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NATIONAL RENEWABLE ENERGY LABORATORY

Process Design of Wastewater Treatment for the NREL Cellulosic Ethanol Model

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Subcontract Report
NREL/SR-5100-51838
September 2011

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Prepared under Subcontract No. RGB-0-40607-01

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Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

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Process Design of Wastewater Treatment for the NREL Cellulosic Ethanol Model

Prepared for
Harris Group, Inc. and
The National Renewable Energy Laboratory
January 24, 2011
Rev. A: February 11, 2011
Rev. B: July 27,2011
Rev. C: September 1, 2011

139646

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Table of Contents

List of Tables

List of Abbreviations

AACE	Association for the Advancement of Cost Engineering
BC	Brown and Caldwell
BFD	block flow diagram
BOD	biochemical oxygen demand
CBOD	carbonaceous biological oxygen demand
COD	chemical oxygen demand
GFD	gallons per square foot per day
GPD	gallons per day
GPM	gallons per minute
HRT	hydraulic retention time
MBR	membrane bioreactor
MCRT	mean cell residence time
MG	million gallons
MGD	million gallons per day
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MPB	methane producing bacteria
ND	non-detect
NREL	National Renewable Energy Laboratory
RO	reverse osmosis
SCFM	standard cubic feet per minute
SMP	soluble microbial product
SOW	statement of work
SRB	sulfate reducing bacteria
SRT	solids residence time
TCOD	total chemical oxygen demand
TDFS	total dissolved fixed solids
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TIC	total inorganic carbon
TSS	total suspended solids
TVS	total volatile solids
VSS	volatile suspended solids

Section 1
Introduction

1.1 Background

The National Renewable Energy Laboratory (NREL) is evaluating a novel process for the production of ethanol from the cellulosic feedstock, corn stover. This process results in a liquid by-product stream that must be treated with the goal of reusing the effluent water in the production process, thus minimizing waste and the impact of this process on the environment. In the Statement of Work (SOW), NREL describes the treatment concept as consisting of anaerobic treatment of condensed pretreatment vapors, boiler and cooling tower blowdown streams, and filtered beer stillage followed by aerobic treatment. The biogas captured in the anaerobic process, the surplus biological sludge, as well as the captured lignin would be burned in a biomass boiler to generate steam and ultimately electricity from a steam turbine. The treated effluent would be recycled to the ethanol fermentation process.

Since the development of this conceptual design in 1998, NREL has updated the fermentation process which has caused changes to the resultant process wastewater. In general the wastewater contains high concentrations of organic compounds, measured as chemical oxygen demand (COD) and biochemical oxygen demand (BOD). It also contains high concentrations of ammonia-nitrogen (NH_3-N). The treatment process developed for this wastewater must provide the capacity to reduce the levels of these constituents sufficiently for recycle. It should be noted that this evaluation was performed for a specific corn stover using dilute acid pretreatment. Changes to the corn stover source and/or method of pretreatment may result in changes to the conclusions summarized in this document. As a secondary objective, energy in the form of biogas could be recovered during anaerobic treatment and used to meet or supplement the facility energy demand.

1.2 Scope of Work

The objective of this project was to develop a preliminary process design for treating the wastewater from the cellulosic ethanol production process to quality levels required for recycle. Originally, two treatment concepts were developed, each accommodating one of the key drivers: 1) high confidence, or 2) low cost. These treatment process options have a shared design basis developed from characterization of the proposed wastewater. The original design basis was modified by NREL in order to account for improved efficiencies in the upstream process. The revised design basis included lower total suspended solids (TSS) due to the installation of centrifugation upstream of wastewater treatment. Since a portion of the total COD, total BOD, and Total Kjeldahl Nitrogen (TKN) were comprised of particulate matter, these concentrations decreased accordingly. A third conceptual design was developed based on the revised design basis.

The scope of work for this project consists of three main tasks:

1. Characterization
2. Development of the Process Design for each Option
3. Development of a Cost Estimate

A sample of the effluent from the ammonia-conditioned hydrolyzate fermentation process was collected by NREL and transferred to the Brown and Caldwell (BC) Treatability Laboratory in Nashville, Tennessee. This sample was taken after ethanol distillation and removal of usable solids. The sample was analyzed

for those organic and inorganic compounds that might impact the design and performance of potential treatment processes. The analytical results were used to develop the original design basis for the wastewater. This original design basis was then modified to include lower concentrations of TSS, TKN, and non-soluble constituents. The modified design basis is presented in Section 2 and the analytical data are presented in Appendix A.

The process design is summarized on a block flow diagram (BFD) and presented in Appendix B. A heat and materials balance was developed for key parameters in order to indicate material flows through the process. The major equipment is provided in Appendix C as a list with the associated sizing and capacity requirements. Estimated chemical addition and power requirements were also provided. The block flow diagrams and equipment lists associated with the original design basis are provided in Appendix E.

A capital and operational cost estimate was developed for the treatment concept option and is presented in Section 4 and Appendix D. The capital cost estimate was developed based on the major equipment list. The power, chemical, and maintenance requirements were the basis for the operational cost estimate. The draft cost estimates associated with the original design basis are also provided in Appendix E.

Section 2
Characterization

2.1 Characterization

BC's Nashville Treatability Laboratory received a five gallon cube container of sample from the NREL on September 23, 2010. The sample was immediately placed in the cold room (4°C) for preservation. A portion of the sample was submitted to an outside analytical laboratory, TestAmerica, for analysis. Additional analyses and some duplicate analyses were performed by BC staff in the BC Nashville Treatability Laboratory. Results of TestAmerica and BC characterization analyses are summarized in Table 2-1. The raw analytical results are provided in Appendix A. A basis of design for the wastewater constituents was developed from the characterization data as well as from input from NREL. The basis of design is also provided in Table 2-1.

The characterization data indicate the following:

- The wastewater sample provided has a very high total chemical oxygen demand (TCOD) of approximately 125,000 mg/L. This indicates that if the wastewater is amenable to anaerobic treatment, there is potential for large quantities of biogas generation and methane recovery. The high influent organic load will also result in large quantities of biological sludge to be produced which must be handled, dewatered, and disposed.
- The wastewater sample provided has high TSS concentration (14,000 to 21,000 mg/L) that may exclude high-rate anaerobic treatment. As a result, upfront solids removal will be provided via centrifugation upstream of wastewater treatment. The average effluent TSS concentration in the centrate would be approximately 1,500 mg/L. In the revised design basis, a TSS concentration of 1,500 mg/L was used.
- The high TKN values in the sample are a concern for anaerobic treatment. This TKN will be converted to ammonia during treatment and the pH will have to be maintained in order to assure the un-ionized ammonia concentrations do not reach inhibitory levels. The resulting high ammonia concentrations from anaerobic hydrolysis of TKN will require nitrification (i.e. biological conversion of ammonia-nitrogen to nitrate-nitrogen). The nitrification process will also have a high alkalinity demand, approximately 7.15 lb CaCO3 per lb of ammonia-nitrogen removed. Based on preliminary testing by NREL, a large fraction of the TKN is associated with the TSS as particulate organic nitrogen. Adding centrifugation will remove the majority of the particulate organic nitrogen. Based on input from NREL, a TKN value of 1,200 mg/L was used for the design basis.
- Based on the sulfate concentration (4,400 mg/L), higher concentrations of hydrogen sulfide (H_2S) will be expected in the biogas. Additional gas treatment processes will be required to remove H_2S.
- Based on the information provided in Table 2-1, the COD-to-sulfate ratio is approximately 20. At this level, the methane producing bacteria (MPB) will out compete sulfate reducing bacteria (SRB) thus no significant loss of methane production will occur[1].
- The silica concentration (1,580 mg/L) is high enough to cause concern for treatment via reverse osmosis (RO) if it has a large soluble component. The analytical results in Table 2-1 do not distinguish between soluble or particulate silica. Soluble silica at circum-neutral pH has a solubility of approximately 150 mg/L. As the concentration in the RO reject exceeds this concentration, silica will form a precipitate on the membrane surface, potentially reducing the flux and/or causing membrane

[1] Speece, R.E., *Anaerobic Biotechnology and Odor/Corrosion Control*. 2008. Archae Press, Nashville, TN.

fouling. However, it is anticipated that the silica concentration is primarily particulate in nature (e.g. associated with the corn stover suspended particles). The majority of this particulate silica will be removed by the centrifuge upstream of wastewater treatment and will not pose a threat to the RO performance.

Another option for mitigating the risk of fouling due to silica precipitation is operating the RO system at an elevated pH (i.e., 10 to 10.5 s.u.). There are RO units specifically developed for this type of operation such as the GE high efficiency RO (HERO™) system. Operating the RO at an elevated pH reduces the risk of silica fouling and bio-fouling.

- The calcium, magnesium, and manganese concentrations in this sample were lower than expected for a cellulose-based wastewater. The low hardness will reduce concerns of chemical precipitation on membrane surfaces.
- The sodium and potassium concentrations (15.8 mg/L and 498 mg/L, respectively) were an order of magnitude lower than the concentration estimated by the Aspen model (342 mg/L and 5,678 mg/L, respectively). The lower concentrations reduce concern of cation toxicity in the anaerobic reactor.

Table 2 1. Characterization Data and Design Basis

Parameter	Units	TestAmerica	Brown and Caldwell	Design Basis	Comments
CBOD	mg/L	38,300	-	33,000	Adjusted for increased TSS removal
Soluble CBOD	mg/L	32,600	-	32,600	
Total COD	mg/L	117,000	124,900	87,400	Adjusted for increased TSS removal
Soluble COD	mg/L	116,000	84,600	84,600	
TOC	mg/L	32,800	-	32,800	
TIC	mg/L	732	-	732	
Total Solids	mg/L	70,800	88,583	68,433	Adjusted for increased TSS removal
TVS	mg/L	71,300	76,750	58,460	TestAmerica value not possible. Adjusted BC value for increased TSS removal
TSS	mg/L	14,500	21,650	1,500	Based on guidance from NREL
VSS	mg/L	12,800	19,650	1,360	Adjusted for increased TSS removal
TDS	mg/L	51,900	66,933	66,933	Used higher value
TDFS	mg/L	-	9,833	9,833	
Ammonia-N	mg/L	1,060	-	1,060	
Nitrate-N	mg/L	12	-	12	
TKN	mg/L	4,950	-	1,200	Assumes a large fraction of the non-ammonia nitrogen is particulate organic nitrogen and is thus removed via centrifugation
Total P	mg/L	805	-	805	Assumed equal to Ortho-P
Ortho-P	mg/L	805	-	805	
Acidity	mg/L	44	-	44	

Table 2 1. Characterization Data and Design Basis					
Parameter	Units	TestAmerica	Brown and Caldwell	Design Basis	Comments
Hydroxide Alkalinity	mg/L as $CaCO_3$	ND	-	0	
Total Alkalinity	mg/L as $CaCO_3$	-	2,750	2,750	
Hardness	mg/L as $CaCO_3$	36	-	36	
Sulfate	mg/L	5,600	4,400	4,400	Corroborated by NREL
Sulfide	mg/L	ND	-	-	
Sulfide, Dissolved	mg/L	36.6	-	36.6	
Silica (SiO2)	mg/L	1,580	-	1,580	
Aluminum	mg/L	ND	-	ND	
Barium	mg/L	0.0147	-	0.0147	
Cadmium	mg/L	ND	-	*0.0005*	
Calcium	mg/L	6.79	-	6.79	
Chromium	mg/L	0.177	-	0.177	
Copper	mg/L	ND	-	*0.005*	
Iron	mg/L	0.814	-	0.814	
Lead	mg/L	ND	-	*0.0025*	
Magnesium	mg/L	4.63	-	4.63	
Manganese	mg/L	0.0957	-	0.0957	
Potassium	mg/L	498	-	498	
Chloride	mg/L	-	-	2,473	Calculated from TDFS
Sodium	mg/L	15.8	-	15.8	
Strontium	mg/L	0.0863	-	0.0863	

Non-detect values (ND) are listed as 50% of the reporting limit in the design basis.

Additional parameters used in the basis of design but not captured in the analytical results are provided in Table 2-2.

Table 2 2. Additional Design Basis Parameters			
Parameter	Units	Value	Reference
Flow	MGD	2.15	Estimated from Aspen modeling by NREL
pH	s.u.	5.2	BC laboratory analysis
Temperature	°C	50	Estimated from Aspen modeling by NREL

Section 3
Process Design

3.1 Introduction

The basis of design provided in Table 2-1 was used to develop the process design. Certain aspects of the characterization data drive the process design. As mentioned in Section 2.1, this wastewater contains high COD, sulfate, and potentially silica. Special attention has been paid to these parameters.

3.2 Process Description

In general, proposed treatment process consists of anaerobic treatment and biogas collection followed by aerobic treatment, and finally salt removal via reverse osmosis. A number of additional processes have been included in this treatment concept in order to increase flexibility, reduce risk of inhibition or upset, and reduce the final waste product. The major process components are summarized in Table 3-1. A block flow diagram showing the treatment process is provided in Appendix B.

