Landfill Leachate Duration Testing and Treatability Study Report

UTILIZING MEMBRANE TECHNOLOGY TO TREAT
LEACHATE WASTEWATER FROM
MAT-SU BOROUGH CENTRAL LANDFILL

Client: Matanuska-Susitna Borough
Palmer, Alaska

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A. Introduction:

A.1 Overview

Upon completion of preliminary engineering report, PER in February 2018, Clark was to start the second phase of the project which included a duration testing and parametric study and full design of a landfill leachate wastewater treatment plant at the Mat-Su Borough's ("Borough") Central Landfill. The study was initiated in September 2018 by shipping a scaled down model of the LeachBuster® leachate treatment plant and conducting an onsite study for a period of nearly six weeks. As part of the deliverables for this study is a report containing a review and inferencing the test results, summarizing the conclusions, and determining the LeachBuster® leachate treatment plant's membrane level for treatment of landfill leachate at this site. This report is a partial fulfilment of the scope of the contract with the Borough.

A.2 Objectives

The objectives of the study are as follows:

1. Evaluate the ability of LeachBuster® to treat the leachate generated at the MSB Landfill.
2. Identify and select suitable membrane level and procedures to effectively and economically treat the leachate and assist MSB to achieve their operational and financial goals.
3. Obtain wastewater samples of incoming leachate (influent), treated leachate or clean water (permeate) and concentrate for quantitative and qualitative analysis.
4. Establish optimum operating conditions (flow, pressure, etc.) for a full-scale LEACHBUSTER® leachate treatment plant. This step will be finalized during design of the full-scale leachate treatment plant.
5. Establish a suitable cleaning regiment for the full-scale plant to achieve a stable water flux. This step will be finalized during design of the full-scale leachate treatment plant.
6. Collect sufficient information during the study to estimate membrane life and frequency of replacement.
7. Collect sufficient information to verify approximate full-scale LeachBuster® leachate treatment system capital costs and annual operating expenses (including: annual energy use, filter replacement frequency, and cleaning costs).
8. The full scale LeachBuster® system design, layout, etc. will be provided during the PIH(Plans-in-Hand) phase with the final design completed during the CD (Construction/Contract Design/Drawing) phase in cooperation with other sub-consultants and MSB.

A.3 The Technology

The LEACHBUSTER® is a single-stage membrane system that removes fine particulates and dissolved components from a waste stream. The system is capable of removing organics, metals, , and minerals using a single stage membrane system.

A.4 Definitions

The following is a brief description of the some of the terminologies used in this report.

A.4.1 Treatment Levels

The Clark LEACHBUSTER® system provides fourteen (14) different levels of treated water quality ranging from level 1 to level 14. For this project, Levels 1, 2, 6 and 9 were used.

A.4.2 VCF

Volumetric Concentration Factor, or VCF, is a measure of the clean water recovery rate. For example, a VCF of 10 represents 90% recovery rate (9 part clean water and 1 part concentrate); similarly, VCF of 20 represents a 95% recovery rate.

A.4.3 TNTC

Too Numerous to Count, or TNTC, occurs when the bacteria levels exceed 10^7; the testing laboratory will report them as TNTC. For calculation purposes, we will use 10^7.

A.4.4 ND – Non-Detect

Each laboratory test has a detection limit below which the analyte cannot be detected using current technologies. These are often very close to 0 (zero). For calculation purposes, we will use 0 (zero).

A.4.5 NR – Not Reported

Often due to some event such as a spill, spoil, or some damage to the samples, a meaningful analysis cannot be performed. We normally collect extra samples to cover these events; however, on rare occasions no results can be obtained for a given sample. These samples are not used in our calculations.

A.4.6 Recovery Rate

During the process the LEACHBUSTER® parses the incoming leachate (influent) into two streams of clean water (sometimes referred to as permeate or effluent) and the concentrate. Recovery Rate is the ratio of the volume of clean water to the volume of the concentrate produced. For example, a recovery rate of 80% means that out of 100 gallons of leachate treated about 80 gallon is clean water and 20 gallons is the concentrate.

A.4.7 Rejection Rate

When processing leachate, LEACHBUSTER® rejects the contaminants while allowing the clean water pass thru the membrane system. This includes the suspended as well as dissolved solids which are normally chlorides and sugars. Rejection rate is the ratio of the amount of contaminants in the concentrate to the amount of these materials in the clean water.

A.4.8 Operating Modes

LEACHBUSTER® wastewater treatment plant can operate in three different modes, however only the continuous mode was used for the study, since it provides for the most efficient treatment mode for this wastewater stream.

- Continuous Mode

  This option does not employ any tanks for concentration of the solids; instead, they are concentrated within the system and continuously discharged into a sludge storage

tank. An up to 3 gpm membrane scaled down plant was operated at the Central Landfill site to achieve these objectives. This mode was used for the initial duration and treatability study too. The LEACHBUSTER® treatment plant was fitted with LB L-1, L-2, L-6, L-8 and L-9 membranes using stainless steel modules in high-pressure mode. The pilot plant was run in continuous mode. The temperature of the screened wastewater was over 50°F; therefore, no heating of the wastewater was necessary before starting the plant. The wastewater was delivered through a pressurized feed line into the recirculation line for the continuous mode. Permeate from the pilot plant was collected in a customer supplied tote with a nominal volume of about 250 gallons; this was used for sampling and analysis. The flow was measured throughout to monitor the flux rate.

Prior to design and implementation of a full-sized LEACHBUSTER® wastewater treatment plant, it is necessary to conduct several preliminary bench tests, as well as an extended on-site duration and treatability study utilizing standard protocols.

The study was conducted in two stages:

1. Off-site study (at Clark's Laboratory)
   a. Exploratory and/or preliminary treatability study was conducted as part of the first phase of this project.

2. On-site study at Mat-Su Borough Central Landfill at Palmer, Alaska
   a. Problem identification and wastewater re- characterization
   b. Process definition/development/duration and treatability study
   c. Repeatability and durability study

B. Off-site - Exploratory and/or Treatability Study

The first step, as discussed and agreed to with MSB, was conducted at Clark's laboratory in Minneapolis after receiving wastewater samples from the client. The samples were tested using a bench scale LEACHBUSTER® unit. This brief test allowed Clark to evaluate the treatability of the client's wastewater prior to conducting the full-scale duration and treatability study.

In mid-September 2017, some samples of raw leachate and septage were collected and sent to laboratory in Minneapolis. In late September, the test was conducted using a Level 1, 6, and 9 membranes to examine the membrane's performance in relation to the waste steam at the MSB.

The wastewater was screened through a fine screen (opening of approximately 2000 µm) for easy separation of large solids, as well as to protect pumps, membranes, and other process equipment from damage. The screened influent is effectively filtered at a temperature of 50°F or higher. The LEACHBUSTER® System achieved up to 90% recovery of the liquid, leaving the solids and minerals in the remaining approximately 10% concentrate. During the treatment, a volumetric concentration factor (VCF) of 20, which translates to a recovery rate of about 95%, was achieved but a more definitive number will be established during the project's second phase on-site study. A scale model of the full-sized LEACHBUSTER® wastewater treatment plant, capable of running up to 3 GPM in all modes, was used during the study. This system utilized four-foot modules using the same membranes as will be used for the full-scale system. Samples were collected and sent to the analytical laboratory for analysis.

The objective of this test was to identify the best membrane level which can provide an optimum water quality which balances economical and technical parameters. Treated samples were collected and sent to an EPA certified laboratory for testing and analysis.

The following laboratory tests (as required by EPA/ADEC) were conducted on the samples:

- Biological Oxygen Demand (BOD)
- Total Suspended Solids (TSS)
- Chemical Oxygen Demand (COD)
- ICP Metals
- Semi Metals and their salts such as Phosphorus, Nitrogen, Nitrates, Nitrites, Ammonia
- Volatile Organic Compounds (VOCs)
- Semi-Volatile Organic Compounds (SVOCs)
- Chlorides,
- Sulfides
- Perfluorocarbons (PFCs),
- Polychlorinated Biphenyls (PCBs)
- Polycyclic Aromatic Hydrocarbons and Halogenated (PAHs)
- E-Coli
- Fecal Coliforms

Initially, the intention of the MSB was to evaluate possibility of co-treating leachate and septage (from septic tanks in and around the Borough). Following completion of the Preliminary Engineering Report (PER), it was decided that only the issue of leachate should be addressed at this stage and the treatment of the septage will be determined as part of another project in the near future.

Based on this, both leachate and septage were tested at the off-site (laboratory) study and only design parameters for leachate treatment was determined during the on-site trials.

B.1 Leachate

About 30 gallons of leachate was processed using LB L-2, L-6, and L-9 membranes. The results indicated that to satisfy the Drinking Water Standards, LB-L9 can be used.

B.1.1 Indicator Parameters

These are measures of a combination of parameters which collectively indicate the level of contaminants in the waste and wastewater. These are:

- Biological Oxygen Demand (BOD)
- Total Dissolved Solids (TDS)
- Chemical Oxygen Demand (COD)

Table 1. Levels of BOD, TDS and COD using LB models 2, 6, and 9

	LEACHATE BOD_5, COD, TDS (mg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
BOD_5	3820	3110	398	80	4050
COD	6040	4640	2700	143	15600

TDS	5900	3700	3580	186	12000

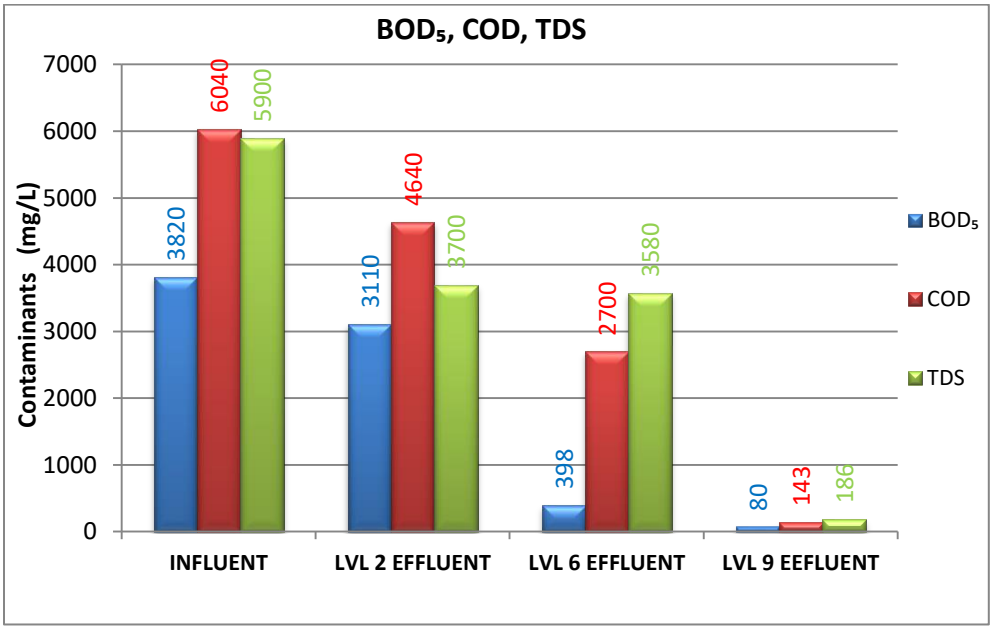


Figure 1. Levels of BOD, TDS and COD using LB models 2, 6, and 9

LB-L9 produced effluents which can meet both standards mentioned earlier.

B.1.2 Semi Metals

The following is the results of Semi metals and their salts tested during this study

- **Cyanide**
- **Phosphorus**
- **TKN**
- **Ammonia**
- **TSS**

Table 2. Levels of Cyanide and Phosphorus LB models 2, 6, and 9

	LEACHATE Cyanide & Phosphorus (µg/L)				
PARAMETER	**INFLUENT**	**LVL 2 EFFLUENT**	**LVL 6 EFFLUENT**	**LVL 9 EEFLUENT**	**LVL 9 CONCENTRATE**
Cyanide	10.7	4.6	ND	ND	58
Phosphorus	ND	ND	ND	ND	0.89

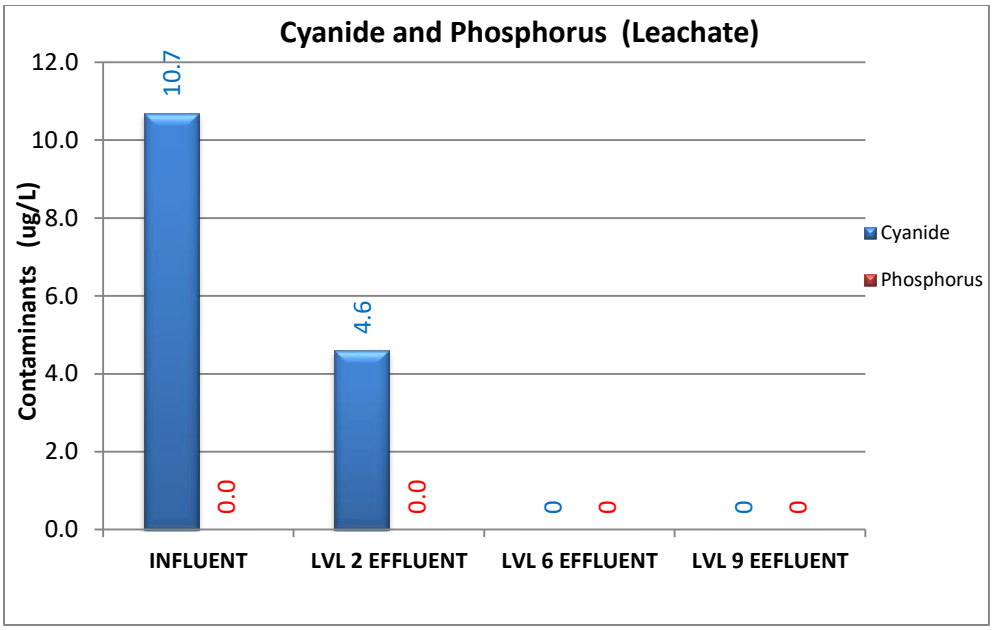


Figure 2. Levels of Cyanide and Phosphorus LB models 2, 6, and 9

All the levels L2, L6, and L9 met the discharge requirement for both standards.

Table 3. Levels of TSS, TKN and Ammonia using LB models 2, 6, and 9

	LEACHATE TSS, TKN, & Ammonia Nitrogen (mg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
TSS	340	97.5	40	ND	860
TKN	605	539	349	38.7	1540
Ammonia N	225	208	175	33.6	470

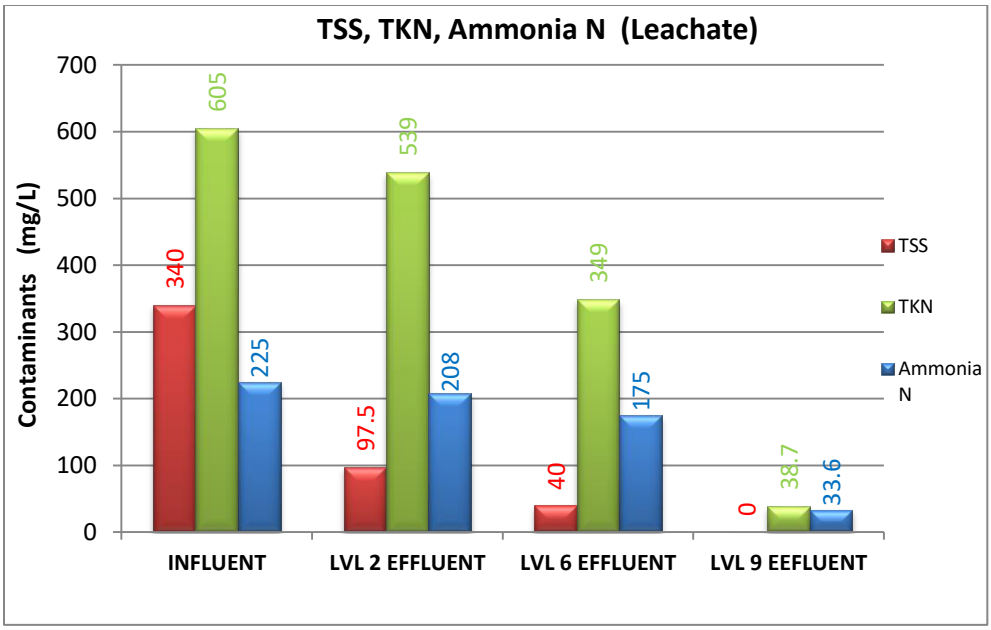


Figure 3. Levels of TSS, TKN and Ammonia using LB models 2, 6, and 9

Table 4. Levels of Pathogen and Ammonia using LB models 6 and 10

	LEACHATE Total E.coli (MPN/100/mL)		
PARAMETER	INFLUENT	LVL 6 EEFLUENT	
E.coli	23100	<1	
Total Coliform	2420	<1	

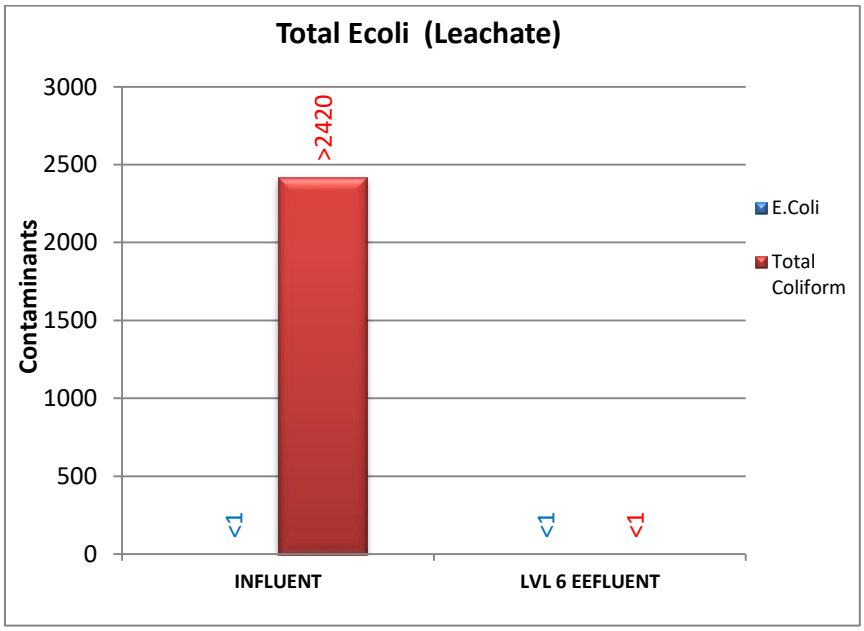


Figure 4. Levels of Pathogen and Ammonia using LB models 6

Both Fecal Coliform and E-Coli levels were well below the levels required by both standards, which are 100 and 10 CFU/100 ml.

B.1.3 Metals

Samples were analyzed for all the following metals and the results are given below.

- **Arsenic**
- **Barium**
- **Chromium**
- **Cobalt**
- **Copper**
- **Lead**
- **Nickel**
- **Manganese**
- **Zink**
- **Iron**
- **Calcium**

Table 5. Levels of ICP metals using LB models 2, 6, and 9

	LEACHATE METALS ICP (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Arsenic	31.6	ND	ND	ND	ND
Barium	264	138	61.8	ND	430
Chromium	134	55.7	11	ND	286
Cobalt	49.4	27.4	ND	ND	117
Copper	21.1	11.3	ND	ND	159
Lead	18.1	ND	ND	ND	ND
Nickel	536	325	71.7	ND	1370

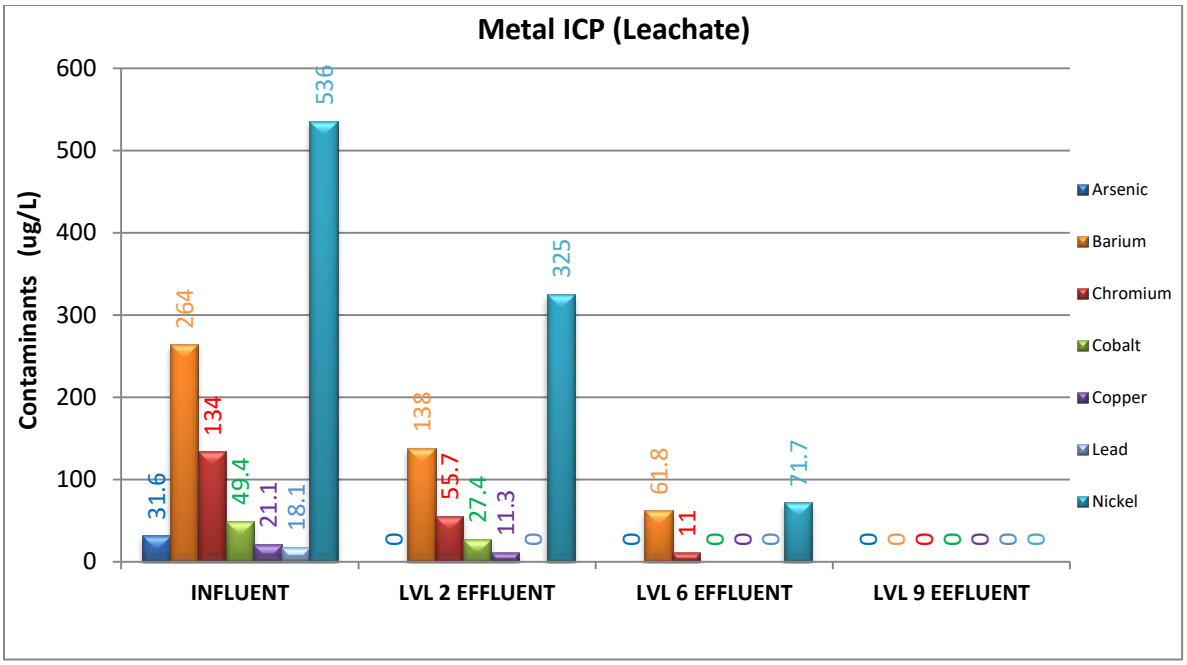


Figure 5. Levels of ICP metals using LB models 2, 6, and 9

Table 6. Levels of ICP metals using LB models 2, 6, and 9

	LEACHATE METALS ICP (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Manganese	3820	2020	427	34.4	3980
Zinc	2180	44.2	ND	ND	3210

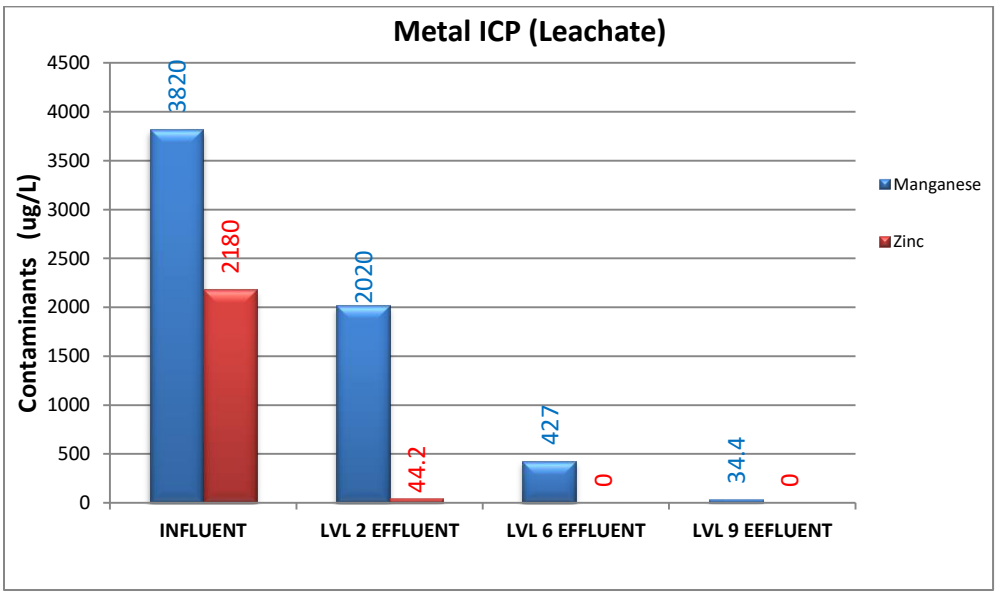


Figure 6. Levels of ICP metals using LB models 2, 6, and 9

Table 7. Levels of ICP metals using LB models 2, 6, and 9

	LEACHATE METALS ICP (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Iron	131000	58400	22500	945	198000
Calcium	363000	277000	122000	4840	691000
Magnesium	198000	169000	122000	2900	481000
Potassium	280000	238000	178000	11200	673000

