on removal of $SCBOD_5$ through the RBC/SR secondary treatment process. Grab samples obtained for primary effluent, mixed liquor from the solids contact tanks and the RBC units were filtered prior to testing to remove the biological solids to minimize additional removal of $CBOD_5$ during sample preparation and shipment, and to identify the soluble portion of $CBOD_5$. A summary of the $CBOD_5$ and $SCBOD_5$ testing results is presented in Table 6.

Table 6 CBOD$_5$ Testing Results

Date	PE(a)	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1(a)	RBC 2(a)	CBOD$_5$ Effluent
	Concentration, mg/l								
	SCBOD$_5$								CBOD$_5$
Date	PE(a)	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1(a)	RBC 2(a)	Effluent
8/2/2016	80.0	8.0	11.0	10.0	11.0	12.0	5.0	5.0	2.0
8/3/2016	31.0	9.0	10.0	9.0	10.0	10.0	5.0	5.0	3.0
8/4/2016	83.0	6.0	11.0	11.0	11.0	11.0	5.0	5.0	1.5
8/9/2016	74.0	12.0	8.0	7.0	6.0	8.0	2.0	3.0	1.5
8/10/2016	50.0	11.0	7.0	7.0	7.0	8.0	3.0	1.5	2.0
8/11/2016	45.0	6.0	13.0	15.0	14.0	14.0	2.5	2.5	2.0
Minimum	31.0	6.0	7.0	7.0	6.0	8.0	2.0	1.5	1.5
Average	60.5	8.7	10.0	9.8	9.8	10.5	3.8	3.7	2.0
Maximum	83.0	12.0	13.0	15.0	14.0	14.0	5.0	5.0	3.0

(a)Filtered Sample

COD. COD testing was performed for influent, primary effluent, RSS, Solids Contact Tanks No.1 through No. 4 mixed liquor, RBC Units No. 1 and No. 2 effluent, and final effluent to provide additional information for the characterization of the wastewater as treatment progresses through the WWTP. Grab samples of primary effluent, RSS, mixed liquor from the solids contact tanks, and the effluent from RBC units were filtered to remove biological solids to prevent additional removal of COD during sample preparation and shipment, and to identify the soluble portion of COD. A summary of the COD and soluble COD (SCOD) testing results is presented in Table 7.

Table 7 COD Testing Results

	Concentration, mg/l											
	COD		SCOD									COD
Date	Influent	PE	PE(a)	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1(a)	RBC 2(a)	Effluent	Effluent
8/2/2016	322	361	172	76	69	62	64	76	49	46	58	44
8/3/2016	313	340	94	67	71	58	55	64	37	71	64	53
8/4/2016	410	331	170	55	69	71	55	60	60	46	73	40
8/9/2016	372	368	166	57	68	63	70	77	57	59	72	59
8/10/2016	661	352	152	52	61	55	59	63	46	48	59	70
8/11/2016	341	296	146	57	72	86	79	70	52	50	59	55
Minimum	313	296	94	52	61	55	55	60	37	46	58	40
Average	403	341	150	61	68	66	64	68	50	53	64	54
Maximum	661	368	172	76	72	86	79	77	60	71	73	70

(a)Filtered Sample

BOD$_5$/COD. The relationship of BOD$_5$, CBOD$_5$, and SCBOD$_5$ to COD, SCOD was calculated to provide additional information for the characterization of the wastewater as treatment progresses through the WWTP. A summary of the relationship of the BOD$_5$ to COD is presented in Table 8.

TSS/VSS/Mixed Liquor Suspended Solids (MLSS). The WPDES permit requires testing the WWTP influent and effluent for TSS three times a week. Supplemental testing for suspended solids was performed during the Phase 1 testing program to identify the TSS in the primary effluent, volatile fraction of the TSS in the influent, effluent and primary effluent, and the TSS and VSS content of the mixed liquor in the RSS, and the SCTs. Grab samples of primary effluent, RSS, and mixed liquor from each SCT were collected for suspended solids testing. A summary of the TSS and VSS testing results for the influent, primary effluent, and effluent are presented in Table 9. A summary of the MLSS and mixed liquor volatile suspended solids (MLVSS) testing results is presented in Table 10.

Table 8 BOD/COD Relationship

Date	Influent			Primary Effluent						Effluent					
	COD, mg/l	BOD_5, mg/l	BOD_5/COD	COD, mg/l	$CBOD_5$, mg/l	$CBOD_5$/COD	SCOD, mg/l	$SCBOD_5$, mg/l	$SCBOD_5$/SCOD	COD, mg/l	$CBOD_5$, mg/l	$CBOD_5$/COD	SCOD, mg/l	$SCBOD_5$, mg/l	$SCBOD_5$/SCOD
8/2/2016	322	179	0.56	361	137	0.38	172	80	0.47	58	4	0.07	44	2	0.05
8/3/2016	313	151	0.48	340	89	0.26	94	31	0.33	64	5	0.08	53	3	0.06
8/4/2016	410	144	0.35	331	111	0.34	170	83	0.49	73	9	0.12	40	2	0.05
8/9/2016	372	172	0.46	368	111	0.30	166	74	0.45	72	3	0.04	59	2	0.03
8/10/2016	661	206	0.31	352	113	0.32	152	50	0.33	70	4	0.06	59	2	0.03
8/11/2016	341	180	0.53	296	101	0.34	146	45	0.31	59	5	0.08	55	2	0.04
Minimum	313	144	0.31	296	89	0.26	94	31	0.31	58	3	0.04	40	2	0.03
Average	403	172	0.45	341	110	0.32	150	61	0.39	66	5	0.08	52	2	0.04
Maximum	661	206	0.56	368	137	0.38	172	83	0.49	73	9	0.12	59	3	0.06

Table 9 TSS and VSS Testing Results

Date	TSS concentration, mg/l			VSS concentration, mg/l		Percent VSS	
	Influent	PE	Effluent	Influent	PE	Influent	PE
8/2/2016	252	106	18	224	84	89.0	79.2
8/3/2016	143	151	9	127	119	88.5	78.8
8/4/2016	200	100	9	152	81	76.0	81.0
8/9/2016	182	140	10	154	110	84.5	78.6
8/10/2016	277	120	7	256	115	92.5	95.8
8/11/2016	160	116	7	145	96	90.6	82.8
Minimum	143	100	7	127	81	76.0	78.6
Average	202	122	10	176	101	86.9	82.7
Maximum	277	151	18	256	119	92.5	95.8

Table 10 MLSS and MLVSS Testing Results

Date	Average Solids Contact Tank			Return Secondary Sludge		
	MLSS, mg/l	MLVSS, mg/l	Percent VSS	MLSS, mg/l	MLVSS, mg/l	Percent VSS
8/2/2016	4,748	3,508	73.9	8,640	6,310	73.0
8/3/2016	4,088	3,095	75.7	6,780	4,960	73.2
8/4/2016	4,285	3,163	73.8	6,860	4,930	71.9
8/9/2016	4,450	3,258	73.2	6,620	4,800	72.5
8/10/2016	4,585	3,460	75.5	6,920	5,040	72.8
8/11/2016	3,380	2,400	71.0	8,480	5,800	68.4
Minimum	3,380	2,400	71.0	6,620	4,800	68.4
Average	4,256	3,147	73.8	7,383	5,307	72.0
Maximum	4,748	3,508	75.7	8,640	6,310	73.2

TP/Orthophosphate. The WPDES permit requires testing the WWTP effluent for TP. Supplemental testing for TP and orthophosphate was performed during the Phase 1 testing program to provide information on the removal of TP, and the removal, uptake, and release of orthophosphate through the WWTP. Supplemental TP testing was performed on grab samples of mixed liquor in each SCT and the RSS to determine the TP fraction of the MLSS. Grab samples of RSS and the mixed liquor from each SCT were filtered prior to sample preparation and shipping to identify the soluble portion of orthophosphate. A summary of the TP testing results is presented in Table 11. A summary of the orthophosphate testing results is presented in Table 12.

Table 11 TP Testing Results

Date	TP concentration, mg/l							
	Influent	PE	RSS	SCT 3	SCT 1	SCT 2	SCT 4	Effluent
8/2/2016	5.46	4.77	336	196	210	197	201	0.71
8/3/2016	4.23	4.00	285	187	135	172	204	0.43
8/4/2016	4.80	4.26	260	175	167	158	167	0.44
8/9/2016	5.77	5.57	279	195	179	190	191	0.36
8/10/2016	6.90	3.94	282	196	182	201	196	0.47
8/11/2016	5.41	3.72	396	176	135	152	160	0.31
Minimum	4.23	3.72	260	175	135	152	160	0.31
Average	5.43	4.38	306	188	168	178	187	0.45
Maximum	6.90	5.57	396	196	210	201	204	0.71

Table 12 Orthophosphate Testing Results

Date	Orthophosphate concentration, mg/l									
	Influent	PE	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1	RBC 2	Effluent
8/2/2016	3.36	3.09	0.22	2.59	0.93	2.29	2.86	0.22	0.21	0.22
8/3/2016	2.36	2.47	0.22	1.81	1.80	0.79	2.49	0.22	0.22	0.23
8/4/2016	2.90	2.65	0.22	2.44	0.28	0.55	1.62	0.25	0.26	0.30
8/9/2016	3.38	3.33	0.25	2.44	0.32	0.62	3.47	0.26	0.26	0.26
8/10/2016	3.71	2.52	0.26	4.01	1.95	2.46	5.26	0.26	0.28	0.26
8/11/2016	3.30	2.2	0.38	7.95	7.32	7.58	10.2	0.57	0.24	0.34
Minimum	2.36	2.20	0.22	1.81	0.28	0.55	1.62	0.22	0.21	0.22
Average	3.17	2.71	0.26	3.54	2.10	2.38	4.32	0.30	0.25	0.27
Maximum	3.71	3.33	0.38	7.95	7.32	7.58	10.20	0.57	0.28	0.34

(a)Filtered Sample

<u>BOD_5/TP</u>. The BOD_5/TP relationship was calculated to determine the ratio of substrate to TP. The BOD_5/TP ratio was calculated for the influent and primary effluent. The BOD_5/TP ratio of the influent ranged from 30:1 to 36:1 and averaged 32:1. The $CBOD_5$/TP ratio of the primary effluent ranged from 20:1 to 29:1 and averaged 25:1. A summary of the BOD_5/TP ratios are included in Appendix "F", Page F-2.

<u>MLSS Phosphorus Content</u>. The TP content of the MLSS was calculated to determine how much phosphorus was stored in the sludge mass. The TP/MLSS ratio was calculated for the MLSS in the RSS, and each SCT. The phosphorus content of the MLSS ranged from 3.8 percent to 4.8 percent and averaged 4.2 percent. A summary of the TP/MLSS ratio is presented in Table 13.

Table 13 TP/MLSS Ratio

Date	TP/MLSS Ratio				
	RSS	SCT 3	SCT 1	SCT 2	SCT4
8/2/2016	0.039	0.042	0.043	0.043	0.042
8/3/2016	0.042	0.042	0.042	0.043	0.044
8/4/2016	0.038	0.040	0.039	0.038	0.039
8/9/2016	0.042	0.043	0.043	0.041	0.042
8/10/2016	0.041	0.042	0.043	0.043	0.042
8/11/2016	0.047	0.048	0.046	0.047	0.044
Minimum	0.038	0.040	0.039	0.038	0.039
Average	0.041	0.043	0.042	0.042	0.042
Maximum	0.047	0.048	0.046	0.047	0.044

TKN/Ammonia/NO_x. The WPDES permit requires testing the WWTP effluent for ammonia once a month. Supplemental testing for TKN, ammonia, and NO_x was performed during the Phase 1 testing program to provide information on removal of nitrogen through the WWTP. Supplemental TKN testing was performed for the influent, primary effluent, and final effluent. A summary of the TKN testing results is presented in Table 14.

Table 14 TKN Testing Results

	TKN concentration, mg/l		
Date	Influent	PE	Final Effluent
8/2/2016	43.6	39.7	5.3
8/3/2016	31.3	31.8	9.9
8/4/2016	37.2	29.0	5.7
8/9/2016	41.5	32.8	6.7
8/10/2016	48.7	30.6	8.6
8/11/2016	41.5	28.7	9.9
Minimum	31.3	28.7	5.3
Average	40.6	32.1	7.7
Maximum	48.7	39.7	9.9

Supplemental ammonia testing was performed for the influent, primary effluent, RSS, each SCT mixed liquor, and each RBC unit effluent. Grab samples of RSS, mixed liquor from each SCT, and the mixed liquor from each RBC unit were filtered to remove biological solids to prevent additional conversion of ammonia during sample preparation and shipment. A summary of the ammonia testing results is presented in Table 15.

Table 15 Ammonia Testing Results

	Ammonia concentration, mg/l									
Date	Influent	PE	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1(a)	RBC 2(a)	Effluent
8/2/2016	27.3	23.8	0.6	7.4	6.9	7.3	7.6	4.2	0.2	1.7
8/3/2016	18.7	16.6	2.8	8.0	7.6	7.7	8	6.9	1.4	6.6
8/4/2016	22.5	17.0	1.2	6.8	5.4	6.1	6.3	5.3	0.2	1.7
8/9/2016	26.9	18.4	3.5	8.4	8.1	7.9	8.8	8.4	1.5	3.1
8/10/2016	29.0	18.2	5.5	10.0	9.5	9.2	10.4	10.4	3.8	5.2
8/11/2016	27.4	16.7	7.7	13.9	14.3	14.3	13.9	10.8	4.4	6.9
Minimum	18.7	16.6	0.6	6.8	5.4	6.1	6.3	4.2	0.2	1.7
Average	25.3	18.5	3.6	9.1	8.6	8.8	9.2	7.7	1.9	4.2
Maximum	29.0	23.8	7.7	13.9	14.3	14.3	13.9	10.8	4.4	6.9

(a)Filtered Sample

Supplemental NO_x testing was performed for the influent, primary effluent, RSS, each SCT mixed liquor, each RBC unit effluent, and the final effluent. Grab Samples of RSS, mixed liquor from each SCT, and the mixed liquor from each RBC unit were filtered to remove biological solids to prevent additional conversion of NO_x during sample preparation and shipment. A summary of the NO_x testing results is presented in Table 16.