Table 3 1. Major Process Components

Process Component	Purpose
Anaerobic Treatment	Organic load reduction Biogas generation
Activated Sludge System	Organic load reduction Ammonia-nitrogen removal
Membrane Filtration	Total suspended solids removal Colloidal organic material removal Protection of reverse osmosis system
Reverse Osmosis	Removal of dissolved inorganic salts
Evaporation	Volume reduction of reverse osmosis reject flow Reduction of crystallizer size
Crystallization	Volume reduction of evaporator discharge Allow for zero liquid discharge
Centrifugation	Biological sludge dewatering

Certain biomass burners are capable of accommodating brine waste. If this capability is in place, then a crystallizer would not be required in the process. If the biomass burner is not capable of accommodating brine, a crystallizer would be installed to further reduce the volume of the reject brine and produce a solid waste discharge instead of a liquid stream. The crystallizer effluent can be combined with the dewatered sludge and sent to the biomass burner (i.e. discharged as ash) or sent to a landfill.

The dewatering process used in the process will be centrifugation. In general, centrifugation provides higher solids capture and a drier biomass cake compared to other dewatering systems thus reducing the size of the biomass burner system. It also provides a margin of safety against changes in sludge quality which would typically have an impact on dewatering processes relying upon filtration (e.g. belt filter press).

As discussed in Section 2-1, the silica concentrations in the sample characterized were at levels that could be a concern for the reverse osmosis process. However, it is anticipated that a large fraction of the silica is associated with particulate corn stover material and would be removed by upstream centrifugation. Soluble silica removal has not been included as a part of this process design.

3.3 Process Design

The design criteria and assumptions for each main treatment process are discussed below. The major equipment detailed below is summarized in the equipment list provided in Appendix C.

3.3.1 Anaerobic Process

The original characterization data were submitted to two anaerobic wastewater treatment system manufacturers, ADI and Biothane (Veolia) in order to evaluate the treatability of this wastewater through their systems. ADI is a supplier of low rate anaerobic systems while Biothane provides both high-rate and low rate systems. BC is familiar with these providers and requested them to submit a treatment evaluation and cost estimate because of their proven qualifications.

Due to the expected TSS concentration of 1,500 mg/L as well as the high COD concentration, a low rate anaerobic treatment system was recommended. According to ADI, high organic loading (at the concentrations associated with this wastewater) inhibits the growth of granular sludge which is required for high rate systems. The vendors performed anaerobic modeling in order to provide estimates on COD removal as well as total gas generation, percent methane, and H_2S generation from their systems and expected effluent ammonia.

The two vendors recommended the following treatment:

3.3.1.1 ADI

ADI wishes to keep the type, number and size of their proposed system confidential. Table 3-2 presents the estimated effluent COD, BOD, and TSS from the ADI System.

Table 3 2. ADI System Estimated Effluent Concentrations

Parameter	Units	Value
COD	mg/L	<18,750
CBOD	mg/L	<3,800
TSS	mg/L	<2,200
Estimated Methane	%	65

3.3.1.2 Biothane

Biothane recommended a 4 MG equalization tank followed by 40 MG total of anaerobic digesters with solids separation through membranes. The bioreactors proposed are mixed tanks that keep the biomass in suspension. Solids separation is provided by cross flow membranes mounted on a skid separate from the anaerobic reactors. The biomass is recycled back into the digester. Sludge is periodically wasted from the reactors at an estimated production rate of 200,000 lbs/day at 20 percent solids (120 yd^3/day). Biogas blowers continuously pull a negative pressure from the surface via a pressure loop on the biogas system. Table 3-3 presents the estimated effluent COD, BOD, and TSS from the Biothane reactor.

Table 3 3. Biothane Estimated Effluent Concentrations		
Parameter	Units	Value
COD	mg/L	<2,500
TSS	mg/L	1,000 (from filtrate only)
Estimated Methane	%	55

Due to the additional cost for the membrane technology proposed by Biothane compared to the ADI System and the fact that the effluent will be treated through an aerobic process after anaerobic treatment, the ADI System was the recommended anaerobic treatment option.

3.3.2 Biogas Reuse

Approximately 17 million cubic feet per day of biogas will be produced by the anaerobic treatment system. The average methane content will be 65 percent. This results in a gross fuel potential of approximately 9.5 billion BTUs per day or an equivalent power usage of 2.8 million KWh per day. The biogas will be conveyed via blowers/compressors through a suction-side sediment and moisture trap, which consists of a baffle that produces a pressure drop allowing water to condense out of the gas phase as well as drop any particulates from the gas stream. On the discharge side of the blowers/compressors, gas cooling equipment such as heat exchangers (cooling fans), refrigerated dryers, and/or automatic moisture drip traps may be required before the biogas can be used.

The preferred use of the biogas is in facility boilers or biomass burner due to the large power generating potential. However, economic factors may drive the sale of the gas to other customers via a pipeline. In all cases, an emergency flare is required in the event the gas production exceeds the demand from both the facility boilers and outside customers.

Due to the estimated H_2S concentration of approximately 2.5 percent, excess sulfur emissions would occur if the biogas were burned, and additional treatment is required prior to use. Potential H_2S removal systems are listed below:

- Sulfur control at the biogas boiler/biomass burner (limestone, dolomite, etc.)
- Iron sponge gas filter
- Scrubbing and biological oxidation

Two combinations of these treatment control options are described in the following sections.

3.3.2.1 Sulfur Removal Option 1: Biogas Boiler/Biomass Burner

In this option, the biogas boiler or biomass burner will be equipped with a sulfur control option that can accommodate H_2S concentration of approximately 2.5 percent. The biogas will be conveyed directly from the blowers/compressors to the boiler. The boiler is equipped with a sulfur control mechanism which brings the biogas into contact with a sulfur absorbing substance, usually limestone or dolomite. The sorbent captures the sulfur in the H_2S-laden biogas, reducing the emission SO_x concentration.

A secondary sulfur control mechanism is required in the event that biogas production exceeds the boiler demand and must be burned at the flare (such as boiler maintenance shutdowns), or if the biogas is sold to outside customers. An iron sponge is proposed for these conditions. An iron sponge consists of a compartment filled with ferric oxide shavings on a wood chip carrier. The biogas flows down through the compartment and the H_2S reacts with the ferric oxide to form ferric sulfide and water. Some units also contain automatic oxygen regeneration equipment that consists of a small air stream added to the

system to react with the ferric sulfide to re-create ferric oxide and elemental sulfur. The iron sponge must be replaced when the bed is exhausted or when it becomes plugged with sulfur. Spray wash nozzles are required to keep the iron sponge hydrated.

Iron sponges are typically used in applications where the H_2S concentration in the biogas is lower than 2.5 percent. Therefore, the iron sponge will tend to foul more quickly than normal, causing higher operating costs. This sulfur removal option is not recommend if any of the following conditions are present:

- The biogas boilers are not equipped with a sulfur control option.
- The biogas boilers will be regularly out of service for more than just routine maintenance.
- Biogas production is consistently in excess of biogas boiler demand, requiring biogas to be burned at the flare.
- The primary user of biogas is not the boilers, rather outside customers.

If any of the above conditions are present, then sulfur removal option 2 is recommended.

3.3.2.2 Sulfur Removal Option 2: Scrubbing and Biological Oxidation

In this option, the biogas will be treated with the same system regardless of its end use at the boilers, the flare, or outside customers. The scrubber and biological oxidizer will be installed downstream of the sediment and moisture trap on the suction side of the blowers/compressors. This treatment system, which goes by the trade name THIOPAQ®, consists of a caustic scrubber and a bioreactor. In a caustic scrubber, gas enters the bottom of a chamber and is sprayed with a weak alkaline solution (usually caustic). The caustic solution contacts the H_2S and CO_2 in the biogas and reacts to form sodium bisulfide (NaHS) and sodium carbonate (Na_2CO_3). The scrubbed gas travels upwards through the chamber and exits at the top. Caustic scrubbers are commonly used in the desulfurization of gas streams, but gas flows and sulfur concentrations of this magnitude typically require such large quantities of caustic chemicals that the treatment process is cost prohibitive. If scrubbing is combined with biological oxidation, the chemical costs can be greatly diminished. In the biological oxidation step, the spent caustic solution, which also contains sodium bisulfide and sodium carbonate, is pumped to an aerobic reactor. The biomass in this reactor converts the dissolved sulfide into elemental sulfur and regenerates caustic for reuse at the scrubber.

3.3.3 Aerobic Process

The wastewater generated from the anaerobic process will be treated to target effluent concentrations through an aerobic activated sludge process. Eckenfelder modeling by BC was used to evaluate required tank sizes as well as oxygen and energy demands. Nitrification was required due to the high effluent ammonia concentrations and governed the mean cell residence time (MCRT) required for treatment. In order to determine the summer and winter MCRT required, a sludge age was estimated and the kinetic model was performed. The MCRT was then allowed to change until the active nitrifier population required for complete nitrification was established. The model was then performed at this MCRT in order to determine the heterotrophic population.

The following Eckenfelder activated sludge kinetic coefficients were used to calculate aerobic treatment based on experience for similar types of wastewaters:

a_H = sludge yield from cell synthesis (mg $VSS_{Heterotrophs}$/mg $COD_{Removed}$) = 0.40

a'_H = oxygen required for heterotrophic cell synthesis (mg O_2/mg $COD_{Removed}$) = 0.44

a_N = sludge yield from nitrification (mg $VSS_{Nitrifiers}$/mg NH_3-$N_{Removed}$) = 0.125

a'_N = oxygen required for autotrophic cell synthesis (mg O_2/mg NH_3-$N_{Removed}$) = 4.25

q_N = nitrification removal rate (mg NH_3-N/mg $VSS_{Nitrifiers}$ · day) = 0.8

T = Summer and winter temperatures (°C) = 30 and 15

3.3.3.1 Aerobic Influent Flow

The influent flow used for the organic loading on the aerobic design was the anaerobic effluent flow after waste anaerobic sludge removal or 1.86 MGD plus the fraction of filtrate from solids dewatering that was anaerobic solids. The anaerobic fraction of the 0.62 MDG centrate volume is 29 percent or 0.184 MGD. The total organic loading to the aerobic system is represented by an influent flow of 2.044 MGD.

3.3.3.2 Influent Solids (TSS_I)

The anaerobic vendor estimated an anaerobic effluent TSS concentration of 2,000 mg/L which was used for the conceptual design. The majority of these solids were assumed to remain in the system as inert solids, with 30 percent of these solids being degraded. The accumulated concentration in the aerobic system was calculated by multiplying influent concentration by the MCRT and dividing by the hydraulic retention time (HRT).

3.3.3.3 Aerobic COD Removed

The anaerobic vendors estimated an effluent TCOD concentration of 18,750 and 2,500 mg/L, respectively. The TCOD concentration used for the aerobic design was 10,000 mg/L. Research presented by Eckenfelder, Davis, and Ford, presents a non-degradable COD value contributed by soluble microbial products (SMPs) to be 2 to 10 percent of the degraded COD concentrations when the wastewater is aerobically degraded[2]. Simpler wastewaters treated at a lower MCRT will have a lower percentage of non-degradable COD value associated with SMP while harder to degrade wastewater at higher sludge ages will have a higher percentage of effluent COD associated with SMP. The non-degradable COD concentration was estimated to be 2,000 mg/L or 2.3 percent of the aerobic influent COD concentration for this wastewater. The COD removed (S_R) was calculated to be 8,000 mg/L (136,400 lbs/day).

3.3.3.4 Aerobic Influent Ammonia Nitrogen Oxidized (N_R)

The wastewater contained 1,200 mg/L TKN. The TKN was assumed to be converted to ammonia nitrogen. The amount of ammonia-nitrogen oxidized during the study period was determined by the following equation.

$$N_R = \left(NH_3 - N_{Influent}\right) - \left(NH_3 - N_{Effluent}\right) - \left(NH_3 - N_{Cellsynthesis}\right)$$

where:

NH_3-$N_{Influent}$	=	*influent ammonia-nitrogen = 1,200 mg/day*
NH_3-$N_{Effluent}$	=	*effluent ammonia-nitrogen = 0 mg/day*
NH_3-$N_{Cell\ Synthesis}$	=	*Ammonia nitrogen used for cell synthesis (anaerobic and aerobic) = 663 mg/L*
N_R	=	*537 mg/L (9,154 lbs/day)*

3.3.3.5 Endogenous Decay Coefficient (b_H and b_N)

The endogenous heterotrophic decay coefficient "b_H" was assumed equal to 0.10 day^{-1} at 20°C. The decay coefficient was increased or decreased for summer and winter temperatures using the following equation:

$$b_T = b \cdot 1.04^{(Temperature\ -\ 20)}$$

where:

[2] Eckenfelder, W.W., Ford D.L., and Englande, A.J. *Industrial Water Quality Fourth Edition.* 2009. McGraw Hill. New York

b_T = b at operating temperature

The "b_T" value at summer and winter temperatures was calculated to be 0.148 and 0.082 day^{-1}, respectively. The endogenous autotrophic decay coefficient "b_N" was assumed equal to 0.05 day^{-1} at 20°C. The decay coefficient was corrected for summer and winter temperatures using the same equation for the heterotrophic b resulting in a temperature corrected b_N to 0.074 and 0.041 day^{-1}.