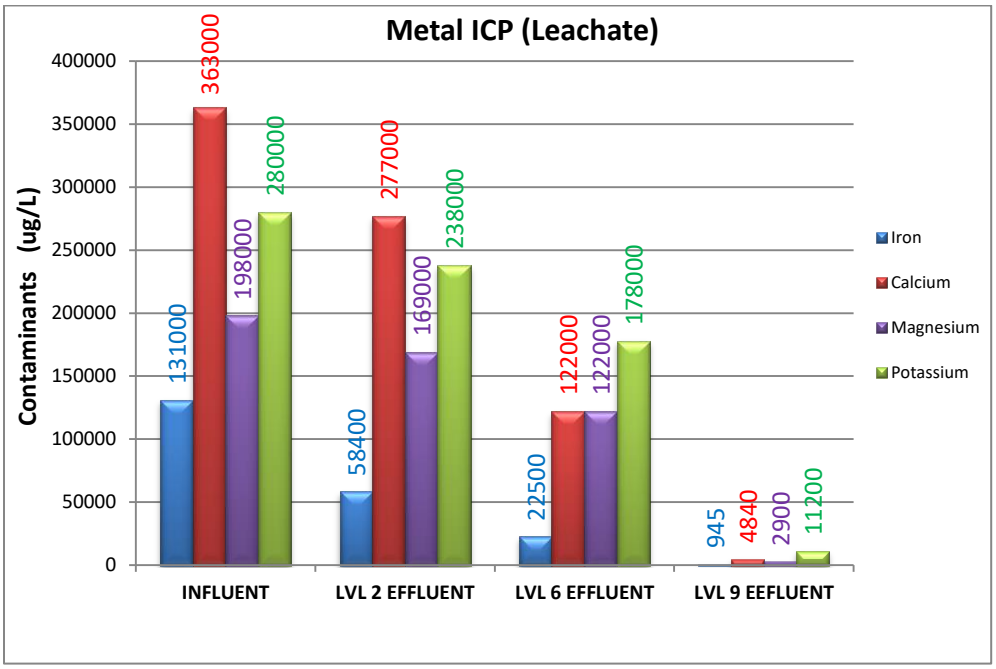


Figure 7. Levels of ICP metals using LB models 2, 6, and 9

Table 9. Levels of ICP metals using LB models 2, 6, and 9

	LEACHATE METALS ICP (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Sodium	1010000	862000	692000	39800	2470000

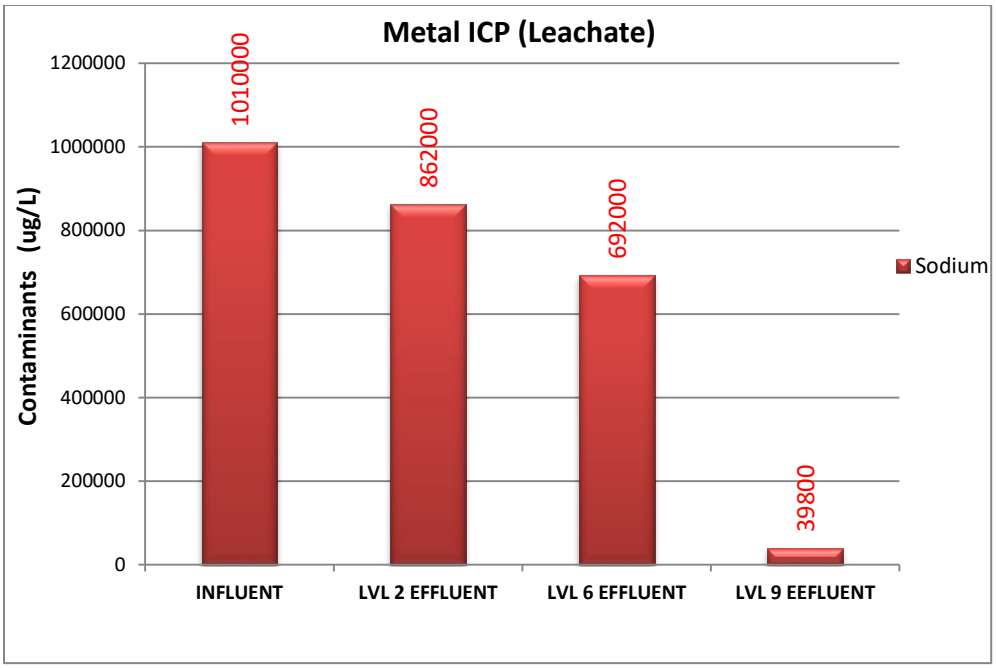


Figure 9. Levels of ICP metals using LB models 2, 6, and 9

B.1.4 Toxicity Characteristic Leaching Procedure (TCLP) Metals

In order to be able to return the leachate concentrate back to the landfill, it has to be confirmed that the concentrate is non-hazardous. To achieve this objective, Toxicity Characteristic Leaching Procedure (TCLP) had to be conducted. This test was conducted and the results indicated that the concentrate generated by this process is non-hazardous. Following is the results of this test.

Table 10. Levels of TCLP metals using LB models 9

	LEACHATE METALS TCLP (mg/L)	
PARAMETER	TCLP Regulatory Level	LVL 9 Concentrate Level
Arsenic	5.0	ND
Barium	100.0	ND
Cadmium	1.0	ND
Chromium	5.0	0.19
Lead	5.0	ND
Mercury	0.2	ND
Selenium	1.0	ND
Silver	5.0	ND

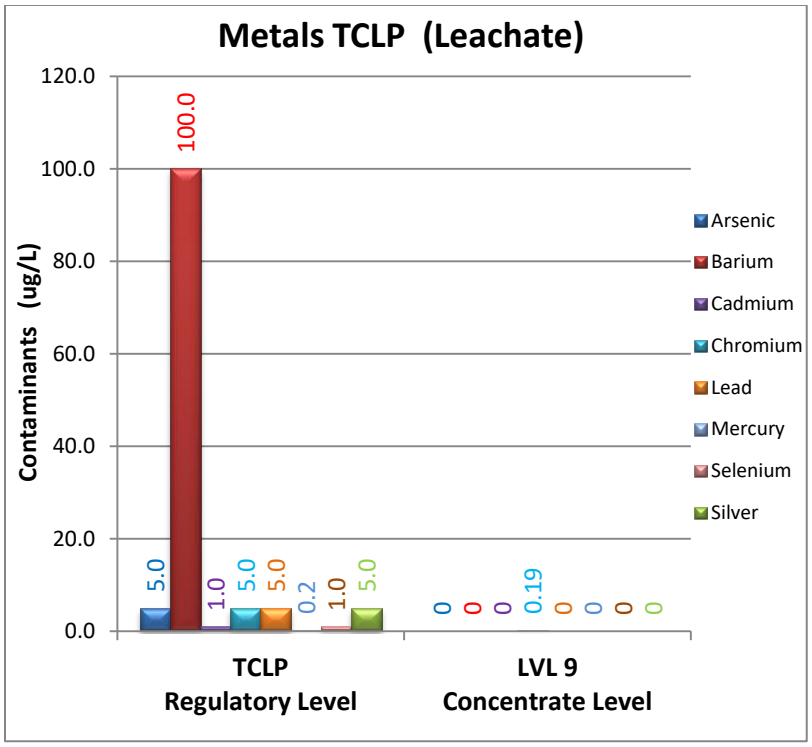


Figure 10. Levels of TCLP metals using LB models 9

B.1.5 Volatile Organic Compounds (VOCs)

This system oxidizes most of the VOCs into less harmful material such as carbon dioxide and water, as well as removing them from the waste stream. The results in the following tables indicate that almost all the VOCs are removed by all the LB modes. Even LB L-2 removed majority of VOCs from the waste stream.

Following tables and graphs show the results of the test with different LB models. Lack of VOCs in the concentrate indicates that the VOCs were oxidized and destroyed.

Table 11. Levels of Volatile Organic Compounds using LB models 2,6, and 9

	LEACHATE VOC By 8260 (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Benzene	7.5	5.8	ND	ND	ND
1,2-Dichloroethane	5.5	ND	ND	ND	ND
Methyl-tert-butyl ether	5.8	ND	ND	ND	12.6
1,2,4-Trimethylbenzene	8.9	ND	ND	ND	ND
Xylene (Total)	25.5	ND	ND	ND	ND

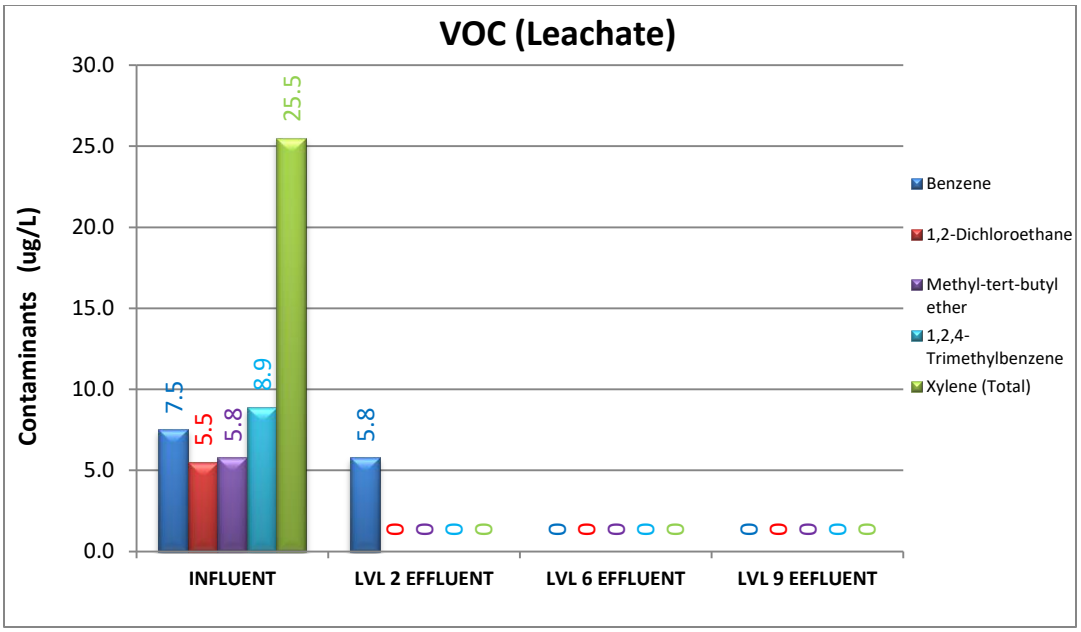


Figure 11. Levels of Volatile Organic Compounds using LB models 2,6, and 9

Table 12. Levels of Volatile Organic Compounds using LB models 2,6, and

	LEACHATE VOC By 8260 (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Acetone	14300	11900	11400	7310	21100
2-Butanone (MEK)	9150	7260	5990	2940	18300

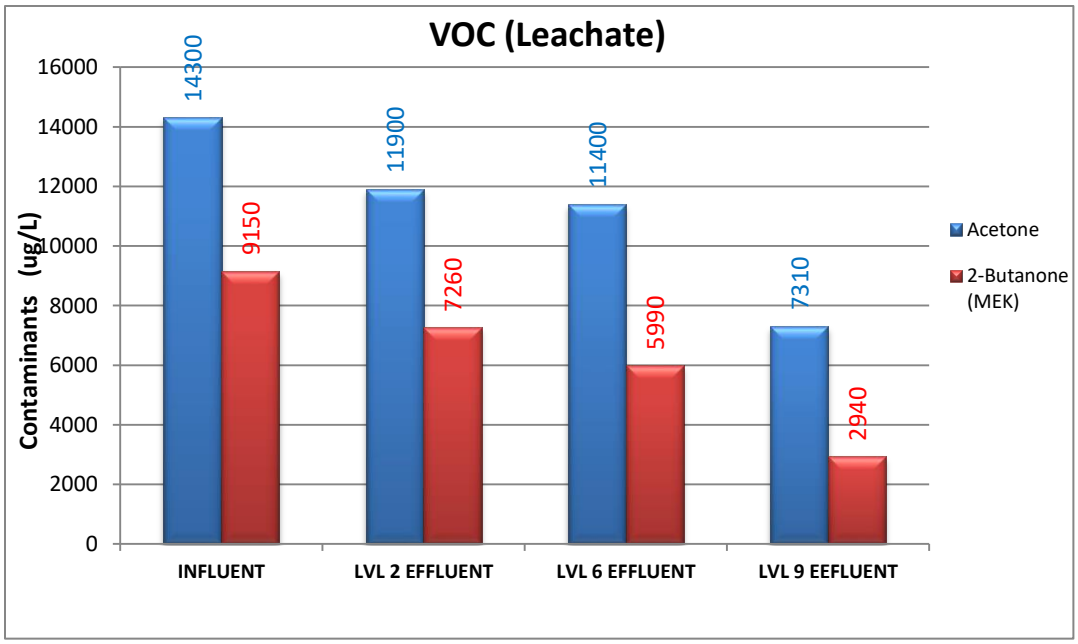


Figure 12. Levels of Volatile Organic Compounds using LB models 2,6, and 9

Table 13. Levels of Volatile Organic Compounds using LB models 2,6, and

	LEACHATE VOC By 8260 (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Diethyl ether (Ethyl ether)	142	114	54.9	20.9	232
4-Methyl-2-pentanone (MIBK)	149	119	93.9	ND	367

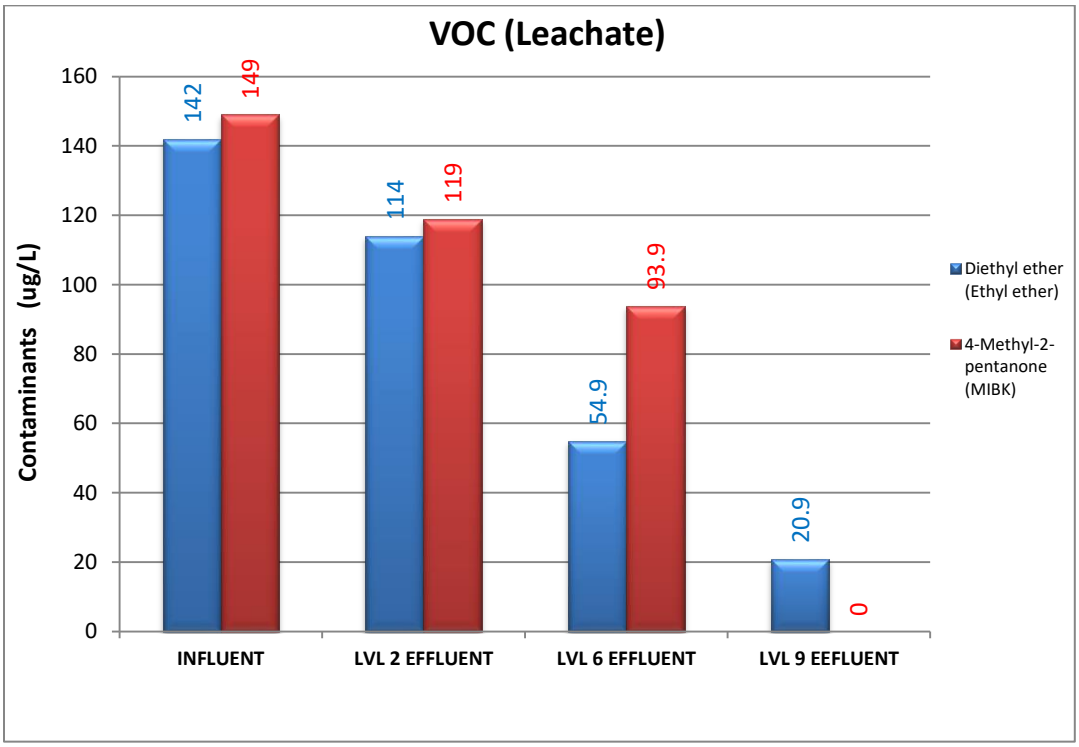


Figure 13. Levels of Volatile Organic Compounds using LB models 2,6, and 9

Table 14. Levels of Volatile Organic Compounds using LB models 2,6, and 9

	LEACHATE VOC By 8260 (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
Tetrahydrofuran	1210	1010	681	198	1850
Toluene	981	493	223	22.5	980

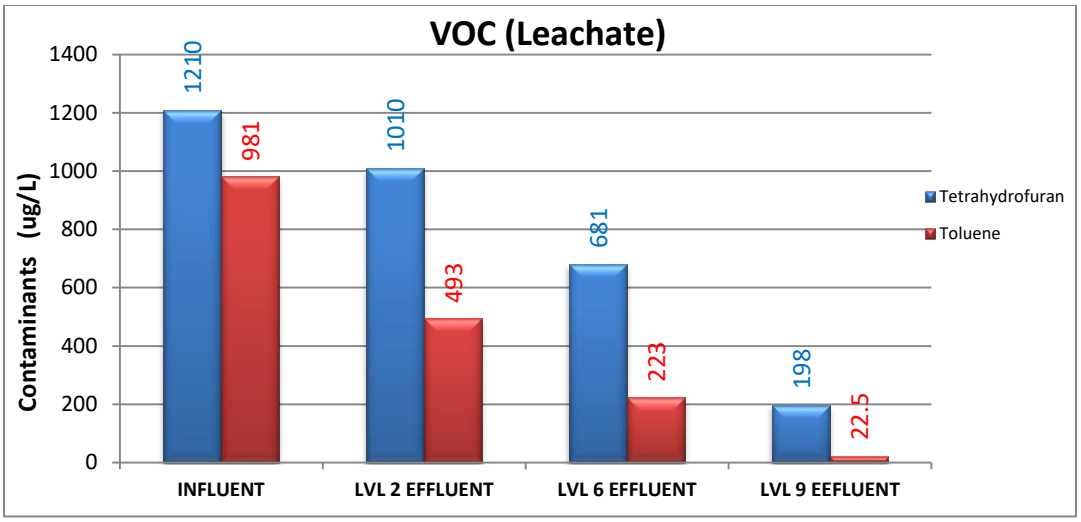


Figure 14. Levels of Volatile Organic Compounds using LB models 2,6, and 9

B.1.6 Perfluorocarbons (PFCs)

Perfluorocarbons are emerging contaminants of concern that are increasingly showing up in landfills and gathering importance in terms of health risk. They are durable and non-biodegradable. As such, they were used for their non-degradability as fire retardant as well as fire suppressants.

Although in this particular leachate sample only trace PFOA was detected; but, in many other landfill leachate samples that we have tested, there has been substantial levels of PFCs, especially high carbon >8 species present. The treatment plant successfully removed them to non-detect levels.

Following tables and graph show the results for this test.

Table 15. Levels of Fluorinated Alkyl Substances using LB models 2,6, and 9

	LEACHATE Fluorinated Alkyl Substances (µg/L)				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 9 CONCENTRATE
PFBS*	ND	ND	ND	ND	ND
PFHpA*	ND	ND	ND	ND	ND
PFHxS*	ND	ND	ND	ND	ND
PFNA*	ND	ND	ND	ND	ND
PFOS*	ND	ND	ND	ND	ND
PFOA*	0.35	0.23	0.11	ND	0.94

***PFBS → Perfluorobutanesulfonic acid, PFHpA → Perfluoroheptanoic acid, PFHxS → Perfluorohexanesulfonic acid, PFNA → Perfluorononanoic acid, PFOS → Perfluorooctanesulfonic acid, PFOA → Perfluorooctanoic acid.**

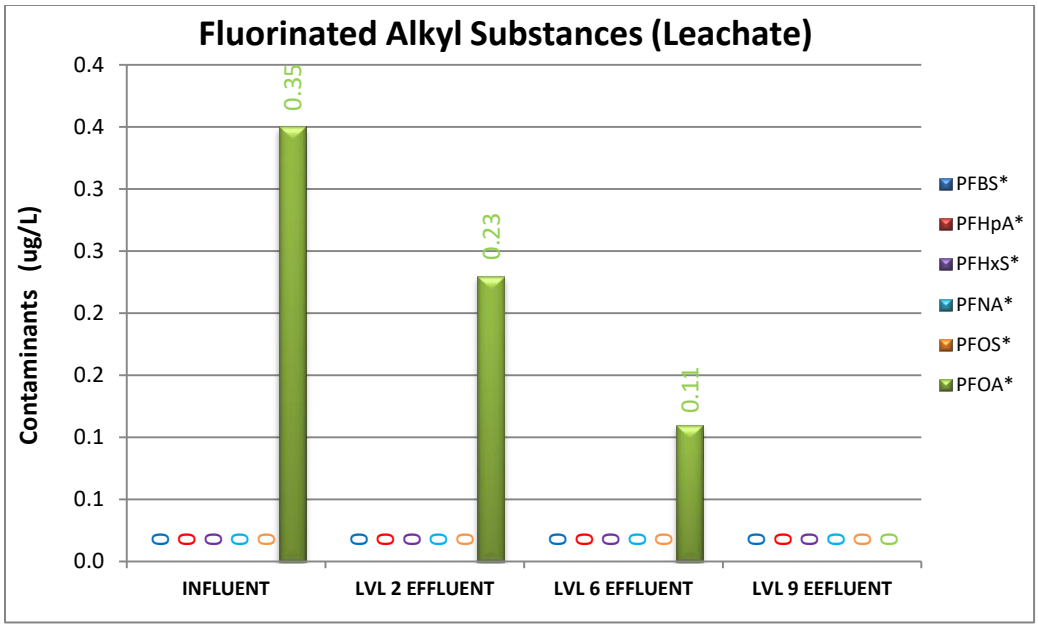


Figure 15. Levels of Volatile Organic Compounds using LB models 2,6, and 9

B.2 Septage

The sptage treatment may be conducted during a future design and engineering Phase if desired by the Borough. Similarly septage samples were treated using LB L-2, L-6, L-9 , and L-10 and results indicated that LB L-10 removed all the contaminants to levels below the Drinking Water and Clean Water Standards.

The graphs and table presented here show these results for indicator parameters such as BOD, COD, TSS, TDS; metals such as ferrous and non-ferrous as well as heavy metal; semi-metals such as Phosphorus, Nitrogen, Sulfur, Chlorine ; VOCs and SVOCs.