VFA. Supplemental VFA testing was performed on grab samples of primary effluent during the Phase 1 testing program to identify the quantity of VFA available for phosphorus accumulating organism in the solids contact tanks. The VFA concentration of the primary effluent ranged from 7.62 mg/l to 44.7 mg/l, and averaged 28.5 mg/l.

Table 16 NO_x Testing Results

Date	Influent	PE	RSS(a)	SCT 3(a)	SCT 1(a)	SCT 2(a)	SCT 4(a)	RBC 1(a)	RBC 2(a)	Final Effluent
	NOx concentration, mg/l									
8/2/2016	1.30	1.30	4.00	0.09	0.09	0.09	0.09	3.40	9.00	8.90
8/3/2016	1.20	1.30	6.00	0.09	0.09	0.09	0.10	2.50	9.10	8.00
8/4/2016	0.80	0.20	8.10	0.09	0.09	0.09	0.09	3.20	10.90	10.40
8/9/2016	0.80	2.10	10.10	0.09	0.70	0.10	0.10	3.20	12.20	11.10
8/10/2016	0.80	1.40	7.10	0.09	0.09	0.09	0.09	1.40	8.70	9.70
8/11/2016	0.70	0.90	0.50	0.09	0.09	0.09	0.09	0.09	7.10	7.50
Minimum	0.70	0.20	0.50	0.09	0.09	0.09	0.09	0.09	7.10	7.50
Average	0.93	1.20	5.97	0.09	0.19	0.09	0.09	2.30	9.50	9.27
Maximum	1.30	2.10	10.10	0.09	0.70	0.10	0.10	3.40	12.20	11.10

(a)Filtered Sample

Temperature/pH. Supplemental temperature and pH testing was performed during sample collection of the process wastewater for the influent, primary effluent, RSS, mixed liquor in each SCT, mixed liquor in each RBC unit, and effluent to identify changes as treatment progresses. In general, the temperature of the wastewater increased as the wastewater proceeded through the treatment process. The influent temperature ranged from 65°F to 67°F, and averaged 66°F. The effluent temperature ranged from 68°F to 70°F, and averaged 68°F. A summary of the temperature testing results is presented in Table 17.

Table 17 Temperature Testing Results

Date	Influent	PE	RSS	SCT 3	SCT 1	SCT 2	SCT 4	RBC 1	RBC 2	Final Effluent
	Temperature, degrees Fahrenheit									
8/2/2016	66	--	68	66	68	68	67	68	68	--
8/3/2016	67	65	68	68	68	68	68	68	68	68
8/4/2016	67	68	70	69	69	69	69	69	69	--
8/9/2016	65	65	68	67	66	67	67	68	68	69
8/10/2016	65	67	69	68	67	68	68	68	68	68
8/11/2016	65	66	69	69	69	68	68	69	69	70
Minimum	65	65	68	66	66	67	67	68	68	68
Average	66	66	69	68	68	68	68	68	68	69
Maximum	67	68	70	69	69	69	69	69	69	70

The pH of the influent wastewater was ranged from 7.36 to 7.65, the pH of the primary effluent ranged from 6.71 to 7.03, the pH of the mixed liquor in the SCTs ranged from 6.73 to 7.27, the pH of the mixed liquor in the RBC units ranged from 7.03 to 7.31, and the pH of the effluent ranged from 7.15 to 7.34. A summary of the pH testing results is presented in Table 18.

K/Mg/Hardness/Alkalinity. Supplemental testing was performed for K, Mg, hardness, and alkalinity during the Phase 1 testing program. The primary effluent was tested for K, Mg, and hardness to identify the concentration of micronutrients necessary for phosphorus accumulating organisms. The influent and effluent was tested for alkalinity to identify the concentrations and quantity available and consumed for nitrification or recovered from denitrification. A summary of the K, Mg, and Hardness testing results is presented in Table 19.

Table 18 pH Testing Results

Date	pH, standard units									
	Influent	PE	RSS	SCT 3	SCT 1	SCT 2	SCT 4	RBC 1	RBC 2	Final Effluent
8/2/2016	7.50	6.80	7.14	7.05	7.03	7.05	7.00	7.31	7.31	7.34
8/3/2016	7.50	6.96	7.04	7.07	7.08	7.07	7.04	7.11	7.03	7.32
8/4/2016	7.65	6.73	7.11	7.10	7.14	7.16	7.13	7.26	7.23	7.15
8/9/2016	7.42	6.75	7.07	7.24	7.24	7.27	7.22	7.23	7.21	7.22
8/10/2016	7.36	6.71	7.06	7.07	7.00	6.73	7.06	7.20	7.14	7.29
8/11/2016	7.43	7.03	7.12	7.14	7.02	7.05	7.03	7.21	7.08	7.19
Minimum	7.36	6.71	7.04	7.05	7.00	6.73	7.00	7.11	7.03	7.15
Maximum	7.65	7.03	7.14	7.24	7.24	7.27	7.22	7.31	7.31	7.34

Table 19 K, Mg, and Hardness Testing Results

Date	Primary Effluent		
	K, mg/l	Mg, mg/l	Hardness, mg/l (a)
8/2/2016	12.9	11.6	147
8/3/2016	11.9	11.2	153
8/4/2016	11.5	11.7	156
8/9/2016	13.9	12.2	156
8/10/2016	12.4	11.2	143
8/11/2016	9.9	7.5	105
Minimum	9.9	7.5	105
Average	12.1	10.9	143
Maximum	13.9	12.2	156

(a)Reported as $CaCO_3$

The influent alkalinity ranged from 204 mg/l to 266 mg/l, and averaged 243 mg/l as calcium carbonate ($CaCO_3$). The effluent alkalinity ranged from 115 mg/l to 158 mg/l, and averaged 132 mg/l as $CaCO_3$. A summary of the alkalinity testing results is presented in Table 20.

Table 20 Alkalinity Test Results

Date	Alkalinity, mg/l as $CaCO_3$	
	Influent	Final Effluent
8/2/2016	245	119
8/3/2016	204	142
8/4/2016	221	115
8/9/2016	256	119
8/10/2016	263	136
8/11/2016	266	158
Minimum	204	115
Average	243	132
Maximum	266	158

SIGNIFICANCE OF RESULTS

The Phillips WWTP performed well during the Phase 1 testing program. The nitrification and denitrification process testing results are as would be expected in RBC/SR secondary treatment process. The EBPR process testing results indicate variation from what would be expected. The following sections describe the significance of results for primary treatment and secondary treatment processes at the Phillips WWTP.

Primary Treatment

The primary clarifiers removed approximately 34 percent of the BOD_5, 22 percent of the COD, 44 percent of the TSS, 24 percent of the TKN, 28 percent of the ammonia, 20 percent of the TP, and 17 percent of the orthophosphate from the influent wastewater based on average loadings during the Phase 1 testing program.

VFA formation can occur in the wastewater collection system when the collection system is relatively large where the temperature of the wastewater and detention time can promote fermentation of organics. The wastewater collection system in the City of Phillips is relatively small and does not provide adequate detention time for fermentation of organics. The northern climate in the City of Phillips provides for cooler temperatures and significant frost penetration in the winter months, which results in cooler wastewater temperatures. The WWTP staff operates the sludge pumps once a month to maintain sludge blanket in the primary clarifiers. The objective of maintaining a primary sludge blanket is to ferment the primary sludge to generate VFA. The average mass of VFA leaving the primary clarifiers was 40 ppd. The average mass of $SCBOD_5$ leaving the primary clarifiers was 85 ppd. The mass of VFA is approximately 50 percent of the $SCBOD_5$ mass leaving the primary clarifiers. Typical VFA to TP ratios to support EBPR range from 4:1 to 16:1. The VFA to TP ratio includes the mass phosphorus in the primary effluent and the RSS. The VFA to TP ratio was calculated for the Phase 1 testing program. The VFA to TP ratio and ranged from 1.8:1 to 8.9:1, and averaged 5.9:1.

The long detention time of the primary sludge in primary clarifiers when wastewater temperatures are warm can result in conversion of VFA to carbon dioxide and methane as fermentation of the sludge continues to progress to methane phase digestion.

The alkalinity of the wastewater must be adequate to provide buffering capacity for nitrification of ammonia. Alkalinity is destroyed as ammonia is oxidized. For estimating purposes, 7.14 milligrams (mg) of Alkalinity as $CaCO_3$ per mg of ammonia oxidized is used to determine if alkalinity is adequate. The average alkalinity of the influent wastewater during the Phase 1 testing program was 243 mg/l as $CaCO_3$. The average ammonia concentration of the primary effluent during the Phase 1 testing program was 18.5 mg/l. Approximately 132 mg of alkalinity is required to oxidize 18.5 mg of ammonia. The wastewater appears to have adequate buffering capacity for nitrification.

K and Mg are used by phosphorus accumulating organisms to maintain an ionic charge balance when release and uptake of phosphorus occurs. The molar ratio of K to soluble orthophosphate necessary for EBPR ranges from 0.25:1 to 0.28:1. The molar ratio of Mg to soluble orthophosphate necessary for EBPR ranges from 0.26:1 to 0.36:1. The Phase 1 testing program results for K and Mg indicate that primary effluent contains adequate K and Mg for the EBPR process.

Secondary Treatment

The secondary treatment system removed 95 percent of the $CBOD_5$, 96 percent of the $SCBOD_5$, 81 percent of the COD, 64 percent of the SCOD, 92 percent of the TSS, 76 percent of the TKN, 77 percent of the ammonia, 90 percent of the TP, and 91 percent of the orthophosphate from the primary effluent based on average loadings during the Phase 1 testing program.

A $SCBOD_5$ mass balance was calculated for the first SCT compartment where the primary effluent mixes with the RSS. The mass balance calculations are included in Appendix "F", Page F-3. Approximately 63 percent of the combined $SCBOD_5$ from the primary effluent and RSS was removed in the first SCT compartment. No additional $SCBOD_5$ removal occurred through the remaining three SCT compartments. It appears that no additional $SCBOD_5$ removal occurs under anoxic or anaerobic conditions in the second, third, and fourth SCT compartments. The first stage RBC unit removed approximately 64 percent of the $SCBOD_5$ remaining after the SCT compartments. Little or no additional $SCBOD_5$ removal occurred in the second stage RBC unit.

The alkalinity of the final effluent ranged from 115 mg/l to 158 mg/l, and averaged 132 mg/l as $CaCO_3$ during the Phase 1 testing program. On average, approximately 111 mg/l of alkalinity was destroyed through the secondary treatment process.

Nitrification/Denitrification. Nitrification of ammonia occurs in the secondary treatment process under aerobic conditions. The results of the Phase 1 testing program indicate a reduction in the concentration of ammonia in the first compartment of the SCT. The primary effluent ammonia concentration was reduced in the SCT because of dilution from the addition of RSS. A mass balance for ammonia indicate no ammonia removal occurs in the SCT. The mass balance calculations are included in Appendix "F", Page F-4. All ammonia removal occurred in the RBC units. RBC Unit No. 1 removed approximately 16 percent of the ammonia based on the average concentration during the Phase 1 testing period. RBC Unit No. 2 removed approximately 75 percent of the ammonia based on the average concentration during the Phase 1 testing period.

Denitrification of NO_x during the Phase 1 testing program occurred in the first SCT compartment. A mass balance of NO_x was calculated for the first SCT compartment where the primary effluent mixes with the RSS. The mass balance calculations are included in Appendix "F", Page F-5. Approximately 4.14 mg/l of NO_x was converted to nitrogen gas in the first SCT compartment, which is approximately 98 percent conversion. Conversion of 1 mg of NO_x to nitrogen gas requires approximately 2.86 mg of BOD_5.

The secondary treatment system removed approximately 76 percent of the TKN from the primary effluent during the Phase 1 testing program. The secondary treatment system removed approximately 48 percent of the total nitrogen from the primary effluent during the Phase 1 testing program. The WWTP removed approximately 81 percent of the influent TKN of which 74 percent of the influent TKN was removed in the secondary treatment system during the Phase 1 testing program. A summary of the data for nitrification and nitrogen removal is included in Appendix "F", Pages F-6.1 and F-6.2.

Phosphorus Removal. A phosphorus mass balance was calculated for the first SCT compartment and last SCT compartment to determine the mass of phosphorus added to the SCT from the primary effluent and the RSS, and to determine total mass measured in the tank. The difference between the mass measured in the SCTs and the calculated mass added to the tank from the primary effluent and RSS flow streams is the amount released. The mass balance calculations indicate slight phosphorus release occurred, 0.47 mg/l to 2.14 mg/l, during the first four (4) days of the Phase 1 testing program. A moderate amount of phosphorus was released, 4.24 mg/l to 9.22 mg/l, during the last two (2) days of the Phase 1 testing program.

The TP content of the MLSS in an EBPR process typically ranges from 3 to 6 percent, while the typical TP content of the MLSS in biological processes typically range from 1 to 2 percent. The average TP content of the MLSS in the RSS was 4.1 percent, and the average TP content of the MLSS in the SCTs was 4.2 percent during the Phase 1 testing program. The TP content of the MLSS calculated using the data from the Phase 1 testing program indicates EBPR is occurring even when phosphorus release across the SCTs was not significant, and soluble substrate removal was not measured. A moderate amount of phosphorus release was measured in the last SCT Compartment SCT 4 during the last two (2) days of the Phase 1 testing program. A review of the TP/MLSS ratios in the SCTs on August 11, 2016, as shown in Table 13, indicates a slight reduction in the TP content of the MLSS as phosphorus is released in the last SCT compartment.

It appears that denitrification of NO_x consumed a large portion of the readily biodegradable $SCBOD_5$ and VFA in the first SCT compartment during the first five (5) days of the Phase 1 testing program. No additional $SCBOD_5$ removal occurred in the second, third, or fourth SCT compartment.

In a typical EBPR process, orthophosphate concentrations would increase significantly through the SCT and the $SCBOD_5$ concentration would decrease through the SCT. The results of the Phase 1 testing program indicate a slight release of orthophosphate in the SCT during the first five days of testing, and a moderate release of orthophosphate in the SCT the sixth day of testing. The results of the Phase 1 testing program indicated the $SCBOD_5$ significantly decreased as the primary effluent entered the first SCT compartment and then remained at a constant concentration through the remaining three SCT compartments. The $SCBOD_5$ concentration showed a significant decrease as the wastewater passed through the first stage RBC unit and little or no decrease as the wastewater passed through the second stage RBC unit.