3.3.3.6 Biodegradable Fraction (X_{dH} and X_{dN})

The biodegradable fraction of biomass X_d was calculated using the following equation.

$$X_d = \frac{0.8}{(1 + 0.2 \cdot b \cdot MCRT)}$$

where:

MCRT = mean cell residence time (or SRT)

b = b_H for X_{dH} calculation and b_N for X_{dN} calculation

The required sludge age for complete nitrification was determined to be 3 days for the summer and 36 days for the winter, however the sludge age was not allowed to decrease below the hydraulic retention time of 9.5 days. These sludge ages produced the following X_d values:

The X_{dH} value for summer and winter was calculated to be 0.62 and 0.50.

The X_{dN} value for summer and winter was determined to be 0.70 and 0.62.

3.3.3.7 Required Nitrifier Population (X_{VN})

The nitrification removal rate (q_N) was assumed to be 0.8 day^{-1} at 20°C and adjusted for temperature using the following equation:

$$q_{NT} = q_N \cdot 1.085^{(\text{Temperature} - 20)}$$

where:

q_{NT} = q_N at operating temperature

The "q_{NT}" value at summer and winter temperatures was calculated to be 1.81 and 0.53 day^{-1}.

The required active nitrifier population was determined by dividing the ammonia nitrogen nitrified (N_R) by the removal rate q_{NT}. The required pounds of active nitrifiers were determined to be 6,400 lbs and 16,600 lbs for summer and winter temperatures. The total nitrifier population was determined by dividing the active nitrifiers required by the active fraction of nitrifiers at the determined sludge age. The active fraction of nitrifiers (f_a) was determined by the following equation:

$f_a = X_{dN}/0.8 = 0.88$ and 0.77 for summer and winter temperatures

The total nitrifier population was calculated to be 7,300 lbs and 21,500 lbs for summer and winter temperatures.

3.3.3.8 Chemical Requirements

Do to the high concentrations of ammonia nitrogen and phosphorus in the influent, these macronutrients will not have to be added. For nitrification to occur, an alkalinity concentration of at least 75 mg/L as $CaCO_3$ plus 7.15 mg additional alkalinity per mg ammonia nitrogen to be nitrified is required. The influent alkalinity was 2,750 mg/L (46,880 lbs/day). The required alkalinity is 65,500 lbs/day indicating an additional 18,620 lbs/day of alkalinity is required. This can be supplied by 2,340 gallons per day of 50 percent sodium hydroxide.

3.3.3.9 Sludge Production

The daily sludge generation "ΔX_V" in the equation below was calculated according to the following relationship:

$$\Delta X_V = a_H \cdot S_R - b_H \cdot X_{d\,H} \cdot X_{V\,H} + a_N \cdot N_R - b_N \cdot X_{d\,N} \cdot X_{V\,N} + VSS_I$$

where:

ΔX_V = total change in MLVSS per day, lbs/day

a_H = heterotrophic sludge yield from synthesis, mg VSS/mg $COD_{Removed}$, day

S_R = COD removed, lbs/day

b_H = heterotrophic endogenous decay coefficient, 1/day

X_{dH} = biodegradable fraction of heterotrophic biomass

X_{VH} = total heterotrophic biomass in system, lbs

a_N = autotrophic sludge yield from synthesis, 1/day

N_R = ammonia-nitrogen oxidized, lbs/day

b_N = autotrophic endogenous decay coefficient, 1/day

X_{dN} = biodegradable fraction of autotrophic biomass

X_{VN} = total autotrophic biomass in system, lbs

VSS_I = volatile suspended solids from influent that is not biomass and is not degradable, lbs/day

The actual biomass in the system and sludge wastage was calculated using the above equation and the required sludge ages. The results are presented in Table 3-4.

Table 3 4. System VSS			
Parameter	Units	Summer	Winter
Required Sludge Age	days	9.5	36
Heterotrophs	lbs	280,000	800,000
Nitrifiers	lbs	7,300	21,500
Total Solids	lbs	287,300	821,500
VSS Sludge Wastage	lbs/day	30,340	22,860

The TSS concentration was estimated from the VSS concentration and the sludge age. The VSS/TSS ratio with respect to sludge age (MCRT) was estimated to be 87 and 57 percent for summer and winter sludge age respectively which includes the influent particulate TSS. The final TSS concentrations are presented in Table 3-5.

Table 3 5. Aerobic System TSS			
Parameter	Units	Summer	Winter
Total TSS Inventory	lbs	334,100	1,550,000
TSS Wastage Rate	lbs/day	34,900	40,300

3.3.3.10 Basin Volume

The sizing of the aerobic system was determined by solids under aeration at a 36-day MCRT (winter concentration) and maintaining a TSS concentration of less than 10,000 mg/L. The target operating mixed liquor suspended solids (MLSS) of the membrane reactor was kept to 10,000 mg/L in order to provide additional protection to the membrane. The resulting volume requirement was 19.5 MG. Table 3-6 presents the dimensions that were determined to be required for three aeration tanks operating in parallel.

Table 3 6. Aeration Basin Sizing		
Parameter	Units	Value
Number of Basins	--	3
Liquid Volume (per basin)	MG	6.5
Liquid Depth	ft	22
Tank Depth	ft	25
Tank Width	ft	115
Tank Length	ft	344

3.3.3.11 Oxygen Requirements (r_r)

The oxygen requirements "r_r'" for the heterotrophic and autotrophic (nitrifying) bacteria was calculated using the following equation.

3.3.3.12 Endogenous Oxygen Demand (b')

The heterotrophic an autotrophic endogenous oxygen demand b' value was calculated using the following equation.

$$b' = 1.4 \cdot b$$

Expected oxygen demand after COD correction, required blower horsepower for aeration, and required blower horsepower for mixing are presented in Table 3-7.

Table 3 7. Aeration Requirements for Oxygen Demand

Parameter	Value
Total Oxygen Demand Summer, lbs O^2/day	136,440
Total Oxygen Demand Winter, lbs O^2/day	147,000
Air Flow Summer, SCFM/1,000 ft^3	22
Air Flow Winter, SCFM/1,000 ft^3	27

Coarse bubble aeration was selected because it is not prone to fouling like fine bubble aeration. Table 3-8 presents the calculated blower horsepower required in order to generate the required oxygen demand.

Table 3 8. Blower Requirements to Provide Required Oxygen Transfer

Parameter	Value
Required Blower Power Summer, HP	3,650
Required Blower Power Winter, HP	4,450

Five, 1,000 HP blowers will be required to provide the required oxygen transfer. A sixth installed spare blower will be provided.

3.3.4 Secondary Clarification

Secondary clarification will be provided by an ultra-filtration membrane as an integral part of the membrane bioreactor (MBR) process. Utilizing a membrane solid-liquid separation process as opposed to conventional gravity settling provides the following benefits:

- Approximately no TSS in the effluent
- Removal of colloidal particles
- Protection of the downstream membrane systems (i.e. reverse osmosis)
- Ability to operate MLSS at a higher concentration
- Higher COD removal per unit area of footprint required

A MBR membrane is sized based on hydraulic flux which is typically in the range of 16 to 18 gallons per square foot per day (gfd). The units used in both treatment options were hollow fiber and were sized based on design criteria from projects with similar wastewater and design basis.

In order to protect the membrane system, an influent screen is typically employed. The screen opening size ranges from 2 to 3 mm.

3.3.5 Sludge Handling

Sludge storage will be provided in order to hold waste activated sludge for approximately 12 hours. This will allow for dewatering during two of the three shifts. The total sludge wastage rate of 475 gpm and includes the following:

- Anaerobic Wastage = 140 gpm
- Aerobic Wastage = 335 gpm

The sludge holding tank size is estimated to be 375,000 gallons.

3.3.6 Sludge Dewatering

All waste sludge is pumped from the sludge holding tank to a dewatering device in order to reduce the volume and water content of the sludge. A centrifuge was evaluated due to its relatively high water recovery. A belt filter press system could also be used; however, the final sludge cake would have a higher moisture content.

Three 275 gpm centrifuge units, operated in parallel will be used. Three Ashbrook Simon-Hartley CQ7000 units were assumed. The centrifuge units will provide a solids capture rate of up to 95 percent and a cake concentration of approximately 20 percent. A cake discharge rate of approximately 8,700 ft^3/day will travel via conveyor to either a biomass burner or offloaded to a truck for transport to a landfill. The centrate flow of approximately 620,000 gpd will be pumped back to the activated sludge system.

3.3.7 Salt Removal

In order for the wastewater to be recycled in the production process, the dissolved inorganic salts must be removed. Reverse Osmosis was evaluated for salt removal. Approximately 2 MGD of treated wastewater is pumped to the reverse osmosis system. A high pressure is applied to the upstream side of the membrane, forcing the clean water through while maintaining the dissolved salts. The flow recovery is expected to be approximately 80 percent with a salt capture of approximately 95 percent. An effluent of 1.6 MGD will be recycled back to the production process. The concentrate or reject stream will have an approximate flow rate of 0.4 MGD and an approximate TDS concentration of 49,000 mg/L. Both options will require 200,000 ft^2 of membrane area based on typical flux rates of 10 gfd for RO systems. In most systems up to 1.5 times the required membrane area is installed in order to allow for cleaning cycles and out of service time.

The reject flow will be pumped to an evaporator in order to reduce the volume of the reject brine by an additional 90 percent. The effluent from the evaporator will be a concentrated brine flow of 40,000 gpd at an approximate TDS concentration of 490,000 mg/L. This concentrated brine could be combined with the dewatered sludge and sent to the biomass burner if the burner is a fluidized bed type unit that could accommodate the brine flow. If the biomass burner cannot accommodate the evaporator brine, then this flow would be sent to a crystallizer unit in order to further reduce the volume to about 4,000 gpd as semi-solid slurry. The crystallization process would allow for zero-liquid discharge. The final slurry could be sent to a secondary user or disposed in a landfill. If the concentrated brine final product were to be sent to the biomass burner, it would be a means of disposing the salt with the resulting ash but would not provide a fuel benefit. For the purposes of this evaluation, it is assumed that the biomass burner can accommodate the concentrated brine from the evaporator.

Section 4
Cost Estimate

4.1 Introduction

Capital and operational conceptual level cost estimates were developed for the treatment process. The capital cost estimate was an Association for the Advancement of Cost Engineering International (AACE) Class 4 estimate. A Class 4 estimate is performed when 1 to 15 percent of the engineering is complete and is used at the planning level. The expected accuracy for a Class 4 estimate typically ranges from -30 percent to +50 percent. The major assumptions made for the development of the cost estimates are listed below:

- The site is a new site located in the northern Midwest
- The site will not need to be cleared and no significant site preparation is required (e.g. blasting)
- Power cost is $0.12 per KWh
- Non-unionized labor
- Concentrated brine from the evaporator can be handled by the biomass burner
- Cost estimates do not include the biogas conditioning, storage, or transfer
- Cost estimates do not include biomass burner
- Cost estimates do not include transfer of final waste material to landfill

A detailed breakdown of the Class 4 cost estimate and additional information related to the assumptions can be found in Appendix D.

4.2 Cost Estimates

The capital cost estimate treatment concept described above is $98 million. Therefore the range associated with this level of cost estimate is $67 million to $147 million. The major process components and their associated base costs are provided in Table 4-1. This table acted as the basis for the detailed cost estimate. The estimated annual operations and maintenance cost is $12.6 million. A breakdown of this annual cost is provided in Table 4-2.

Table 4 1. Major Capital Cost Components		
Item	Cost	Information
Anaerobic Treatment Basins	$25,000,000 to $30,000,000	ADI System confidential per vendor request
Iron Sponge	$275,000	Equipment only
Aeration Basins	$15,100,000	Includes basin materials, installation, and coarse bubble aeration grid
Membrane Bioreactor	$4,750,000	Includes approximately 140,000 ft² of membrane, associated hardware, permeate and backwash pumping systems, membrane scour and cleaning systems, and RAS pumps
Sludge Holding Tank	$475,000	Bolted steel tank of approximately 535,000 gallons Equipment only
Centrifuge	$1,950,000	Three 275 gpm model Ashbrook CQ7000 units Equipment only
Reverse Osmosis	$1,667,500	Equipment only
Evaporator	$3,440,000	Evaporator with capacity of approximately 411,000 GPD Equipment only
Pumps	$540,600	Equipment Only
Blowers	$1,150,000	Six 1000 HP blowers Equipment only

Table 4 2. Operations and Maintenance Cost Estimate					
Item	Quantity	Units	Unit Cost	Annual Cost	Notes
Anaerobic Treatment Operations	-	-	-	$3,682,000	Estimated
Power Requirements	49,417	MWH	$120	$5,930,000	Assumes $0.12/kWh and 350 operating days/year
Iron Sponge Replacement	-	-	-	$100,000	Assumes 1 week of use per year (biomass boiler maintenance, emergency flares, etc.)
Polymer Addition	185,355	LB	$2.25	$417,000	For use in sludge dewatering
Alkalinity Addition	5,120	TON	$150	$782,000	Assumes 50% sodium hydroxide (NaOH) is used as alkalinity source
Operators	5	FTE	$50,000	$250,000	Assumes cost per FTE is fully burdened
Maintenance	-	-	-	$1,410,000	Assumes 10% of all equipment with moving parts except the anaerobic system which is included separately above
Total O&M Costs				**$12,571,000**	

References

Eckenfelder, W.W., Ford D.L., and Englande, A.J. *Industrial Water Quality Fourth Edition.* 2009. McGraw Hill. New York

Speece, R.E., *Anaerobic Biotechnology and Odor/Corrosion Control*. 2008. Archae Press, Nashville, TN.