Table 16.1. Levels of general Chemistry using LB models 2,6, 9, and 10

	SEPTAGE BOD_5, COD, TDS, & TSS (mg/L)					
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT	LVL 9 CONCENTRATE
BOD_5	1850	289	ND	6.9	ND	7760
COD	3490	543	193	ND	ND	24800
TDS	1300	1360	947	41	22	1430
TSS	2380	117	74	ND	ND	9500

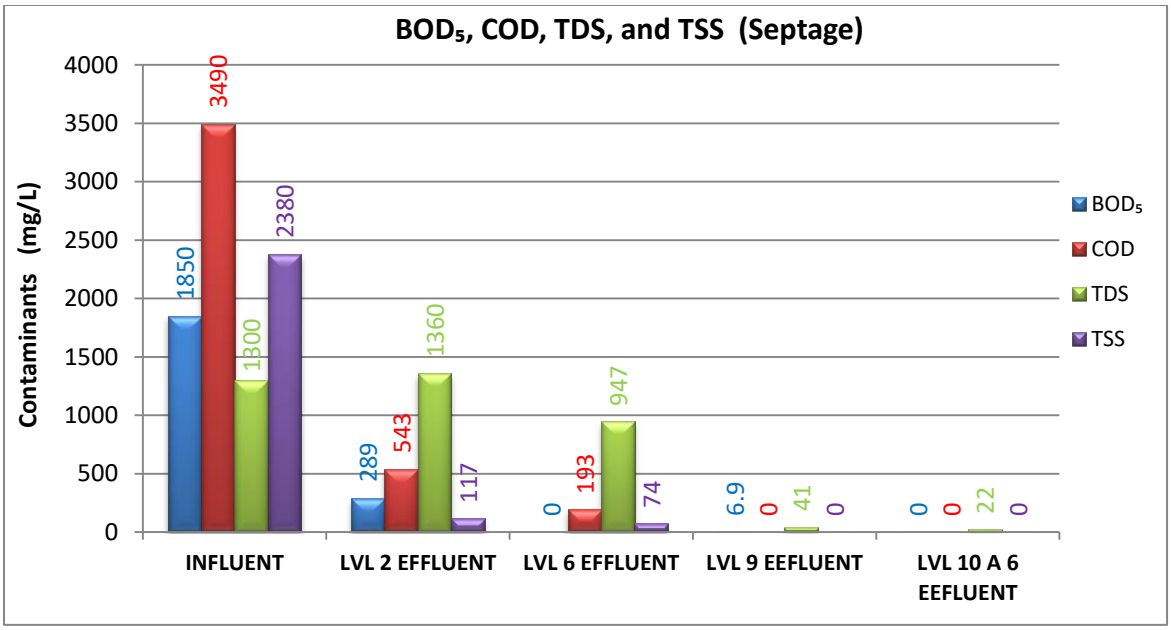


Figure 16. Levels of general Chemistry using LB models 2,6, 9, and 10

Table 16.2. Levels of general Chemistry using LB models 2,6, 9, and 10

	SEPTAGE BOD_5, COD, TDS, & TSS Removal %				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT
BOD_5	1850	84.38%	100.00%	99.63%	100.00%
COD	3490	84.44%	94.47%	100.00%	100.00%
TDS	1300	0.00%	27.15%	96.85%	98.31%
TSS	2380	95.08%	96.89%	100.00%	100.00%

Table 17.1. Levels of TKN & Ammonia using LB models 2,6, 9, and 10

	SEPTAGE TKN & Ammonia Nitrogen (mg/L)					
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT	LVL 9 CONCENTRATE
TKN	217	129	106	8.6	2.6	673
Ammonia N	112	105	83	6.6	1.9	140

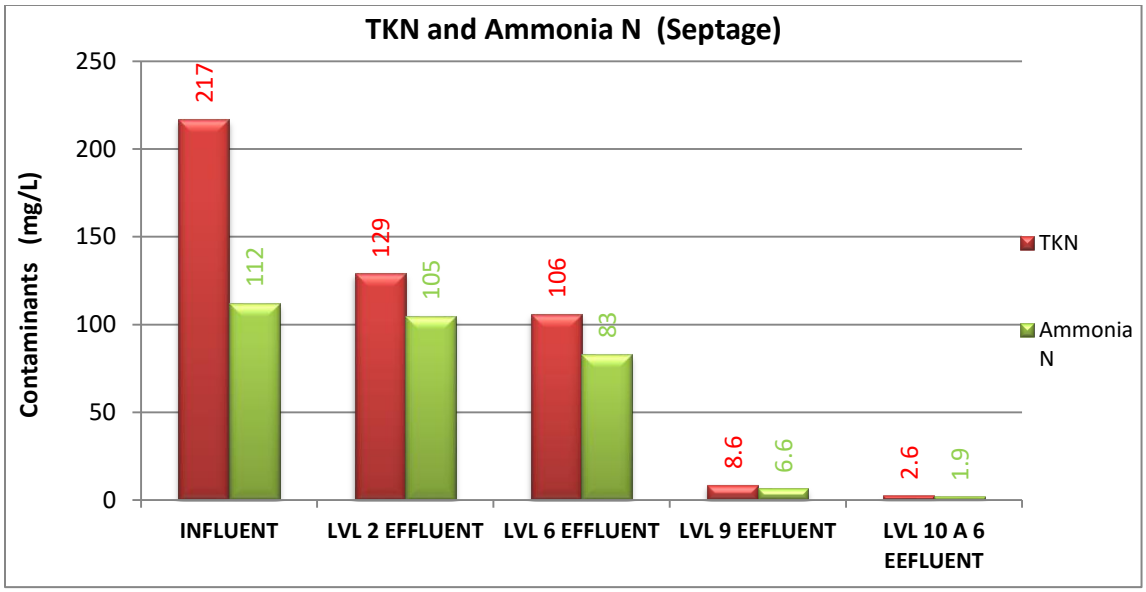


Figure 17. Levels of TKN & Ammonia using LB models 2,6, 9, and 10

Table 17.2. Levels of TKN & Ammonia using LB models 2,6, 9, and 10

	SEPTAGE TKN & Ammonia Nitrogen Removal %				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT
TKN	217	40.55%	51.15%	96.04%	98.80%
Ammonia N	112	6.25%	25.89%	94.11%	98.30%

Table 18.1. Levels of Nitrate, Nitrite & Phosphorus using LB models 2,6, 9, and 10

	SEPTAGE Nitrate + Nitrite & Phosphorus (mg/L)					
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT	LVL 9 CONCENTRATE
Nitrate + Nitrite NO_2 plus NO_3	ND	ND	ND	ND	ND	0.16
Phosphorus	8.3	0.5	ND	ND	ND	28.2

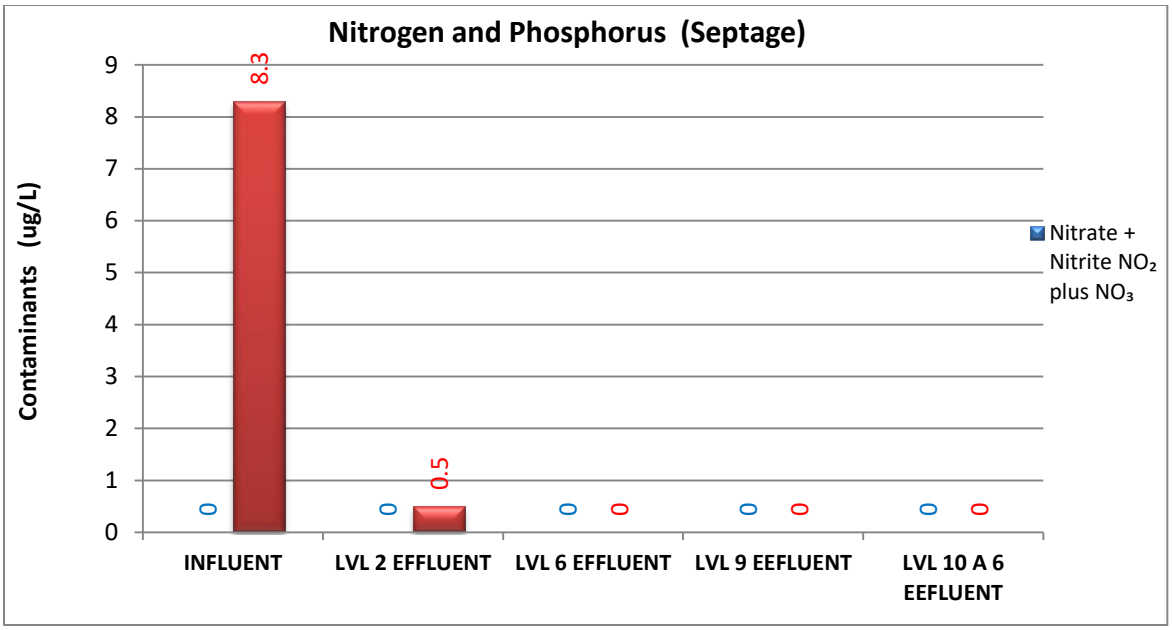


Figure 18. Levels of Nitrate, Nitrite & Phosphorus using LB models 2,6, 9, and 10

Table 18.2. Levels of Nitrate, Nitrite & Phosphorus using LB models 2,6, 9, and 10

	SEPTAGE Nitrate + Nitrite & Phosphorus Removal %				
PARAMETER	INFLUENT	LVL 2 EFFLUENT	LVL 6 EFFLUENT	LVL 9 EEFLUENT	LVL 10 A 6 EEFLUENT
Nitrate + Nitrite NO_2 plus NO_3	ND	N/A	N/A	N/A	N/A
Phosphorus	8.3	93.98%	100.00%	100.00%	100.00%

C. On-Site Study at Borough's Central Landfill

In order to obtain more representative results which can account for daily fluctuations of landfill leachate quality, an on-site duration and treatability study was organized and conducted for a period of six weeks (three weeks on-site testing and study and three weeks for transit, mobilization, demobilization). The following is a rough chronology of the events:

Sept5:	Equipment shipped to the site in Palmer Alaska
Sept 5 to 14:	Transit
Sept 15 to 16:	System setup and clean water test
Sept 17:	Problem Definition and Leachate Characterization
Sept 18 to 21:	Process definition/development and duration study
Sept 24 to 28:	Repeatability study
Oct. 1 to Oct. 6.	Durability and performance test
Oct. 8 to 9:	Demobilization and packing the plant and equipment
Oct. 10:	Shipping the equipment back to Clark Office

Although there were some delays by the shipping company on the pick-up and transit duration, by utilizing the weekend, the study started on-time and according to schedule on September 17th, 2018.

Clark Personnel arrived to the site on September 12 and started the preparation at the site, reviewing the test protocol, arranging for power, freshwater and leachate supply procedures.

On September 16th , the leachate treatment plant was unpacked, set up, calibrated, and prepared for testing.

An up to 5 gpm membrane leachate treatment plant was utilized to achieve the set objectives. Two modes of full batch and topped batch were examined during this study. The LeachBuster® unit was fitted with LB L-2, L-6, L-8, and L-9 membranes using stainless steel modules in a high-pressure mode. When the temperature of the screened wastewater was below 50°F; a heater was used to increase the temperature to >50°F. The wastewater was delivered through a pressurized feed line into the batch tank for full batch, continuous batch, and the topped batch modes. Permeate from the pilot plant was collected in a series of 50 gallon containers; this was used for sampling, analysis and further processing when necessary. The flow, conductivity, temperature, inlet and outlet pressure; pH and other parameters were measured continuously to monitor the flux rate.

The test system and associated equipment arrived in a twenty foot container to the test site. Clark arranged for additional forty foot container, which was delivered to the site and was used as an enclosure for conducting the testing.

Raw leachate was transported from the pumping station to the storage containers (200 gallon tote) inside the test enclosure. The raw leachate was then pumped into the treatment plant's on-board tank from which the leachate was processed by the membranes. The treated leachate and concentrate were collected in separate containers (50 gal containers for treated leachate and 200 gallons tote for concentrate) and processed accordingly.

The process was repeated utilizing different membranes for the first week, until a suitable membrane level was selected. Using the selected membrane, the test was repeated for the remaining two weeks to obtain repeatable results and also test membrane performance.

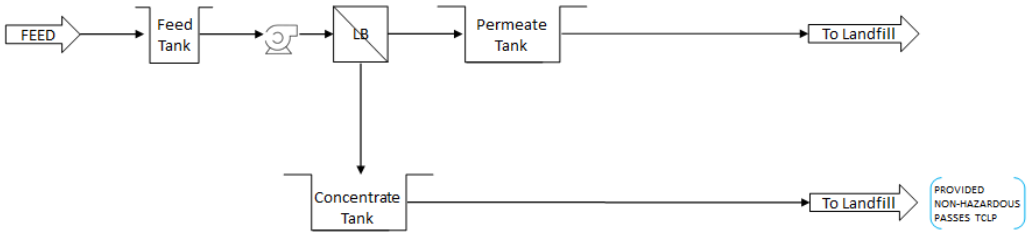
At the end of the third week, the system was dismantled, packaged and shipped back to the Clark's office.

The compiled study results are presented in this report. The following is a simplified process flow diagram of the layout plan for the leachate treatment process conducted at the site:

CLARK ENGINEERING

Clark Project # E17003

Mat-Su Landfill - Palmer, AK
Process Flow Diagram



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PRELIMINARY, NOT FOR CONSTRUCTION

Photographs showing the treatment plant, equipment, and test setup

C.1 Problem identification and wastewater characterization

In order to design a system for treatment of leachate from MSB's Central landfill, the characteristics of the leachate waste stream was required. This was conducted during the first day of the study (Monday, 17th of September 2018) by taking a series of samples and sending them to the Laboratory. Test America Laboratories, a nationally accredited independent third-party laboratory in Anchorage, Alaska was selected to conduct the laboratory wastewater and water tests. A series of sample bottles were ordered and received at the site by Thursday, September 13. The samples were analyzed for the parameters listed above and the results from these samples were used to characterize the leachate at the site.

At the same time some indicator parameters such as pH, conductivity (EC), total dissolved solids (TDS), oxidation/reduction potential (ORP) and temperature (T) were recorded. A set of samples were collected and sent to the laboratory for testing and analysis. The following table summarizes the recorded test data and laboratory analysis:

Table 19. Leachate Characteristics

Leachate Characteristics at the Central Landfill					
PARAMETER	General Chemistry		PARAMETER	Metal ICP	
	INFLUENT	Unit		INFLUENT	Unit
TDS	15000	mg/L	Antimony	0.010	mg/L
TSS	50	mg/L	Arsenic	0.033	mg/L
TKN	1100	mg/L	Barium	0.42	mg/L
BOD_5	13000	mg/L	Beryllium	0.00095	mg/L
COD	17000	mg/L	Cadmium	0.00085	mg/L
Phosphorus, Total	1.2	mg/L	Calcium	1000	mg/L
Phosphorus as PO4	3.8	mg/L	Chromium	0.19	mg/L
Ammonia as N	1100	mg/L	Cobalt	0.14	mg/L
Ammonia as NH3	1300	mg/L	Copper	0.0078	mg/L
PARAMETER	PFC's		Iron	260	mg/L
	INFLUENT	Unit	Lead	0.022	mg/L
PFHpA	350	ng/L	Magnesium	290	mg/L
PFOA	540	ng/L	Manganese	20	mg/L
PFHxS	220	ng/L	Mercury	0.00012	mg/L
PFBA	770	ng/L	Molybdenum	0.0066	mg/L
PFPeA	680	ng/L	Nickel	0.78	mg/L
PFHxA	1200	ng/L	Potassium	450	mg/L
PFNA	18	ng/L	Selenium	0.019	mg/L
PFBS	51	ng/L	Silver	0.0032	mg/L
PFOS	16	ng/L	Sodium	1500	mg/L
6:2 FTS	160	ng/L	Vanadium	0.090	mg/L
			Zinc	5.3	mg/L

PARAMETER	VOC's		PARAMETER	SVOC's	
	INFLUENT	Unit		INFLUENT	Unit
Benzene	15	µg/L	Bis(2-ethylhexyl) phthalate	ND	µg/L
Ethylbenzene	12	µg/L	2-Methylphenol	15	µg/L
Chloroethane	ND	µg/L	Phenol	1100	µg/L
1,2-Dichloroethane	12	µg/L	3-Methylphenol & 4-Methylphenol	7900	µg/L
cis-1,2-Dichloroethene	ND	µg/L			
trans-1,2-Dichloroethene	ND	µg/L			
Methylene Chloride	30	µg/L			
Vinyl chloride	ND	µg/L			
m-Xylene & p-Xylene	26	µg/L			
o-Xylene	14	µg/L			
Toluene	1300	µg/L			

C.2 Process definition/development and durability study

During this period a series of membranes namely, LB L-2, L-6, L-8, and L-9, were tested. This test was completed in three days (September 11 thru 13, 2018) and all the indicator parameters such as conductivity, TDS, ORP and pH were measured and recorded. Also samples were taken and sent to the laboratory for analysis. The comparison of the recorded data and some preliminary numbers were used to decide on the type of the membrane which would provide the desired level of treatment with an optimal performance. It was concluded that LB L-9 membrane yields the best results; therefore, this membrane level was selected for completion of the repeatability and durability study.

Recorded data and laboratory results are provided in the following tables and graphs.

Table 20. Different Leachbuster Levels Laboratory Data vs MCL Limits

PARAMETER	General Chemistry (mg/L)			
	INFLUENT	LVL 8 EFFLUENT	LVL 9 EFFLUENT	*MCL Limits
TDS	15000	650	74	1000
TSS	50	ND	ND	N/A
TKN	1100	160	28	N/A
BOD_5	13000	53	43	N/A
COD	17000	280	120	N/A
Phosphorus, Total	1.2	ND	ND	N/A
Phosphorus as PO4	3.8	ND	ND	N/A
Ammonia as N	1100	190	36	N/A
Ammonia as NH3	1300	230	44	N/A

*According to National Primary Drinking Water Regulation

PARAMETER	VOC's (µg/L)			
	INFLUENT	LVL 8 EFFLUENT	LVL 9 EFFLUENT	*MCL Limits
Benzene	15	1.3	1.2	5
Ethylbenzene	12	ND	ND	700
Chloroethane	ND	1.7	ND	N/A
1,2-Dichloroethane	12	4.8	3.4	5
cis-1,2-Dichloroethene	ND	1.4	1.2	N/A
trans-1,2-Dichloroethene	ND	1.0	ND	N/A
Methylene Chloride	30	19	15	N/A
Vinyl chloride	ND	2.1	1.4	2
m-Xylene & p-Xylene	26	ND	ND	10000
o-Xylene	14	0.19	ND	10000

Toluene	1300	21	8.3	N/A

*According to National Primary Drinking Water Regulation

PARAMETER	Metal ICP (mg/L)			
	INFLUENT	LVL 8 EFFLUENT	LVL 9 EFFLUENT	*MCL Limits
Antimony	0.010	ND	ND	0.006
Arsenic	0.033	ND	ND	0.010
Barium	0.42	0.0037	ND	2.0
Beryllium	0.00095	ND	ND	0.004
Cadmium	0.00085	ND	ND	0.005
Calcium	1000	9.3	2.40	N/A
Chromium	0.19	ND	ND	0.10
Cobalt	0.14	ND	ND	N/A
Copper	0.0078	0.0064	ND	N/A
Iron	260	1.9	0.48	N/A
Lead	0.022	ND	ND	N/A
Magnesium	290	2.3	0.62	N/A
Manganese	20	0.17	0.044	N/A
Mercury	0.00012	ND	ND	0.002
Molybdenum	0.0066	ND	ND	N/A
Nickel	0.78	0.0036	0.0066	N/A
Potassium	450	39	7.9	N/A
Selenium	0.019	ND	ND	0.05
Silver	0.0032	ND	ND	N/A
Sodium	1500	150	19	N/A
Vanadium	0.090	ND	ND	N/A
Zinc	5.3	0.11	0.0075	N/A

Note: 18 AAC 70 water standard quality limits is higher than 40 CFR 16, National Primary Drinking Water Regulation, however the leachate treatment plant is capable of meeting both limit standards.

PARAMETER	SVOC's (µg/L)			
	INFLUENT	LVL 8 EFFLUENT	LVL 9 EFFLUENT	*MCL Limits
Bis(2-ethylhexyl) phthalate	ND	12	5.8	N/A
2-Methylphenol	15	1.5	ND	N/A
Phenol	1100	120	420	N/A
3-Methylphenol & 4-Methylphenol	7900	860	410	N/A

*According to National Primary Drinking Water Regulation

PARAMETER	PFC's (ng/L)			
	INFLUENT	LVL 8 EFFLUENT	LVL 9 EFFLUENT	*MCL Limits
PFHpA	350	1.30	0.38	N/A
PFOA	540	2.90	0.76	N/A
PFHxS	220	0.94	0.40	N/A
PFBA	770	6.0	1.9	N/A
PFPeA	680	2.90	1.1	N/A
PFHxA	1200	4.9	1.6	N/A
PFNA	18	ND	ND	N/A
PFBS	51	0.36	ND	N/A
PFOS	16	ND	ND	N/A
6:2 FTS	160	18	ND	N/A

*According to National Primary Drinking Water Regulation

C.2.1 LB L-6

Upon completion of the problem definition and waste characterization, process definition and selection phase started. From the results of the offsite study and other similar leachate treatment studies and test results, Clark was confident that treatment levels 1 to 5 will not produce a high enough quality effluent to meet the regulatory requirement for surface and subsurface discharge. Based on this, Level 6, LB L-6 was selected as start point in the range of membrane levels LB-L1 to LB-L14 to examine its efficacy to meet the discharge requirements.

The test protocol was designed by taking into account the information gained from the offsite study. Based on the results of this study, it was concluded that LB L-6 produced high enough quality water (Results are provided above in Section A) to meet standard Alaska/National Pollutant Discharge Elimination System APDES/NPDES for surface and subsurface discharge limits but did not meet the National Primary Drinking Water Quality Standard (NPDWS). Using this model, all TSS (<10 mg/l), BOD (<30 mg/l), di or polyvalent molecules for example Zinc, Arsenic, Chromium, Cadmium, VOCs, SVOCs were below the discharge requirements for standard NPDES and in most cases they also met the NPDWS, but fell short on monovalent and some dissolved solids such as ammonia or nitrates. All the pathogens such as *E.coli* and fecal and other coliforms were completely removed from the leachate. The treated leachate (permeate/effluent) quality was high enough to meet even the NPDWS requirements. During the onsite study this test was conducted to obtain operational and design data, but it was not included in the sampling program due to existence of sufficient data from the offsite study.

C.2.2 LB L-8

The model LB L-8 or Level 8 is tighter than LB L-6 in that it rejects more monovalent and dissolved solids than LB L-6, thus producing higher quality water which may meet the higher standards such as NPDWS. This level was included in the test and sampling protocol to obtain the required data to evaluate its ability to meet the higher discharge limit requirements by these standards.

The results of this study are provided in the tables and graphs below:

C.2.2.1 Indicator Parameters

These are parameters which combine two or more parameters and normally measure the presence of several contaminants at once. Some examples are BOD, COD, TSS, and TDS.

Table 21

	Indicator Parameters (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
TDS	15000	650	95.7%
TSS	50	ND	100%

BOD_5	13000	53	99.6%
COD	17000	280	98.4%

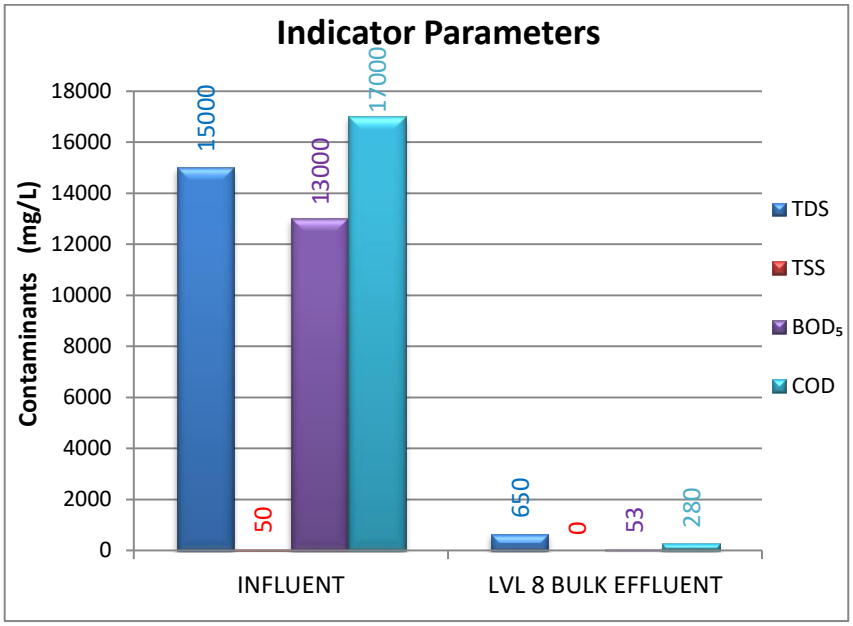

Figure 21

As it can be seen, this model produces high enough quality water which meets the Primary Drinking Water Quality Standard, except for BOD. Although the system removes 99.6% of the BOD;' nevertheless, it is slightly higher than the required standard of 40mg/l.

C.2.2.2 General Chemistry

These are compounds that are commonly monitored in most wastewater treatment plants. They are mainly consisting of phosphorus or nitrogenous compounds. The following are phosphorus species that were sampled.

Table 22

	Phosphorus Compounds (mg/L)		
PARAMETER	**INFLUENT**	**LVL 8 BULK EFFLUENT**	**% Removal**
Phosphorus, Total	1.2	ND	100%
Phosphorus as PO4	3.8	ND	100%

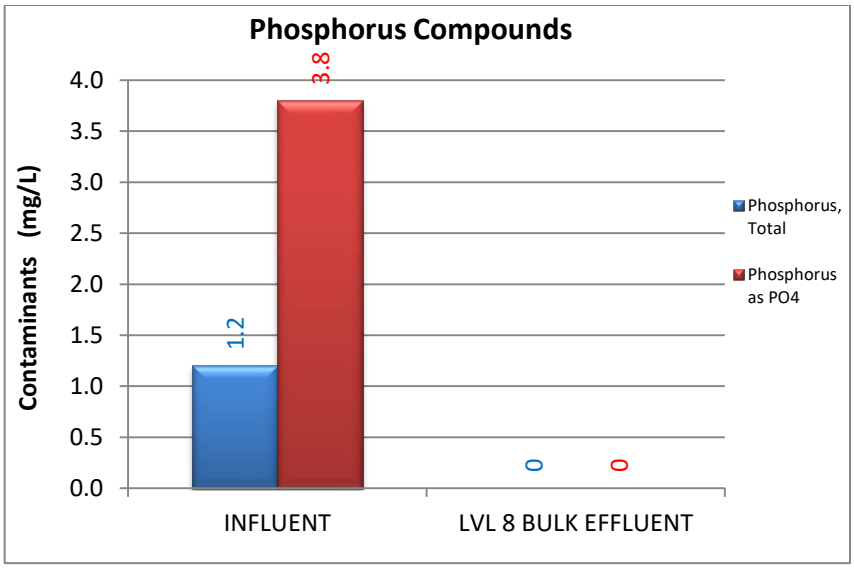

Figure 22

All the wastewater treatment levels starting from LB L-1, remove almost 100 percent of the phosphorus compounds. Level LB L-8 also removed 100% of the phosphorus compounds, thus meeting almost all of the existing discharge limits for surface and subsurface disposal.

Other parameters that are commonly monitored for surface and subsurface discharge are nitrogenous compounds. The following are tabular and graphical representations of these parameters.