The lack of phosphorus release appears to be related to denitrification. The results of the Phase 1 testing program indicate a significant amount of NO_x was being recycled in the RSS flow. The results indicate complete denitrification was occurring in the first SCT. It appears that all or most of the VFA are used in the denitrification process and only a small fraction of VFA are available for the EBPR process. The only day with moderate orthophosphate release was the final day of testing when the NO_x concentration in the RSS flow was only 0.5 mg/l. The nitrate concentration of the RSS during the first five days of testing ranged from 4.0 mg/l to 10.1 mg/l.

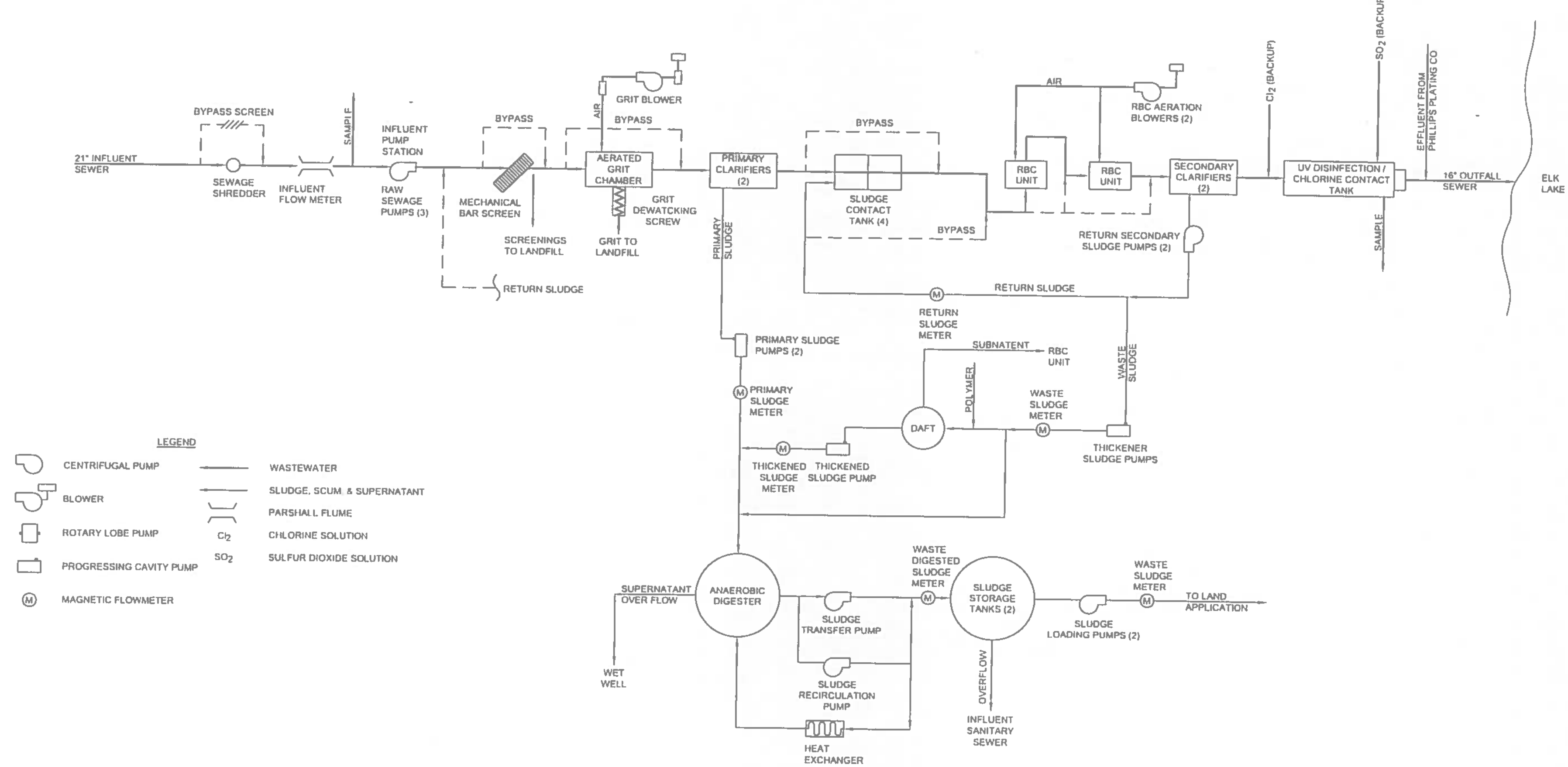
Phase 1 Recommendations

The operation of the Phillips WWTP should be modified to improve BNR during the summer when wastewater temperatures are warmer and nitrification is occurring. The frequency of sludge removal from the primary clarifiers should be increased when the wastewater temperatures increase to optimize fermentation and minimize conversion of VFA to methane and carbon dioxide. Separate denitrification of the RSS in first SCT compartment should be considered when nitrification is occurring in the RBC units. Denitrified RSS would then mix with primary effluent in the second SCT compartment. This method of operation would reduce VFA consumption from denitrification, and allow more opportunity for the phosphorus accumulating organisms to utilize readily biodegradable $SCBOD_5$ and VFA under anaerobic conditions.

Supplemental VFA addition is recommended as a pilot demonstration to determine if the EBPR process can be maintained when the temperature of the wastewater is below 45°F during the winter and early spring. It appears that the rate of primary sludge fermentation decreases significantly when the temperature of the wastewater is below 45°F. The reduced rate of fermentation does not provide adequate readily biodegradable $SCBOD_5$ and VFA for the phosphorus accumulating organisms to provide reliable performance.

APPENDIX A

PROCESS FLOW SCHEMATIC DIAGRAM



Plant Flow Schematic

APPENDIX B

WWTP DESIGN DATA

Item	Value
Flows, mgd	
Average Annual	0.374
Maximum Month	0.603
Maximum Day	1.200
Peak	1.400
BOD_5, ppd	
Average Annual	530
Maximum Month	685
Maximum Week	745
Maximum Day	920
Suspended Solids, ppd	
Average Annual	445
Maximum Month	685
Maximum Week	995
Maximum Day	1135
Total Kjeldahl Nitrogen, ppd	
Average Annual	82
Maximum Month	107
Maximum Week	115
Maximum Day	144
Ammonia, ppd	
Average Annual	48
Maximum Month	63
Maximum Week	67
Maximum Day	84
Phosphorus, ppd	
Average Annual	18
Maximum Month	24
Maximum Week	26
Maximum Day	32
Septage Receiving Station (New)	
Number Units	1
Volume, gal.	6000
Number Pumps	1
Pump Capacity, gpm	20
Motor Size, Hp	2
Sewage Shredder	
Number	1
Capacity, mgd	1.08
Motor Size, Hp	2
Manually Cleaned Bypass Bar Screen	
Number	1
Width, ft.	1.5
Slot Width, inches	1
Parshall Flume	
Number	1
Throat Width, in.	6
Capacity, mgd	1.44
Raw Sewage Pumps (Upgraded)	
Number	3
Capacity Each, gpm	500
Total Dynamic Head, ft	35
Motor Size, Hp	10
Mechanically Cleaned Bar Screen (New)	
Number	1
Slot Width, inches	0.25
Capacity, mgd	1.8
Motor Size, Hp	2
Grit Removal Unit (New)	
Number	1
Surface Area, sq.ft.	44.8
Overflow Rate @ Peak Flow,gpd/sq ft	31,250
Capacity, mgd	1.5
Motor Size, Hp	1
Grit Chamber Blower (New)	
Number	1
Capacity, cfm @ 4 psi	12
Motor Size, Hp	2

Item	Value
Primary Clarifiers	
Number	2
Dimensions	
Length, ft.	30
Width, ft.	10
Sidewater Depth, ft.	7.25
Motor Size, Hp	0.5
Surface Area per Tank, sq ft.	300
Overflow Rate, gpd, sq ft.	
Average Annual Flow	624
Peak Flow	2,333
Volume per Tank, cu ft.	2,175
Weir Length per Tank, ft.	30
Weir Overflow Rate, gpd/ft.	
Average Annual Flow	8,234
Peak Flow	23,333
Primary Sludge Pumps	
Number	2
Capacity, gpm	30
Total Dynamic Head, ft.	115
Motor Size, Hp	5
Sludge Contact Tank (New)	
Number Compartments	4
Dimensions per Compartment	
Length, ft.	16
Width, ft.	8
Sidewater Depth, ft.	12
Volume per Compartment, 1,000 cu ft.	1.563
Sludge Contact Tank Mixers (New)	
Number	4
Motor Size, Hp	1
Rotating Biological Contactors	
Organic Loading, lbs BOD₅/1,000 sq ft.	
Average Annual Loading	2.4
Maximum Day Loading	4.2
RBC Unit No. 1 (1 Stage)	
Dimensions	
Length, ft.	27
Width, ft.	14.33
Depth, ft.	6
Volume, cu.ft.	1,834
RBC Surface Area, 1,000 sq ft.	124.5
Hydraulic Loading, gpd/sq ft.	
Average Annual Flow	3.0
Peak Flow	11.3
Motor Size, Hp	5
RBC Unit No. 2 (2 stages)	
Dimensions	
Length, ft.	27
Width, ft.	14.33
Depth, ft.	6
Volume, cu ft.	1,812
RBC Surface Area, 1,000 sq ft.	96
Hydraulic Loading, gpd/sq ft.	
Average Annual Flow	3.9
Peak Flow	14.6
Motor Size, Hp	5
Supplemental Aeration Blowers	
Number	2
Capacity Each, cfm @ 3.2 psig	385
Motor Size, Hp	7.5
Secondary Clarifiers	
Number	2
Dimensions	
Length, ft.	40
Width, ft.	12
Sidewater Depth, ft.	10
Motor Size, Hp	0.5
Surface Area per Tank, sq ft.	480
Overflow Rate, gpd/sq ft.	
Average Annual Flow	390
Peak Flow	1,458
Volume per Tank, cu ft.	4,800
Weir Length per Tank, ft.	72
Weir Overflow Rate, gpd/ft.	
Average Annual Flow	2,600
Peak Flow	9,722

Item	Value
Return Secondary Sludge Pumps (New)	
Number	2
Capacity Each, gpm	210
Motor Size, Hp	2
Primary/ Secondary Scum Pump	
Number	1
Capacity, gpm	45
Motor Size, Hp	2
Dissolved Air Flotation Thickener (New)	
Number	1
Dimensions	
Diameter, ft.	6
Sidewater Depth, ft.	1.33
Flotation Area, sq ft.	23.6
Solids Loading, lbs TS/sq ft./hr	
Average Annual Loading	0.8
Maximum Week Loading	1.2
Rotating Carriage Motor Size, Hp	0.5
Sludge Scoop Motor Size, Hp	0.5
Thickener Recycle Pump (New)	
Number	1
Capacity, gpm	25
Total Dynamic Head, ft.	185
Motor Size, Hp	7.5
Thickener Air Compressor (New)	
Number	1
Capacity, acfm @ 175 psig	17
Motor Size, Hp	5
Polymer Feed System (New)	
Number	1
Neat Polymer Feed Capacity, gph	0.04
Dilution Water Capacity, gph	4
Thickener Sludge Pumps (New)	
Number	3
Capacity Each, gpm	30
Total Dynamic Head, ft.	115
Motor Size, Hp	5
Chlorine Contact Tank	
Number	1
Volume, 1,000 cu ft.	3.06
Detention Time, minutes	
Average Annual Flow	88
Peak Flow	24
UV Disinfection	
Number of Channels	1
Number of Banks	2
Number of Modules Per Bank	4
Number of Lamps Per Module	6
Total Lamps	48
Chlorination Equipment (Portable)	
Chlorinator	1
Number	100
Capacity, ppd	10
Rotameter Size, ppd	
Dechlorination Equipment	
Sulfonator	1
Number	100
Capacity, ppd	10
Rotameter Size, ppd	
Anaerobic Digester	1
Number	
Dimensions	25
Diameter, ft.	19
Side Water Depth, ft.	10.47
Volume, 1,000 cu ft.	
Anaerobic Digester Mixer (New)	1
Number	5
Motor Size, Hp	

Item	Value
Boiler/Heat Exchanger	
Number	1
Capacity, 1,000 Btu's/hr.	
Boiler	432
Heat Exchanger	110
Recirculation Rate, gpm	75
Sludge Recirculation Pump	
Number	1
Capacity, gpm	75
Total Dynamic Head, ft.	26
Motor Size, Hp	7.5
Sludge Transfer Pump	
Number	1
Capacity, gpm	75
Total Dynamic Head, ft.	26
Motor Size, Hp	7.5
Sludge Storage Tank	
Number	1
Dimensions	
Diameter, ft.	28
Sidewater Depth, ft.	17
Center Water Depth, ft.	20.5
Volume, 1,000 cu.ft.	11.2
Sludge Storage Tank (New)	
Number	1
Dimensions	
Diameter, ft.	36
Sidewater Depth, ft.	20
Center Water Depth, ft.	24.5
Volume, 1,000 cu.ft.	20.4
Sludge Storage Tank Mixing/Loading Pumps (New)	
Number	2
Capacity Each, gpm	600
Motor Size, Hp	7.5
Engine Generator	
Number	1
Capacity, KW	100