Appendix A: Analytical Data

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THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

October 18, 2010 1:00:45PM

Client: Brown & Caldwell (3376)
501 Great Circle Road, Suite 150
Nashville, TN 37228
Attn: Thomas R Steinwinder

Work Order: NTI2395
Project Name: Harris NREL Eval
Project Nbr: 139646
P/O Nbr:
Date Received: 09/23/10

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
NREL	NTI2395-01	09/23/10 08:00

An executed copy of the chain of custody, the project quality control data, and the sample receipt form are also included as an addendum to this report. If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-765-0980. Any opinions, if expressed, are outside the scope of the Laboratory's accreditation.

Tennessee Certification Number: 02008

The Chain(s) of Custody, 3 pages, are included and are an integral part of this report.

These results relate only to the items tested. This report shall not be reproduced except in full and with permission of the laboratory.

All solids results are reported in wet weight unless specifically stated.
Estimated uncertainty is available upon request.
This report has been electronically signed.
Report Approved By:

Jennifer Gambill

Project Manager

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THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

ANALYTICAL REPORT

Analyte	Result	Flag	Units	MRL	Dilution Factor	Analysis Date/Time	Method	Batch
Sample ID: NTI2395-01 (NREL - Waste Water) Sampled: 09/23/10 08:00								
General Chemistry Parameters								
Acidity	**44.0**		mg/L	10.0	1	10/07/10 10:38	SM2310 B	10J1234
Ammonia as N	**1060**		mg/L	10.0	100	10/07/10 16:46	EPA 350.1M	10J1126
Carbonaceous BOD	**38300**	H, L2	mg/L	20000	10000	10/05/10 16:46	SM 5210B	10I5405
Carbonaceous BOD	**32600**	A-01, H, L2	mg/L	20000	10000	10/05/10 16:46	SM 5210B	10I5405
Chemical Oxygen Demand	**117000**		mg/L	2000	200	10/06/10 09:09	EPA 410.4	10J0269
COD, Soluble	**116000**		mg/L	2000	200	10/04/10 08:10	EPA 410.4	10J0268
Fluoride	ND	RL1	mg/L	1000	10000	09/28/10 19:35	SW846 9056	10I4270
Phosphorus	**80.0**		mg/L	4.00	40	10/06/10 16:32	EPA 365.4	10J0620
Sulfate	ND		mg/L	1.00	1	09/27/10 18:10	SW846 9038	10I4677
Sulfide	ND		mg/L	1.00	1	09/28/10 15:30	SM4500-S2 F	10I4412
Total Dissolved Solids	**51900**		mg/L	10.0	1	09/30/10 10:40	SM2540 C	10I5337
Total Inorganic Carbon	**732**		mg/L	100	100	10/11/10 12:44	SW846 9060	10J1184
Total Organic Carbon	**32800**		mg/L	1000	1000	10/06/10 01:02	SW846 9060A	10J0551
Total Solids	**70800**		mg/L	20.0	1	09/30/10 22:43	SM2540 B	10I5334
Total Suspended Solids	**14500**	H	mg/L	1.00	1	10/01/10 03:00	SM2540 D	10I5336
Total Volatile Solids	**71300**		mg/L	NA	1	09/30/10 11:31	EPA 160.4	10I5343
Volatile Suspended Solids	**12800**	H	mg/L	10.0	1	10/01/10 03:00	SM2540 E	10I5340
Hydroxide Alkalinity as CaCO3	ND		mg/L	10.0	1	09/30/10 22:37	SM2320 B	10I5445
Nitrate as N	**12.0**		mg/L	5.00	50	09/24/10 21:06	EPA 353.2	10I4188
Orthophosphate as P	**805**	H	mg/L	100	1000	10/05/10 15:29	SM4500-P E	10I4274
Total Kjeldahl Nitrogen	**4950**		mg/L	200	200	10/07/10 08:47	EPA 351.2	10J0630
General Chemistry Parameters - Dissolved								
Silica (SiO2)	**1580**		mg/L	1000	1000	09/28/10 10:47	SM4500-SiO2 C	10I4704
Sulfide	**36.6**	H, M8	mg/L	1.00	1	10/01/10 14:20	SM 4500-S2 F	10J0020
Metals								
Hardness, CaCO3	**36.0**		mg/L	6.62	1	09/28/10 22:05	SM 2340B	[CALC]
Total Metals by EPA Method 6010B								
Aluminum	ND		mg/L	0.100	1	09/28/10 22:05	SW846 6010B	10I4625
Barium	**0.0147**		mg/L	0.0100	1	09/28/10 22:05	SW846 6010B	10I4625
Cadmium	ND		mg/L	0.00100	1	09/28/10 22:05	SW846 6010B	10I4625
Calcium	**6.79**		mg/L	1.00	1	09/28/10 22:05	SW846 6010B	10I4625
Chromium	**0.177**		mg/L	0.00500	1	09/28/10 22:05	SW846 6010B	10I4625
Copper	ND		mg/L	0.0100	1	09/28/10 22:05	SW846 6010B	10I4625
Iron	**0.814**		mg/L	0.0500	1	09/28/10 22:05	SW846 6010B	10I4625
Lead	ND		mg/L	0.00500	1	09/28/10 22:05	SW846 6010B	10I4625
Magnesium	**4.63**		mg/L	1.00	1	09/28/10 22:05	SW846 6010B	10I4625
Manganese	**0.0957**		mg/L	0.0150	1	09/28/10 22:05	SW846 6010B	10I4625
Potassium	**498**		mg/L	10.0	10	09/29/10 13:00	SW846 6010B	10I4625
Sodium	**15.8**		mg/L	1.00	1	09/28/10 22:05	SW846 6010B	10I4625
Strontium	**0.0863**		mg/L	0.0500	1	09/28/10 22:05	SW846 6010B	10I4625

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

SAMPLE EXTRACTION DATA

Parameter	Batch	Lab Number	Wt/Vol Extracted	Extracted Vol	Date	Analyst	Extraction Method
General Chemistry Parameters							
SM 5210B	10I5405	NTI2395-01	300.00	300.00	09/30/10 15:11	JAG2	BOD/CBOD
SM 5210B	10I5405	NTI2395-01	300.00	300.00	09/30/10 15:11	JAG2	BOD/CBOD
Total Metals by EPA Method 6010B							
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010
SW846 6010B	10I4625	NTI2395-01	50.00	50.00	09/28/10 09:25	DEB	EPA 3010A / 6010

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	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Blank

Analyte	Blank Value	Q	Units	Q.C. Batch	Lab Number	Analyzed Date/Time
General Chemistry Parameters						
10I4188-BLK1						
Nitrate as N	<0.0140		mg/L	10I4188	10I4188-BLK1	09/24/10 20:51
10I4270-BLK1						
Fluoride	<0.0300		mg/L	10I4270	10I4270-BLK1	09/28/10 18:41
10I4270-BLK2						
Fluoride	<0.0300		mg/L	10I4270	10I4270-BLK2	09/30/10 04:57
10I4274-BLK1						
Orthophosphate as P	<0.0100		mg/L	10I4274	10I4274-BLK1	10/05/10 15:29
10I4412-BLK1						
Sulfide	<0.170		mg/L	10I4412	10I4412-BLK1	09/28/10 15:30
10I4677-BLK1						
Sulfate	<0.600		mg/L	10I4677	10I4677-BLK1	09/27/10 18:10
10I5334-BLK1						
Total Solids	<6.00		mg/L	10I5334	10I5334-BLK1	09/30/10 22:43
10I5336-BLK1						
Total Suspended Solids	<0.500		mg/L	10I5336	10I5336-BLK1	10/01/10 03:00
10I5337-BLK1						
Total Dissolved Solids	<3.00		mg/L	10I5337	10I5337-BLK1	09/30/10 10:40
10I5340-BLK1						
Volatile Suspended Solids	<10.0		mg/L	10I5340	10I5340-BLK1	10/01/10 03:00
10I5343-BLK1						
Total Volatile Solids	0.00		mg/L	10I5343	10I5343-BLK1	09/30/10 11:31
10I5405-BLK1						
Carbonaceous BOD	<1.10		mg/L	10I5405	10I5405-BLK1	10/05/10 16:46
Carbonaceous BOD	<1.10		mg/L	10I5405	10I5405-BLK1	10/05/10 16:46
10I5445-BLK1						
Hydroxide Alkalinity as CaCO3	<1.40		mg/L	10I5445	10I5445-BLK1	09/30/10 22:37
10J0268-BLK1						
COD, Soluble	4.40		mg/L	10J0268	10J0268-BLK1	10/04/10 08:10
10J0269-BLK1						

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Blank - Cont.

Analyte	Blank Value	Q	Units	Q.C. Batch	Lab Number	Analyzed Date/Time
General Chemistry Parameters						
10J0269-BLK1						
Chemical Oxygen Demand	<2.00		mg/L	10J0269	10J0269-BLK1	10/04/10 08:10
10J0551-BLK1						
Total Organic Carbon	<0.500		mg/L	10J0551	10J0551-BLK1	10/06/10 01:02
10J0620-BLK1						
Phosphorus	0.0634		mg/L	10J0620	10J0620-BLK1	10/06/10 14:30
10J0630-BLK1						
Total Kjeldahl Nitrogen	<0.0240		mg/L	10J0630	10J0630-BLK1	10/06/10 16:14
10J1126-BLK1						
Ammonia as N	<0.0640		mg/L	10J1126	10J1126-BLK1	10/07/10 16:24
10J1184-BLK1						
Total Inorganic Carbon	<0.500		mg/L	10J1184	10J1184-BLK1	10/11/10 12:44
10J1234-BLK1						
Acidity	<2.40		mg/L	10J1234	10J1234-BLK1	10/07/10 10:38
General Chemistry Parameters - Dissolved						
10I4704-BLK1						
Silica (SiO2)	<0.100		mg/L	10I4704	10I4704-BLK1	09/28/10 10:47
10J0020-BLK1						
Sulfide	<0.170		mg/L	10J0020	10J0020-BLK1	10/01/10 14:20
Total Metals by EPA Method 6010B						
10I4625-BLK1						
Aluminum	<0.0540		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Barium	<0.00600		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Cadmium	<0.000600		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Calcium	<0.320		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Chromium	<0.00260		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Copper	<0.00300		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Iron	<0.0490		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Lead	<0.00290		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Magnesium	<0.0660		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Manganese	<0.00100		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Potassium	<0.150		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59
Sodium	<0.820		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59

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THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Blank - Cont.

Analyte	Blank Value	Q	Units	Q.C. Batch	Lab Number	Analyzed Date/Time
Total Metals by EPA Method 6010B						
10I4625-BLK1						
Strontium	<0.00500		mg/L	10I4625	10I4625-BLK1	09/28/10 20:59

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2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Duplicate

Analyte	Orig. Val.	Duplicate	Q	Units	RPD	Limit	Batch	Sample Duplicated	% Rec.	Analyzed Date/Time
General Chemistry Parameters										
10I4188-DUP2										
Nitrate as N	14.0	14.1		mg/L	0.5	20	10I4188	NTI2340-01RE1		09/24/10 21:10
10I4270-DUP1										
Fluoride	ND	ND		mg/L		20	10I4270	NTI2395-01		09/28/10 19:53
10I4270-DUP2										
Fluoride	ND	ND		mg/L		20	10I4270	NTI1827-04RE1		09/30/10 07:02
10I4274-DUP1										
Orthophosphate as P	ND	ND		mg/L		20	10I4274	NTI2447-06		10/05/10 15:29
10I4412-DUP1										
Sulfide	ND	ND		mg/L		10	10I4412	NTI2395-01		09/28/10 15:30
10I4677-DUP1										
Sulfate	ND	ND		mg/L		10	10I4677	NTI2319-06		09/27/10 18:10
10I5334-DUP1										
Total Solids	1140	1130		mg/L	1	20	10I5334	NTI2799-02		09/30/10 22:43
10I5336-DUP1										
Total Suspended Solids	10.1	9.40	R2	mg/L	7	5	10I5336	NTI2917-07		10/01/10 03:00
10I5337-DUP1										
Total Dissolved Solids	160	156		mg/L	3	5	10I5337	NTI2082-01RE1		09/30/10 10:40
10I5340-DUP1										
Volatile Suspended Solids	12800	12400		mg/L	3	20	10I5340	NTI2395-01		10/01/10 03:00
10I5343-DUP1										
Total Volatile Solids	71300	70500		mg/L	1	20	10I5343	NTI2395-01		09/30/10 11:31
10I5405-DUP1										
Carbonaceous BOD	555	565		mg/L	2	20	10I5405	NTI3064-02		10/05/10 16:46
10I5445-DUP1										
Hydroxide Alkalinity as CaCO3	ND	ND		mg/L		20	10I5445	NTI2395-01		09/30/10 22:37
10J0268-DUP1										
COD, Soluble	999	999		mg/L	0	10	10J0268	NTI2395-01		10/04/10 08:10
10J0268-DUP2										

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
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Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Duplicate - Cont.