Table 23

	Nitrogenous Compounds (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Ammonia as N	1100	190	82.7%
Ammonia as NH3	1300	230	82.3%
TKN	1100	160	85.5%

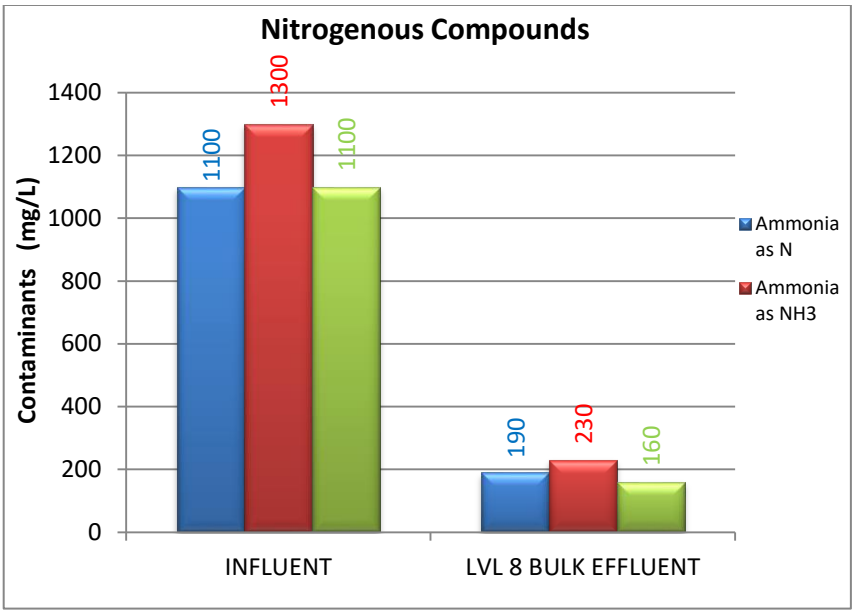

Figure 23

The system removed between 82 to 85% of this material; nevertheless, due to the existence of extremely high levels (>1000 mg/l) of these materials in the raw leachate, the treated leachate still had high enough residuals to not achieve the discharge limit requirements.

C.2.2.3 Metals

The samples were also analyzed for the presence of metals. An EPA approved method of Atomic Emission Spectroscopy called "Inductively Coupled Plasma" or ICP was used to analyze these samples. It was suggested by the regulators that version 6010 should be adopted for this study. The majority of these metals are di- or polyvalent, which are normally removed by level LB L-8. This was the case for the results of this study as well. The Model LB L-8 successfully removed almost all of these elements from the waste stream. In most cases about 100% of these elements were removed. The following are graphical and tabular representations of these results.

Table 24

	Metal ICP 6010 (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Arsenic	0.033	ND	100%
Lead	0.022	ND	100%
Antimony	0.010	ND	100%
Selenium	0.019	ND	100%
Vanadium	0.090	ND	100%

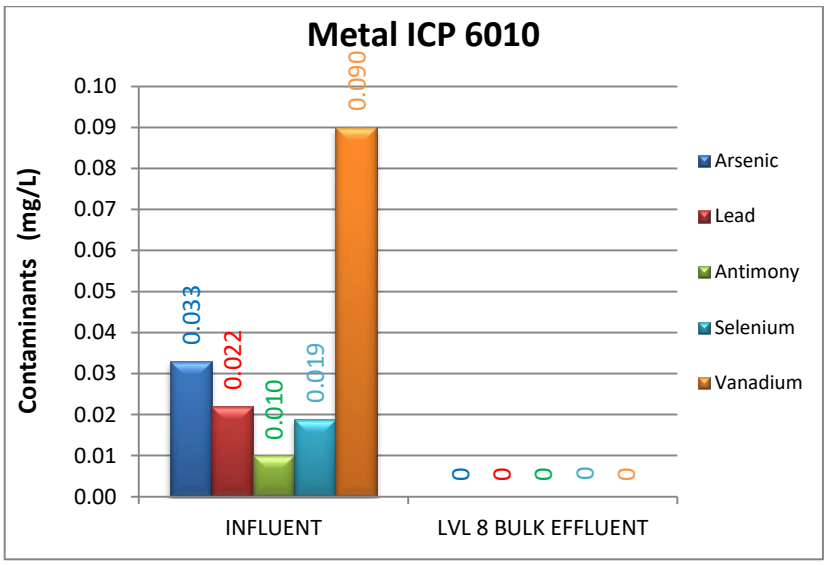

Figure 24

Table 25

	Metal ICP 6010 (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Barium	0.42	0.0037	99.1%
Cobalt	0.14	ND	100%
Chromium	0.19	ND	100%
Nickel	0.78	0.0036	99.5%

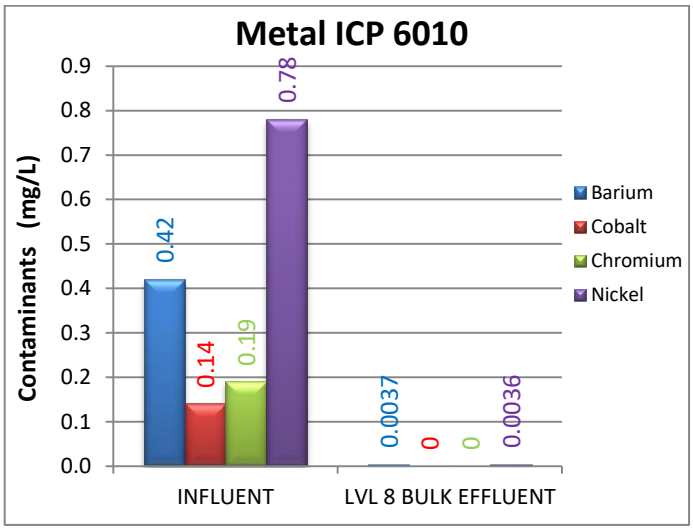

Figure 25

Table 26

PARAMETER	Metal ICP 6010 (mg/L)		
	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Manganese	20	0.17	99.2%
Zinc	5.3	0.11	97.9%

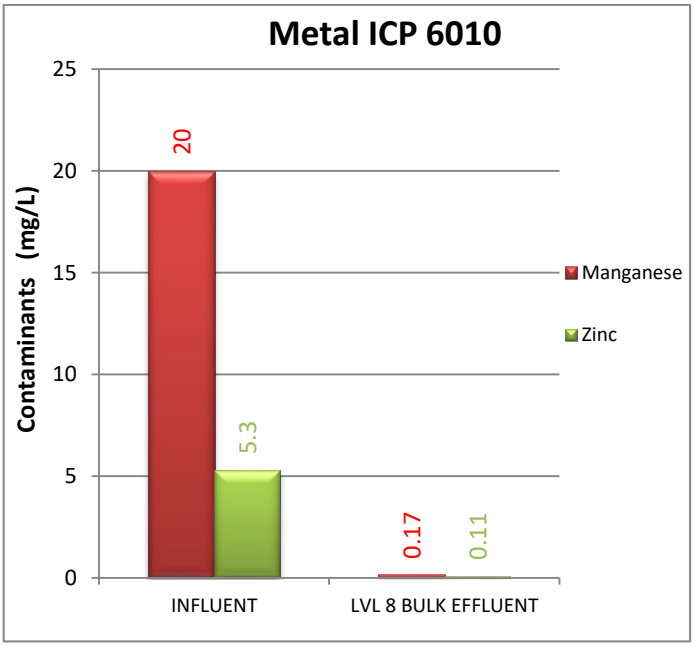

Figure 26

Table 27

PARAMETER	Metal ICP 6010 (mg/L)		
	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Beryllium	0.00095	ND	100%
Cadmium	0.00085	ND	100%
Copper	0.0078	0.0064	18%
Molybdenum	0.0066	ND	100%
Silver	0.0032	ND	100%

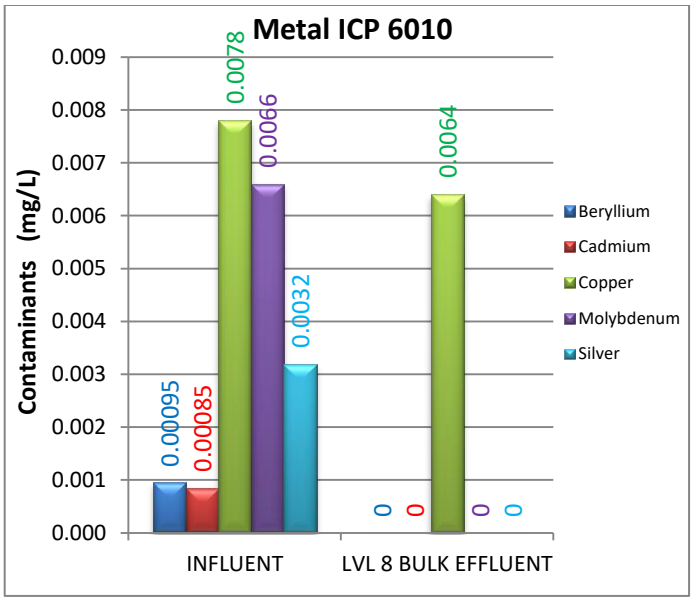

Figure 27

Table 28

	Metal ICP 6010 (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Calcium	1000	9.3	99.1%
Iron	260	1.9	99.3%
Magnesium	290	2.3	99.2%
Potassium	450	39	91.3%
Sodium	1500	150	90%

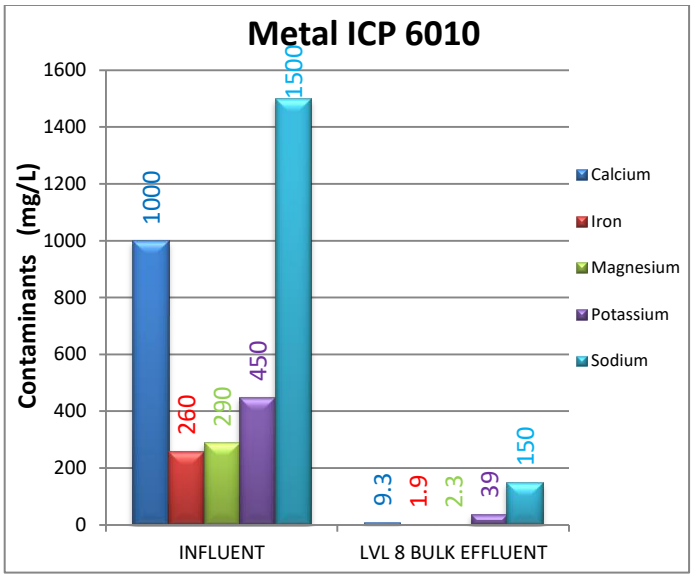

Figure 28

Table 29

	Metal (mg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Mercury	0.00012	ND	100.0%

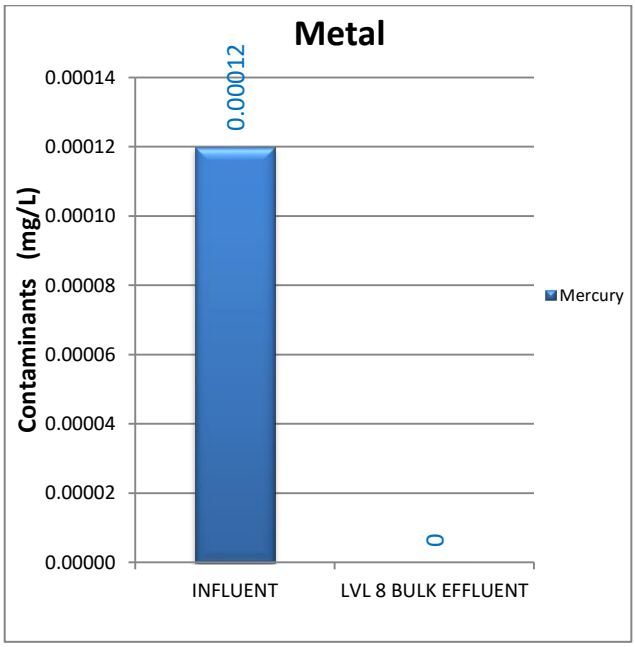

Figure 29

C.2.2.4 Volatile and Semi-Volatile Organic Compound

Volatile and Semi-Volatile Organic Compound (VOC and SVOC) are the compounds that can turn into vapor phase under ambient conditions (temperature and pressure) and disperse into the atmosphere or saturate acquis/vapor interface and disperse into the atmosphere by slight changes from the ambient condition (mixing, aeration). Some of these materials are regulated and others are monitored. They can get into the landfill leachate from daily-use materials such as cleaning products, paints or are generated as degradation byproducts of materials in the landfill.

Samples were collected and sent to the laboratory for analysis using the method 8260 for VOCs and 8270 for SVOCs as recommended by the regulators.

Results indicate that the level LB L-8 removed from 65% to 99% (for a majority of compounds) of these compounds, which meet the discharge requirements into the surface and subsurface waters.

The following tables and graphs show the list of the only materials that were present in the influent. The compounds which are non-detectable in the raw leachate are not listed here, but they are provided in the independent third-party laboratory test reports, attached to this report.

Table 30

	VOC by 8260 (µg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Benzene	15	1.2	92.0%
Ethylbenzene	12	ND	100%
1,2-Dichloroethane	12	3.4	72%
cis-1,2-Dichloroethene	ND	1.2	N/A
Methylene Chloride	30	15	50.0%
Vinyl chloride	ND	1.4	N/A
m-Xylene & p-Xylene	26	ND	100%
o-Xylene	14	ND	100.0%

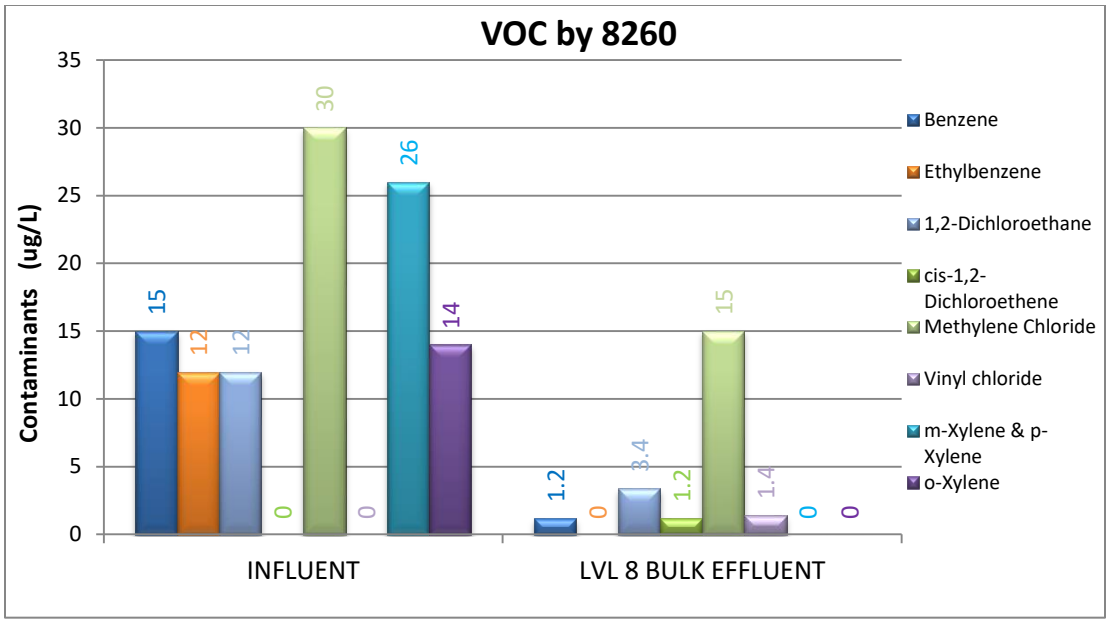

Figure 30

Table 31

	VOC by 8260 (µg/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Toluene	1300	8.3	99.4%

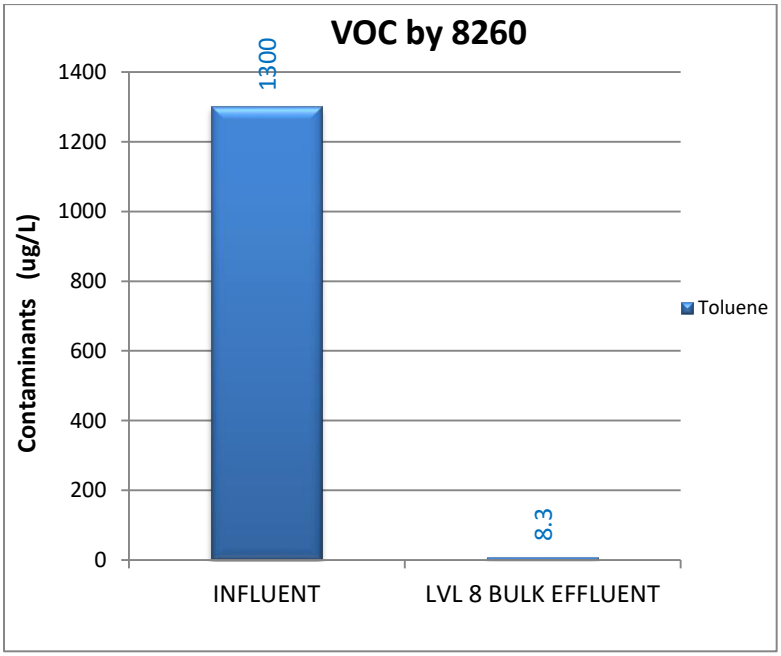

Figure 31

Table 32

PARAMETER	SVOC by 8270 (µg/L)		
	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
Bis(2-ethylhexyl) phthalate	ND	5.8	N/A
2-Methylphenol	15	1.5	90%
Phenol	1100	420	61.8%
3-Methylphenol & 4-Methylphenol	7900	860	89.1%

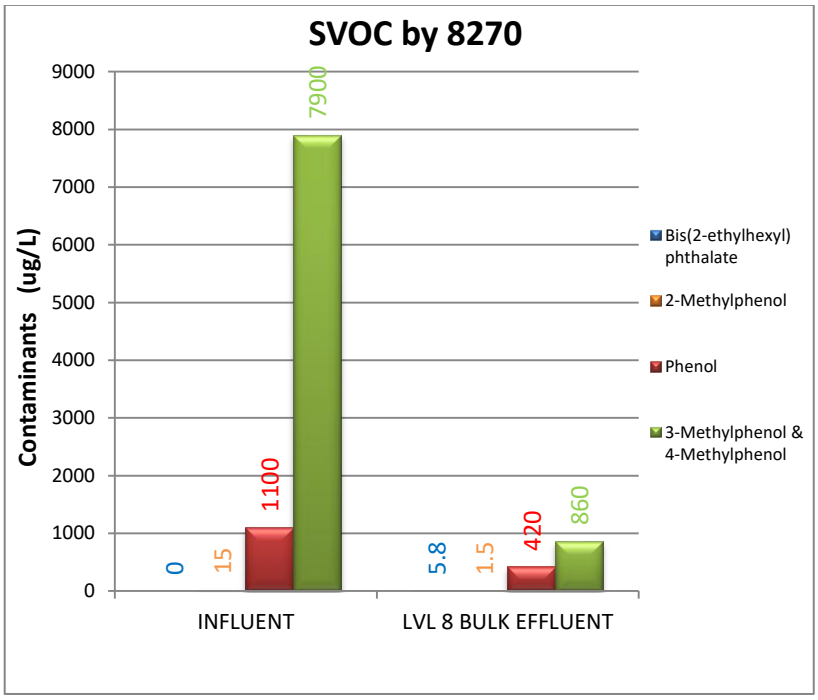

Figure 32

C.2.2.5 Perfluoroalkyl and polyfluoroalkyl substances (PFAS)

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are emerging contaminants of concern, which are gaining more and more attention every day. Due to their amphiphilic properties, they are used in several domestic and industrial applications and have been finding their ways into landfills and ultimately into the landfill leachate. Also due to their characteristics, they are toxic to biota thus resistant to biodegradation and chemo-degradation in the environment. They are relatively soluble and mobile thus are easily leached out of solid wastes into the leachate. Leachate at this site also had a substantial amount of these compounds, which have to be treated. Currently, there is a strong movement towards regulating these compounds and restricting their discharge into the environment. Regulators are drawing discharge limits to be adhered to by wastewater treatment plants, which in some states are already on the books and are being applied to these establishments. These organizations in turn, scrutinize the sources of their wastewater, which often includes landfill leachate. They create challenges to the landfill owners by either refusing to accept their leachate or increasing their treatment costs beyond their fiscal capability.

In order to be prepared for this possibility at the Borough's Central Landfill, the leachate samples from both the raw and treated leachate were collected and sent to the laboratory for analysis.

As it can be seen from the following graphical and tabulated data, the level LB L-8 removed 99.2% to 100% of these compounds from the raw leachate.

Table 33

	Fluorinated Alkyl Substances (ng/L)		
PARAMETER	INFLUENT	LVL 8 BULK EFFLUENT	% Removal
PFHpA*	350	1.30	99.6%
PFOA*	540	2.90	99.5%
PFHxS*	220	0.94	99.6%
PFBA*	770	6.0	99.2%
PFPeA*	680	2.90	99.6%
PFHxA*	1200	4.9	99.6%
PFNA*	18	ND	100%
PFBS*	51	0.36	99.3%
PFOS*	16	ND	100%
6:2 FTS	160	ND	100%

***PFHpA → Perfluoroheptanoic acid, PFOA → Perfluorooctanoic acid, PFHxS → Perfluorohexanesulfonic acid, PFBA → Perfluorobutanoic acid, PFPeA → Perfluoropentanoic acid, PFHxA → Perfluorohexanoic acid, PFNA → Perfluorononanoic acid, PFBS → Perfluorobutanesulfonic acid, PFOS → Perfluorooctanesulfonic acid.**

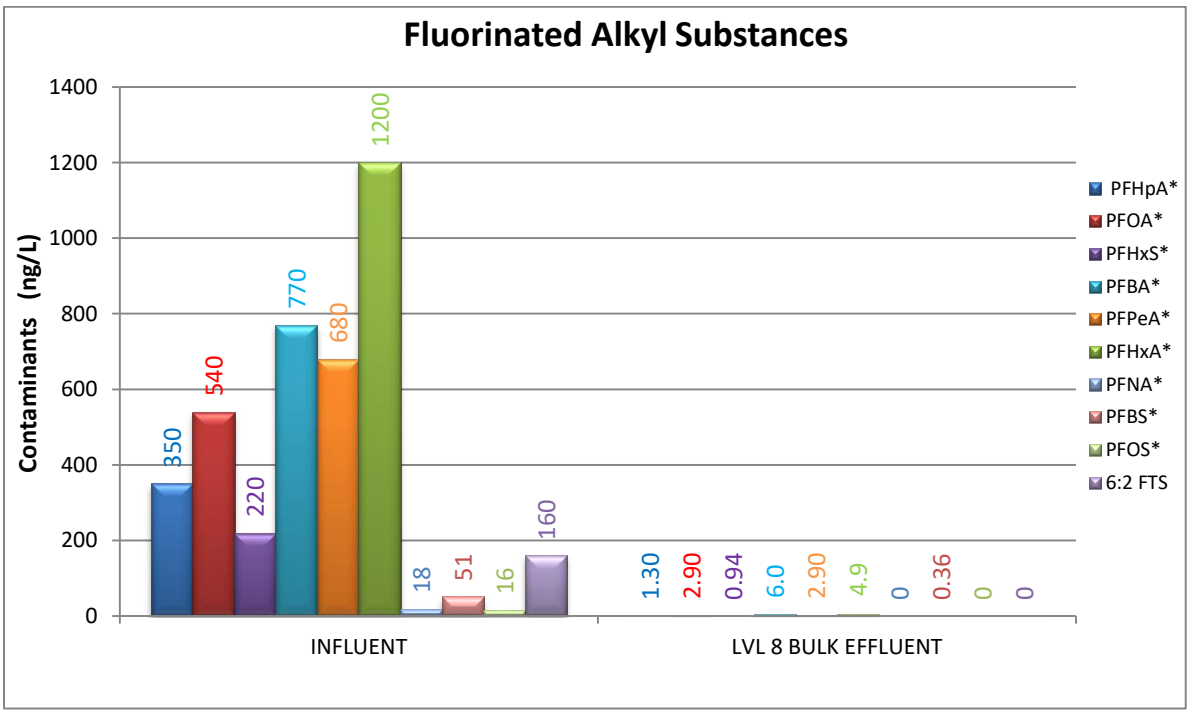

Figure 33

This is one of the unique features of the LEACHBUSTER® system which can remove amphiphilic as well as hydrophilic compounds.