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APPENDIX C

INFLUENT AND EFFLUENT WASTEWATER CHARACTERISTICS

PHILLIPS WASTEWATER TREATMENT PLANT
INFLUENT CHARACTERISTICS

Month	Flow mgd	BOD5 mg/l	BOD5 PPD	SS mg/l	SS PPD	PHOSPHORUS mg/l
Jan 92	0.209	202	352	147	256	
Feb	0.226	188	354	140	264	
Mar	0.308	159	408	121	311	
Apr	0.370	129	398	101	312	
May	0.329	155	425	125	343	
Jun	0.262	200	437	173	378	
Jul	0.258	200	430	175	377	6.3
Aug	0.260	179	388	154	334	7.3
Sep	0.318	153	406	162	430	6.6
Oct	0.323	202	544	202	544	5.1
Nov	0.273	202	460	155	353	9.4
Dec	0.223	223	415	171	318	6.9
Jan 93	0.226	216	407	177	334	8.1
Feb	0.225	192	360	167	313	10.0
Mar	0.230	199	382	148	284	8.4
Apr	0.269	140	314	114	256	6.1
May	0.383	122	390	114	364	2.5
Jun	0.469	120	469	111	434	5.0
Jul	0.308	153	393	121	311	4.2
Aug	0.292	200	487	173	421	2.5
Sep	0.288	180	432	157	377	6.3
Oct	0.273	199	453	140	319	7.3
Nov	0.257	214	459	147	315	6.7
Dec	0.221	199	367	149	275	6.3
Jan 94	0.221	199	367	138	254	6.6
Feb	0.239	212	423	154	307	6.6
Mar	0.231	211	406	145	279	8.8
Apr	0.269	218	489	180	404	6.5
May	0.279	175	407	137	319	6.5
Jun	0.297	160	396	133	329	6.6
Jul	0.267	185	412	164	365	6.6
Aug	0.269	187	420	180	404	4.7
Sep	0.495	124	512	121	500	5.9
Oct	0.376	129	405	134	420	5.2
Nov	0.264	187	412	138	304	6.0
Dec	0.226	223	420	156	294	8.2
Jan 95	0.225	227	426	158	296	7.9
Feb	0.220	237	435	160	294	7.8
Mar	0.256	189	404	165	352	8.0
Apr	0.276	176	405	181	417	7.6
May	0.292	187	455	143	348	6.1
Jun	0.245	201	411	173	353	7.0
Jul	0.265	154	340	151	334	6.7
Aug	0.377	160	503	143	450	7.8
Sep	0.259	185	400	143	309	6.2
Oct	0.273	209	476	170	387	6.9
Nov	0.238	219	435	156	310	6.0
Dec	0.189	231	364	161	254	9.5

PHILLIPS WASTEWATER TREATMENT PLANT
INFLUENT CHARACTERISTICS

Month	Flow	BOD5		SS		PHOSPHORUS
	mgd	mg/l	PPD	mg/l	PPD	mg/l
Jan 96	0.198	227	375	160	264	5.9
Feb	0.227	233	441	140	265	6.9
Mar	0.233	187	363	144	280	6.6
Apr	0.421	126	442	97	341	6.0
May	0.306	163	416	147	375	5.8
Jun	0.323	146	393	156	420	5.6
Jul	0.341	135	384	136	387	6.8
Aug	0.353	130	383	151	445	6.1
Sep	0.299	149	372	172	429	7.4
Oct	0.317	153	404	143	378	6.6
Nov	0.327	161	439	144	393	6.1
Dec	0.217	185	335	151	273	7.4
Jan 97	0.227	185	350	133	252	11.0
Feb	0.264	177	390	152	335	7.3
Mar	0.304	197	499	144	365	9.4
Apr	0.491	96	393	113	463	
May	0.276	149	343	146	336	
Jun	0.288	151	363	141	339	
Jul	0.261	150	327	147	320	
Aug	0.261	150	327	147	320	
Sep	0.275	152	349	163	374	
Oct	0.298	132	328	128	318	
Nov	0.235	163	319	133	261	
Dec	0.208	188	326	157	272	
Jan 98	0.197	172	283	136	223	
Feb	0.243	149	302	133	270	
Mar	0.252	186	391	158	332	
Apr	0.236	128	252	128	252	
May	0.235	177	347	177	347	
Jun	0.240	146	292	158	316	
Jul	0.215	164	294	159	285	
Aug	0.207	218	376	165	285	
Sep	0.212	264	467	188	332	
Oct	0.212	258	456	171	302	
Nov	0.188	238	373	170	267	
Dec	0.186	227	352	168	261	
Jan 99	0.175	227	331	180	263	
Feb	0.187	205	320	158	246	
Mar	0.192	205	328	169	271	
Apr	0.212	178	315	152	269	
May	0.289	131	316	129	311	
Jun	0.257	162	347	149	319	
Jul	0.283	152	359	149	352	
Aug	0.302	154	388	149	375	
Sep	0.260	152	330	151	327	
Oct	0.246	180	369	170	349	
Nov	0.238	213	423	150	298	
Dec	0.245	190	388	157	321	

PHILLIPS WASTEWATER TREATMENT PLANT

INFLUENT CHARACTERISTICS

Month	Flow mgd	BOD5 mg/l	BOD5 PPD	SS mg/l	SS PPD	PHOSPHORUS mg/l
Jan 00	0.243	170	345	169	342	
Feb	0.221	175	323	169	311	
Mar	0.243	143	290	109	221	
Apr	0.299	129	322	128	319	
May	0.231	154	297	139	268	
Jun	0.255	136	289	148	315	
Jul	0.216	129	232	145	261	
Aug	0.194	156	252	135	218	
Sep	0.185	148	228	148	228	
Oct	0.164	187	256	195	267	
Nov	0.166	196	271	155	215	
Dec	0.151	196	247	177	223	
Jan 01	0.159	182	241	145	192	
Feb	0.149	181	225	135	168	
Mar	0.169	166	234	132	186	
Apr	0.293	121	296	97	237	
May	0.253	144	304	136	287	
Jun	0.315	138	363	152	399	
Jul	0.201	178	298	164	275	
Aug	0.211	142	250	120	211	
Sep	0.205	154	263	137	234	
Oct	0.189	187	295	165	260	
Nov	0.178	154	229	123	183	
Dec	0.192	157	251	111	178	
Jan 02	0.163	192	261	160	218	
Feb	0.181	179	270	141	213	8.2
Mar	0.193	193	311	148	238	8.8
Apr	0.548	120	548	88	402	5.8
May	0.346	124	358	105	303	5.2
Jun	0.225	169	317	141	265	5.9
Jul	0.238	152	302	135	268	6.2
Aug	0.284	149	353	139	329	6.3
Sep	0.328	131	358	120	328	5.2
Oct	0.375	114	357	122	382	4.9
Nov	0.220	171	314	134	246	6.4
Dec	0.199	149	247	150	249	6.3
Jan 03	0.206	181	311	137	235	6.8
Feb	0.209	170	296	136	237	6.4
Mar	0.230	145	278	121	232	5.5
Apr	0.368	126	387	120	368	4.4
May	0.369	107	329	110	339	4.0
Jun	0.227	133	252	128	242	5.6
Jul	0.191	156	248	152	242	6.5
Aug	0.166	163	226	166	230	6.2
Sep	0.149	197	245	164	204	7.0
Oct	0.163	187	254	154	209	
Nov	0.154	192	247	173	222	
Dec	0.168	187	262	158	221	

PHILLIPS WASTEWATER TREATMENT PLANT

INFLUENT CHARACTERISTICS

Month	Flow mgd	BOD5 mg/l	BOD5 PPD	SS mg/l	SS PPD	PHOSPHORUS mg/l
Jan 04	0.161	194	260	193	259	
Feb	0.180	184	276	162	243	
Mar	0.263	151	331	139	305	
Apr	0.270	118	266	122	275	
May	0.226	153	288	142	268	
Jun	0.258	154	331	149	321	
Jul	0.165	197	271	208	286	
Aug	0.174	185	268	181	263	
Sep	0.177	177	261	184	272	
Oct	0.189	207	326	207	326	
Nov	0.185	177	273	163	251	
Dec	0.174	224	325	198	287	
Jan 05	0.184	193	296	153	235	
Feb	0.181	190	287	159	240	
Mar	0.190	193	306	153	242	
Apr	0.218	193	351	182	331	
May	0.189	174	274	167	263	
Jun	0.205	150	256	145	248	
Jul	0.167	206	287	166	231	
Aug	0.147	188	230	236	289	
Sep	0.140	174	203	210	244	
Oct	0.252	182	381	184	386	
Nov	0.172	182	261	187	268	
Dec	0.166	170	235	192	266	
Jan 06	0.155	201	259	198	255	
Feb	0.156	233	302	186	241	
Mar	0.193	191	308	187	301	
Apr	0.232	141	273	182	351	
May	0.170	188	266	185	262	
Jun	0.148	220	271	254	313	
Jul	0.155	201	260	235	303	
Aug	0.184	186	285	212	325	
Sep	0.134	225	251	218	244	
Oct	0.136	185	209	194	220	
Nov	0.134	209	234	180	201	
Dec	0.126	239	251	197	207	
Jan 07	0.130	227	247	189	205	
Feb	0.138	245	281	174	200	
Mar	0.138	209	240	214	246	
Apr	0.170	165	234	168	239	
May	0.145	220	265	238	287	
Jun	0.159	183	242	236	313	
Jul	0.176	238	349	222	326	
Aug						
Sep	0.173	179	258	217	313	
Oct	0.319	145	385	159	424	
Nov	0.174	192	279	193	279	
Dec	0.185	180	277	158	244	

PHILLIPS WASTEWATER TREATMENT PLANT

INFLUENT CHARACTERISTICS

Month	Flow mgd	BOD5 mg/l	BOD5 PPD	SS mg/l	SS PPD	PHOSPHORUS mg/l
Jan 08	0.199	198	329	175	290	
Feb	0.194	186	300	172	277	
Mar	0.178	203	301	193	286	
Apr	0.389	122	394	121	394	
May	0.258	140	301	148	318	
Jun	0.240	165	331	188	375	
Jul	0.174	217	316	249	362	
Aug	0.202	239	402	362	609	
Sep	0.221	248	457	340	627	
Oct	0.233	203	394	276	537	
Nov	0.216	222	401	245	442	
Dec	0.215	242	433	273	490	
Jan 09	0.251	187	390	175	366	
Feb	0.270	200	451	235	530	
Mar	0.282	214	503	282	664	
Apr	0.250	188	393	236	493	
May	0.236	202	397	209	411	
Jun	0.199	232	384	269	447	
Jul	0.154	247	317	305	392	
Aug	0.149	223	277	254	316	
Sep	0.096	212	169	239	191	
Oct	0.191	169	269	195	310	
Nov	0.179	210	313	232	347	
Dec	0.156	225	294	231	302	
Jan 10	0.152	218	277	234	298	
Feb	0.158	212	279	209	275	
Mar	0.201	205	344	281	471	
Apr	0.170	227	321	265	375	
May	0.170	201	285	224	317	
Jun	0.343	157	447	214	610	
Jul	0.293	122	298	170	415	
Aug	0.395	126	414	197	649	
Sep	0.363	144	434	176	532	
Oct	0.278	174	403	217	503	
Nov	0.237	176	348	201	397	
Dec	0.190	210	333	189	301	
Jan 11	0.188	196	307	196	307	
Feb	0.155	251	324	216	279	
Mar	0.176	208	305	214	313	
Apr	0.282	119	279	149	351	
May	0.254	133	283	191	405	
Jun	0.174	161	234	187	271	
Jul	0.140	173	201	188	218	
Aug	0.187	155	242	200	313	
Sep	0.177	203	300	228	336	
Oct	0.155	204	263	226	292	
Nov	0.165	210	289	191	263	
Dec	0.177	223	328	205	302	