Analyte	Orig. Val.	Duplicate	Q	Units	RPD	Limit	Batch	Sample Duplicated	% Rec.	Analyzed Date/Time
General Chemistry Parameters										
10J0268-DUP2										
COD, Soluble	116000	98100	R2	mg/L	16	10	10J0268	NTI2395-01RE1		10/04/10 08:10
10J0269-DUP1										
Chemical Oxygen Demand	36.3	36.3		mg/L	0	10	10J0269	NTI3064-03RE1		10/04/10 08:10
10J0551-DUP1										
Total Organic Carbon	0.750	0.797		mg/L	6	20	10J0551	NTI2840-08		10/06/10 01:02
10J0620-DUP1										
Phosphorus	0.137	ND		mg/L		20	10J0620	NTJ0386-02		10/06/10 14:38
10J0630-DUP1										
Total Kjeldahl Nitrogen	ND	ND		mg/L		46	10J0630	NTJ0386-02		10/06/10 16:19
10J1126-DUP1										
Ammonia as N	5.88	5.49		mg/L	7	41	10J1126	NTI2762-01		10/07/10 16:27
10J1184-DUP1										
Total Inorganic Carbon	732	738		mg/L	0.7	20	10J1184	NTI2395-01		10/11/10 12:44
10J1234-DUP1										
Acidity	44.0	48.0		mg/L	9	10	10J1234	NTI2395-01		10/07/10 10:38
General Chemistry Parameters - Dissolved										
10I4704-DUP1										
Silica (SiO2)	7.83	8.09		mg/L	3	10	10I4704	NTI2497-01		09/28/10 10:47
10J0020-DUP1										
Sulfide	36.6	37.0		mg/L	1	10	10J0020	NTI2395-01		10/01/10 14:20

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Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
LCS

Analyte	Known Val.	Analyzed Val	Q	Units	% Rec.	Target Range	Batch	Analyzed Date/Time
General Chemistry Parameters								
10I4188-BS1								
Nitrate as N	6.00	6.16		mg/L	103%	90 - 110	10I4188	09/24/10 20:57
10I4270-BS1								
Fluoride	2.00	2.11		mg/L	105%	90 - 110	10I4270	09/28/10 18:59
10I4270-BS2								
Fluoride	2.00	1.98		mg/L	99%	90 - 110	10I4270	09/30/10 05:15
10I4274-BS1								
Orthophosphate as P	0.250	0.226		mg/L	90%	90 - 110	10I4274	10/05/10 15:29
10I4412-BS1								
Sulfide	20.0	19.7		mg/L	98%	90 - 110	10I4412	09/28/10 15:30
10I4677-BS1								
Sulfate	10.0	10.1		mg/L	101%	90 - 110	10I4677	09/27/10 18:10
10I5334-BS1								
Total Solids	100	99.0		ug/mL	99%	90 - 110	10I5334	09/30/10 22:43
10I5336-BS1								
Total Suspended Solids	100	94.0		mg/L	94%	90 - 110	10I5336	10/01/10 03:00
10I5337-BS1								
Total Dissolved Solids	100	98.0		ug/mL	98%	90 - 110	10I5337	09/30/10 10:40
10I5340-BS1								
10I5343-BS1								
Total Volatile Solids	100	92.0		ug/mL	92%	80 - 120	10I5343	09/30/10 11:31
10I5405-BS1								
Carbonaceous BOD	198	166	L2	mg/L	84%	85 - 115	10I5405	10/05/10 16:46
Carbonaceous BOD	198	166	L2	ug/mL	84%	85 - 115	10I5405	10/05/10 16:46
10J0268-BS1								
COD, Soluble	300	298		mg/L	99%	90 - 110	10J0268	10/04/10 08:10
10J0269-BS1								
Chemical Oxygen Demand	20.0	21.2		mg/L	106%	90 - 110	10J0269	10/04/10 08:10
10J0551-BS1								
Total Organic Carbon	10.0	10.2		mg/L	102%	90 - 110	10J0551	10/06/10 01:02

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
LCS - Cont.

Analyte	Known Val.	Analyzed Val	Q	Units	% Rec.	Target Range	Batch	Analyzed Date/Time
General Chemistry Parameters								
10J0620-BS1								
Phosphorus	2.00	1.88		mg/L	94%	90 - 110	10J0620	10/06/10 14:31
10J0630-BS1								
Total Kjeldahl Nitrogen	2.50	2.68		mg/L	107%	90 - 110	10J0630	10/06/10 16:15
10J1126-BS1								
Ammonia as N	5.00	5.03		mg/L	101%	90 - 110	10J1126	10/07/10 16:25
10J1184-BS1								
Total Inorganic Carbon	10.0	10.2	MNR	mg/L	102%	90 - 110	10J1184	10/11/10 12:44
10J1234-BS1								
Acidity	100	92.0		ug/mL	92%	90 - 110	10J1234	10/07/10 10:38
General Chemistry Parameters - Dissolved								
10I4704-BS1								
Silica (SiO2)	2.00	2.00		mg/L	100%	90 - 110	10I4704	09/28/10 10:47
10J0020-BS1								
Sulfide	20.0	20.0		mg/L	100%	90 - 110	10J0020	10/01/10 14:20
Total Metals by EPA Method 6010B								
10I4625-BS1								
Aluminum	2.00	2.04		mg/L	102%	80 - 120	10I4625	09/28/10 21:02
Barium	2.00	2.02		mg/L	101%	80 - 120	10I4625	09/28/10 21:02
Cadmium	0.0500	0.0515		mg/L	103%	80 - 120	10I4625	09/28/10 21:02
Calcium	5.00	5.03		mg/L	101%	80 - 120	10I4625	09/28/10 21:02
Chromium	0.200	0.198		mg/L	99%	80 - 120	10I4625	09/28/10 21:02
Copper	0.250	0.246		mg/L	98%	80 - 120	10I4625	09/28/10 21:02
Iron	1.00	1.03		mg/L	103%	80 - 120	10I4625	09/28/10 21:02
Lead	0.0500	0.0515		mg/L	103%	80 - 120	10I4625	09/28/10 21:02
Magnesium	5.00	5.24		mg/L	105%	80 - 120	10I4625	09/28/10 21:02
Manganese	0.500	0.502		mg/L	100%	80 - 120	10I4625	09/28/10 21:02
Potassium	5.00	4.77		mg/L	95%	80 - 120	10I4625	09/28/10 21:02
Sodium	5.00	4.86		mg/L	97%	80 - 120	10I4625	09/28/10 21:02
Strontium	1.00	1.01		mg/L	101%	80 - 120	10I4625	09/28/10 21:02

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Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
LCS Dup

Analyte	Orig. Val.	Duplicate	Q	Units	Spike Conc	% Rec.	Target Range	RPD	Limit	Batch	Sample Duplicated	Analyzed Date/Time
General Chemistry Parameters												
10I4188-BSD1												
Nitrate as N		6.16		mg/L	6.00	103%	90 - 110	0	20	10I4188		09/24/10 20:57
10I4270-BSD1												
Fluoride		1.98		mg/L	2.00	99%	90 - 110	6	20	10I4270		09/28/10 19:17
10I4270-BSD2												
Fluoride		2.00		mg/L	2.00	100%	90 - 110	0.8	20	10I4270		09/30/10 05:33
Total Metals by EPA Method 6010B												
10I4625-BSD1												
Aluminum		2.03		mg/L	2.00	102%	80 - 120	0.1	20	10I4625		09/28/10 22:02
Barium		2.06		mg/L	2.00	103%	80 - 120	2	20	10I4625		09/28/10 22:02
Cadmium		0.0506		mg/L	0.0500	101%	80 - 120	2	20	10I4625		09/28/10 22:02
Calcium		4.88		mg/L	5.00	98%	80 - 120	3	20	10I4625		09/28/10 22:02
Chromium		0.194		mg/L	0.200	97%	80 - 120	2	20	10I4625		09/28/10 22:02
Copper		0.249		mg/L	0.250	100%	80 - 120	1	20	10I4625		09/28/10 22:02
Iron		1.02		mg/L	1.00	102%	80 - 120	1	20	10I4625		09/28/10 22:02
Lead		0.0518		mg/L	0.0500	104%	80 - 120	0.6	20	10I4625		09/28/10 22:02
Magnesium		5.01		mg/L	5.00	100%	80 - 120	4	20	10I4625		09/28/10 22:02
Manganese		0.500		mg/L	0.500	100%	80 - 120	0.4	20	10I4625		09/28/10 22:02
Potassium		4.86		mg/L	5.00	97%	80 - 120	2	20	10I4625		09/28/10 22:02
Sodium		4.89		mg/L	5.00	98%	80 - 120	0.6	20	10I4625		09/28/10 22:02
Strontium		1.01		mg/L	1.00	101%	80 - 120	0.4	20	10I4625		09/28/10 22:02

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PROJECT QUALITY CONTROL DATA
Matrix Spike

Analyte	Orig. Val.	MS Val	Q	Units	Spike Conc	% Rec.	Target Range	Batch	Sample Spiked	Analyzed Date/Time
General Chemistry Parameters										
10I4188-MS1										
Nitrate as N	ND	6.09		mg/L	6.00	101%	90 - 110	10I4188	NTI2340-03	09/24/10 21:03
10I4270-MS1										
Fluoride	ND	1.89		mg/L	2.00	95%	80 - 120	10I4270	NTI1687-08	09/28/10 21:40
10I4274-MS1										
Orthophosphate as P	ND	0.296		mg/L	0.250	118%	74 - 128	10I4274	NTI2447-01	10/05/10 15:29
10I4412-MS1										
Sulfide	ND	19.1		mg/L	20.0	96%	70 - 130	10I4412	NTI2395-01	09/28/10 15:30
10I4677-MS1										
Sulfate	ND	10.7		mg/L	10.0	107%	80 - 120	10I4677	NTI2319-05	09/27/10 18:10
10J0268-MS1										
COD, Soluble	999	1110	E, M3	mg/L	333	33%	90 - 110	10J0268	NTI2395-01	10/04/10 08:10
10J0269-MS1										
Chemical Oxygen Demand	999	1110	E, M3	mg/L	55.6	200%	90 - 110	10J0269	NTI3064-01	10/04/10 08:10
10J0551-MS1										
Total Organic Carbon	ND	19.2		mg/L	20.0	96%	66 - 135	10J0551	NTI3053-01	10/06/10 01:02
10J0620-MS1										
Phosphorus	1.41	3.10		mg/L	2.00	84%	66 - 121	10J0620	NTI2788-01	10/06/10 14:33
10J0630-MS1										
Total Kjeldahl Nitrogen	1.28	4.28	M7	mg/L	2.50	120%	90 - 110	10J0630	NTI2930-01	10/06/10 16:22
10J1126-MS1										
Ammonia as N	0.218	5.28		mg/L	5.00	101%	90 - 110	10J1126	NTI2738-04	10/07/10 16:34
General Chemistry Parameters - Dissolved										
10I4704-MS1										
Silica (SiO2)	7.83	ND	M4	mg/L	2.00	-391%	80 - 120	10I4704	NTI2497-01	09/28/10 10:47
10J0020-MS1										
Sulfide	36.6	45.8	M8	mg/L	20.0	46%	70 - 130	10J0020	NTI2395-01	10/01/10 14:20
Total Metals by EPA Method 6010B										
10I4625-MS1										

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Matrix Spike - Cont.

Analyte	Orig. Val.	MS Val	Q	Units	Spike Conc	% Rec.	Target Range	Batch	Sample Spiked	Analyzed Date/Time
Total Metals by EPA Method 6010B										
10I4625-MS1										
Aluminum	8.10	8.66	MHA	mg/L	2.00	28%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Barium	0.861	2.78		mg/L	2.00	96%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Cadmium	0.00460	0.0523		mg/L	0.0500	95%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Calcium	234	232	MHA	mg/L	5.00	-38%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Chromium	0.0928	0.264		mg/L	0.200	86%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Copper	0.903	1.04	MHA	mg/L	0.250	55%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Iron	41.7	37.3	MHA	mg/L	1.00	-440%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Lead	0.124	0.164		mg/L	0.0500	81%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Magnesium	40.9	43.5	MHA	mg/L	5.00	52%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Manganese	0.872	1.31		mg/L	0.500	88%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Potassium	66.4	70.2		mg/L	5.00	75%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Sodium	39.7	43.5		mg/L	5.00	76%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11
Strontium	0.398	1.36		mg/L	1.00	97%	75 - 125	10I4625	NTI2556-01	09/28/10 22:11

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
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PROJECT QUALITY CONTROL DATA
Matrix Spike Dup