The next level of membrane in the progression to obtain a higher quality effluent was the LB L-9. This has a slightly tighter membrane and better monovalent rejection capabilities. Similar procedures were adopted in evaluating this level. The tests were conducted and samples were collected and sent to the laboratory for analysis. The followings are the results of these analyses. Unlike the previous tests where

C.2.3 Model LB L-9

C.2.3.1. Indicator Parameter

This model removed all of the contaminants in this category to beyond the discharge requirements for drinking water standards. For this level, three samples were taken at three different times during the process. These were:

1. At the start of the process: the contaminant removal rates by this level were at its highest level at the beginning of the process and were reduced toward the end of the test. A sample was collected at about an hour after the start of the test.
2. At the end of the process: similarly, a sample was taken just before the end of the test prior to draining the final concentrate.
3. Bulk sample: For this test, all the treated leachate processed during the entire test was collected in an appropriate container and a sample was taken from the collected treated leachate (permeate). This sample is the representative of a field condition where the treated leachate (permeate/effluent) from the entire process will be collected in the discharge pond or container (effluent tank) and discharged to environment and/or re-used.

Tables and graphs below represent these results for all three samples.

Table 34

	Indicators Parameters (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
TDS	4900	43	67	99%	170	28000
TSS	60	ND	ND	100%	ND	880
BOD_5	3100	19	19	99%	19	6800
COD	120	27	33	73%	80	540

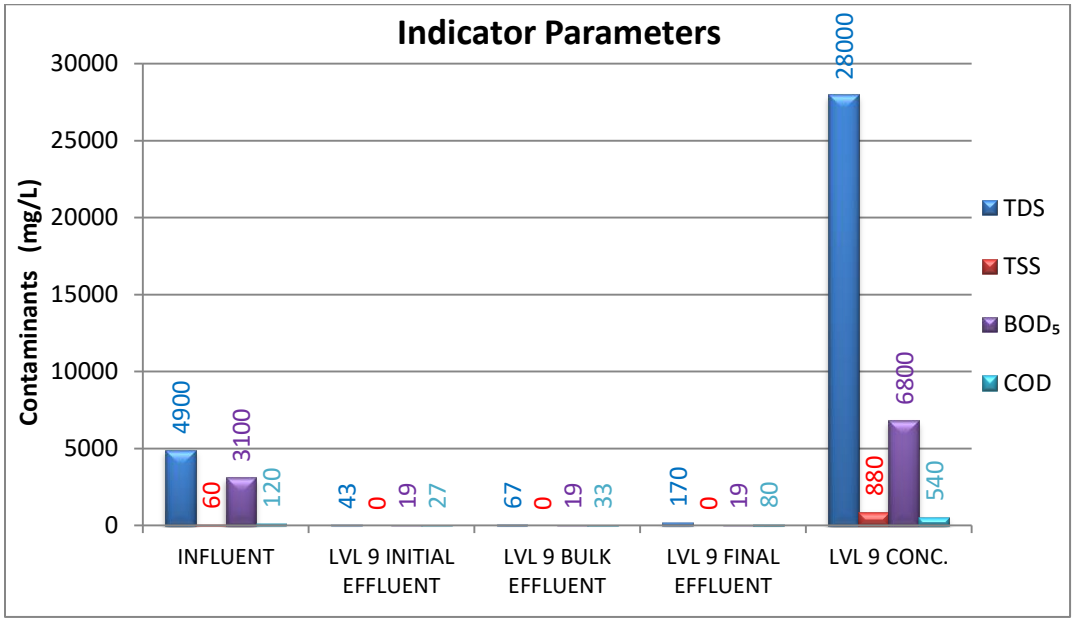

Figure 34

C.2.3.2. General Chemistry

These are the common parameters that are normally used to characterize wastewater matrices. They are different forms of phosphorus and nitrogen based analyses. This model removed all the phosphorus based compounds to non-detectible levels, thus meeting the most stringent discharge requirement.

As for nitrogenous compounds, the system also met the requirements for drinking water standards as provided in tables and figures below.

Table 35

	Phosphorus Compounds (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Phosphorus, Total	0.8	ND	ND	100%	ND	8.8
Phosphorus as PO4	2.6	ND	ND	100%	ND	27

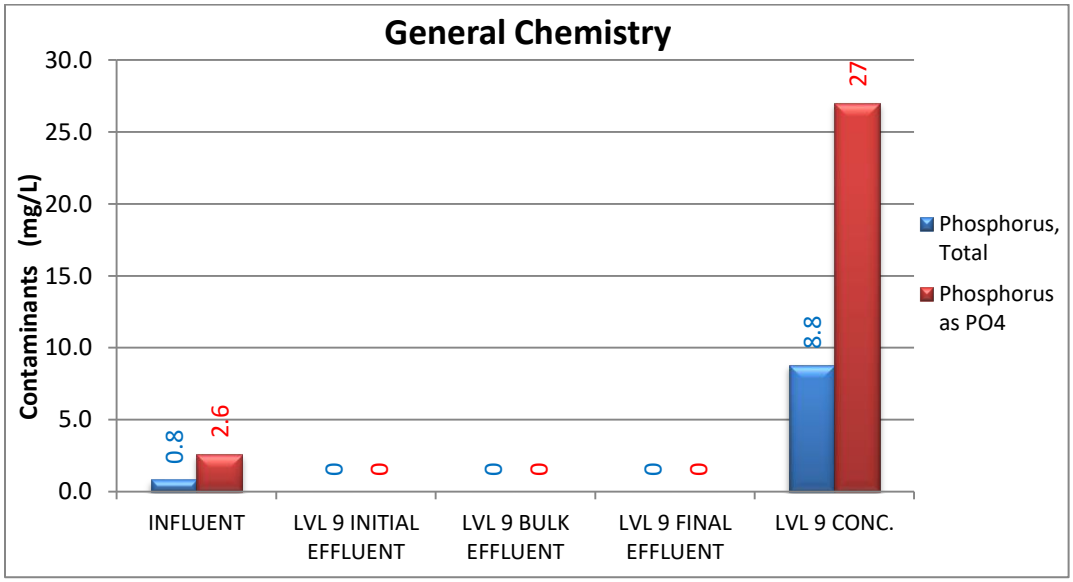

Figure 35

Table 36

	Nitrogenous Compounds (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Ammonia N	550	11	24	96%	83	2900
Ammonia as NH3	670	13	29	96%	100	3500

TKN	510	10	21	96%	74	2900

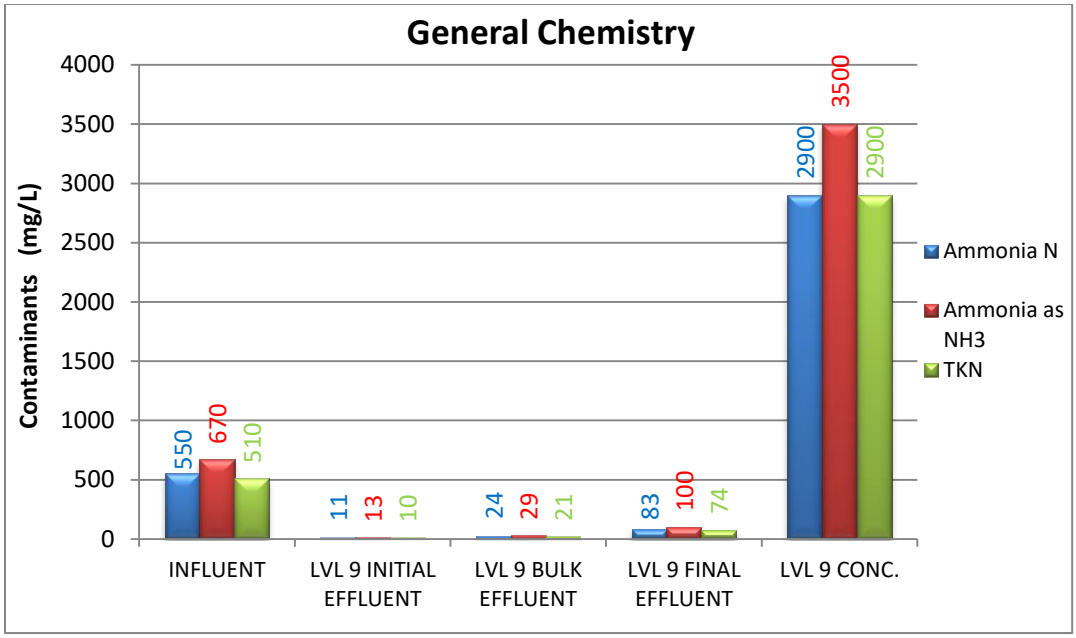

Figure 36

C.2.3.3. Metals

Samples were also analyzed for metals using ICP 6010 method recommended by the regulators. The results indicated that there were trace amount of these metals present in the raw leachate, which exceeded the limits set for primary drinking water quality standard. The system removed almost all of these contaminants from the raw leachate to non-detectable levels right thru to the end of the process. All three samples obtained at the start, end of the process, and the bulk effluent were completely void of these elements. Slightly less removal of around 98% was achieved for some of the non-regulated monovalent elements such as sodium and potassium. Even at this level of removal the values in the treated leachate were much lower than the threshold for the National Primary drinking water quality standard.

Table 37

	Metal ICP 6010 (mg/L)					
PARAMETER	**INFLUENT**	**LVL 9 INITIAL EFFLUENT**	**LVL 9 BULK EFFLUENT**	**% Removal**	**LVL 9 FINAL EFFLUENT**	**LVL 9 CONC.**
Arsenic	0.030	ND	ND	100%	ND	0.14
Cobalt	0.041	ND	ND	100%	ND	0.22
Chromium	0.086	ND	ND	100%	ND	0.38

Copper	0.013	ND	ND	100%	ND	0.043
Lead	0.015	ND	ND	100%	ND	0.041
Antimony	0.013	ND	ND	100%	ND	ND
Vanadium	0.050	ND	ND	100%	ND	0.17

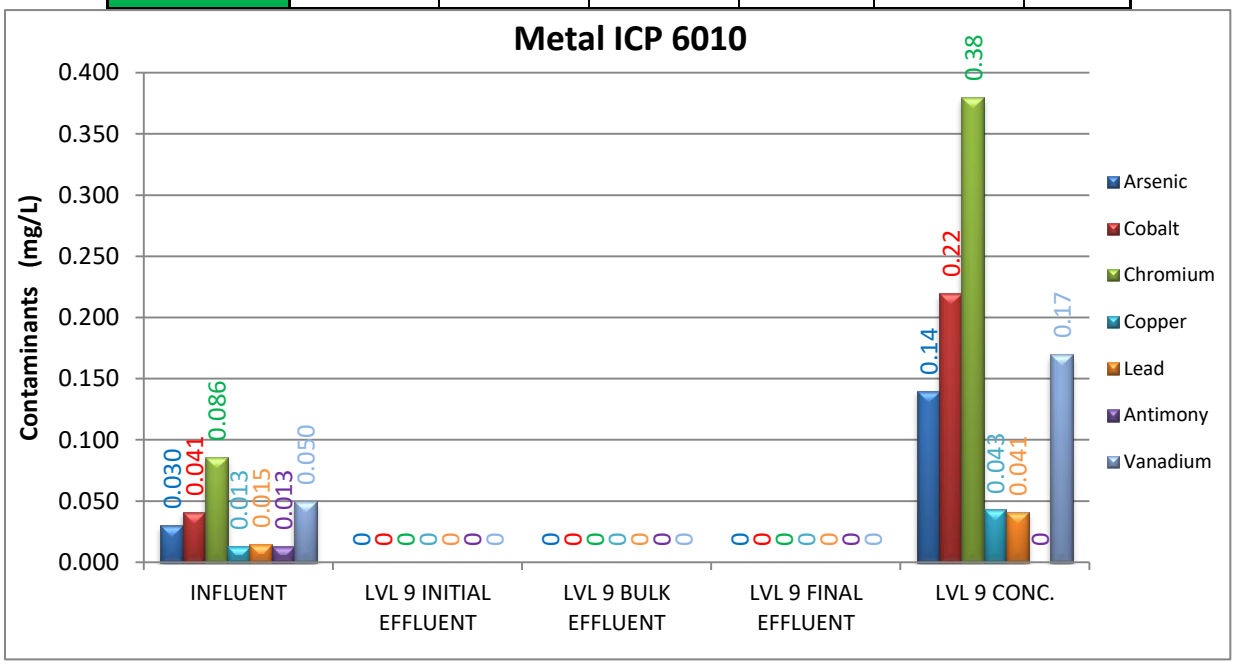

Figure 37

Table 38

	Metal ICP 6010 (mg/L)					
PARAMETER	**INFLUENT**	**LVL 9 INITIAL EFFLUENT**	**LVL 9 BULK EFFLUENT**	**% Removal**	**LVL 9 FINAL EFFLUENT**	**LVL 9 CONC.**
Barium	0.20	ND	0.0079	96.1%	ND	0.32
Nickel	0.42	ND	ND	100%	0.0032	2.2

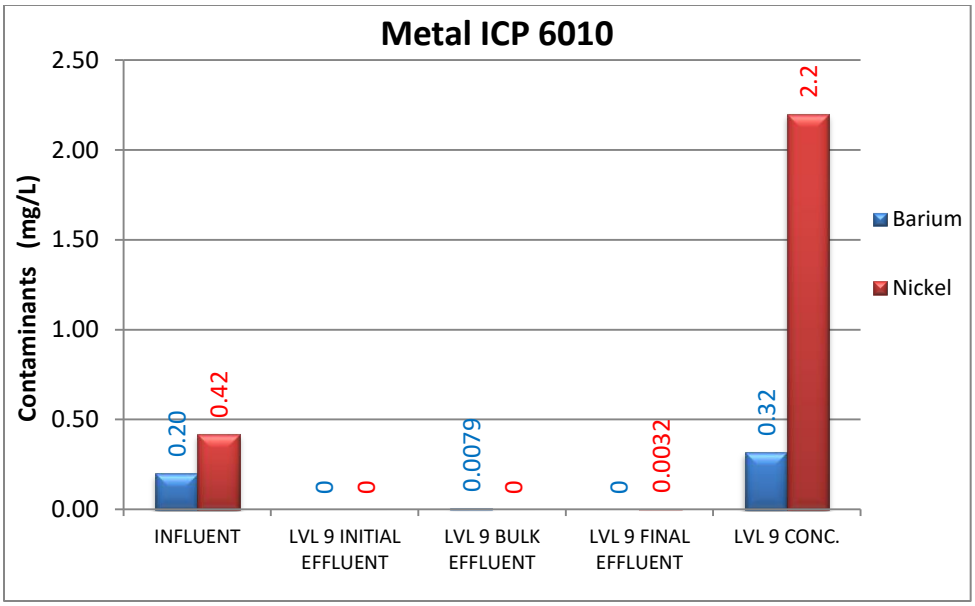

Figure 38

Table 39

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Manganese	5.1	0.013	0.039	99.2%	0.019	8.7
Zinc	2.0	0.01	0.026	98.7%	0.011	5.8

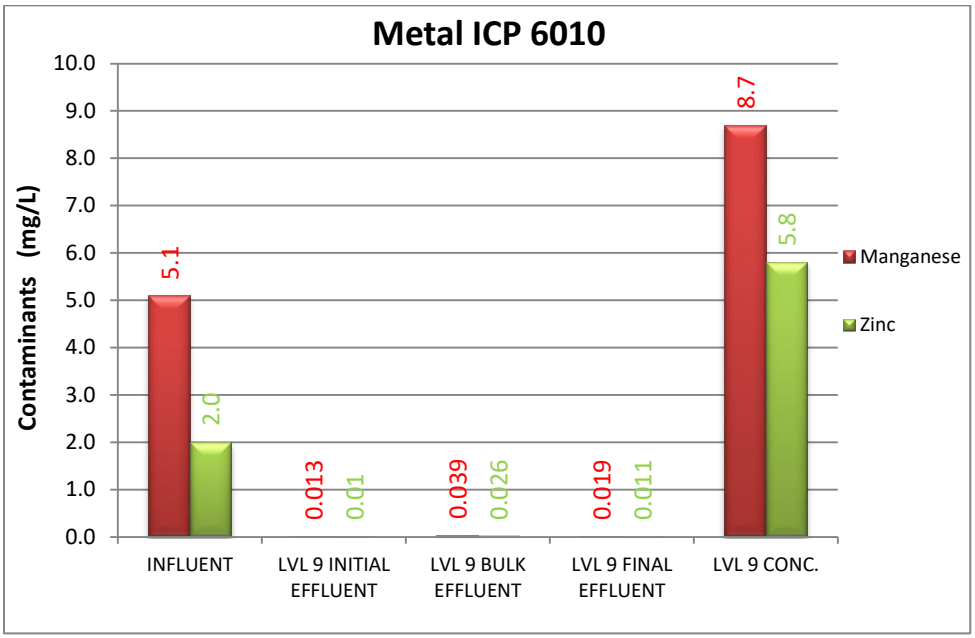

Figure 39

Table 40

PARAMETER	Metal ICP 6010 (mg/L)					
	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Silver	0.0016	ND	ND	100%	ND	ND
Beryllium	0.00044	ND	ND	100%	ND	0.00069
Cadmium	0.0046	ND	ND	100%	ND	0.011
Molybdenum	0.0036	ND	ND	100%	ND	ND

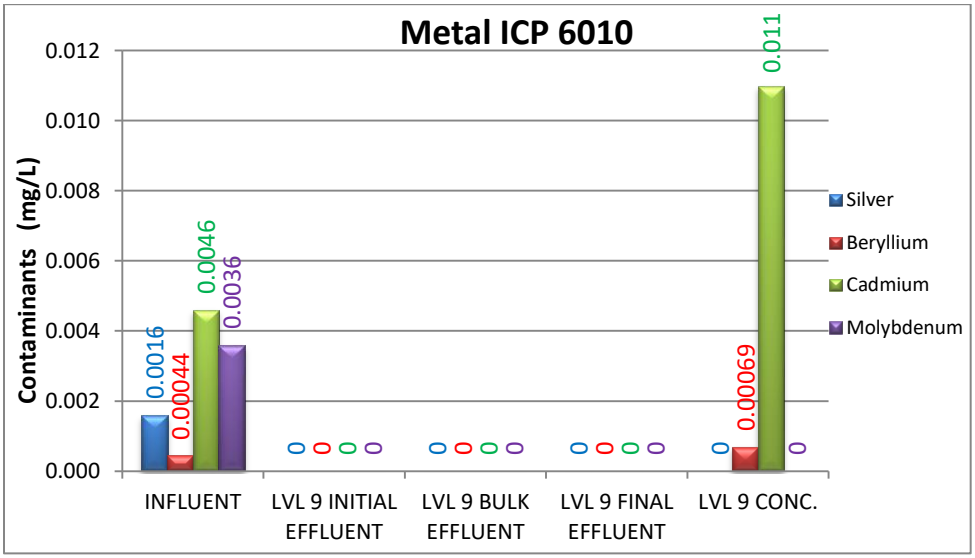

Figure 40

Table 41

PARAMETER	Metal ICP 6010 (mg/L)					
	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Calcium	360	0.88	1.5	99.6%	1.6	920
Iron	54	0.076	0.23	99.6%	0.11	140
Magnesium	170	0.44	0.58	99.7%	0.85	850
Potassium	250	3.4	5.3	97.9%	17	1200
Sodium	870	8.4	14	98.4%	41	4600

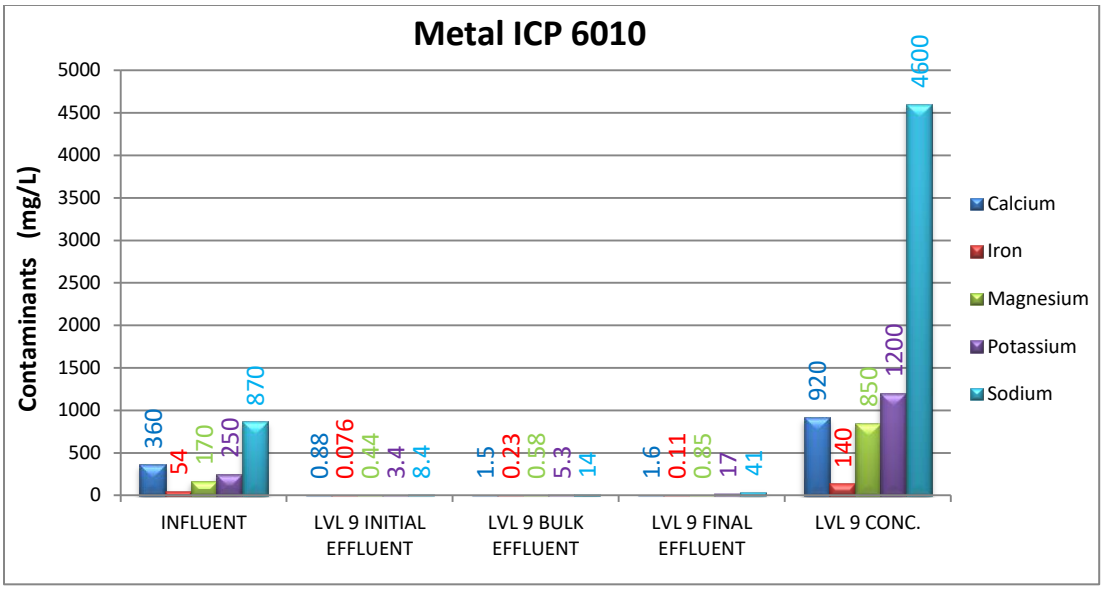

Figure 41

C.2.3.4. Volatile Organic Compounds, VOC

Samples were analyzed for all the volatile organic compounds listed in the EPA method N°. 8260. About 7 of these compounds were present in the raw leachate. The system removed 88 to 98% of these material well below the requirements of the primary drinking water quality standard.

The results are provided below.

Table 42

	VOC by 8260 (µg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Benzene	15	1.0	1.0	93.3%	1.1	20
Ethylbenzene	12	0.2	0.20	98.3%	0.26	20
Chlorobenzene	ND	0.3	0.33	N/A	0.33	ND
1,2-Dichloroethane	12	1.2	1.4	88.3%	1.9	ND
cis-1,2-Dichloroethene	ND	0.4	0.39	N/A	0.53	ND
trans-1,2-Dichloroethene	ND	0.4	0.42	N/A	0.38	ND
Methylene Chloride	30	5.0	5.5	81.7%	6.5	ND
Vinyl chloride	ND	1.3	ND	100%	1.6	ND
m-Xylene & p-Xylene	26	0.9	0.86	96.7%	1.0	47

o-Xylene	11	0.3	0.37	96.6%	0.45	23
Toluene	1600	80	84	95%	100	3900

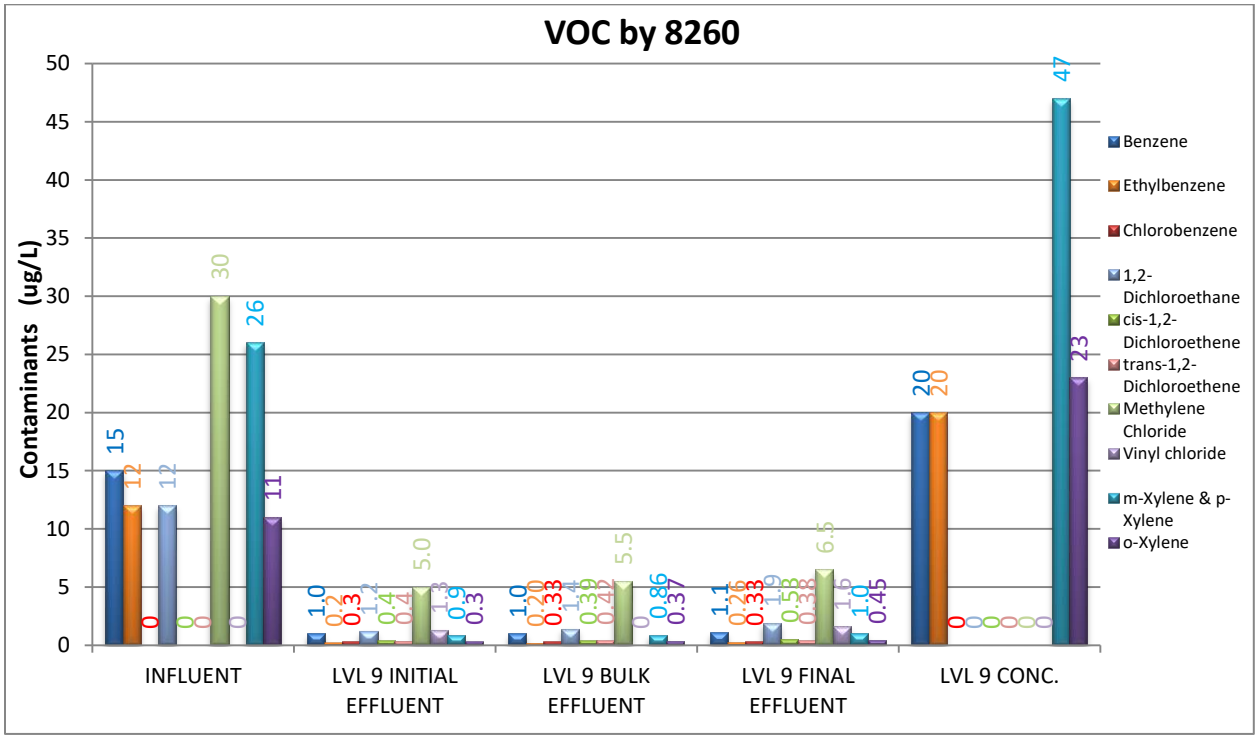

Figure 42.1.