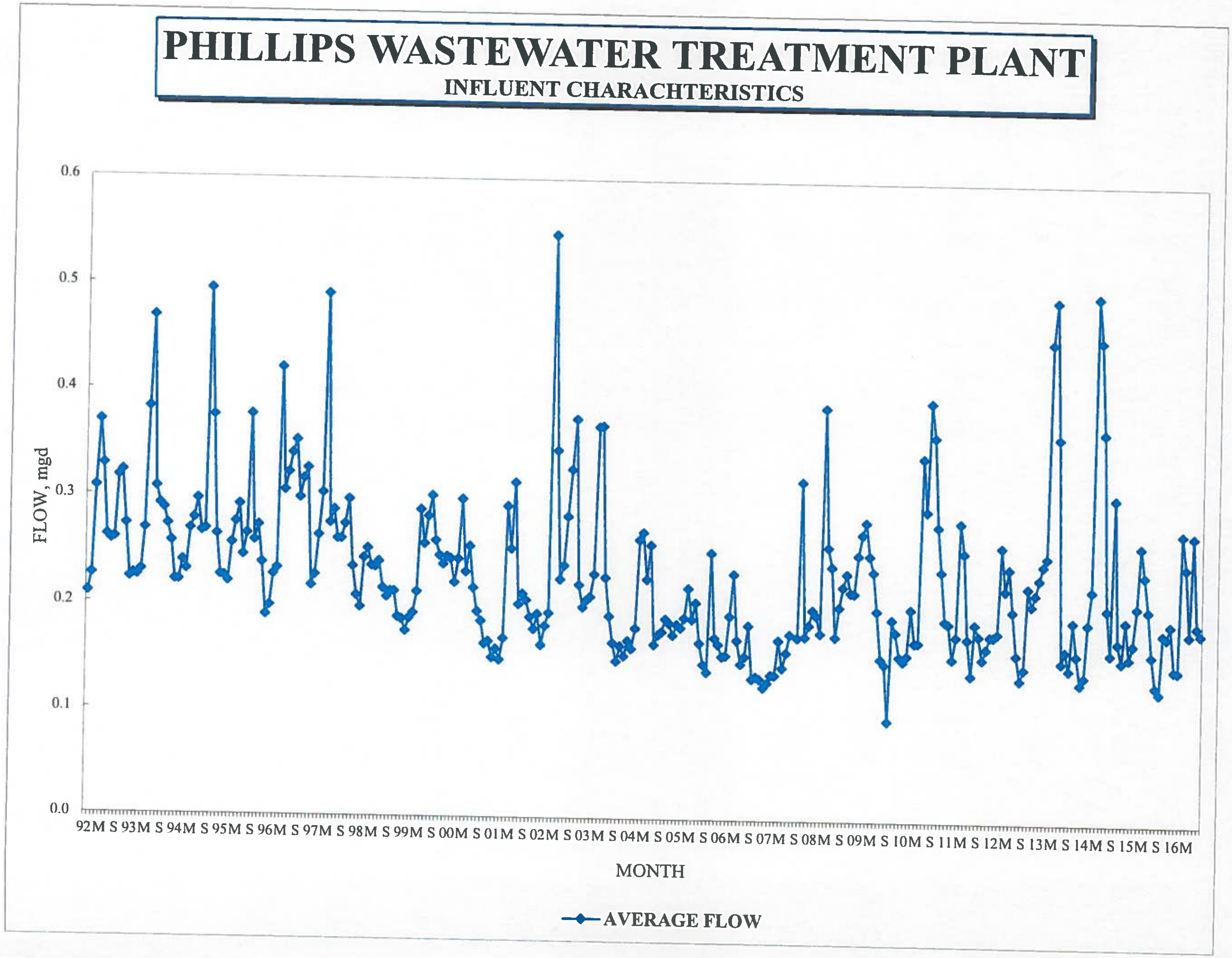
PHILLIPS WASTEWATER TREATMENT PLANT

INFLUENT CHARACTERISTICS

Month	Flow mgd	BOD5 mg/l	BOD5 PPD	SS mg/l	SS PPD	PHOSPHORUS mg/l
Jan 12	0.176	251	369	226	333	
Feb	0.179	211	315	182	272	
Mar	0.260	166	360	158	342	
Apr	0.220	229	420	217	399	
May	0.240	173	345	184	367	
Jun	0.200	186	311	214	358	
Jul	0.160	196	261	215	286	
Aug	0.136	211	239	205	233	
Sep	0.146	198	241	206	251	
Oct	0.222	175	324	198	368	
Nov	0.206	174	298	174	298	
Dec	0.216	209	376	195	352	
Jan 13	0.230	197	379	182	350	
Feb	0.243	197	399	265	538	
Mar	0.251	213	446	210	439	
Apr	0.452	116	439	132	499	
May	0.492	91	372	108	441	
Jun	0.363	139	422	156	470	
Jul	0.153	151	193	140	178	
Aug	0.163	182	248	232	316	
Sep	0.146	171	209	182	221	
Oct	0.191	143	227	156	248	
Nov	0.160	155	206	137	183	
Dec	0.133	202	223	182	201	
Jan 14	0.140	208	242	185	216	
Feb	0.189	149	235	161	253	
Mar	0.220	123	225	130	239	
Apr	0.496	96	397	117	484	
May	0.454	122	462	154	585	
Jun	0.368	143	438	242	742	
Jul	0.203	141	239	154	260	
Aug	0.161	188	253	200	269	
Sep	0.306	114	292	174	444	
Oct	0.172	150	215	171	245	
Nov	0.154	150	192	158	203	
Dec	0.192	155	247	168	269	
Jan 15	0.158	178	234	182	240	
Feb	0.170	153	218	147	208	
Mar	0.205	158	270	174	298	
Apr	0.262	160	349	210	459	
May	0.235	151	295	171	335	
Jun	0.202	180	303	218	368	
Jul	0.160	187	250	199	266	
Aug	0.131	203	222	242	265	
Sep	0.125	214	224	244	255	
Oct	0.180	199	299	242	364	
Nov	0.178	144	213	165	244	
Dec	0.189	144	228	177	279	

PHILLIPS WASTEWATER TREATMENT PLANT
INFLUENT CHARACTERISTICS

Month	Flow	BOD5		SS		PHOSPHORUS
	mgd	mg/l	PPD	mg/l	PPD	mg/l
Jan 16	0.147	190	233	184	225	
Feb	0.146	179	218	158	192	
Mar	0.274	113	258	113	258	
Apr	0.243	149	302	203	411	
May	0.180	178	267	168	252	
Jun	0.272	141	320	167	379	
Jul	0.188	174	273	216	339	
Aug	0.181	168	254	196	296	
Minimum	0.096	91	169	88	168	2.5
Average	0.230	178	328	172	318	6.6
Maximum	0.548	264	548	362	742	11.0
Jan 92-Jul 03						
Minimum	0.149	96	225	88	168	2.5
Average	0.259	172	361	147	311	6.6
Maximum	0.548	264	548	202	544	11.0
Aug 03-Dec 12						
Minimum	0.096	118	169	121	191	6.2
Average	0.196	192	306	201	325	6.6
Maximum	0.395	251	503	362	664	7.0
Jan 13- Aug 16						
Minimum	0.125	91	192	108	178	0.0
Average	0.224	160	221	179	251	
Maximum	0.496	214	462	265	742	0.0



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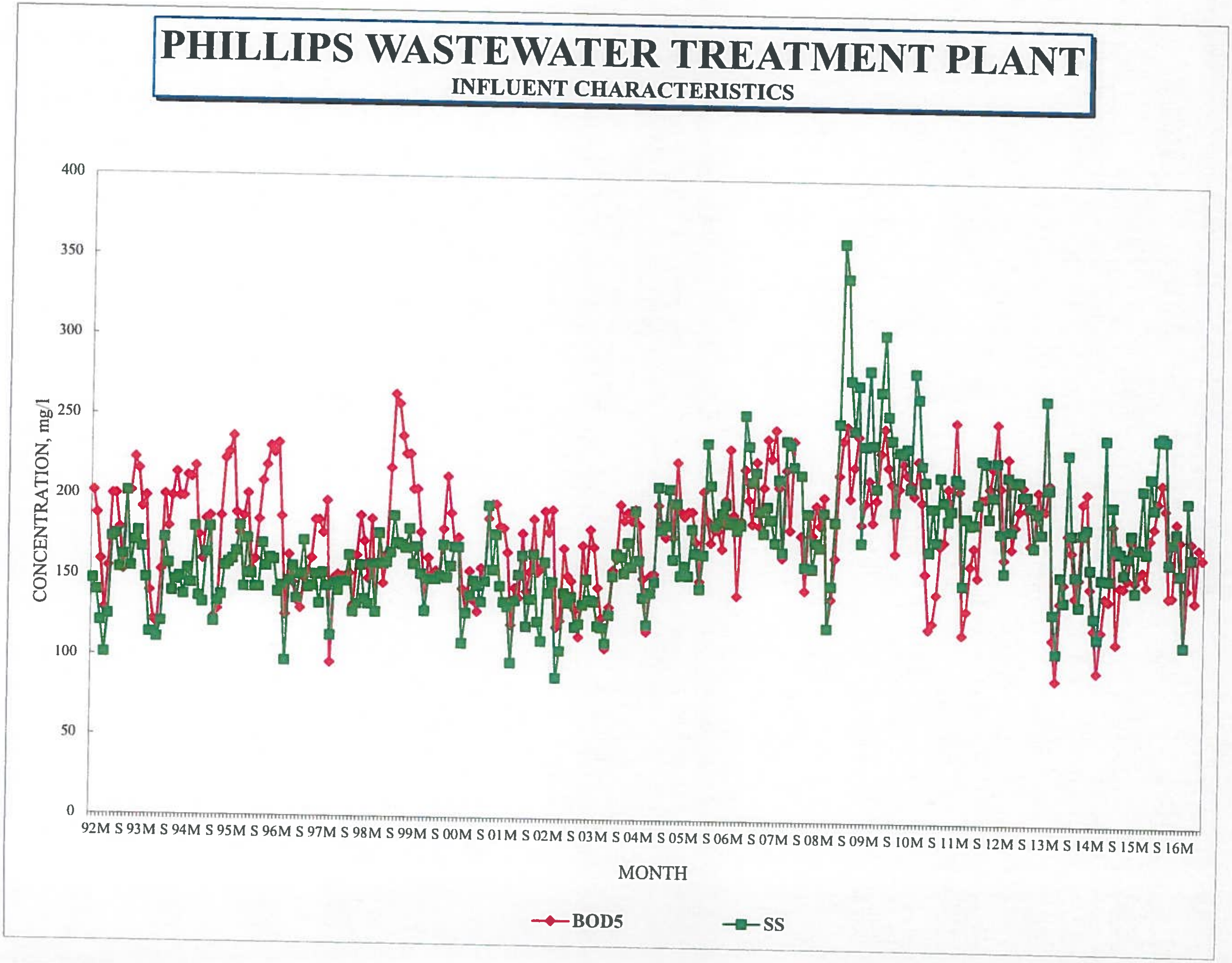

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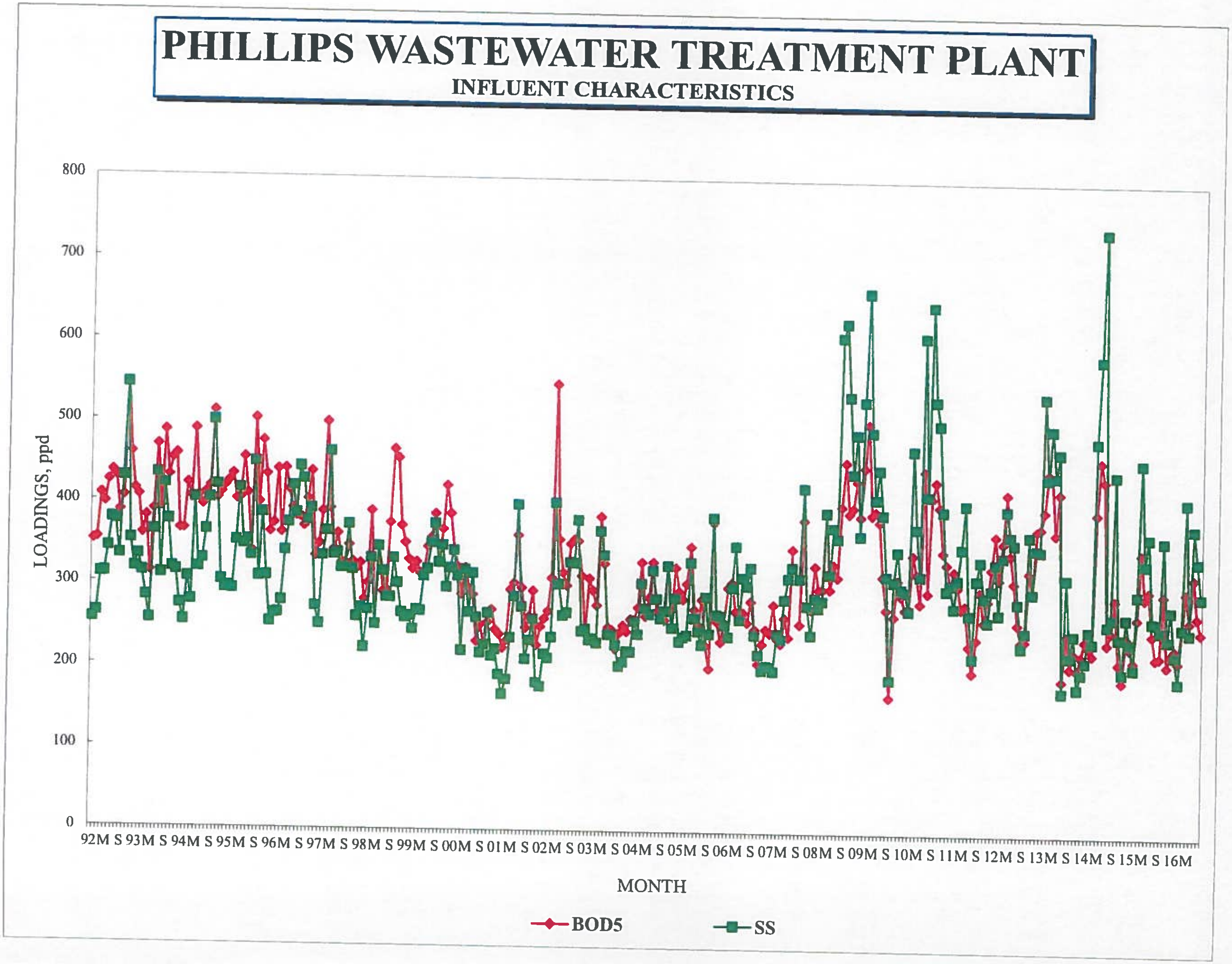

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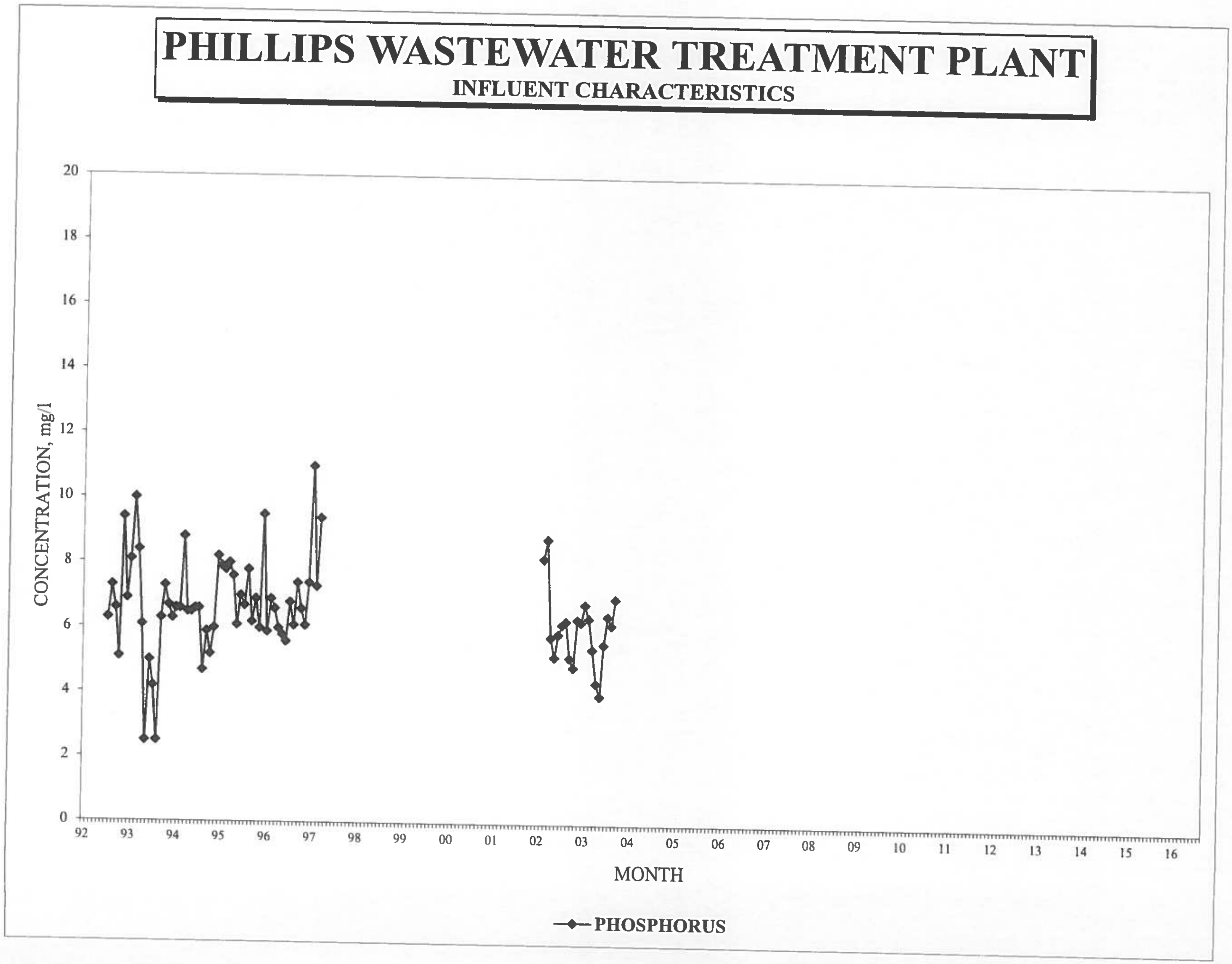