Analyte	Orig. Val.	Duplicate	Q	Units	Spike Conc	% Rec.	Target Range	RPD	Limit	Batch	Sample Duplicated	Analyzed Date/Time
General Chemistry Parameters												
10I4188-MSD1												
Nitrate as N	ND	6.09		mg/L	6.00	102%	90 - 110	0.1	20	10I4188	NTI2340-03	09/24/10 21:04
10I4270-MSD1												
Fluoride	ND	1.96		mg/L	2.00	98%	80 - 120	4	20	10I4270	NTI1687-08	09/28/10 21:58
10I4274-MSD1												
Orthophosphate as P	ND	0.298		mg/L	0.250	119%	74 - 128	0.8	20	10I4274	NTI2447-01	10/05/10 15:29
10I4412-MSD1												
Sulfide	ND	19.0		mg/L	20.0	95%	70 - 130	0.5	10	10I4412	NTI2395-01	09/28/10 15:30
10I4677-MSD1												
Sulfate	ND	10.8		mg/L	10.0	108%	80 - 120	0.4	10	10I4677	NTI2319-05	09/27/10 18:10
10J0551-MSD1												
Total Organic Carbon	ND	19.1		mg/L	20.0	95%	66 - 135	0.7	20	10J0551	NTI3053-01	10/06/10 01:02
10J0620-MSD1												
Phosphorus	1.41	3.45		mg/L	2.00	102%	66 - 121	11	20	10J0620	NTI2788-01	10/06/10 14:34
10J0630-MSD1												
Total Kjeldahl Nitrogen	1.28	4.38	M7	mg/L	2.50	124%	90 - 110	2	46	10J0630	NTI2930-01	10/06/10 16:23
10J1126-MSD1												
Ammonia as N	0.218	5.70		mg/L	5.00	110%	90 - 110	8	41	10J1126	NTI2738-04	10/07/10 16:35
General Chemistry Parameters - Dissolved												
10I4704-MSD1												
Silica (SiO2)	7.83	ND	M4	mg/L	2.00	-391%	80 - 120		10	10I4704	NTI2497-01	09/28/10 10:47
10J0020-MSD1												
Sulfide	36.6	46.6	M8	mg/L	20.0	50%	70 - 130	2	10	10J0020	NTI2395-01	10/01/10 14:20
Total Metals by EPA Method 6010B												
10I4625-MSD1												
Aluminum	8.10	9.17	MHA	mg/L	2.00	53%	75 - 125	6	20	10I4625	NTI2556-01	09/28/10 22:15
Barium	0.861	2.76		mg/L	2.00	95%	75 - 125	0.6	20	10I4625	NTI2556-01	09/28/10 22:15
Cadmium	0.00460	0.0526		mg/L	0.0500	96%	75 - 125	0.6	20	10I4625	NTI2556-01	09/28/10 22:15
Calcium	234	240		mg/L	5.00	108%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15
Chromium	0.0928	0.271		mg/L	0.200	89%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15
Copper	0.903	1.05	MHA	mg/L	0.250	59%	75 - 125	1	20	10I4625	NTI2556-01	09/28/10 22:15

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA

Matrix Spike Dup - Cont.

Analyte	Orig. Val.	Duplicate	Q	Units	Spike Conc	% Rec.	Target Range	RPD	Limit	Batch	Sample Duplicated	Analyzed Date/Time
Total Metals by EPA Method 6010B												
10I4625-MSD1												
Iron	41.7	38.9	MHA	mg/L	1.00	-278%	75 - 125	4	20	10I4625	NTI2556-01	09/28/10 22:15
Lead	0.124	0.164		mg/L	0.0500	81%	75 - 125	0.06	20	10I4625	NTI2556-01	09/28/10 22:15
Magnesium	40.9	45.0		mg/L	5.00	82%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15
Manganese	0.872	1.34		mg/L	0.500	93%	75 - 125	2	20	10I4625	NTI2556-01	09/28/10 22:15
Potassium	66.4	72.2		mg/L	5.00	117%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15
Sodium	39.7	42.4	MHA	mg/L	5.00	55%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15
Strontium	0.398	1.40		mg/L	1.00	100%	75 - 125	3	20	10I4625	NTI2556-01	09/28/10 22:15

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	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

CERTIFICATION SUMMARY

TestAmerica Nashville

Method	Matrix	AIHA	Nelac	Tennessee
EPA 160.4	Water	N/A	X	
EPA 350.1M	Water	N/A	X	
EPA 351.2	Water	N/A	X	
EPA 353.2	Water	N/A	X	N/A
EPA 365.4	Water	N/A	X	
EPA 410.4	Water	N/A	X	
SM 2340B	Water	N/A	X	
SM 4500-S2 F	Water			
SM 5210B	Water	N/A	X	N/A
SM2310 B	Water		X	
SM2320 B	Water		X	
SM2540 B	Water		X	
SM2540 C	Water	N/A	X	
SM2540 D	Water		X	
SM2540 E	Water			
SM4500-P E	Water		X	
SM4500-S2 F	Water		X	
SM4500-SiO2 C	Water		X	
SW846 6010B	Water	N/A	X	N/A
SW846 9038	Water	N/A	X	N/A
SW846 9056	Water	N/A	X	N/A
SW846 9060A	Water		X	
SW846 9060	Water	N/A	X	

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

DATA QUALIFIERS AND DEFINITIONS

A-01	Soluble CBOD Analysis
E	Concentration exceeds the calibration range and therefore result is semi-quantitative.
H	Sample analysis performed past method-specified holding time.
L2	Laboratory Control Sample and/or Laboratory Control Sample Duplicate recovery was below acceptance limits.
M3	Results exceeded the linear range in the MS/MSD and therefore are not available for reporting. The batch was accepted based on acceptable recovery in the Blank Spike (LCS).
M4	The MS/MSD required a dilution due to matrix interference. Because of this dilution, the matrix spike concentrations in the sample were reduced to a level where the recovery calculation does not provide useful information. See Blank Spike (LCS).
M7	The MS and/or MSD were above the acceptance limits. See Blank Spike (LCS).
M8	The MS and/or MSD were below the acceptance limits. See Blank Spike (LCS).
MHA	Due to high levels of analyte in the sample, the MS/MSD calculation does not provide useful spike recovery information. See Blank Spike (LCS).
MNR	No results were reported for the MS/MSD. The sample used for the MS/MSD required dilution due to the sample matrix. Because of this, the spike compounds were diluted below the detection limit.
R2	The RPD exceeded the acceptance limit.
RL1	Reporting limit raised due to sample matrix effects.
ND	Not detected at the reporting limit (or method detection limit if shown)

METHOD MODIFICATION NOTES

350.1 M - M = Ammonia-Nitrogen method modified for midi-distillation with Lachat Procedure 10-107-06-1-A.

COD 410.4 M - M = COD method modified for use of Hach method 8000.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
Nashville, TN

COOLER R

NTI2395

Cooler Received/Opened On: 9/23/2010 @ 11:32

Route Tracking number_____

IR Gun ID: 9560068

1. Temperature of rep. sample or temp blank when opened: 14.0 *Degrees Celsius*
3. If Item #2 temperature is 0°C or less, was the representative sample or temp blank frozen? YES NO...NA
4. Were custody seals on outside of cooler? YES...NO...NA

   If yes, how many and where:_____
5. Were the seals intact, signed, and dated correctly? YES...NO...NA
6. Were custody papers inside cooler? YES...NO...NA

I certify that I opened the cooler and answered questions 1-6 (intial) _____

7. Were custody seals on containers: YES NO and Intact YES...NO...NA

   Were these signed and dated correctly? YES...NO...NA
8. Packing mat'l used? Bubblewrap Plastic bag Peanuts Vermiculite Foam Insert Paper Other None
9. Cooling process: Ice Ice-pack Ice (direct contact) Dry ice Other None
10. Did all containers arrive in good condition (unbroken)? YES...NO...NA
11. Were all container labels complete (#, date, signed, pres., etc)? YES...NO...NA
12. Did all container labels and tags agree with custody papers? YES...NO...NA

13a. Were VOA vials received? YES...NO...NA

   b. Was there any observable headspace present in any VOA vial? YES...NO...NA

14. Was there a Trip Blank in this cooler? YES...NO...NA If multiple coolers, sequence #_____

I certify that I unloaded the cooler and answered questions 7-14 (intial) _____

15a. On pres'd bottles, did pH test strips suggest preservation reached the correct pH level? YES...NO...NA

   b. Did the bottle labels indicate that the correct preservatives were used YES...NO...NA

16. Was residual chlorine present? YES...NO...NA

I certify that I checked for chlorine and pH as per SOP and answered questions 15-16 (intial) _____

17. Were custody papers properly filled out (ink, signed, etc)? YES...NO...NA
18. Did you sign the custody papers in the appropriate place? YES...NO...NA
19. Were correct containers used for the analysis requested? YES...NO...NA
20. Was sufficient amount of sample sent in each container? YES...NO...NA

I certify that I entered this project into LIMS and answered questions 17-20 (intial) _____

I certify that I attached a label with the unique LIMS number to each container (intial) _____

21. Were there Non-Conformance issues at login? YES...NO Was a PIPE generated? YES...NO...#_____

BIS = Broken in shipment

Brown and Caldwell Chain of Custody Record

2169

Ship to:
Brown and Caldwell
501 Great Circle Road
Suite 150
Nashville, TN 37228
Attn: Treatability Laboratory
(615) 255-2288 (phone)
(615) 256-8332 (fax)

Send Results to:
Name Thomas Steinwinder
Company Brown and Caldwell
Address 501 Great Circle Rd, Ste 150
City,State,Zip Nashville, TN 37228
Phone 615-250-1268
Fax 615-256-8332
E-mail tsteinwinder@brwncald.com

Send Invoice To:
Name Same as results
Company
Address
City,State,Zip
Phone
Fax
E-mail

Details:
Page 1 of 1
Cooler No. 1 of 1
Date Shipped 9/23/10
Shipped By MM
Turnaround 5 day

Project No./Name Harris NREL Eval 139646

Samplers (Signature)* Michael E Merrill

NTI2395

10/07/10 23:59

Lab Use Only Lab #	Date Sampled	Time	Comp./ Grab	Sample Location/Description	Sample Matrix	ANALYSIS REQUIRED	No. Bottles	Containers/Pres.
	9/23/10	0800	G	NREL	WW	see attached Test America Quote *	4	4 oz

Sample Kit Prep'd by: (Signature)	Date/Time	Received By: (Signature)
Relinquished by: (Signature) Michael E Merrill	Date/Time 9/23/10 0925	Received By: (Signature)
Relinquished by: (Signature)	Date/Time	Received By: (Signature) 9/23/10 1132
Received for Laboratory by: (Signature)	Date/Time 9/23/10 1132	*Work Order No. / Temp.(°C)*

REMARKS
*Signature required to ensure validity

* Please ensure that the quoted analyses on the attached quote include the following:
Al, Ba, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Na, Sr, S:O_2 (diss), SO_4, Sulfide, NO_3-N, F,

Lab Use Only	14.0		
VOA Headspace	Y	N	NA
Field Filtered	Y	N	NA
Correct Containers	Y	N	NA
Discrepancies	Y	N	NA
Cust. Seals intact	Y	N	NA
Containers Intact	Y	N	NA

Airbill # _____

CAR # _____

Distribution: Original and yellow copies accompany sample shipment to laboratory; Pink retained by samplers.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
2960 Foster Creighton Drive · Nashville, TN 37204 · (800) 765-0980· FAX (615) 726-3404

Analytical Services Quotation

Brown & Caldwell (3376)
Brown Caldwell SP

Printed: 4/8/10
Effective: 09/08/08
Expires: 09/30/10

TestAmerica is pleased to extend the following prices for analytical services according to the terms and conditions below.
(please reference quote name/number on COC to insure correct pricing)

Parameter	Method	Qty	Rush	Unit Price	Extended Price
Water					
Acidity SM2310 B	SM2310 B	1	5	$25.00	$25.00
Alkalinity Total SM2320 B	SM2320 B	1	5	$15.00	$15.00
Ammonia 350.1	EPA 350.1M	1	5	$20.00	$20.00
CBOD SM5210B	SM 5210B	1	5	$30.00	$30.00
CBOD Soluble SM5210B	SM 5210B	1	5	$30.00	$30.00
COD EPA 410.4	EPA 410.4	1	5	$20.00	$20.00
COD Soluble 410.4	EPA 410.4	1	5	$20.00	$20.00
Fluoride IC SW846 9056	SW846 9056	1	5	$20.00	$20.00
Hardness, Calculation by 6010B	varies	1	5	$25.00	$25.00
ICP Metals Each	varies	1	5	$20.00	$20.00
ICP MS Metals Each 6020	varies		5	$30.00	
Inorganic Carbon, Total 9060	SW846 9060	1	5	$35.00	$35.00
Nitrate N, 353.2	EPA 353.2	1	5	$20.00	$20.00
Phosphorus Total 365.4	EPA 365.4	1	5	$20.00	$20.00
Phosphorus, Ortho SM4500-P E	SM4500-P E	1	5	$35.00	$35.00
Project metals, (13) 6010	varies	1	5	$100.00	$100.00
Silica Dissolved SM4500-SiO2 C	SM4500-SiO2 C	1	5	$30.00	$30.00
Solids Dissolved SM2540 C (TDS)	SM2540 C	1	5	$15.00	$15.00
Solids Suspended SM2540 D	SM2540 D	1	5	$15.00	$15.00
Solids Suspended Volatile SM2540 E	SM2540 E	1	5	$15.00	$15.00
Solids Total SM2540 B	SM2540 B		5	$15.00	
Solids Volatile 160.4	EPA 160.4		5	$15.00	
Sulfate Turbidimetric 9038	SW846 9038	1	5	$20.00	$20.00
Sulfate Turbidimetric, ASTM D516-90	ASTM D516-90		5	$20.00	
Sulfide Dissolved SM 4500-S2 F	SM 4500-S2 F		5	$20.00	
Sulfide SM4500-S2 D	SM4500-S2 D		5	$20.00	
Sulfide SM4500-S2 F	SM4500-S2 F		5	$20.00	
Sulfide SW846 9030B/9034	SW846 9030B/9034	1	5	$20.00	$20.00
TKN 351.2	EPA 351.2	1	5	$40.00	$40.00
TOC 9060A	SW846 9060A	1	5	$40.00	$40.00
				Bid Total:	**$630.00**

Additional Charges

Description	ItemType	Quantity	Price	Rate	ItemTotal
Level 4 Data Package-15%	Percent	0	$ 0.00	15.00%	$ 0.00
Encore each 3 per sample/analysis	Standard	0	$ 10.00		$ 0.00
Minimum Charge	Standard	0	$ 100.00		$ 0.00
Send invoice hard copy	Standard	0	$ 0.00		$ 0.00
Terracore each	Standard	0	$ 10.00		$ 0.00

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

December 01, 2010 11:02:49AM

Client: Brown & Caldwell (3376)
501 Great Circle Road, Suite 150
Nashville, TN 37228
Attn: Thomas R Steinwinder

Work Order: NTI2395
Project Name: Harris NREL Eval
Project Nbr: 139646
P/O Nbr:
Date Received: 09/23/10

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
DRAFT: NREL	NTI2395-01	09/23/10 08:00

An executed copy of the chain of custody, the project quality control data, and the sample receipt form are also included as an addendum to this report. If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-765-0980. Any opinions, if expressed, are outside the scope of the Laboratory's accreditation.