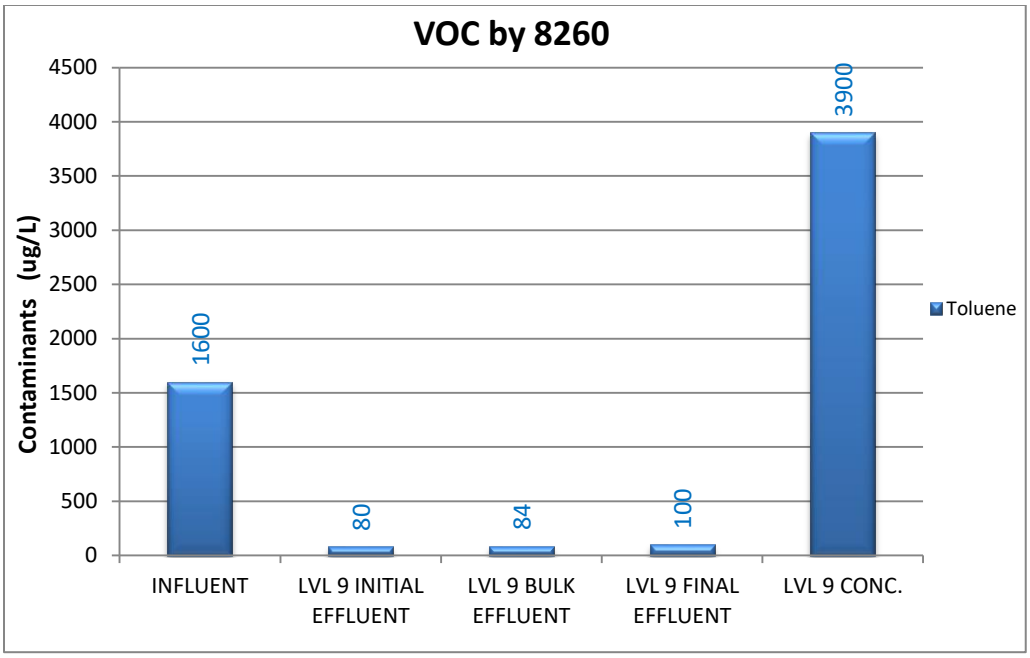

Figure 42.2

C.2.3.5. Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are some of the most important contaminants of emerging concern which are generating big challenges to the wastewater industry. As it was mentioned earlier due to their unique characteristics, they are very stable and resistant to bio or chemical degradation. They are also called Perfluorocarbons or Perflourinated Chemicals (PFCs). Using LB L-9 enabled the removal of these contaminants by 98 to 99% producing the concentration levels of these chemicals in the effluent to single digit parts per trillion, which is well below the requirements set by the EPA.

The following tables and graphs are showing the results of analysis for about fourteen species of these chemicals, which showed up in the leachate in measurable quantities.

Table 43

	Fluorinated Alkyl Substances (ng/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
PFHpA*	250	0.48	0.98	99.6%	1.9	1200
PFOA*	350	1.1	1.7	99.5%	1.8	1900
PFHxS*	110	0.43	0.75	99.3%	1.6	640
PFBA*	440	1.4	6.1	98.6%	3.8	1400
PFPeA*	500	0.98	8.6	98.3%	3.1	2100
PFHxA*	740	1.4	5.3	99.3%	3.5	3800

6:2 FTS	680	4.3	4.9	99.3%	ND	780

***PFHpA → Perfluoroheptanoic acid, PFOA → Perfluorooctanoic acid, PFHxS → Perfluorohexanesulfonic acid, PFBA → Perfluorobutanoic acid, PFPeA → Perfluoropentanoic acid, PFHxA → Perfluorohexanoic acid.**

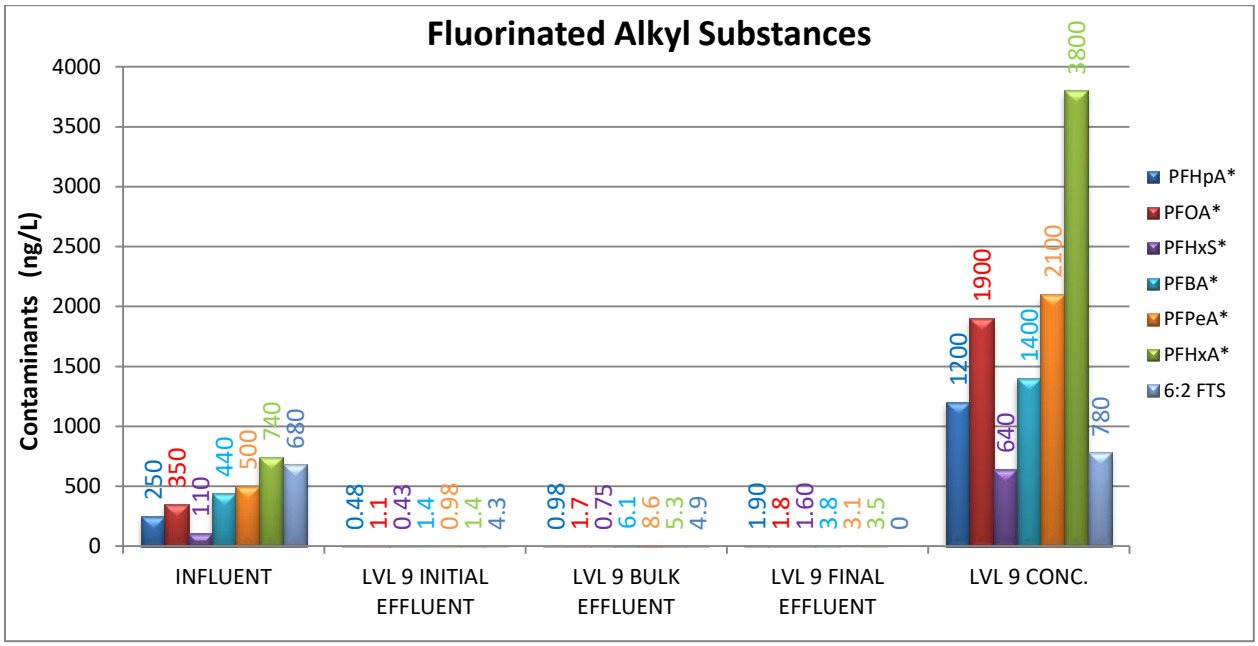

Figure 43

Table 44

	Fluorinated Alkyl Substances (ng/L)					
PARAMETER	**INFLUENT**	**LVL 9 INITIAL EFFLUENT**	**LVL 9 BULK EFFLUENT**	**% Removal**	**LVL 9 FINAL EFFLUENT**	**LVL 9 CONC.**
PFNA*	23	ND	0.42	98.2%	0.32	80
PFDA*	4.4	ND	ND	100%	ND	6.6
PFDoA*	0.67	ND	ND	100%	ND	ND
PFBS*	48	0.23	0.47	99%	1.5	290
PFHpS*	1.5	ND	ND	100%	0.56	6.6
PFOS*	47	ND	1.1	98%	ND	110
FOSA*	0.57	ND	ND	100%	ND	ND

***PFNA → Perfluorononanoic acid, PFDA → Perfluorodecanoic acid, PFDoA → Perfluorododecanoic acid, PFBS → Perfluorobutanesulfonic acid, PFHpS → Perfluoroheptanesulfonic Acid, PFOS → Perfluorooctanesulfonic acid, FOSA → Perfluorooctanesulfonamide.**

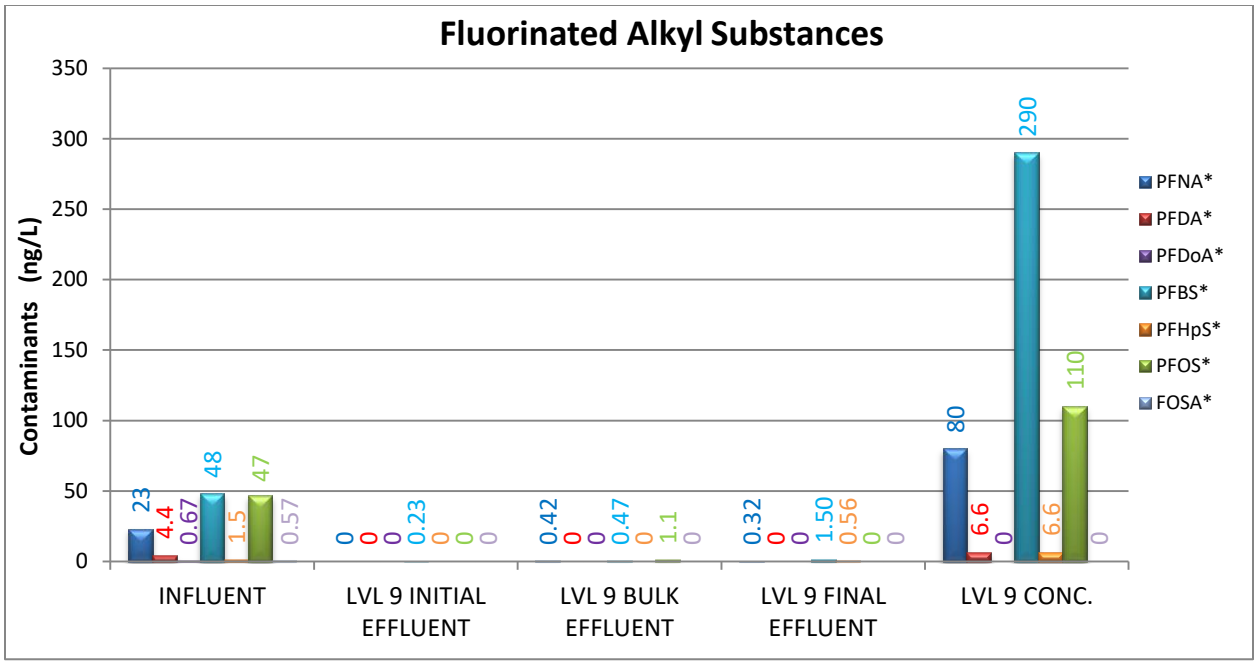

Figure 44

The treatment plant successfully removed all the high, medium and low chain (Carbon) PFCs to either non-detectable levels or low single digit numbers.

C.3 Repeatability and Durability Study

Upon completion of the process definition, the operating data were reviewed and it was concluded that the LeachBuster® LB L-9 produced the optimum operating condition (pressure/flow) as well as high enough quality water to meet or exceed the discharge criteria for the national primary drinking water quality standards. This level was selected and as of September 14 until the end of trials, membrane Level LB L-9 was installed and the treatment plant was operated with a fresh batch of leachate from the collection tank every day. The objectives of this part of the test were to evaluate the repeatability of the results for different days as well as test the durability of the membranes (drop in flow rates and quality). The quality of the incoming leachate varied substantially during this period; however, the quality of the treated effluent remained relatively constant. The conductivity of the fresh leachate varied from 11,000 to 17,000 µS/cm, while the conductivity of the treated leachate (effluent) from LB L-9 varied from 250 to 300 µS/cm.

The process was repeated for thirteen different runs and operating conditions. Data as well as two sets of samples were collected. Both the operating data and the sample results were similar during each run despite substantial variations in the quality of the incoming leachate. Also, during this part of the test, membranes were used until a substantial drop in performance was achieved, at which time they were cleaned and full recovery of the flow rates were obtained.

The following is a summary of the results obtained during this phase of the study. As it can be seen, these results are similar to the ones obtained in earlier runs which confirm the repeatability of the test results.

All the contaminant levels in the in the effluent/clean water were below the regulatory discharge requirements.

Table 45

	Indicator Parameters (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
TDS	15000	13.0	74	99.5%	290	55000
TSS	50	ND	ND	100%	ND	1400
BOD_5	13000	70	43	99.7%	19	21000
COD	17000	99	120	99.3%	450	1000

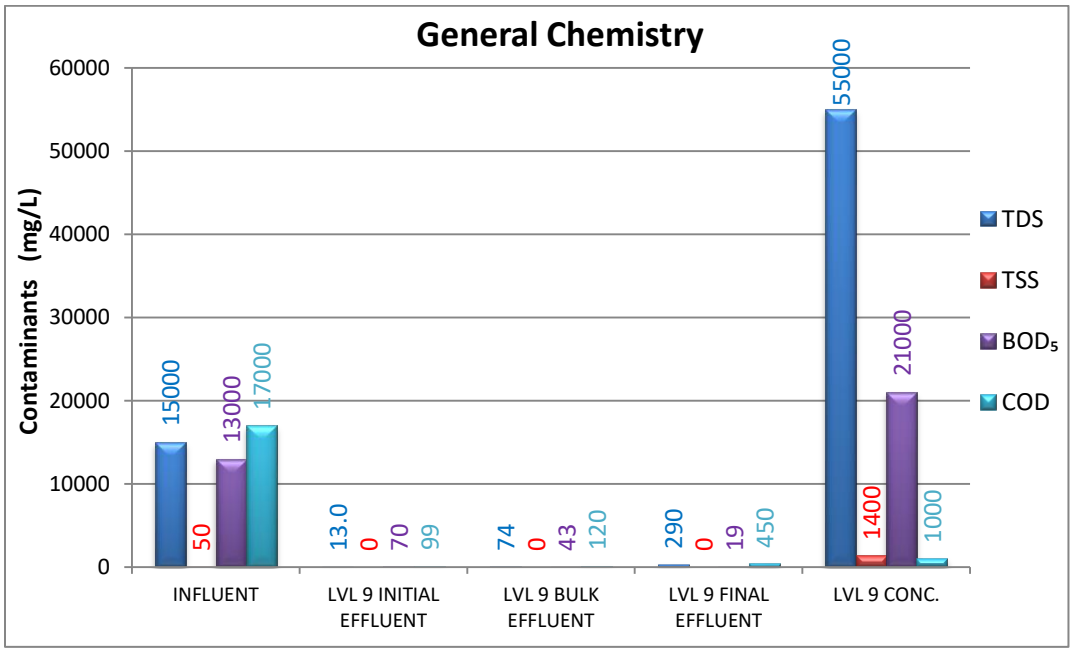

Figure 45

Table 46

	Phosphorus compounds (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Phosphorus, Total	1.2	ND	ND	100%	0.15	2.2
Phosphorus as PO4	3.8	ND	ND	100%	0.45	6.7

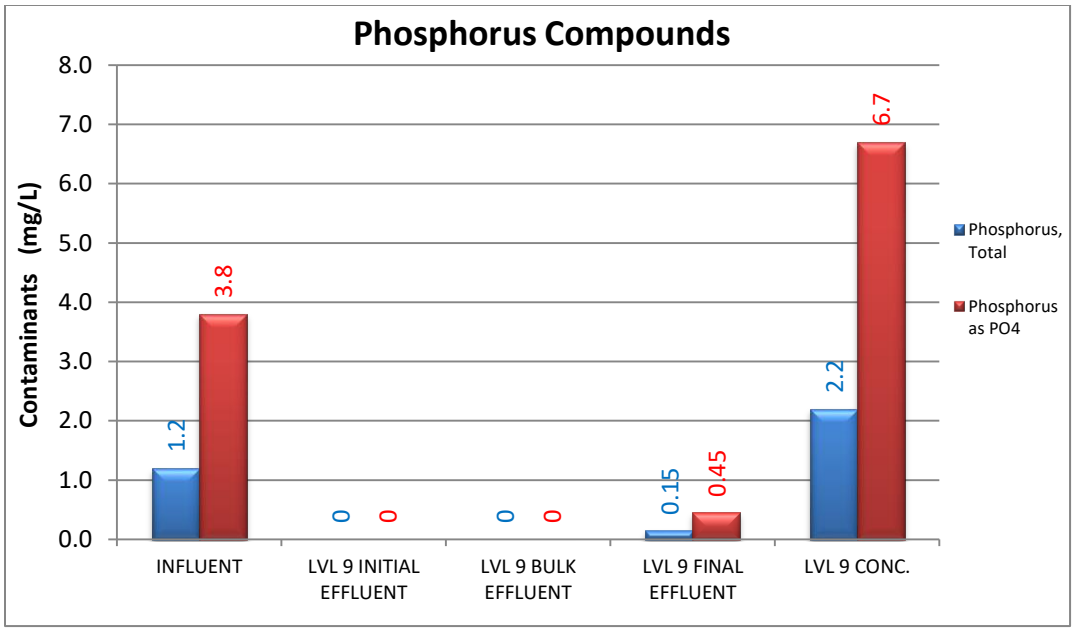

Figure 46

Table 47

	Nitrogenous Compounds (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Ammonia as N	1100	20	36	96.7%	150	4000
Ammonia as NH3	1300	25	44	96.6%	190	4800
TKN	1100	17	28	97.5%	130	3800

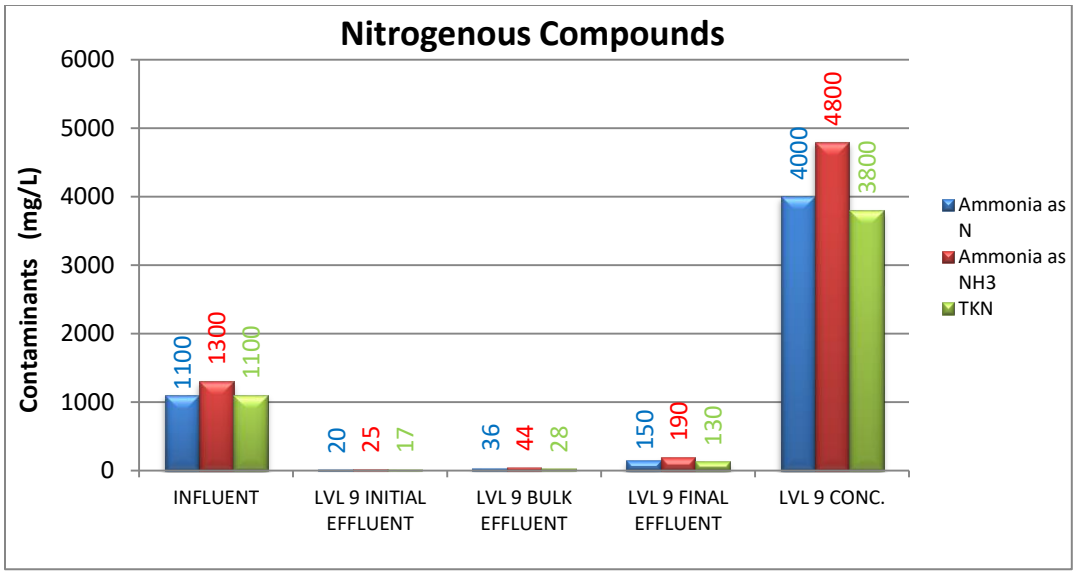

Figure 47

Table 48

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Arsenic	0.033	ND	ND	100%	ND	0.078
Lead	0.022	ND	ND	100%	ND	0.088
Antimony	0.010	ND	ND	100%	ND	ND
Selenium	0.019	ND	ND	100%	ND	ND
Vanadium	0.090	ND	ND	100%	ND	0.28

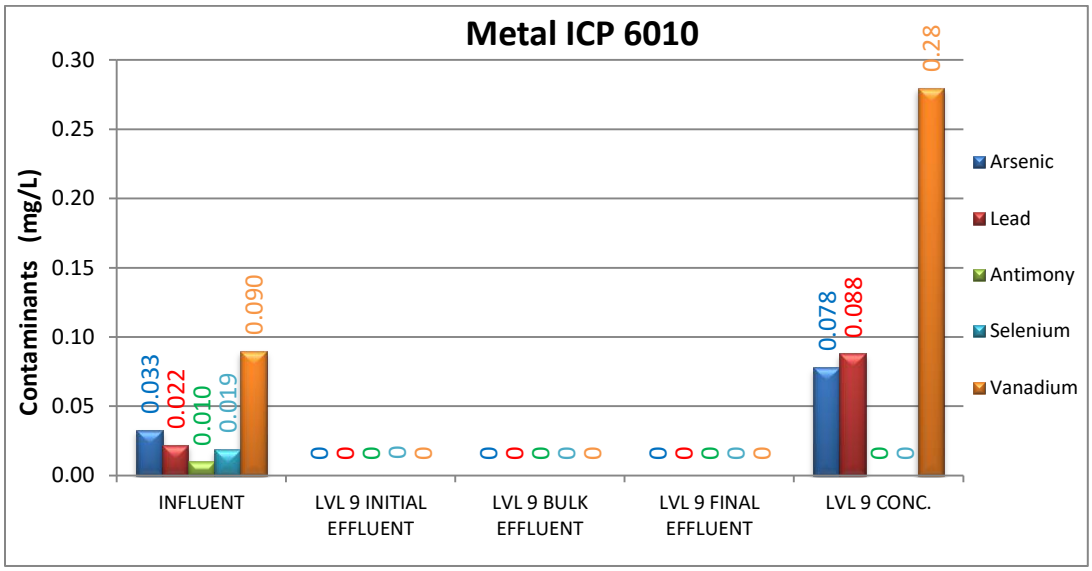

Figure 48

Table 49

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Barium	0.42	ND	ND	100%	ND	1.3
Cobalt	0.14	ND	ND	100%	ND	0.44
Chromium	0.19	ND	ND	100%	ND	0.58
Nickel	0.78	ND	0.0066	99.2%	0.0027	2.4

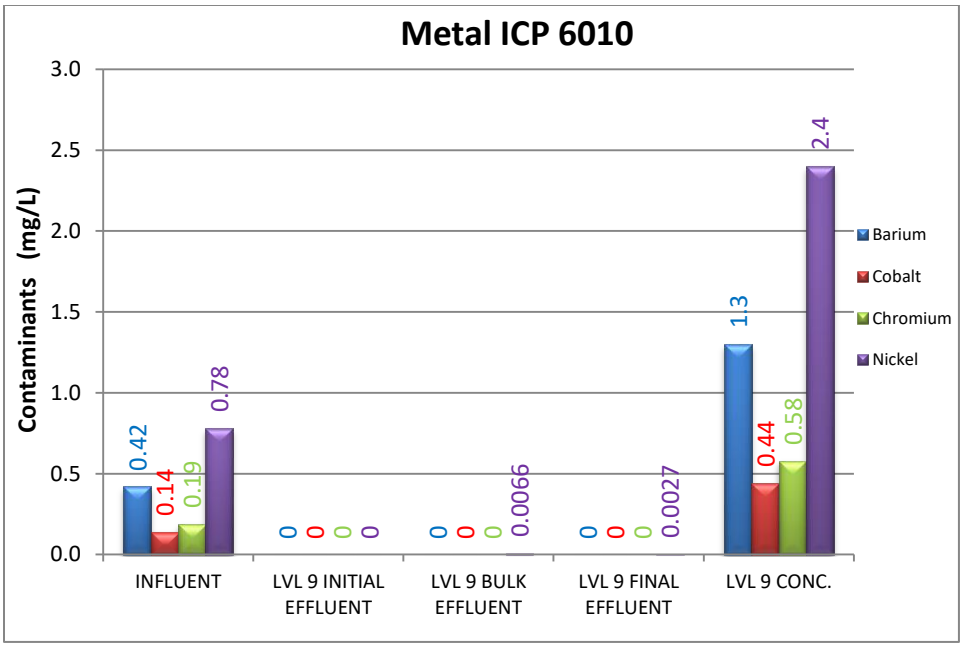

Figure 49

Table 50

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Manganese	20	0.58	0.044	99.8%	0.098	73
Zinc	5.3	0.011	0.0075	99.9%	0.038	18