PHILLIPS WASTEWATER TREATMENT PLANT
INFLUENT CHARACTERISTICS
CONCENTRATION, mg/l
0
2
4
6
8
10
12
14
16
18
20
92
93
94
95
96
97
98
99
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
MONTH
PHOSPHORUS

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
Jan 92	33		10		
Feb	26		10		
Mar	33		15		
Apr	29		12		
May	27		11		
Jun	24		13		
Jul		12	16	4.8	
Aug		10	16	5.2	
Sep		11	17	5.7	
Oct		14	15	4.0	
Nov		14	17		
Dec		13	15	3.8	
Jan 93		10	11	6.4	
Feb		9	9	6.9	
Mar		11	11	6.6	
Apr		10	10	4.0	
May		9	9	2.5	
Jun		10	11	4.2	
Jul		8	13	2.6	
Aug		9	16	4.2	
Sep		10	17	5.2	
Oct		12	12	5.0	
Nov		11	11	3.9	
Dec		10	10	4.8	
Jan 94		10	9	5.8	
Feb		12	10	4.6	
Mar		12	9	5.4	
Apr		12	12	3.4	
May		8	10	3.4	
Jun		9	9	4.1	
Jul		9	12	4.6	
Aug		9	20	4.9	
Sep		10	18	4.7	
Oct		10	14	3.8	
Nov		13	14	4.3	
Dec		12	13	11.0	
Jan 95		10	10	7.9	
Feb		13	12	5.5	
Mar		12	12	5.2	
Apr		15	15	4.8	
May		12	11	4.4	
Jun		11	11	5.7	
Jul		10	11	5.6	
Aug		11	15	7.3	
Sep		10	11	6.2	
Oct		13	14	4.7	
Nov		12	11	4.3	
Dec		14	12	5.8	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
Jan 96		16	12	3.8	
Feb		16	13	4.5	
Mar		17	13	4.5	
Apr		15	13	3.4	
May		14	13	7.1	
Jun		10	12	3.5	
Jul		7	8	5.5	
Aug		8	8	4.8	
Sep		7	8	6.3	
Oct		7	7	4.7	
Nov		9	7	4.4	
Dec		9	6	5.2	
Jan 97		15	12	6.1	
Feb		15	12	5.7	
Mar		18	12	6.2	
Apr		14	12	3.4	
May		9	10	4.4	
Jun		12	10	5.6	
Jul		8	9	6.4	
Aug		8	9	6.4	
Sep		9	9	3.6	
Oct		8	11	4.8	
Nov		9	11	5.4	
Dec		10	9	5.2	
Jan 98		10	9	6.3	
Feb		11	11	5.9	
Mar		12	16	5.9	
Apr		12	16	5.4	
May		10	11	1.8	
Jun		8	10	2.2	
Jul		7	9	2.3	
Aug		12	16	5.0	
Sep		14	20	7.6	
Oct		11	14	4.8	
Nov		13	13	5.6	
Dec		13	12	5.3	
Jan 99		12	11	6.2	
Feb		12	10	7.8	
Mar		13	10	7.5	
Apr		13	15	2.7	
May		10	12	4.8	
Jun		11	12	4.5	
Jul		9	13	7.4	
Aug		8	14	4.3	
Sep		9	15	5.2	
Oct		8	13	6.6	
Nov		9	11	5.2	
Dec		9	11	5.6	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
		CONCENTRATION, mg/l			
Jan 00		8	10	4.5	
Feb		12	10	6.2	
Mar		9	12	5.1	
Apr		8	11	4.9	
May		8	10	3.9	
Jun		7	11	5.4	
Jul		7	12	4.3	
Aug		6	9	3.2	
Sep		6	11	4.2	
Oct		7	12	4.7	
Nov		9	10	6.1	
Dec		8	11	6.7	
Jan 01		11	11	1.0	
Feb		12	14	4.6	
Mar		11	12	6.5	
Apr		14	16	3.3	
May		9	13	4.1	
Jun		8	9	6.2	
Jul		7	9	5.0	
Aug		7	12	6.2	
Sep		9	14	6.0	
Oct		9	8	7.4	
Nov		17	15	5.8	
Dec		12	16	5.3	
Jan 02		6	10	4.4	
Feb		6	8	3.3	
Mar		12	16	3.4	
Apr		21	26	4.3	
May		13	20	3.0	
Jun		9	13	2.5	
Jul		7	14	2.4	
Aug		14	19	1.7	
Sep		11	21	2.9	
Oct		8	15	1.2	
Nov		10	13	1.9	
Dec		15	19	4.9	
Jan 03		20	25	5.0	
Feb		16	19	4.8	
Mar		14	22	4.2	
Apr		13	17	2.9	
May		15	23	2.9	
Jun		13	25	3.8	
Jul		11	22	3.8	
Aug		10	22	3.3	
Sep		7	11	0.5	
Oct		6	6	0.4	
Nov		6	7	0.4	
Dec		11	10	0.6	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	6-Month Ave
Jan 04		10	12	1.2	
Feb		10	11	0.7	
Mar		9	11	0.7	
Apr		8	8	3.0	
May		12	15	4.0	
Jun		7	11	1.4	
Jul		3	17	0.6	
Aug		6	15	0.8	
Sep		5	15	0.6	
Oct		4	9	0.4	
Nov		3	10	0.5	
Dec		11	14	0.6	
Jan 05		5	9	1.3	
Feb		5	5	1.4	
Mar		10	10	1.9	
Apr		9	13	2.5	
May		6	15	3.4	
Jun		4	9	2.3	
Jul		5	12	0.4	
Aug		3	13	0.5	
Sep		5	14	0.7	
Oct		10	17	1.5	
Nov		7	14	1.2	
Dec		12	14	1.9	
Jan 06		11	14	1.3	
Feb		9	9	1.6	
Mar		12	12	1.0	
Apr		12	15	1.2	
May		10	14	0.7	
Jun		3	11	0.6	
Jul		6	11	0.6	
Aug		3	13	0.7	
Sep		6	10	0.7	
Oct		3	11	0.6	
Nov		16	20	1.5	
Dec		14	17	0.9	
Jan 07		19	18	1.3	
Feb		15	10	1.1	
Mar		15	10	1.0	
Apr		9	8	0.5	
May		6	7	0.5	
Jun		3	6	0.3	
Jul		3	4	0.4	
Aug		6	9	0.7	
Sep		5	8	0.4	
Oct		3	5	0.3	
Nov		5	9	1.3	
Dec		4	4	0.9	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
Jan 08		8	8	1.8	
Feb		9	8	0.6	
Mar		9	9	0.9	
Apr		9	10	0.8	
May		4	5	0.9	
Jun		3	6	1.0	
Jul		6	11	0.9	
Aug		4	8	0.4	
Sep		5	8	0.5	
Oct		4	6	0.3	
Nov		3	7	0.6	
Dec		8	8	1.1	
Jan 09		10	11	0.9	
Feb		9	12	1.1	
Mar		9	9	0.9	
Apr		7	10	0.4	
May		7	9	0.4	
Jun		5	7	0.3	
Jul		3	10	0.4	
Aug		3	6	0.4	
Sep		2	7	0.5	
Oct		2	11	0.7	
Nov		3	10	1.0	
Dec		4	11	1.2	
Jan 10		7	10	0.9	
Feb		6	14	0.8	
Mar		7	8	0.6	
Apr		6	6	0.3	
May		4	7	0.4	
Jun		4	9	0.4	
Jul		4	12	0.4	
Aug		5	12	0.6	
Sep		4	8	0.3	
Oct		3	8	0.4	
Nov		4	7	0.5	
Dec		4	9	0.6	
Jan 11		5	9	0.6	
Feb		7	9	0.6	
Mar		6	8	0.6	
Apr		7	11	0.8	
May		4	5	0.3	
Jun		3	6	0.3	
Jul		5	7	0.4	
Aug		4	5	0.3	
Sep		2	5	0.3	
Oct		4	5	0.4	
Nov		5	5	0.6	
Dec		7	6	0.9	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

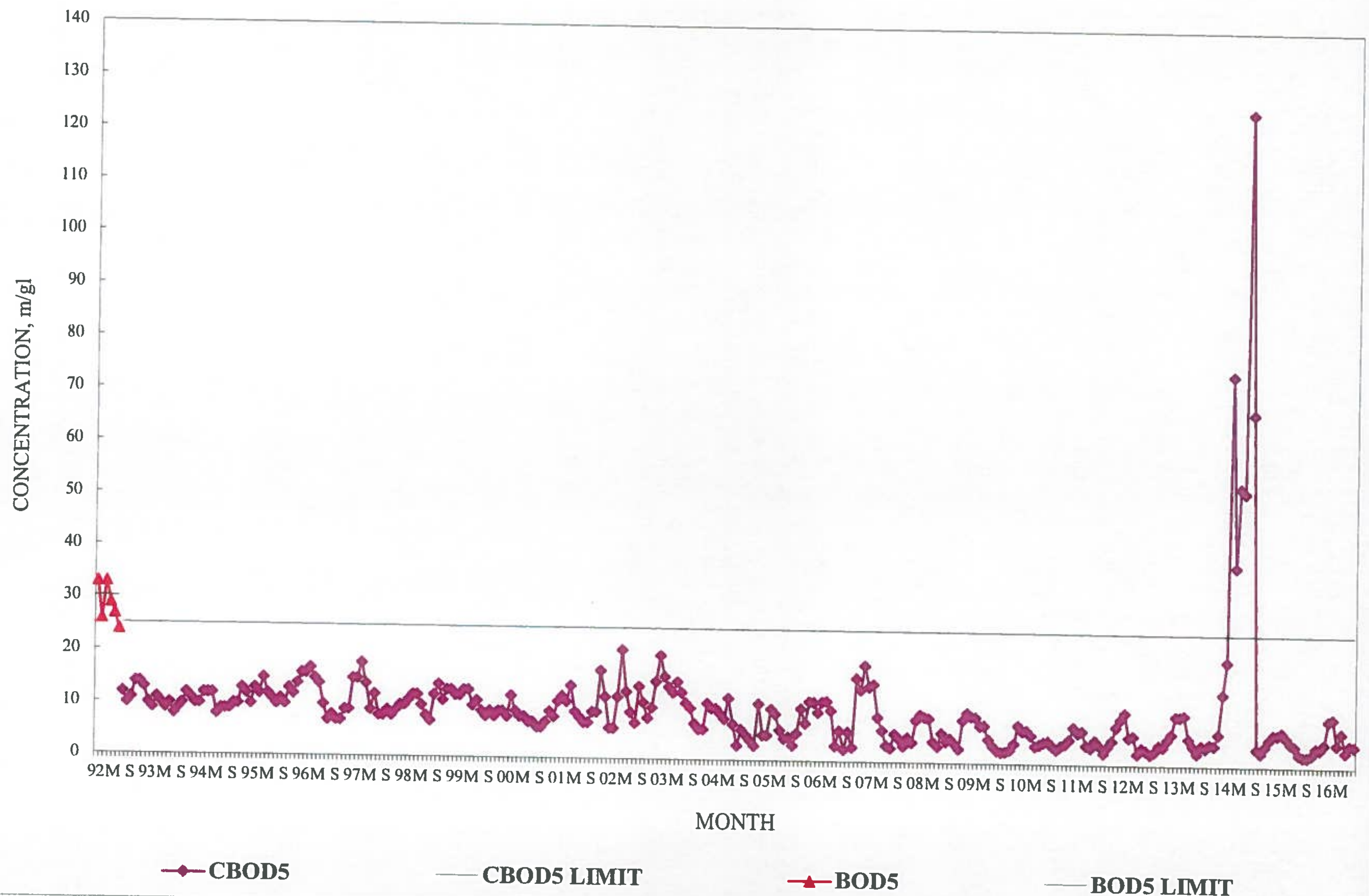
MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
Jan 12		9	6	0.4	
Feb		10	7	0.5	
Mar		5	5	0.3	
Apr		6	6	0.4	
May		2	3	0.2	
Jun		3	7	0.4	
Jul		3	7	0.5	
Aug		2	3	0.8	
Sep		3	6	0.6	
Oct		4	4	0.5	
Nov		4	6	0.4	
Dec		5	6	0.4	
Jan 13		6	8	0.9	
Feb		10	11	0.8	
Mar		9	8	0.6	
Apr		10	11	0.8	
May		5	6	0.5	
Jun		4	3	0.3	
Jul		3	5	0.2	
Aug		4	6	0.3	
Sep		4	8	0.4	
Oct		4	7	0.8	0.4
Nov		4	7	0.5	
Dec		6	6	0.5	
Jan 14		14	14	0.5	
Feb		20	29	1.0	
Mar		74	73	3.6	
Apr		38	57	2.3	
May		53	60	2.6	
Jun		52	57	2.4	
Jul		125	61	3.9	
Aug		67	30	3.0	
Sep		3	9	0.3	
Oct		3	6	0.3	2.1
Nov		4	6	2.3	
Dec		5	6	2.3	
Jan 15		6	5	3.9	
Feb		6	8	1.3	
Mar		7	8	0.7	
Apr		6	8	0.7	
May		5	8	1.0	
Jun		4	8	0.5	
Jul		3	6	0.3	
Aug		2	7	0.4	
Sep		2	5	0.3	
Oct		3	6	0.2	0.4
Nov		4	16	0.4	
Dec		4	6	0.2	

PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS

MONTH	BOD5	CBOD	CONCENTRATION, mg/l SS	PHOSPHORUS Monthly Ave	PHOSPHORUS 6-Month Ave
Jan 16		5	8	0.3	
Feb		9	19	0.5	
Mar		9	16	0.5	
Apr		5	6	0.3	
May		7	6	0.4	
Jun		3	5	0.2	
Jul		4	8	0.3	
Aug		4	9	0.3	
Minimum		2	3	0.2	
Average		10	12	2.7	
Maximum		125	73	11.0	
Jan 92-Jul 03					
Minimum		6	6	1.0	
Average		11	13	4.8	
Maximum		21	26	11.0	
Aug 03-Dec 12					
Minimum		2	3	0.2	
Average		6	9	0.8	
Maximum		19	22	4.0	
Jan 13- Aug 16					
Minimum		2	5	0.2	
Average		15	16	1.1	
Maximum		125	73	3.9	

PHILLIPS WASTEWATER TREATMENT PLANT

EFFLUENT CHARACTERISTICS



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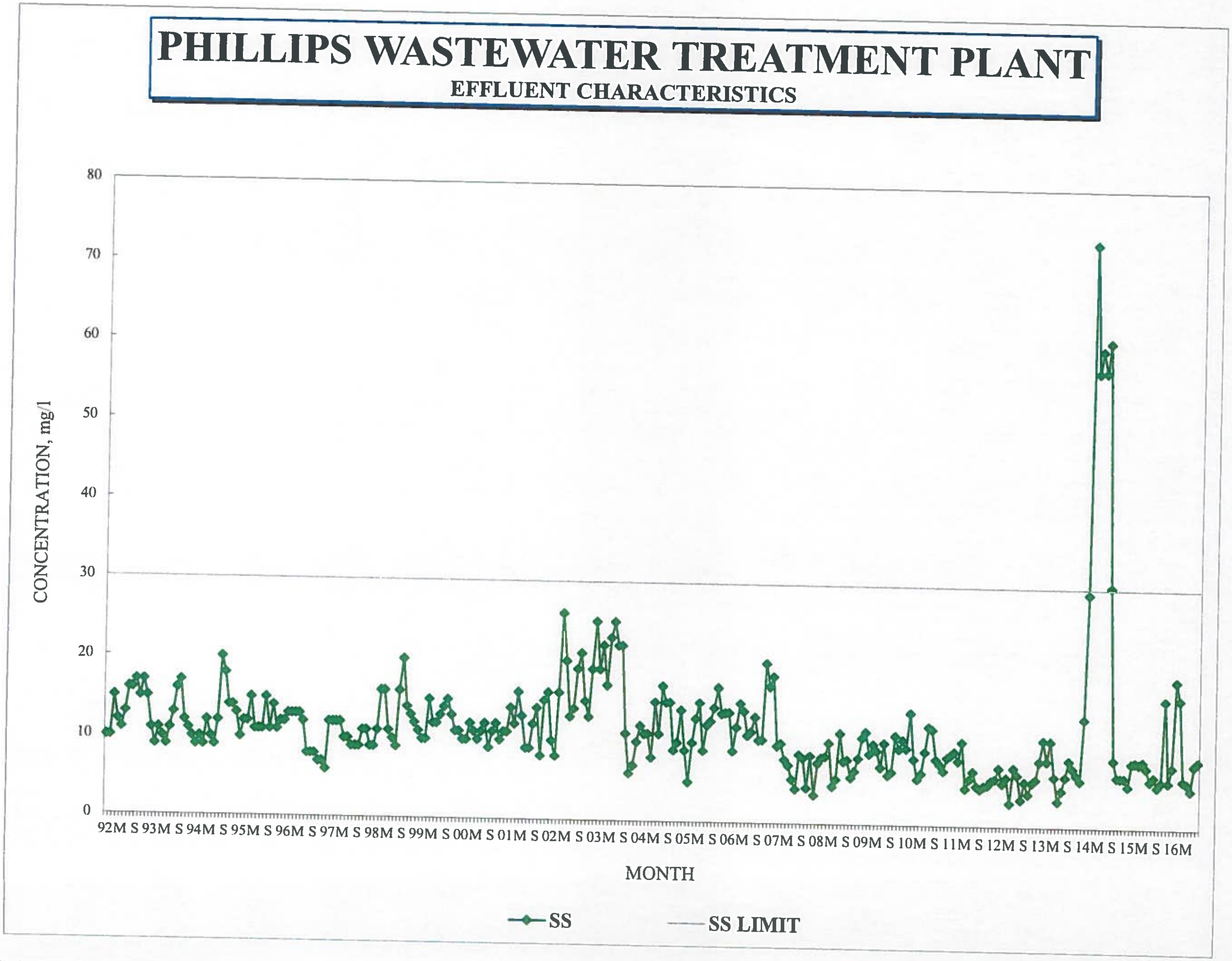
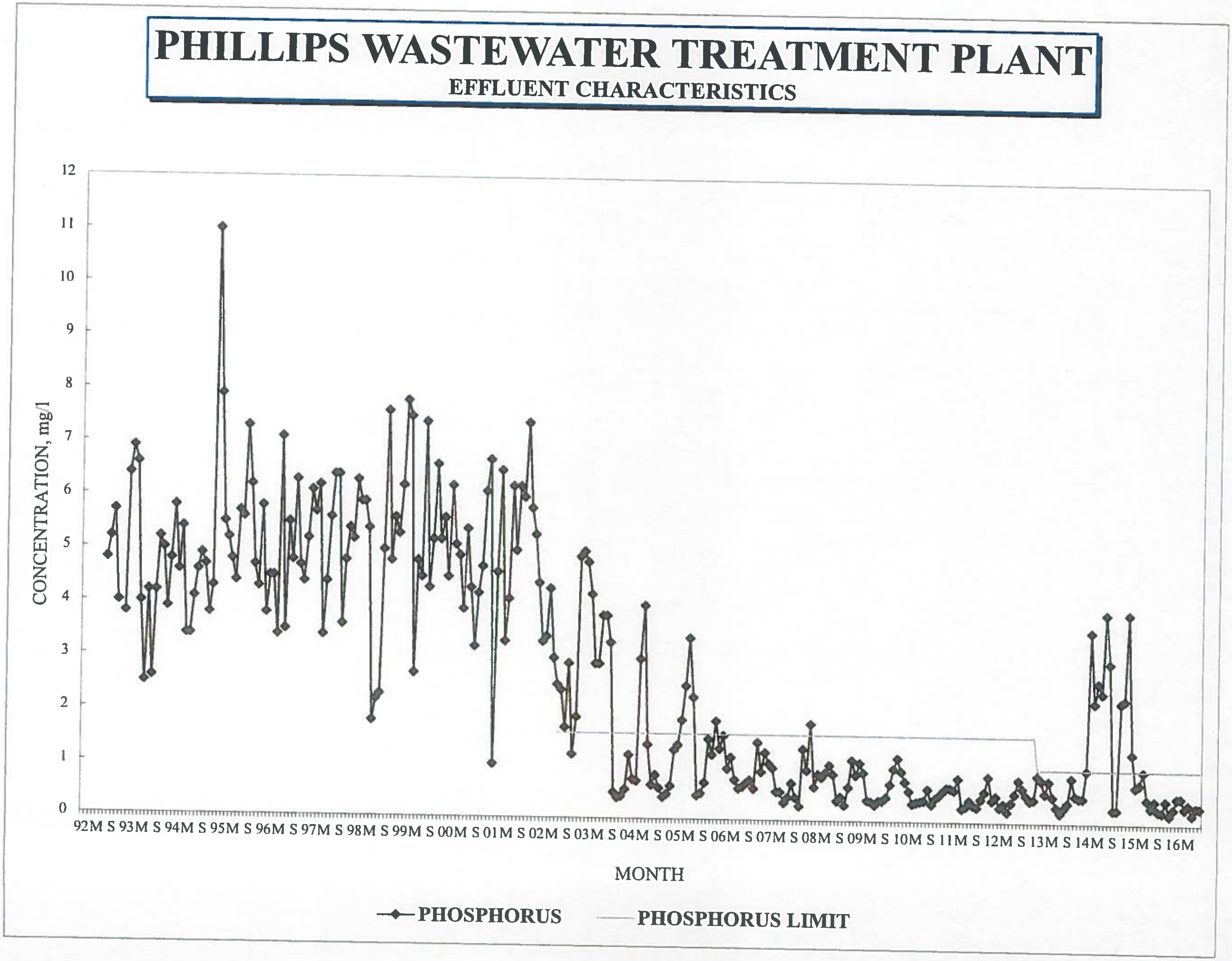


PHILLIPS WASTEWATER TREATMENT PLANT
EFFLUENT CHARACTERISTICS
CONCENTRATION, mg/l
80
70
60
50
40
30
20
10
0
92M S 93M S 94M S 95M S 96M S 97M S 98M S 99M S 00M S 01M S 02M S 03M S 04M S 05M S 06M S 07M S 08M S 09M S 10M S 11M S 12M S 13M S 14M S 15M S 16M
MONTH
SS
SS LIMIT



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APPENDIX D

SUMMARY OF PHASE 1 TESTING PROGRAM

Walker Process
Phillips - BNR Pilot Study
Special Testing Program

Phase 1 - Special Testing Program

Characteristic, mg L[(a)]	Sample Location and Type: Influent No.	Influent Type	Primary Effluent No.	Primary Effluent Type	Return Sludge No.	Return Sludge Type	Solids Contact Tank No. 1 No.	Solids Contact Tank No. 1 Type	Solids Contact Tank No. 2 No.	Solids Contact Tank No. 2 Type	Solids Contact Tank No. 3 No.	Solids Contact Tank No. 3 Type	Solids Contact Tank No. 4 No.	Solids Contact Tank No. 4 Type	RBC Unit No. 1 Effluent No.	RBC Unit No. 1 Effluent Type	RBC Unit No. 2 Effluent No.	RBC Unit No. 2 Effluent Type	Effluent No.	Effluent Type	Remarks
Flow, mgd	Daily																				Recorded by WWTP Staff
Temperature, °F	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	
pH, s.u.	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	Daily	Composite	
Dissolved Oxygen	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	3x per Wk	Field	
Fecals																			Weekly	Composite	
BOD_5	3x per Wk	Composite																			
Soluble BOD_5					3x per Wk	Grab															WWTP Staff to filter at time of collection
$CBOD_5$			3x per Wk	Grab															3x per Wk	Composite	
Soluble $CBOD_5$			3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Composite	WWTP Staff to filter at time of collection
COD	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	
Soluble COD			3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Composite	WWTP Staff to filter at time of collection
TSS	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	
VSS	3x per Wk	Composite	3x per Wk	Grab																	
MLSS					3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab							
MLVSS					3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab							
Total Phosphorus (Total-P)	3x per Wk	Composite	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab					3x per Wk	Composite	
Orthophosphate	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	
Soluble Orthophosphate					3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab			WWTP Staff to filter at time of collection
TKN	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	
Ammonia-N	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	WWTP collects effluent NH_3 samples on a monthly basis
Soluble Ammonia-N					3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab			WWTP Staff to filter at time of collection
NOx-N (Nitrite & Nitrate)	3x per Wk	Composite	3x per Wk	Grab															3x per Wk	Composite	
Soluble NOx-N					3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab	3x per Wk	Grab			WWTP Staff to filter at time of collection
VFA			3x per Wk	Grab																	
K			3x per Wk	Grab																	
Mg			3x per Wk	Grab																	
Hardness ($CaCO_3$)			3x per Wk	Grab																	
Alkalinity ($CaCO_3$)	3x per Wk	Composite																	3x per Wk	Composite	

(a) Unless indicated otherwise

red-completed by WWTP Staff during routine testing

APPENDIX E

SAMPLE TEST RESULTS

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 10/19/2016

Phase I - Special Testing Sampling Summary

	Sample Locations															
	Influent						Primary Effluent			Effluent						Notes
Characteristic, mg/L (a)	8/2/2016		8/3/2016		8/4/2016		8/2/2016	8/3/2016	8/4/2016	8/2/2016		8/3/2016		8/4/2016		
Flow, mgd	0.163		0.203		0.187											
Temperature, °F	66		67		67			65	68			68				
pH, s.u.	7.5		7.5		7.65		6.8	6.96	6.73	7.34		7.32		7.15		
Dissolved Oxygen	1.85		3.64		3.7		0.74	1.68	2.01	1.64		1.6		3.1		
Fecals													240			
BOD_5	179	179	<12	151		144										
Soluble BOD_5																Filtered at time of collection
$CBOD_5$							137	89	111	4	4	6	5	<2	9	
Soluble $CBOD_5$							80	31	83	2		3		<2		Filtered at time of collection
COD	322		313		410		361	340	331	58		64		73		
Soluble COD							172	94	170	44		53		40		Filtered at time of collection
TSS	73	252	234	143	217	200	106	151	100	15	18	12	9	12	9	
VSS	65		207		165		84	119	81			9				
MLSS																
MLVSS																
Total Phosphorus (Total-P)	5.46		4.23		4.80		4.77	4.00	4.26	0.64	0.71	0.51	0.43	0.74	0.44	
Orthophosphate	3.36		2.36		2.90		3.09	2.47	2.65	0.22		0.23		0.30		
Soluble Orthophosphate																Filtered at time of collection
TKN	43.6		31.30		37.20		39.70	31.80	29.00	5.3		9.90		5.70		
Ammonia-N	27.30		18.70		22.50		23.80	16.60	17.00	1.80	1.60	6.60		1.70		
Soluble Ammonia N								16.30								Filtered at time of collection
NOx-N (Nitrite & Nitrate)	1.3		1.20		0.80		1.3	1.30	0.20	8.9		8.00		10.40		
Soluble NOx-N																Filtered at time of collection
VFA							44.70	7.62	41.20							
K							12.90	11.90	11.50							
Mg							11.60	11.20	11.70							
Hardness ($CaCO_3$)							147	153	156							
Alkalinity ($CaCO_3$)	245		204		221					119		142		115		

(a) Unless indiated otherwise

Red dates indicate sample temperature at time of receipt at lab greater than 6 degrees C