Tennessee Certification Number: 02008

The Chain(s) of Custody, 3 pages, are included and are an integral part of this report.

All solids results are reported in wet weight unless specifically stated.
Estimated uncertainty is available upon request.

Report Approved By:

DRAFT REPORT

DATA SUBJECT TO CHANGE

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

2960 Foster Creighton Road Nashville, TN 37204 * 800-765-0980 * Fax 615-726-3404

Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

ANALYTICAL REPORT

Analyte	Result	Flag	Units	MDL	MRL	Dilution Factor	Analysis Date/Time	Method	Batch
Sample ID: NTI2395-01 (DRAFT: NREL - Waste Water) Sampled: 09/23/10 08:00									
DRAFT: General Chemistry Parameters									
Fluoride	**40.0**	H, J	mg/L	30.0	100	1000	11/12/10 13:37	SM4500-F C	10K2676
Fluoride	ND	RL1	mg/L	300	1000	10000	09/28/10 19:35	SW846 9056	10I4270
Sulfate	ND		mg/L	0.600	1.00	1	09/27/10 18:10	SW846 9038	10I4677
Sulfate	**5600**	H2	mg/L	300	500	500	11/24/10 17:25	ASTM D516-90	10K1153

TestAmerica
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Client	Brown & Caldwell (3376)	Work Order:	NTI2395
	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Blank

Analyte	Blank Value	Q	Units	Q.C. Batch	Lab Number	Analyzed Date/Time
DRAFT: General Chemistry Parameters						
10I4270-BLK1						
Fluoride	<0.0300		mg/L	10I4270	10I4270-BLK1	09/28/10 18:41
10I4270-BLK2						
Fluoride	<0.0300		mg/L	10I4270	10I4270-BLK2	09/30/10 04:57
10I4677-BLK1						
Sulfate	<0.600		mg/L	10I4677	10I4677-BLK1	09/27/10 18:10
10K1153-BLK3						
Sulfate	<0.600		mg/L	10K1153	10K1153-BLK3	11/24/10 17:25
10K2676-BLK1						
Fluoride	<0.0300		mg/L	10K2676	10K2676-BLK1	11/12/10 13:37

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Duplicate

Analyte	Orig. Val.	Duplicate	Q	Units	RPD	Limit	Batch	Sample Duplicated	% Rec.	Analyzed Date/Time
DRAFT: General Chemistry Parameters										
10I4270-DUP1										
Fluoride	ND	<300		mg/L		20	10I4270	NTI2395-01		09/28/10 19:53
10I4270-DUP2										
Fluoride	ND	<0.600		mg/L		20	10I4270	NTI1827-04RE1		09/30/10 07:02
10I4677-DUP1										
Sulfate	ND	<0.600		mg/L		10	10I4677	NTI2319-06		09/27/10 18:10
10K1153-DUP1										
Sulfate	0.610	0.780	J	mg/L	24	10	10K1153	NTJ3326-01		11/06/10 11:01
10K2676-DUP1										
Fluoride	40.0	40.0	J	mg/L	0	20	10K2676	NTI2395-01		11/12/10 13:37

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
LCS

Analyte	Known Val.	Analyzed Val	Q	Units	% Rec.	Target Range	Batch	Analyzed Date/Time
DRAFT: General Chemistry Parameters								
10I4270-BS1								
Fluoride	2.00	2.11		mg/L	105%	90 - 110	10I4270	09/28/10 18:59
10I4270-BS2								
Fluoride	2.00	1.98		mg/L	99%	90 - 110	10I4270	09/30/10 05:15
10I4677-BS1								
Sulfate	10.0	10.1		mg/L	101%	90 - 110	10I4677	09/27/10 18:10
10K1153-BS3								
Sulfate	10.0	10.9		mg/L	109%	90 - 110	10K1153	11/24/10 17:25
10K2676-BS1								
Fluoride	1.00	0.950		mg/L	95%	90 - 110	10K2676	11/12/10 13:37

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
LCS Dup

Analyte	Orig. Val.	Duplicate	Q	Units	Spike Conc	% Rec.	Target Range	RPD	Limit	Batch	Sample Duplicated	Analyzed Date/Time
DRAFT: General Chemistry Parameters												
10I4270-BSD1												
Fluoride		1.98		mg/L	2.00	99%	90 - 110	6	20	10I4270		09/28/10 19:17
10I4270-BSD2												
Fluoride		2.00		mg/L	2.00	100%	90 - 110	0.8	20	10I4270		09/30/10 05:33
10K2676-BSD1												
Fluoride		0.950		mg/L	1.00	95%	90 - 110	0	20	10K2676		11/12/10 13:37

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	501 Great Circle Road, Suite 150	Project Name:	Harris NREL Eval
	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA
Matrix Spike

Analyte	Orig. Val.	MS Val	Q	Units	Spike Conc	% Rec.	Target Range	Batch	Sample Spiked	Analyzed Date/Time
DRAFT: General Chemistry Parameters										
10I4270-MS1										
Fluoride	ND	1.89		mg/L	2.00	95%	80 - 120	10I4270	NTI1687-08	09/28/10 21:40
10I4677-MS1										
Sulfate	ND	10.7		mg/L	10.0	107%	80 - 120	10I4677	NTI2319-05	09/27/10 18:10
10K2676-MS1										
Fluoride	ND	0.370	M4	mg/L	1.00	37%	80 - 120	10K2676	NTJ2916-02	11/12/10 13:37

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Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

PROJECT QUALITY CONTROL DATA

Matrix Spike Dup

Analyte	Orig. Val.	Duplicate	Q	Units	Spike Conc	% Rec.	Target Range	RPD	Limit	Batch	Sample Duplicated	Analyzed Date/Time
DRAFT: General Chemistry Parameters												
10I4270-MSD1												
Fluoride	ND	1.96		mg/L	2.00	98%	80 - 120	4	20	10I4270	NTI1687-08	09/28/10 21:58
10I4677-MSD1												
Sulfate	ND	10.8		mg/L	10.0	108%	80 - 120	0.4	10	10I4677	NTI2319-05	09/27/10 18:10
10K2676-MSD1												
Fluoride	ND	0.390	M4	mg/L	1.00	39%	80 - 120	5	20	10K2676	NTJ2916-02	11/12/10 13:37

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	Nashville, TN 37228	Project Number:	139646
Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

CERTIFICATION SUMMARY

TestAmerica Nashville

Method	Matrix	AIHA	Nelac	Tennessee
ASTM D516-90	Water	N/A	X	
SM4500-F C	Water		X	
SW846 9038	Water	N/A	X	N/A
SW846 9056	Water	N/A	X	N/A

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THE LEADER IN ENVIRONMENTAL TESTING

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Attn	Thomas R Steinwinder	Received:	09/23/10 11:32

DATA QUALIFIERS AND DEFINITIONS

H	Sample analysis performed past method-specified holding time.
H2	Initial analysis within holding time. Reanalysis for the required dilution or confirmation was past holding time.
J	Analyte detected at a level less than the Reporting Limit (RL) and greater than or equal to the Method Detection Limit (MDL). Concentrations within this range are estimated.
M4	The MS/MSD required a dilution due to matrix interference. Because of this dilution, the matrix spike concentrations in the sample were reduced to a level where the recovery calculation does not provide useful information. See Blank Spike (LCS).
RL1	Reporting limit raised due to sample matrix effects.
ND	Not detected at the reporting limit (or method detection limit if shown)

METHOD MODIFICATION NOTES

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
Nashville, TN

COOLER R

NTI2395

Cooler Received/Opened On: 9/23/2010 @ 11:32

Route Tracking number_____

IR Gun ID: 9560068

1. Temperature of rep. sample or temp blank when opened: 14.0 *Degrees Celsius*
3. If Item #2 temperature is 0°C or less, was the representative sample or temp blank frozen? YES NO...NA
4. Were custody seals on outside of cooler? YES...NO...NA

   If yes, how many and where:_____
5. Were the seals intact, signed, and dated correctly? YES...NO...NA
6. Were custody papers inside cooler? YES...NO...NA

I certify that I opened the cooler and answered questions 1-6 (intial) _____

7. Were custody seals on containers: YES NO and Intact YES...NO...NA

   Were these signed and dated correctly? YES...NO...NA
8. Packing mat'l used? Bubblewrap Plastic bag Peanuts Vermiculite Foam Insert Paper Other None
9. Cooling process: Ice Ice-pack Ice (direct contact) Dry ice Other None
10. Did all containers arrive in good condition (unbroken)? YES...NO...NA
11. Were all container labels complete (#, date, signed, pres., etc)? YES...NO...NA
12. Did all container labels and tags agree with custody papers? YES...NO...NA

13a. Were VOA vials received? YES...NO...NA

   b. Was there any observable headspace present in any VOA vial? YES...NO...NA

14. Was there a Trip Blank in this cooler? YES...NO...NA If multiple coolers, sequence #_____

I certify that I unloaded the cooler and answered questions 7-14 (intial) _____

15a. On pres'd bottles, did pH test strips suggest preservation reached the correct pH level? YES...NO...NA

   b. Did the bottle labels indicate that the correct preservatives were used YES...NO...NA

16. Was residual chlorine present? YES...NO...NA

I certify that I checked for chlorine and pH as per SOP and answered questions 15-16 (intial) _____

17. Were custody papers properly filled out (ink, signed, etc)? YES...NO...NA
18. Did you sign the custody papers in the appropriate place? YES...NO...NA
19. Were correct containers used for the analysis requested? YES...NO...NA
20. Was sufficient amount of sample sent in each container? YES...NO...NA

I certify that I entered this project into LIMS and answered questions 17-20 (intial) _____

I certify that I attached a label with the unique LIMS number to each container (intial) _____

21. Were there Non-Conformance issues at login? YES...NO Was a PIPE generated? YES...NO...#_____

BIS = Broken in shipment

Brown and Caldwell Chain of Custody Record

2169

Ship to:
Brown and Caldwell
501 Great Circle Road
Suite 150
Nashville, TN 37228
Attn: Treatability Laboratory
(615) 255-2288 (phone)
(615) 256-8332 (fax)

Send Results to:
Name Thomas Steinwinder
Company Brown and Caldwell
Address 501 Great Circle Rd, Ste 150
City,State,Zip Nashville, TN 37228
Phone 615-250-1268
Fax 615-256-8332
E-mail tsteinwinder@brwncald.com

Send Invoice To:
Name Same as results
Company
Address
City,State,Zip
Phone
Fax
E-mail

Details:
Page 1 of 1
Cooler No. 1 of 1
Date Shipped 9/23/10
Shipped By MM
Turnaround 5 day

Project No./Name Harris NREL Eval 139646

Samplers (Signature)* Michael E Merrill

NTI2395

10/07/10 23:59

Lab Use Only Lab #	Date Sampled	Time	Comp./ Grab	Sample Location/Description	Sample Matrix	ANALYSIS REQUIRED	No. Bottles	Containers/Pres.
	9/23/10	0800	G	NREL	WW	see attached Test America Quote *	4	4 oz

Sample Kit Prep'd by: (Signature)	Date/Time	Received By: (Signature)
Relinquished by: (Signature) Michael E Merrill	Date/Time 9/23/10 0925	Received By: (Signature)
Relinquished by: (Signature)	Date/Time	Received By: (Signature) 9/23/10 1132
Received for Laboratory by: (Signature)	Date/Time 9/23/10 1132	*Work Order No. / Temp.(°C)*

REMARKS
*Signature required to ensure validity

* Please ensure that the quoted analyses on the attached quote include the following:
Al, Ba, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Na, Sr, S:O_2 (diss), SO_4, Sulfide, NO_3-N, F,

Lab Use Only	14.0		
VOA Headspace	Y	N	NA
Field Filtered	Y	N	NA
Correct Containers	Y	N	NA
Discrepancies	Y	N	NA
Cust. Seals intact	Y	N	NA
Containers Intact	Y	N	NA