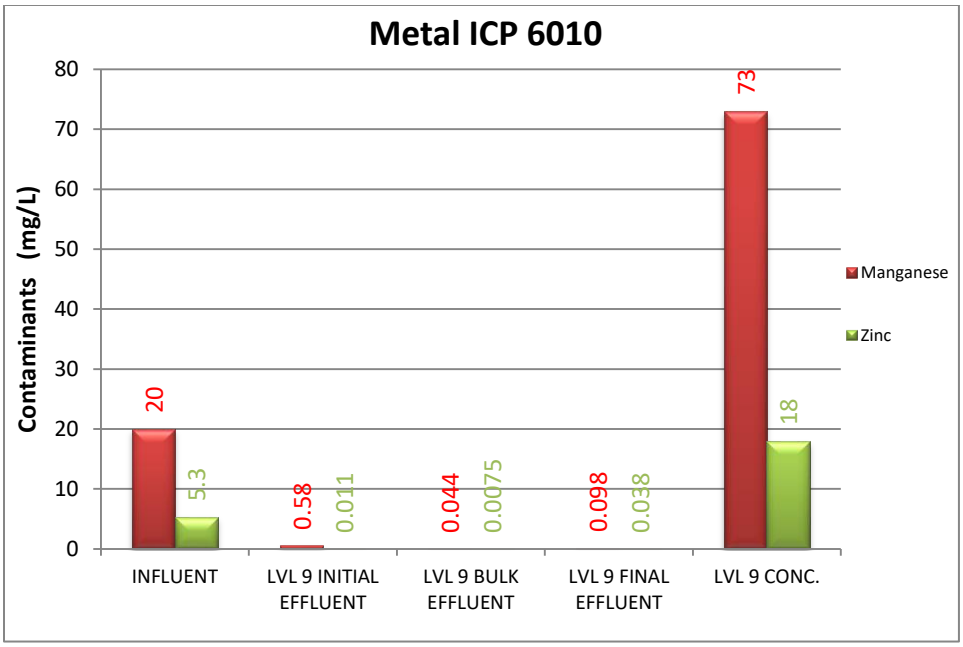

Figure 50

Table 51

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Beryllium	0.00095	ND	ND	100%	ND	0.0027
Cadmium	0.00085	ND	ND	100%	ND	ND
Copper	0.0078	0.0038	ND	100%	0.014	0.039
Molybdenum	0.0066	ND	ND	100%	ND	0.022
Silver	0.0032	ND	ND	100%	ND	0.0073

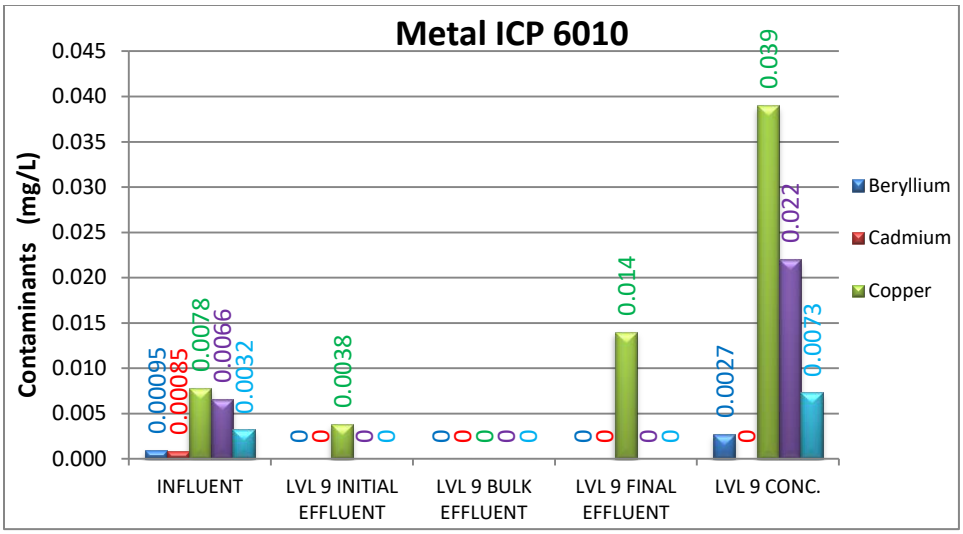

Figure 51

Table 52

	Metal ICP 6010 (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Calcium	1000	2.3	2.40	99.8%	5.4	3800
Iron	260	0.41	0.48	99.8%	0.99	810
Magnesium	290	0.58	0.62	99.8%	1.4	1100
Potassium	450	4.9	7.9	98.2%	32	1500
Sodium	1500	12	19	98.7%	77	5900

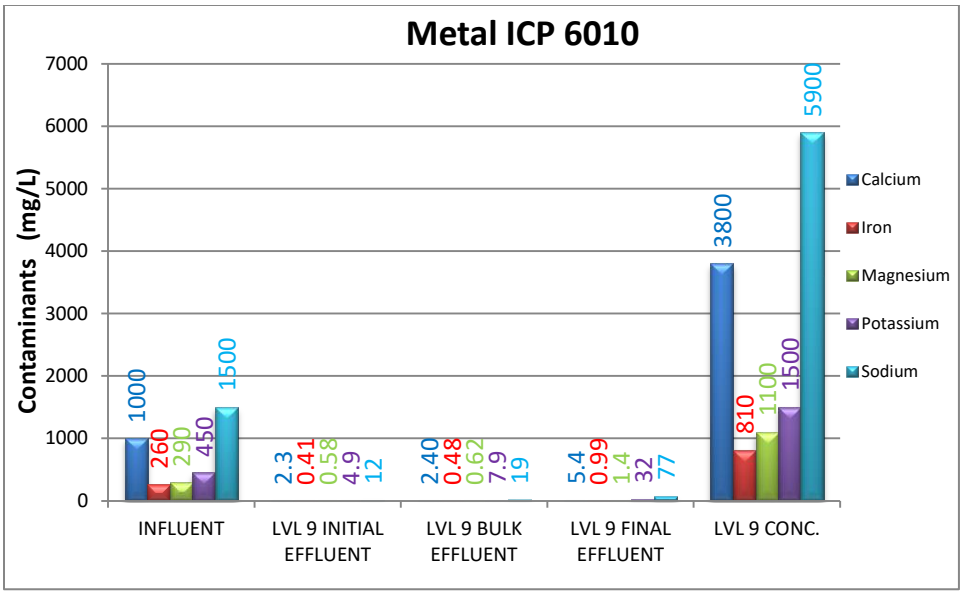

Figure 52

Table 53

	Metal (mg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Mercury	0.00012	ND	ND	100.0%	ND	0.00018

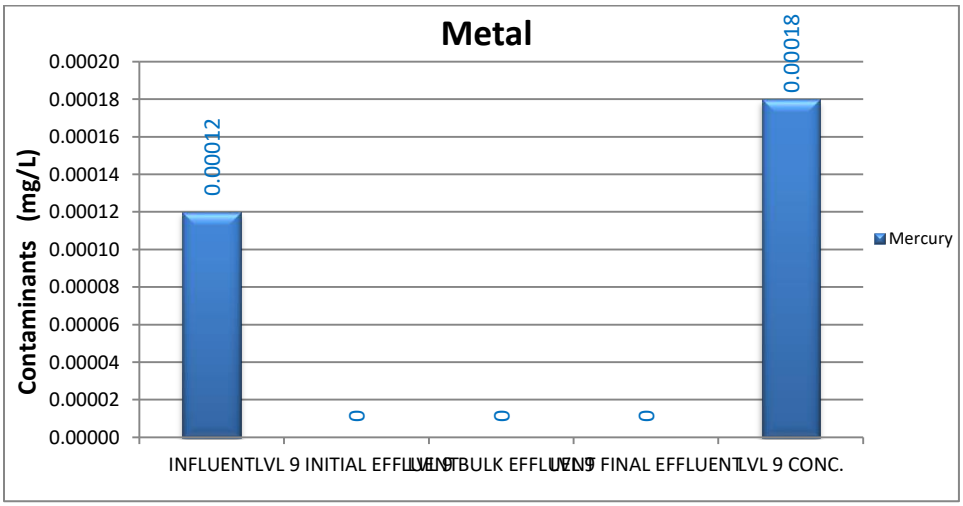

Figure 53

	VOC by 8260 (µg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Benzene	15	0.99	1.3	91.3%	1.7	29
Ethylbenzene	12	ND	ND	100%	ND	29
Chloroethane	ND	ND	1.7	N/A	1.5	ND
1,2-Dichloroethane	12	3.4	4.8	60%	6.9	ND
cis-1,2-Dichloroethene	ND	0.89	1.4	N/A	1.7	ND
trans-1,2-Dichloroethene	ND	0.45	1.0	N/A	ND	ND
Methylene Chloride	30	16	19	36.7%	22	ND
Vinyl chloride	ND	1.4	2.1	N/A	1.9	ND
m-Xylene & p-Xylene	26	ND	ND	100%	ND	59
o-Xylene	14	ND	0.19	98.6%	0.22	29
Toluene	1300	14	21	98.4%	30	1900

Table 54

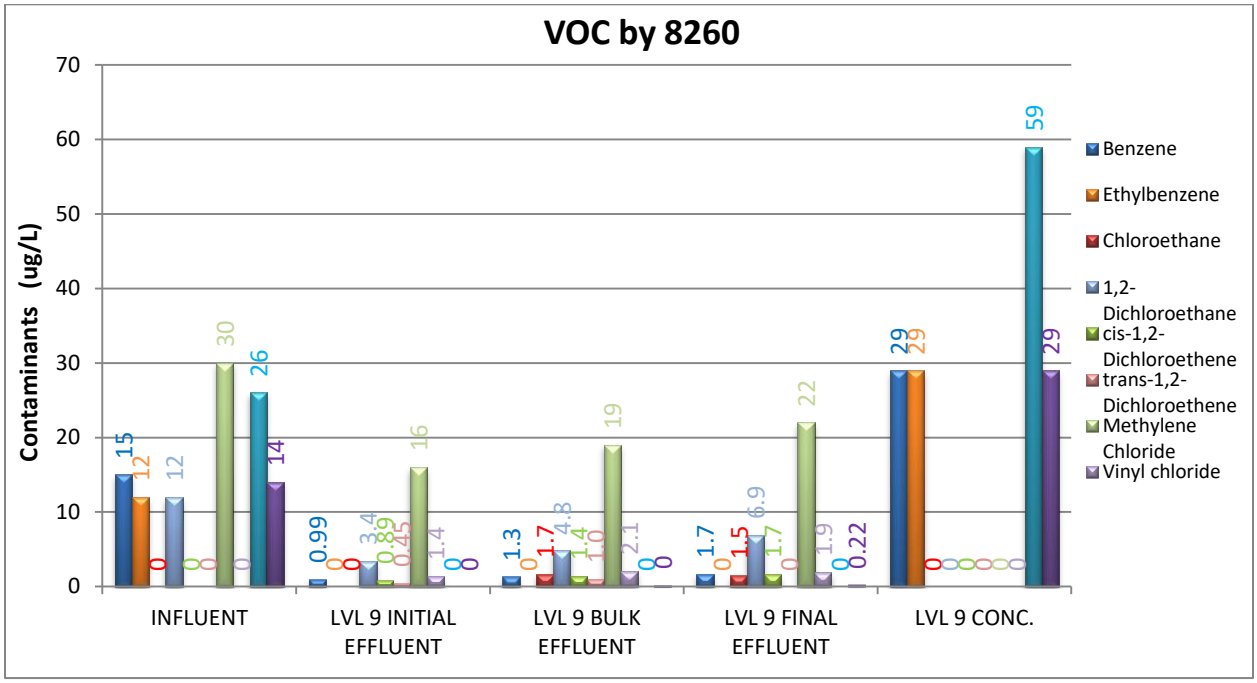

Figure 54

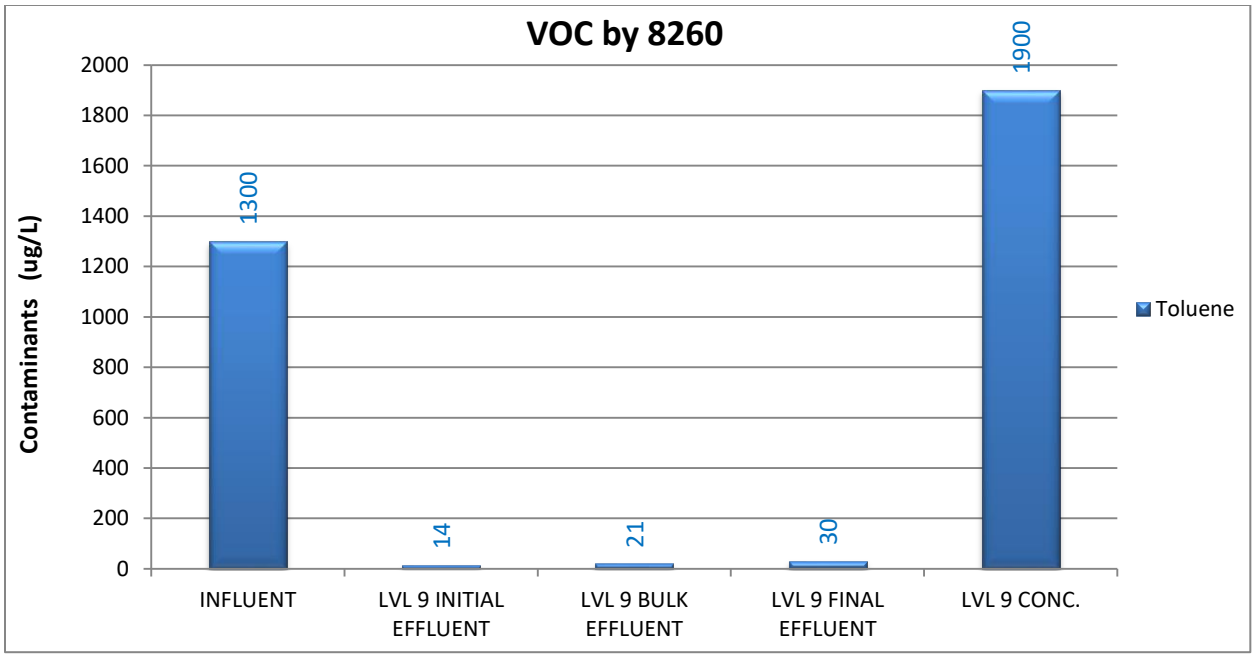

Figure 55

Table 55

	SVOC by 8270 (µg/L)					
PARAMETER	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
Bis(2-ethylhexyl) phthalate	ND	5.4	12	N/A	29	140
2-Methylphenol	15	ND	ND	100%	1.1	ND
Phenol	1100	110	120	89.1%	200	2100
3-Methylphenol & 4-Methylphenol	7900	340	410	94.8%	590	14000

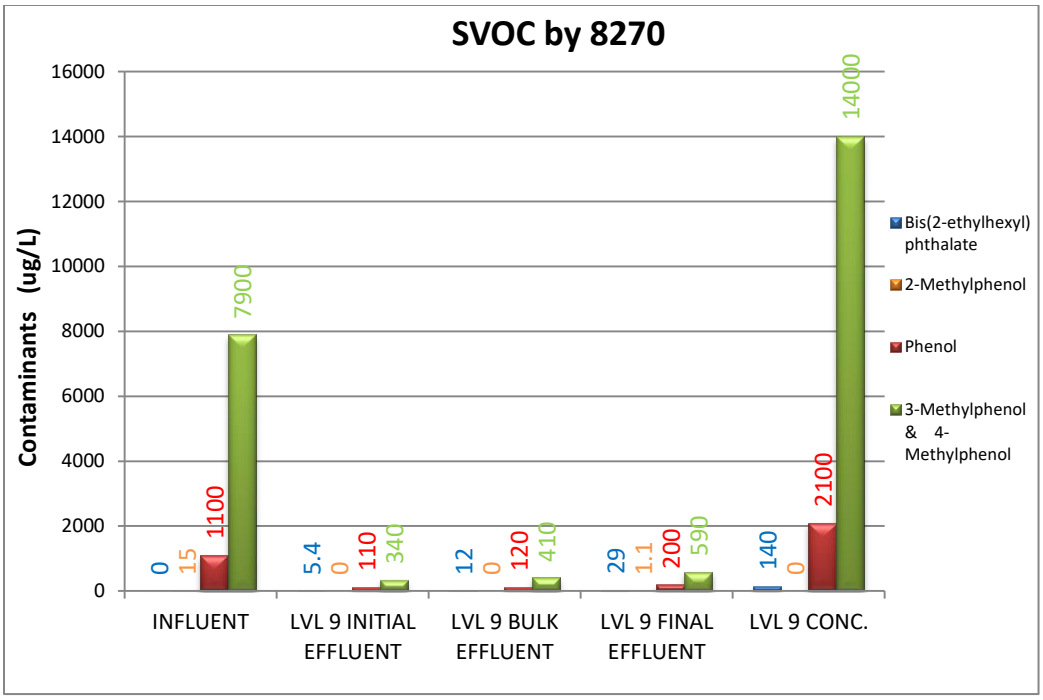

Figure 56

Table 56

PARAMETER	Fluorinated Alkyl Substances (ng/L)					
	INFLUENT	LVL 9 INITIAL EFFLUENT	LVL 9 BULK EFFLUENT	% Removal	LVL 9 FINAL EFFLUENT	LVL 9 CONC.
PFHpA*	350	0.54	0.38	99.9%	0.91	1200
PFOA*	540	0.69	0.76	99.9%	1.0	1100
PFHxS*	220	0.38	0.40	99.8%	0.53	600
PFBA*	770	2.5	1.9	99.8%	3.8	3300
PFPeA*	680	0.92	1.1	99.8%	2.4	2700
PFHxA*	1200	1.5	1.6	99.9%	3.7	4700
PFNA*	18	ND	ND	100%	ND	9.1
PFBS*	51	ND	ND	100.0%	0.31	240
PFOS*	16	ND	ND	100%	ND	ND
6:2 FTS	160	ND	18	88.8%	6.0	270

***PFHpA → Perfluoroheptanoic acid, PFOA → Perfluorooctanoic acid, PFHxS → Perfluorohexanesulfonic acid, PFBA → Perfluorobutanoic acid, PFPeA → Perfluoropentanoic acid, PFHxA → Perfluorohexanoic acid, PFNA → Perfluorononanoic acid, PFBS → Perfluorobutanesulfonic acid, PFOS → Perfluorooctanesulfonic acid.**

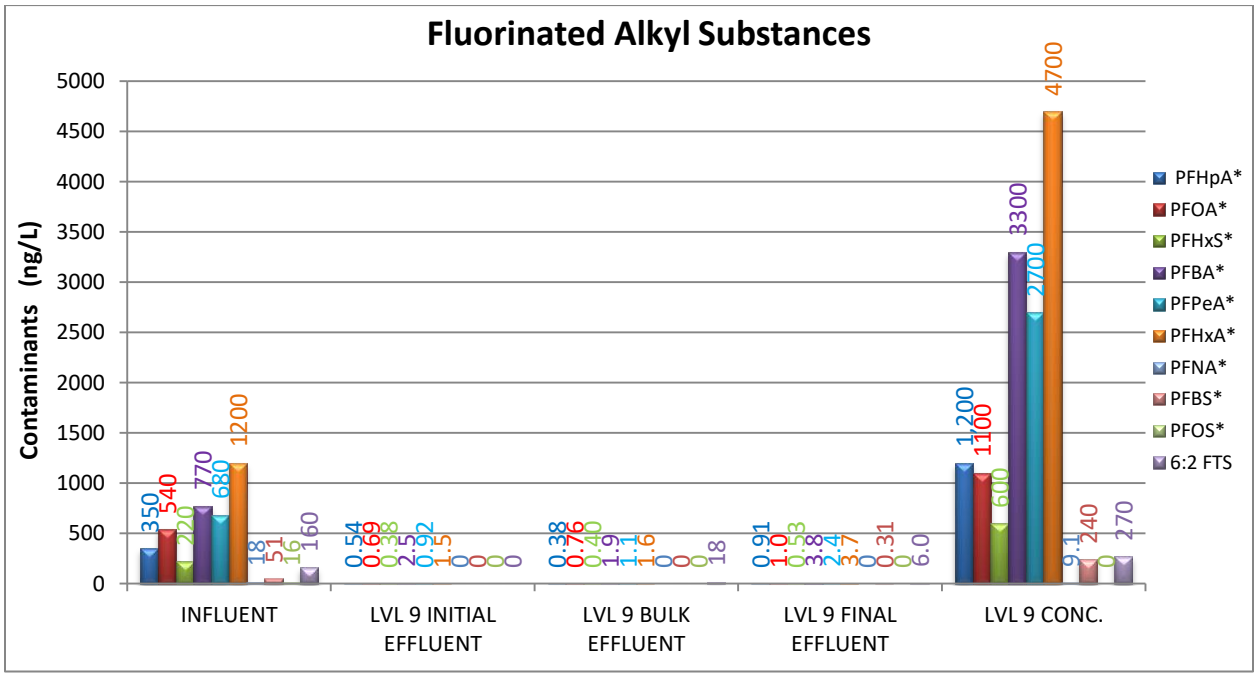

Figure 57

D. Concentrate Management:

The proposed treatment plant, parses the raw leachate into two streams of treated leachate (which is also referred to as effluent, clean water or permeate) and concentrate. Depending on the level of treatment, the treated leachate generally is void of most of the contaminants and can be discharged into the environment or put into a beneficial use, such as irrigation, dust control or vehicle washing.

The concentrate which contains most of the contaminants is returned to the landfill for confinement and further degradation and digestion by the biota in the landfill. In order to return the concentrate back to the landfill, the concentrate should not be hazardous and should pass the Toxic Characteristic Leaching Procedure (TCLP) test set by the Resource Conservation and Recovery Act (RCRA) which governs the management of hazardous wastes. This test is conducted to mitigate the risks posed by chemicals seeping out of buried waste. It is designed by the US EPA to prove that the volume of hazardous substances that will "leach out" into the environmental is below thresholds set by US EPA.