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 10/19/2016

Phase I - Special Testing Sampling Summary

Characteristic, mg/L (a)	Sample Locations: Return Sludge			First Sludge Contact Tank (No. 3)			Second Sludge Contact Tank (No. 1)			Third Sludge Contact Tank (No. 2)			Fourth Sludge Contact Tank (No. 4)			RBC Unit No. 1 Effluent			RBC Unit No. 2 Effluent			Notes
	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	8/2/2016	8/3/2016	8/4/2016	
Flow, mgd																						
Temperature, °F	68	68	70	66	68	69	68	68	69	68	68	69	67	68	69	68	68	69	68	68	69	
pH, s.u.	7.14	7.04	7.11	7.05	7.07	7.1	7.03	7.08	7.14	7.05	7.07	7.16	7	7.04	7.13	7.31	7.11	7.26	7.31	7.03	7.23	
Dissolved Oxygen	1.11	0.54	1.33	1.04	1.31	1.5	1.49	1.54	1.83	1.13	1.38	1.58	1.24	1.46	1.73	4.24	3.14	3.48	5.73	3.62	3.1	
Fecals																						
BOD_5																						
Soluble BOD_5	10	<6	9																			Filtered at time of collection
$CBOD_5$																						
Soluble $CBOD_5$	8	9	<6	11	10	<12	10	9	<12	11	10	<12	12	10	<12	<6	<6	<6	<6	<6	<6	Filtered at time of collection
COD																						
Soluble COD	76	67	55	69	71	69	62	58	71	64	55	55	76	64	60	49	37	60	46	71	46	Filtered at time of collection
TSS																						
VSS																						
MLSS	8640	6780	6860	4710	4490	4370	4930	3210	4310	4600	4000	4190	4750	4650	4270							
MLVSS	6310	4960	4930	3510	3360	3220	3630	2450	3180	3190	3050	3080	3500	3520	3170							
Total Phosphorus (Total P)	336	285	260	196	187	175	210	135	167	197	172	158	201	204	167							
Orthophosphate																						
Soluble Orthophosphate	0.22	0.22	0.22	2.59	1.81	2.44	0.93	1.80	0.28	2.29	0.79	0.55	2.86	2.49	1.62	0.22	0.22	0.25	0.21	0.22	0.26	Filtered at time of collection
TKN																						
Ammonia-N																						
Soluble Ammonia-N	0.60	2.80	1.20	7.40	8.00	6.80	6.90	7.60	5.40	7.30	7.70	6.10	7.60	8.00	6.30	4.20	6.90	5.30	0.20	1.40	0.20	Filtered at time of collection
NOx-N (Nitrite & Nitrate)																						
Soluble NOx-N	4.00	6.00	8.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.10	<0.1	3.40	2.50	3.20	9.00	9.10	10.90	Filtered at time of collection
VFA																						
K																						
Mg																						
Hardness ($CaCO_3$)																						
Alkalinity ($CaCO_3$)																						

(a) Unless indicated otherwise
Red dates indicate sample temperature at time of receipt at lab greater than 6 degrees C

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 10/19/2016

Phase I - Special Testing Sampling Summary

	Sample Locations															
	Influent						Primary Effluent			Effluent						Notes
Characteristic, mg/L (a)	8/9/2016		8/10/2016		8/11/2016		8/9/2016	8/10/2016	8/11/2016	8/9/2016		8/10/2016		8/11/2016		
Flow, mgd	0.163		0.154		0.15											
Temperature, °F	65		65		65		65	67	66	69		68		70		
pH, s.u.	7.42		7.36		7.43		6.75	6.71	7.03	7.22		7.29		7.19		
Dissolved Oxygen	3.28		2.56		5.04		1.98	0.98	2.51	3.89		2.74		2.56		
Fecals											270					
BOD_5	154	172	228	206		180										
Soluble BOD_5																Filtered at time of collection
$CBOD_5$							111	113	101	3	3	4	4		5	
Soluble $CBOD_5$							74	50	45	<2		2		2		Filtered at time of collection
COD	372		661		341		368	352	296	72		59		59		
Soluble COD							166	152	146	59		70		55		Filtered at time of collection
TSS	194	182	294	277		160	140	120	116	14	10	9	7		7	
VSS	164		372		145		110	115	96							
MLSS																
MLVSS																
Total Phosphorus (Total-P)	5.77		6.90		5.41		5.57	3.94	3.72	0.49	0.36	0.44	0.47		0.31	
Orthophosphate	3.38		3.71		3.30		3.33	2.52	2.20	0.26		0.26		0.34		
Soluble Orthophosphate																Filtered at time of collection
TKN	41.5		48.7		41.5		32.8	30.6	28.7	6.7		8.6		9.9		
Ammonia-N	26.9		29.0		27.4		18.4	18.2	16.7	3.1		5.2		6.9		
Soluble Ammonia-N																Filtered at time of collection
NOx-N (Nitrite & Nitrate)	0.8		0.8		0.7		2.1	1.4	0.9	11.1		9.7		7.5		
Soluble NOx-N																Filtered at time of collection
VFA							26.4	37.4	13.9							
K							13.9	12.4	9.9							
Mg							12.2	11.2	7.5							
Hardness ($CaCO_3$)							156	143	105							
Alkalinity ($CaCO_3$)	256		263		266					119		136		158		

(a) Unless indicated otherwise

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 10/19/2016

Phase I - Special Testing Sampling Summary

Characteristic, mg/L (a)	Sample Locations																					Notes
	Return Sludge			First Sludge Contact Tank (No. 3)			Second Sludge Contact Tank (No. 1)			Third Sludge Contact Tank (No. 2)			Fourth Sludge Contact Tank (No. 4)			RBC Unit No. 1 Effluent			RBC Unit No. 2 Effluent			
	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	8/9/2016	8/10/2016	8/11/2016	
Flow, mgd																						
Temperature, °F	68	69	69	67	68	69	66	67	69	67	68	68	67	68	68	68	68	69	68	68	69	
pH, s.u.	7.07	7.06	7.12	7.24	7.07	7.14	7.24	7	7.02	7.27	6.73	7.05	7.22	7.06	7.03	7.23	7.2	7.21	7.21	7.14	7.08	
Dissolved Oxygen	1.43	1.49	0.97	1.38	0.57	1.23	1.61	0.77	1.53	1.44	0.62	1.32	1.55	0.66	1.05	4.1	1.72	1.96	5.24	2.98	2.74	
Fecals																						
BOD_5																						
Soluble BOD_5	12	11	6																			Filtered at time of collection
$CBOD_5$																						
Soluble $CBOD_5$	3	4	16	8	7	13	7	7	15	6	7	14	8	8	14	2	3	<3	3	<2	<3	Filtered at time of collection
COD																						
Soluble COD	57	52	57	68	61	72	63	55	86	70	59	79	77	63	70	57	46	52	59	48	50	Filtered at time of collection
TSS	6,620	6,920	8,480	4,540	4,700	3,680	4,170	4,260	2,960	4,580	4,720	3,220	4,510	4,660	3,660							
VSS	4,800	5,040	5,800	3,280	3,520	2,560	3,040	3,240	2,040	3,430	3,520	2,280	3,280	3,560	2,720							
MLSS																						
MLVSS																						
Total Phosphorus (Total-P)	279	282	396	195	196	176	179	182	135	190	201	152	191	196	160							
Orthophosphate																						
Soluble Orthophosphate	0.25	0.26	0.38	2.44	4.01	7.95	0.32	1.95	7.32	0.62	2.46	7.58	3.47	5.26	10.20	0.26	0.26	0.57	0.26	0.28	0.24	Filtered at time of collection
TKN																						
Ammonia-N																						
Soluble Ammonia-N	3.5	5.5	7.7	8.4	10.0	13.9	8.1	9.5	14.3	7.9	9.2	14.3	8.8	10.4	13.9	8.4	10.4	10.8	1.5	3.8	4.4	Filtered at time of collection
NOx-N (Nitrite & Nitrate)																						
Soluble NOx-N	10.1	7.1	0.5	<0.1	<0.1	<0.1	0.7	<0.1	<0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	3.2	1.4	0.9	12.2	8.7	7.1	Filtered at time of collection
VFA																						
K																						
Mg																						
Hardness ($CaCO_3$)																						
Alkalinity ($CaCO_3$)																						

(a) Unless indicated otherwise

APPENDIX F

PROCESS CALCULATIONS

Walker Process
Phillips BNR Demonstration
Date: 11/8/2016

The calculations are based on the following volumes:

Volume SCT compartment	11,691 gal, each
Volume RBC No. 1	13,718 gal
Volume RBC No. 2	13,554 gal

Secondary Treatment Detention Time

Date	Process Flow, mgd	Detention Time, hours			Detention Time, minutes		
		All SCT's	RBC No. 1	RBC No. 2	All SCT's	RBC No. 1	RBC No. 2
8/2/2016	0.465	2.41	0.71	0.70	145	42	42
8/3/2016	0.505	2.22	0.65	0.64	133	39	39
8/4/2016	0.489	2.30	0.67	0.67	138	40	40
8/9/2016	0.465	2.41	0.71	0.70	145	42	42
8/10/2016	0.456	2.46	0.72	0.71	148	43	43
8/11/2016	0.452	2.48	0.73	0.72	149	44	43
Minimum	0.452	2.22	0.65	0.64	133	39	39
Average	0.472	2.38	0.70	0.69	143	42	41
Maximum	0.505	2.48	0.73	0.72	149	44	43

Walker Process
Phillips BNR Demonstration
Date: 11/10/2016

BOD5 to TP Ratio

Date	BOD_5, mg/l		TP, mg/l		BOD_5/TP Ratio	
	Influent	PE(a)	Influent	PE	Influent	PE(a)
8/2/2016	179	137	5.46	4.77	33 :1	29 :1
8/3/2016	151	89	4.23	4.00	36 :1	22 :1
8/4/2016	144	111	4.80	4.26	30 :1	26 :1
8/9/2016	172	111	5.77	5.57	30 :1	20 :1
8/10/2016	206	113	6.90	3.94	30 :1	29 :1
8/11/2016	180	101	5.41	3.72	33 :1	27 :1
Minimum	144	89	4.23	3.72	30 :1	20 :1
Average	172	110	5.43	4.38	32 :1	25 :1
Maximum	206	137	6.90	5.57	36 :1	29 :1

(a) $CBOD_5$

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 11/8/2016

SCBOD5 Removal in First SCT

	Primary Effluent		Return Secondary Sludge		First Sludge Contact Tank			
Date	Flow, mgd	$SCBOD_5$, mg/l	Flow, mgd	$SCBOD_5$, mg/l	Flow, mgd	Measured $SCBOD_5$, mg/l	Calculated $SCBOD_5$, mg/l	Removal $SCBOD_5$, mg/l
8/2/2016	0.163	80	0.302	8	0.465	11	33	22
8/3/2016	0.203	31	0.302	9	0.505	10	18	8
8/4/2016	0.187	83	0.302	6	0.489	11	35	24
8/9/2016	0.163	74	0.302	12	0.465	8	34	26
8/10/2016	0.154	50	0.302	11	0.456	7	24	17
8/11/2016	0.150	45	0.302	6	0.452	13	19	6
Average	0.170	61	0.302	9	0.472	10	27.21	17
Percent Removal								63.3%

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 10/10/2016

Ammonia Mass Balance

Date	Primary Effluent		Return Secondary Sludge		First Sludge Contact Tank		
	Flow, mgd	NH_3, mg/l	Flow, mgd	NH_3, mg/l	Flow, mgd	NH_3, mg/l	Calculated NH_3, mg/l
8/2/2016	0.163	23.8	0.302	0.6	0.465	7.4	8.7
8/3/2016	0.203	16.6	0.302	2.8	0.505	8.0	8.3
8/4/2016	0.187	17.0	0.302	1.2	0.489	6.8	7.2
8/9/2016	0.163	18.4	0.302	3.5	0.465	8.4	8.7
8/10/2016	0.154	18.2	0.302	5.5	0.456	10.0	9.8
8/11/2016	0.150	16.7	0.302	7.7	0.452	13.9	10.7

Walker Process
Phillips - BNR Pilot Study
Special Testing Program
Date: 11/8/2016

NOx Removal in First SCT

	Primary Effluent		Return Secondary Sludge		First Sludge Contact Tank			
Date	Flow, mgd	NOx, mg/l	Flow, mgd	Nox, mg/l	Flow, mgd	Measured NOx, mg/l	Calculated NOx, mg/l	Removal NOx, mg/l
8/2/2016	0.163	1.3	0.302	4	0.465	- 0.09	3.05	2.96
8/3/2016	0.203	1.3	0.302	6	0.505	0.09	4.11	4.02
8/4/2016	0.187	0.2	0.302	8.1	0.489	0.09	5.08	4.99
8/9/2016	0.163	2.1	0.302	10.1	0.465	0.09	7.30	7.21
8/10/2016	0.154	1.4	0.302	7.1	0.456	0.09	5.18	5.09
8/11/2016	0.150	0.9	0.302	0.5	0.452	0.09	0.63	0.54
Average	0.170	1.2	0.302	6.0	0.472	0.09	4.23	4.14
Percent Removal								97.9%

Walker Process
Phillips BNR Demonstration
Date: 11/8/2016

Nitrification

Date	Concentration, mg/l			Percent Removal	
	INF TKN	PE TKN	Eff TKN	WWTP	Sec Treat
8/2/2016	43.6	39.7	5.3	87.8	86.6
8/3/2016	31.3	31.8	9.9	68.4	68.9
8/4/2016	37.2	29.0	5.7	84.7	80.3
8/9/2016	41.5	32.8	6.7	83.9	79.6
8/10/2016	48.7	30.6	8.6	82.3	71.9
8/11/2016	41.5	28.7	9.9	76.1	65.5
Minimum	31.3	28.7	5.3	68.4	65.5
Average	40.6	32.1	7.7	80.5	75.5
Maximum	48.7	39.7	9.9	87.8	86.6

Walker Process
Phillips BNR Demonstration
Date: 11/8/2016

Nitrogen Removal

Date	Concentration, mg/l						Percent Removal
	Primary Effluent			Effluent			
	TKN	NOx	TKN+NOx	TKN	NOx	TKN+NOx	
8/2/2016	39.7	1.3	41.0	5.3	8.9	14.2	65.4
8/3/2016	31.8	1.3	33.1	9.9	8.0	17.9	45.9
8/4/2016	29.0	0.2	29.2	5.7	10.4	16.1	44.9
8/9/2016	32.8	2.1	34.9	6.7	11.1	17.8	49.0
8/10/2016	30.6	1.4	32.0	8.6	9.7	18.3	42.8
8/11/2016	28.7	0.9	29.6	9.9	7.5	17.4	41.2
Minimum	28.7	0.2	29.2	5.3	7.5	14.2	41.2
Average	32.1	1.2	33.3	7.7	9.3	17.0	48.2
Maximum	39.7	2.1	41.0	9.9	11.1	18.3	65.4