Historic data from previous LeachBuster® leachate treatment plants indicated that all of the concentrates produced meet the TCLP threshold set for non-hazardous landfills. During the study at the Central Landfill, samples were collected from the concentrate and sent to the laboratory for TCLP analysis. Initially, only ICP metals were tested, however after consulting with the regulators, additional requirements for the elements to be included in the tests were established and VOCs and SVOCs were also tested.
The following is the results of these tests:

METALS TCLP		
Parameter	**TCLP Regulatory Level (mg/L)**	**TCLP Concentrate Lab Results (mg/L)**
Arsenic	5.0	ND
Barium	100.0	0.11
Beryllium	N/A	ND
Cadmium	1.0	ND
Cobalt	N/A	0.21
Chromium	5.0	0.32
Copper	N/A	ND
Mercury	0.2	ND
Molybdenum	N/A	0.021

*ND: Non Detected

Table 57

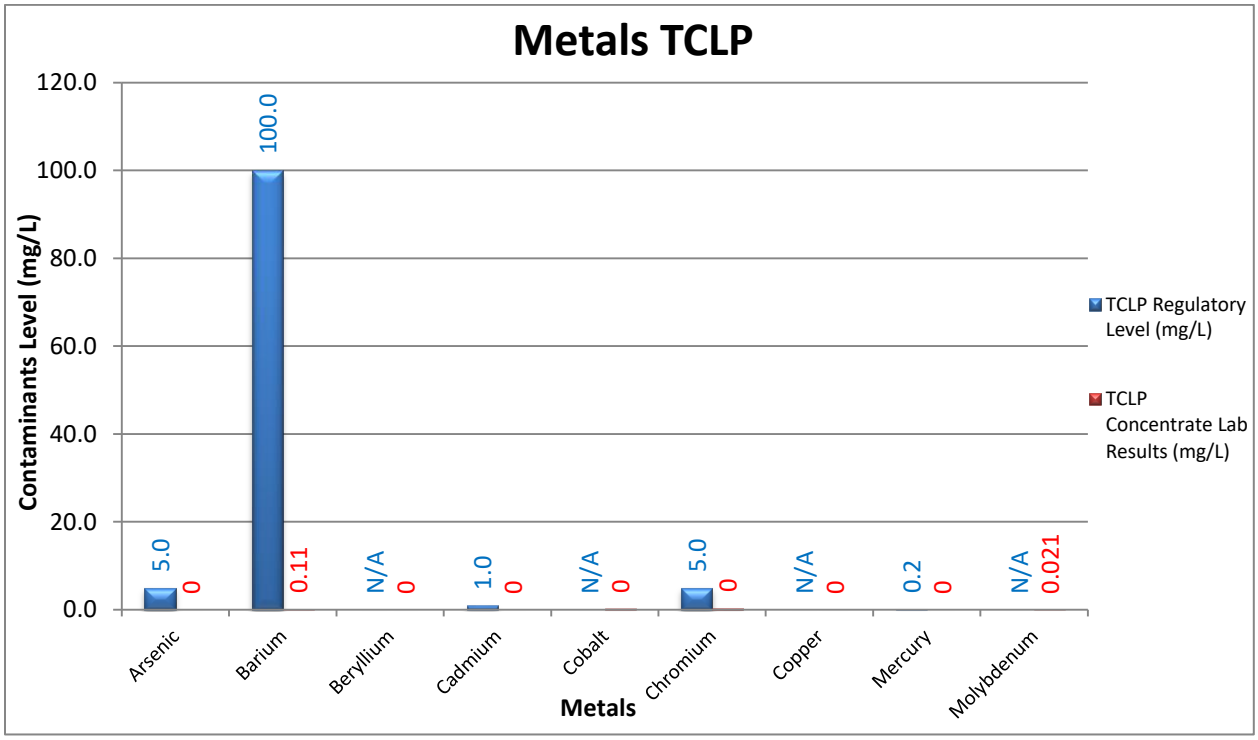

Figure 58

Table 58

METALS TCLP		
Parameter	**TCLP Regulatory Level (mg/L)**	**TCLP Concentrate Lab Results (mg/L)**
Antimony	N/A	ND
Nickel	N/A	2.3
Lead	1.0	ND
Selenium	1.0	ND
Silver	5.0	ND
Thallium	N/A	ND
Vanadium	N/A	0.17
Zinc	N/A	1.2

*ND: Non Detected

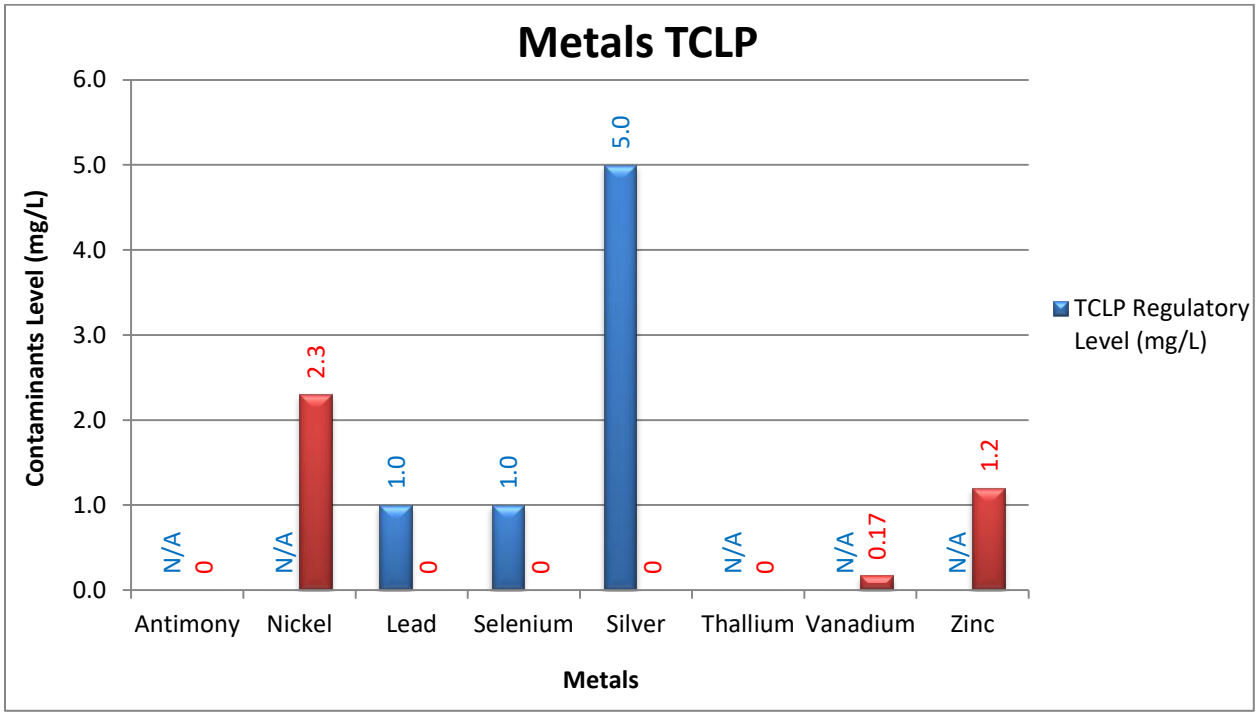

Figure 59

Table 59

METALS TCLP		
Parameter	**TCLP Regulatory Level (mg/L)**	**TCLP Concentrate Lab Results (mg/L)**
Arsenic	5.0	0.10
Barium	100.0	1.5
Beryllium	N/A	0.0035
Cadmium	1.0	ND
Cobalt	N/A	0.56
Chromium	5.0	0.50
Copper	N/A	ND
Mercury	0.2	ND
Molybdenum	N/A	0.16

*ND: Non Detected

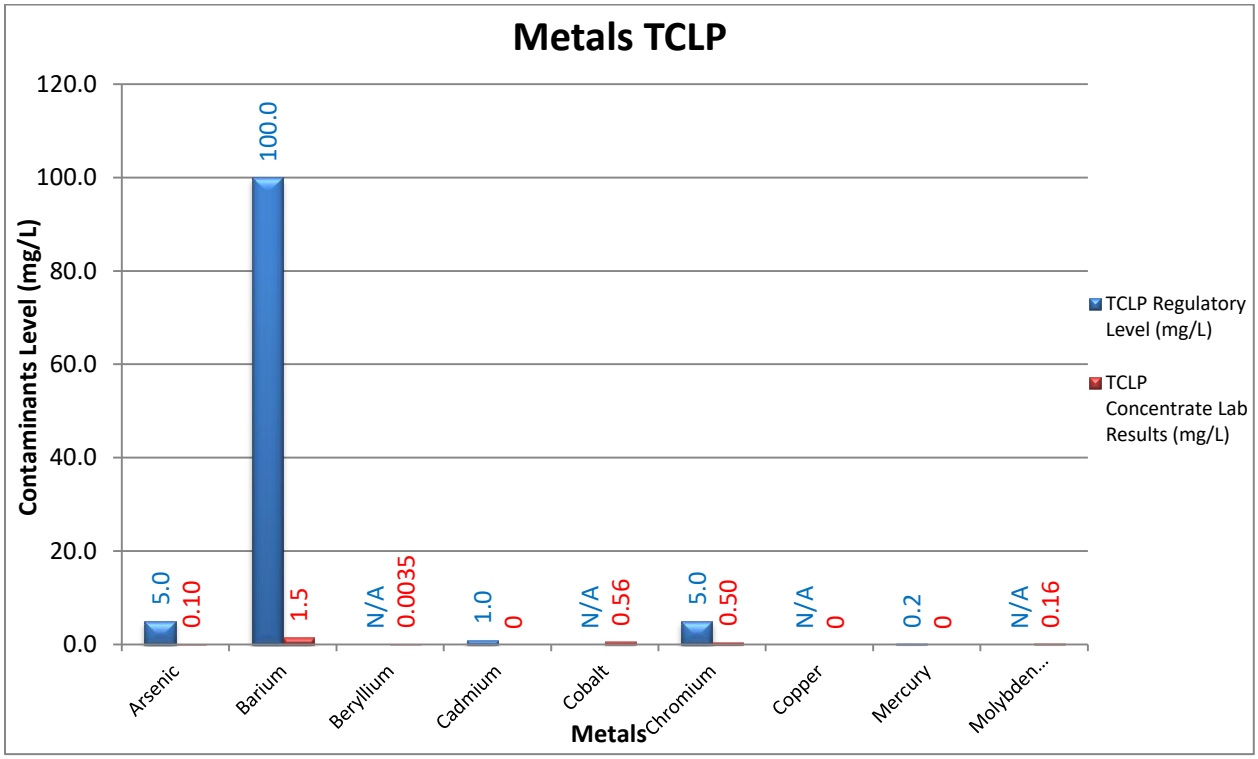

Figure 60

Table 60

METALS TCLP		
Parameter	**TCLP Regulatory Level (mg/L)**	**TCLP Concentrate Lab Results (mg/L)**
Antimony	N/A	ND
Nickel	N/A	3.2
Lead	1.0	0.033
Selenium	1.0	0.065
Silver	5.0	0.0054
Thallium	N/A	ND
Vanadium	N/A	0.30
Zinc	N/A	1.6

*ND: Non Detected

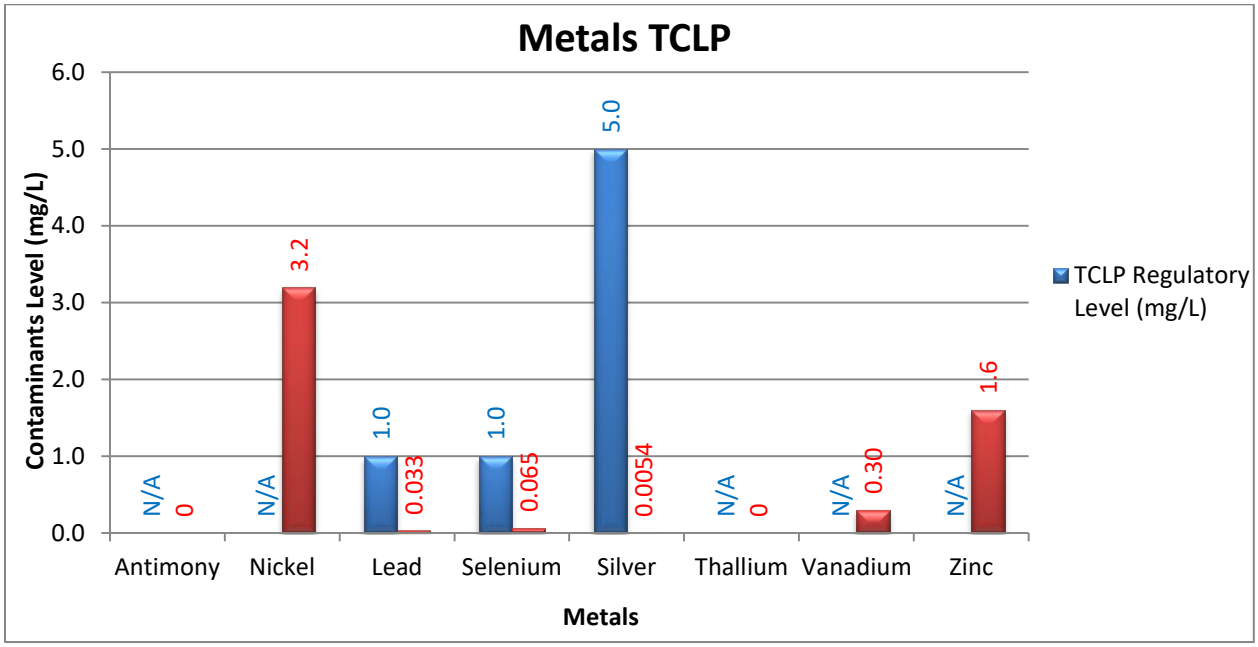

Figure 61

Table 61

Volatile Organics		
Parameter	**TCLP Regulatory Level (mg/L)**	**TCLP Concentrate Lab Results (mg/L)**
Benzene	0.5	ND
Carbon Tetrachloride	0.5	ND
Chlorobenzene	100.0	ND
Chloroform	6.0	ND
1,4-Dichlorobenzene	7.5	ND
1,2-Dichloroethane	0.5	ND
1,1-Dichloroethylene	0.7	ND
MEK	200.0	55
Tetrachloroethylene	0.7	ND
Trichloroethylene	0.5	ND
Hexachlorobutadiene	N/A	ND
Vinyl Chloride	0.2	ND

*ND: Non Detected

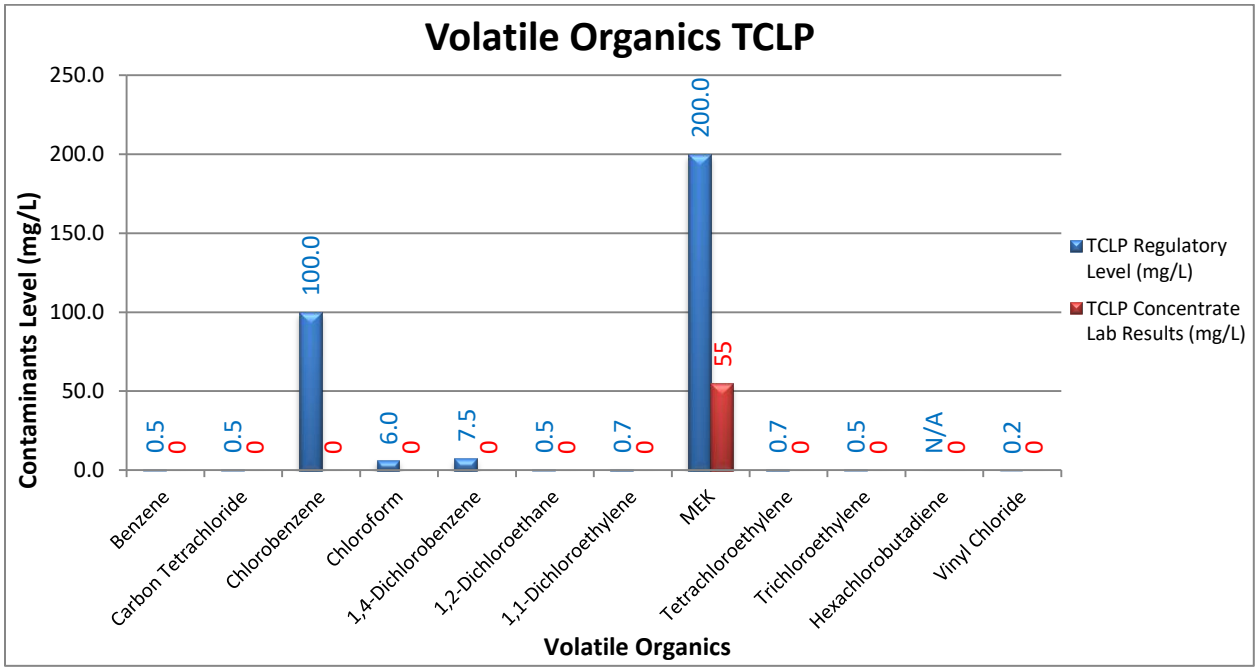

Figure 62

Table 62

Semi-Volatile Organics		
Parameter	TCLP Regulatory Level (mg/L)	TCLP Concentrate Lab Results (mg/L)
Total Cresols	200	27
1,4-Dichlorobenzene	N/A	ND
2,4-Dinitrotoluene	0.1	ND
Hexachlorobenzene	0.1	ND
Hexachlorobutadiene	0.5	ND
Hexachloroethane	3.0	ND
3-Methylphenol & 4-Methylphenol	N/A	27
2-Methylphenol	N/A	ND
Nitrobenzene	2.0	ND
Pentachlorophenol	100.0	ND
Pyridine	5.0	ND
2,4,5-Trichlorophenol	400.0	ND
2,4,6-Trichlorophenol	2.0	ND

*ND: Non Detected

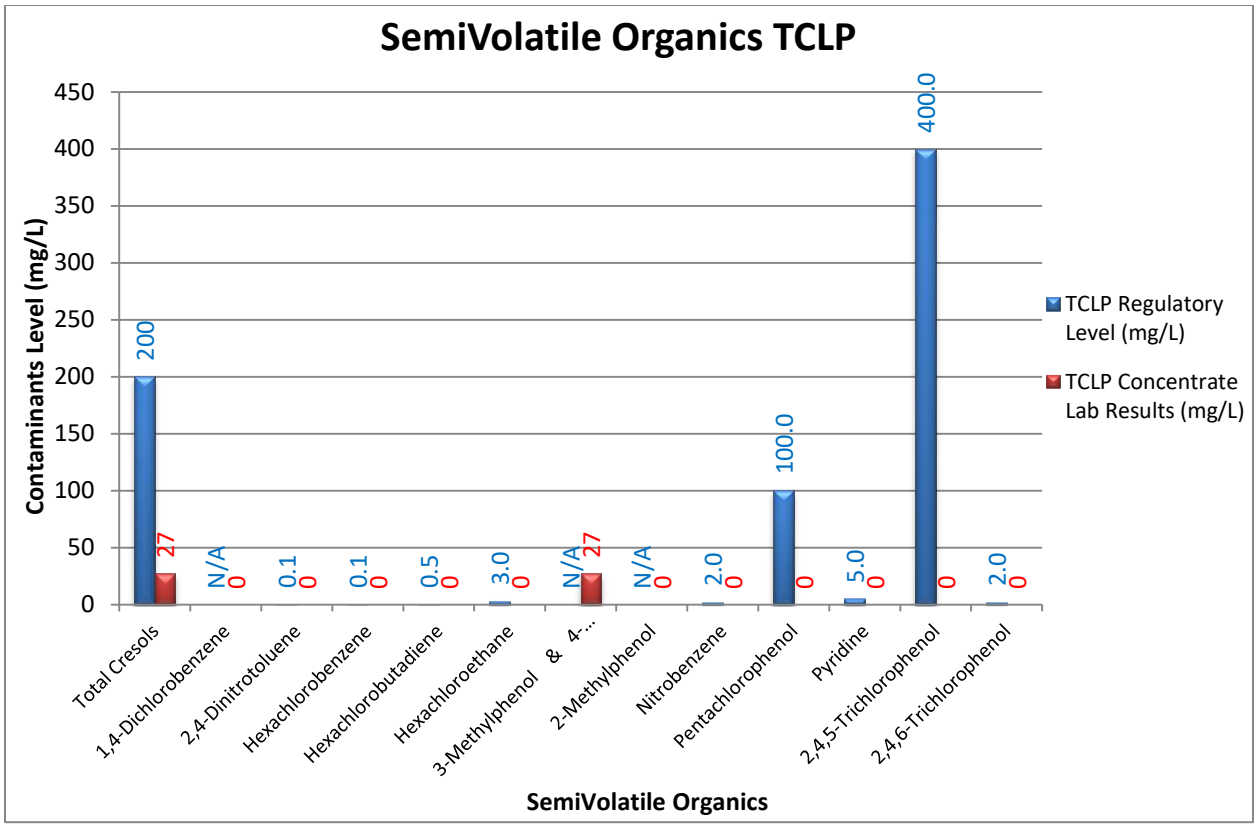

Figure 63

As it can be seen from these tables and graphs, in all occasions, the toxic chemical leaching levels were much lower than those required by the regulatory standards.

One of the primary objectives of the practice of landfilling is containment of contaminants and pathogens (Cradle to Grave) and eliminating the risk of their dispersal into the environment (air and water). By returning the concentrated contaminants back to the landfill, the long term (for the life of the landfill) confinement of these contaminants is achieved. Unlike conventional methods of disposal of landfill leachate, such as land application or discharge into a wastewater treatment plant, which finally release some of these contaminants into the environment either as partially treated effluent or as biosolids; however, this defeats the purpose of "Cradle to Grave" principle. Needless to say, the process recommended here completes this process, which is the main objective of an efficient and environmentally safe solid waste management policy.

E. Clean Water Recovery Rate

Clean water recovery rate is a function of the osmotic pressure of the raw leachate, which is dictated by the amount of salt (mainly chlorides) in the waste stream. A common measure of these salts, the estimation of the osmotic pressure, is the electrical conductivity of the leachate. At this site, the conductivities ranged from 11,000 to about 17,000 µS/cm2. The test conducted produced a recovery rate of 78 to 92% as can be seen below in the table.

Run #	Leachate Effluent Clean Water %	Leachate Concentrate %	Leachate Conductivity uS/cm^2
1	88.00	12.00	11,000
2	87.40	12.60	11,000
3	90.30	9.70	11,000
4	91.50	8.50	11,000
5	78.30	21.70	17,000
6	78.50	21.50	17,000
7	81.00	19.00	17,000
8	75.30	24.70	17,000
9	78.30	21.70	17,000
10	80.00	20.00	17,000
11	80.70	19.30	17,000
12	78.70	21.30	17,000
10	80.00	20.00	17,000
11	80.70	19.30	17,000
12	78.70	21.30	17,000
Average	82	18	

Figure 64

During the first four runs, the leachate tank from which leachate samples were obtained was full of leachate. The conductivities for these runs were around 11,000 uS/cm^2. During these runs recovery rates of 88 to 92% was achieved. During the subsequent runs, the leachate tank was pumped almost empty by the hauler and the samples were obtained from the bottom of the tank, which were more concentrated. This produced conductivity levels at around 17,000 uS/cm^2. During these runs, the recovery rates decreased to 75 to 82%.

F. Conclusions:

Upon completion of this study, the results were collated and reviewed. All the physical data and chemical data were compared and the following conclusions are drawn, as presented herein.

The leachate at the Central Landfill site is a medium strength leachate. Unlike the low or high strength leachates where the conductivities are in single digits or upper 30 mS/cm^2, the range of conductivity levels in the leachate at this site was in the mid-teens.

The pH levels for this leachate were in the normal range, between 6.5 to 7.5, which will require minimal or no adjustment to obtain optimum performance from the leachate wastewater treatment plant.

The osmotic pressure of the leachate and trans-membrane pressure drop, Δp, were at medium ranges, which falls within the anticipated range for this type of leachate.

Some temporal variability was observed within the leachate samples obtained during the study. Conductivity levels ranged between 11,000 uS/cm^2 to about 17,000 uS/cm^2. Spatial variability was normalized by collecting the leachate from all the cells in one tank and utilizing it for the study.

Based on the on-site study, observations, and independent third-party test results, the following pertinent information is concluded regarding the contaminant removal rates utilizing various defined membrane sizes:

- LEACHBUSTER® LB L-1 removed all complex organics, polyvalent and non-polar elements as well as pathogens and bio-contaminants. It only removed about 20% of monovalent and simple compounds such as sodium, potassium, chlorides and nitrogen based contaminants.
- LEACHBUSTER® LB L-6 also removed all complex organics, polyvalent and non-polar elements as well as pathogens and bio-contaminants. In addition, it removed approximately 60 to 70% of monovalent and simple compounds, such as sodium, potassium, chlorides and nitrogen based compounds.
- LEACHBUSTER® LB L-8 also removed all complex organics, polyvalent and non-polar elements as well as pathogens and bio-contaminants. Removal rates for monovalent and simple compounds such as sodium, potassium, chlorides and nitrogen-based compounds increased to a range of 80% to 90%. At this level up to 80% of emerging contaminants of concern such as PFCs and PFASs were removed from the leachate stream.
- LEACHBUSTER® LB L-9 also removed all complex organics, polyvalent and non-polar elements as well as pathogens and bio-contaminants. Its removal of monovalent and simple compounds such as sodium, potassium, chlorides and nitrogen based compounds increased to a range of 99% to 100%. This level removed up to 99% of emerging contaminants of concern such as PFCs and PFASs.
- Temporal variability in the leachate quality did not impact the quality of treated leachate; the LEACHBUSTER® wastewater treatment plant processed leachate with varying levels of conductivity and contaminant concentrations and produced similar qualities of treated leachate for each membrane level.
- LEACHBUSTER® LB L-9 yielded the highest quality effluent, meeting both the Clean Water Discharge Limits as well as the Primary National Drinking Water Standards. The levels LB L-6 and -8 produced high quality effluent which can meet irrigation and NPDES discharge limits, respectively.
- Membrane life based on the test results and data collected during the study is estimated to be at least 18 months for the LB L-9 membranes.

Based on the results of the engineering study, Clark has sufficient data and information to proceed to the next steps outlined in the leachate treatment plant's design phase.

G. Recommendations

Based on the results of this study, Clark recommends that MSB should install a LEACHBUSTER® leachate treatment plant, utilizing LB L-9 membranes, where high-quality water may be produced that can meet both the Drinking Water and Clean Water Standards and be discharged into the environment or, be partially or totally reused in and around the landfill and treatment plant. This option, followed by a concentrate processing system to further reduce the volume of the disposable waste, presents the most economical and practical system for this application.

It is anticipated the leachate will be pumped from the collection point via a force main into the 20,000 gallon receiving tank from which the landfill leachate treatment plant will draw the leachate and process it through the plant. During the large rainfall events, when excess leachate is generated and collected into the existing leachate lagoons, the plant may be throttled up to run at its maximum operating capacity. During low precipitation, thus low leachate generation periods, the system will draw the leachate from the leachate lagoons for treatment utilizing the leachate treatment plant's ability to vary and operate at a reduced capacity.

The treatment plant will produce high quality water, which at a minimum will meet drinking water standards. It can be put into the landfill's beneficial use in variety of ways, such as: dust control, hydrating composting piles (these often consist of trees and shrubs and other woody organics, which are void of enough moisture to achieve proper conversion), irrigation, truck and other vehicle washing and/or similar uses.

Alternatively, if these options are not available or not utilized, the Borough intends to discharge the water into the Central Landfill's dedicated effluent or clean water deposition zone within the landfill. The clean water will not have any adverse impact on the surrounding environment. Some of the options still being considered include: evaporation/infiltration pond, aquifer recharge, and surface or subsurface (drain field) water discharge.

Of these options, our experience indicates that an evaporation/infiltration pond can be the best way to discharge the clean water into the environment. It has several advantages including: it can be built as an irregular shaped pond which can be aesthetically pleasing by creating an aquatic environment for the fauna and flora to flourish and grow. It may create an interception, adsorption and absorption environment for the water to be further cleaned before reaching the aquifer. It also creates a buffer for any possible spills or system malfunction which prevents aquifer impacts and can be remedied (pumped out) before reaching the subsurface water body. Again, Clark recommends moving forward with a full landfill leachate treatment plant design and construction, upon the Borough's receipt and review of the updated plant construction and estimated operating costs.