Airbill # _____

CAR # _____

Distribution: Original and yellow copies accompany sample shipment to laboratory; Pink retained by samplers.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
2960 Foster Creighton Drive · Nashville, TN 37204 · (800) 765-0980· FAX (615) 726-3404

Analytical Services Quotation

Brown & Caldwell (3376)
Brown Caldwell SP

Printed: 4/8/10
Effective: 09/08/08
Expires: 09/30/10

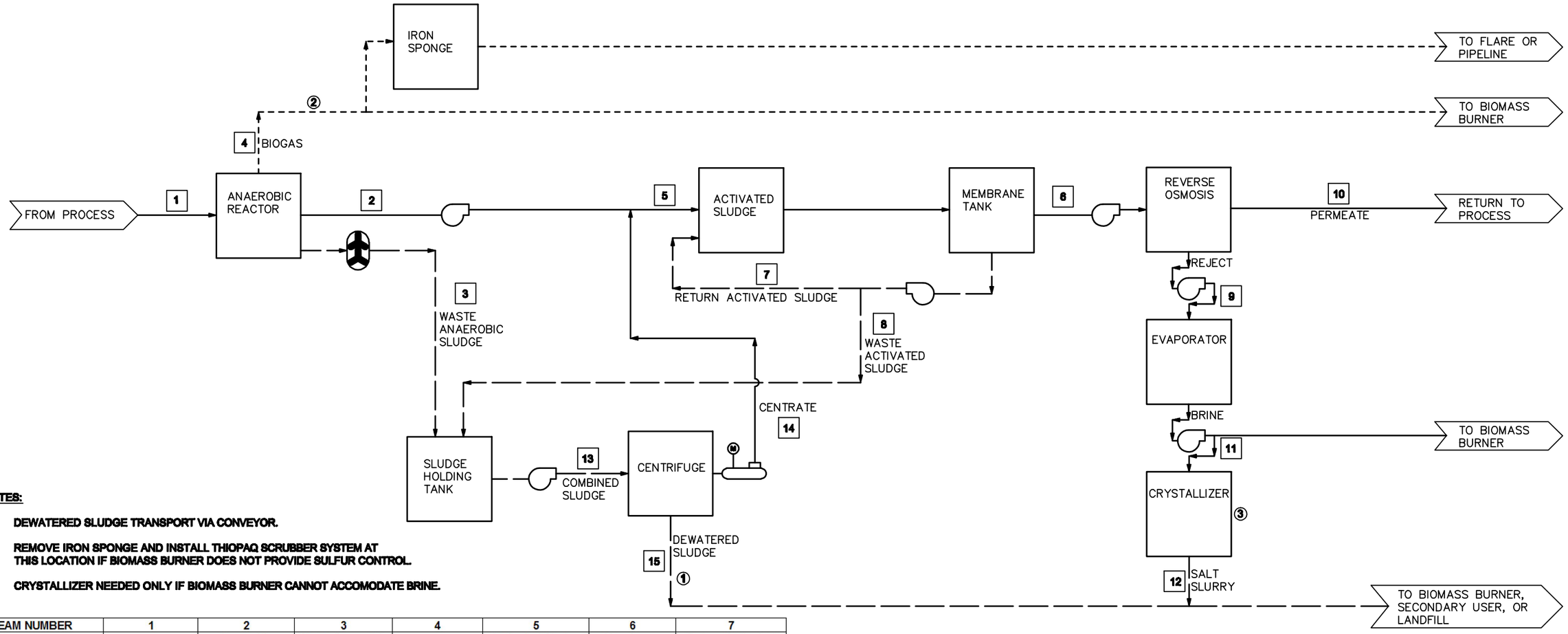
TestAmerica is pleased to extend the following prices for analytical services according to the terms and conditions below.
(please reference quote name/number on COC to insure correct pricing)

Parameter	Method	Qty	Rush	Unit Price	Extended Price
Water					
Acidity SM2310 B	SM2310 B	1	5	$25.00	$25.00
Alkalinity Total SM2320 B	SM2320 B	1	5	$15.00	$15.00
Ammonia 350.1	EPA 350.1M	1	5	$20.00	$20.00
CBOD SM5210B	SM 5210B	1	5	$30.00	$30.00
CBOD Soluble SM5210B	SM 5210B	1	5	$30.00	$30.00
COD EPA 410.4	EPA 410.4	1	5	$20.00	$20.00
COD Soluble 410.4	EPA 410.4	1	5	$20.00	$20.00
Fluoride IC SW846 9056	SW846 9056	1	5	$20.00	$20.00
Hardness, Calculation by 6010B	varies	1	5	$25.00	$25.00
ICP Metals Each	varies	1	5	$20.00	$20.00
ICP MS Metals Each 6020	varies		5	$30.00	
Inorganic Carbon, Total 9060	SW846 9060	1	5	$35.00	$35.00
Nitrate N, 353.2	EPA 353.2	1	5	$20.00	$20.00
Phosphorus Total 365.4	EPA 365.4	1	5	$20.00	$20.00
Phosphorus, Ortho SM4500-P E	SM4500-P E	1	5	$35.00	$35.00
Project metals, (13) 6010	varies	1	5	$100.00	$100.00
Silica Dissolved SM4500-SiO2 C	SM4500-SiO2 C	1	5	$30.00	$30.00
Solids Dissolved SM2540 C (TDS)	SM2540 C	1	5	$15.00	$15.00
Solids Suspended SM2540 D	SM2540 D	1	5	$15.00	$15.00
Solids Suspended Volatile SM2540 E	SM2540 E	1	5	$15.00	$15.00
Solids Total SM2540 B	SM2540 B		5	$15.00	
Solids Volatile 160.4	EPA 160.4		5	$15.00	
Sulfate Turbidimetric 9038	SW846 9038	1	5	$20.00	$20.00
Sulfate Turbidimetric, ASTM D516-90	ASTM D516-90		5	$20.00	
Sulfide Dissolved SM 4500-S2 F	SM 4500-S2 F		5	$20.00	
Sulfide SM4500-S2 D	SM4500-S2 D		5	$20.00	
Sulfide SM4500-S2 F	SM4500-S2 F		5	$20.00	
Sulfide SW846 9030B/9034	SW846 9030B/9034	1	5	$20.00	$20.00
TKN 351.2	EPA 351.2	1	5	$40.00	$40.00
TOC 9060A	SW846 9060A	1	5	$40.00	$40.00
				Bid Total:	**$630.00**

Additional Charges

Description	ItemType	Quantity	Price	Rate	ItemTotal
Level 4 Data Package-15%	Percent	0	$ 0.00	15.00%	$ 0.00
Encore each 3 per sample/analysis	Standard	0	$ 10.00		$ 0.00
Minimum Charge	Standard	0	$ 100.00		$ 0.00
Send invoice hard copy	Standard	0	$ 0.00		$ 0.00
Terracore each	Standard	0	$ 10.00		$ 0.00

Appendix B: Block Flow Diagrams (BFDs)



NOTES:

① **DEWATERED SLUDGE TRANSPORT VIA CONVEYOR.**

② **REMOVE IRON SPONGE AND INSTALL THIOPAQ SCRUBBER SYSTEM AT THIS LOCATION IF BIOMASS BURNER DOES NOT PROVIDE SULFUR CONTROL.**

③ **CRYSTALLIZER NEEDED ONLY IF BIOMASS BURNER CANNOT ACCOMODATE BRINE.**

STREAM NUMBER	1	2	3	4	5	6	7
STREAM NAME	Influent	Anaerobic Effluent	Waste Anaerobic Sludge	Biogas	Activated Sludge Influent	Membrane Tank Effluent	Return Activated Sludge
TEMPERATURE, °C	50	35	35	35	25	30	30
FLOW, MGD	2.15	1.86	0.20	133	2.48	2.00	12.4
SCOD, LBS/DAY	1,517,780	121,878	13,256	-	141,352	33,314	206,839
TSS, LBS/DAY	26,911	23,230	67,421	-	28,131	0	1,034,195
TDFS, LBS/DAY	176,411	159,839	16,572	-	211,207	171,590	1,017,472
DENSITY, LBS/GAL	8.38	8.34	8.47	0.006	8.34	8.34	8.34

STREAM NUMBER	8	9	10	11	12	13	14	15
STREAM NAME	Waste Activated Sludge	Reverse Osmosis Reject	Final Effluent	Evaporator Effluent	Crystallizer Effluent	Sludge Holding Tank Influent	Centrate	Dewatered Sludge
TEMPERATURE, °C	30	25	25	50	50	30	25	25
FLOW, MGD	0.48	0.40	1.60	0.040	0.0040	0.68	0.62	0.06
SCOD, LBS/DAY	8,054	33,314	0	33,314	33,314	21,310	19,474	1,836
TSS, LBS/DAY	40,295	0	0	-	-	107,715	4,901	102,814
TDFS, LBS/DAY	39,617	163,010	8,579	163,010	163,010	56,189	51,368	4,821
DENSITY, LBS/GAL	8.34	8.34	8.34	-	-	8.38	8.34	9.17

LIQUID STREAM ———
SOLID STREAM — —
BIOGAS - - - -

Brown AND Caldwell
NASHVILLE, TENNESSEE

SUBMITTED: _____ DATE: _____ (PROJECT MANAGER)
APPROVED: _____ DATE: _____ (BROWN AND CALDWELL)

DESIGNED: S. McGUIRE
DRAWN: S. McGUIRE
CHECKED: T. STEINWINDER
CHECKED: E. GILL
APPROVED:

EXTERNAL REFERENCE FILES: Xrefs/dwg

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
		FOR CONCEPTUAL DESIGN	SJM	01/17/11	TRB
		REVISED MASS BALANCE TABLE	SJM	03/07/11	ERG
		REVISED MASS BALANCE TABLE	SJM	03/11/11	ERG

NATIONAL RENEWABLE ENERGY LABORATORY

WASTEWATER TREATMENT CONCEPTUAL DESIGN

NEW DESIGN BASIS SCENARIO

FILENAME
BC PROJECT NUMBER 139946
CLIENT PROJECT NUMBER

Appendix C: Major Equipment List

Brown AND Caldwell

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
Major Equipment List

February 2011

Equipment Name	HP	Notes
Lift Station No. 1		2500 gpm pump, submersible rail mounted
Lift Station No. 2		2500 gpm pump, submersible rail mounted
Lift Station No. 3		2500 gpm pump, submersible rail mounted
Lift Station No. 4		2500 gpm pump, submersible rail mounted
Anaerobic Basins		Includes cover, recycle pumps, biogas blowers, and flare
Iron Sponge		
Waste Anaerobic sludge (WANS) Pump No. 1	3	
WANS Pump No. 2	3	Common installed spare
WANS Pump No. 3	3	
WANS Pump No. 4	3	
WANS Pump No. 5	3	Common installed spare
WANS Pump No. 6	3	
Aeration Basin Feed Pump No. 1	15	
Aeration Basin Feed Pump No. 2	15	
Aeration Basin Feed Pump No. 3	15	
Aeration Basin Feed Pump No. 4	15	Common installed spare
Aeration Basin No. 1		25 ft H x 115 ft x 344 ft / 2 ft floor and wall thickness / 4,626 cy concrete, c/w coarse bubble aeration grid
Aeration Basin No. 2		25 ft H x 115 ft x 344 ft / 2 ft floor and wall thickness / 4,626 cy concrete, c/w coarse bubble aeration grid
Aeration Basin No. 3		25 ft H x 115 ft x 344 ft / 2 ft floor and wall thickness / 4,626 cy concrete, c/w coarse bubble aeration grid
Membrane Tank No. 1		Vendor Package, includes membrane, CIP and Scour system
Membrane Tank No. 2		Vendor Package, includes membrane, CIP and Scour system
Membrane Tank No. 3		Vendor Package, includes membrane, CIP and Scour system
Blower No. 1	1000	14,000 SCFM @ 10.3 psig
Blower No. 2	1000	14,000 SCFM @ 10.3 psig
Blower No. 3	1000	14,000 SCFM @ 10.3 psig
Blower No. 4	1000	14,000 SCFM @ 10.3 psig
Blower No. 5	1000	14,000 SCFM @ 10.3 psig
Blower No. 6	1000	14,000 SCFM @ 10.3 psig, common installed spare

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
Major Equipment List

Equipment Name	HP	Notes
RAS Pump No. 1	40	
RAS Pump No. 2	40	
RAS Pump No. 3	40	
RAS Pump No. 4	40	
RAS Pump No. 5	40	
RAS Pump No. 6	40	
Reverse Osmosis Feed Pump		Part of vendor package.
Reverse Osmosis System		
Evaporator Feed Pump		Part of vendor package.
Evaporator		
Conveyor	10	
Dewatering Polymer Addition System	2	11.4 gph neat polymer
Dewatering Polymer Addition System	2	11.4 gph neat polymer, installed spare
Caustic Feed System	1.5	0-300 gph, Aeration Basin No. 1
Caustic Feed System	1.5	0-300 gph, Aeration Basin No. 2
Caustic Feed System	1.5	0-300 gph, Aeration Basin No. 3
Caustic Feed System	1.5	0-300 gph, common installed spare
Sludge Holding Tank		Bolted Steel. H=32', Dia=46'.
Centrifuge Feed Pump No.1	10	
Centrifuge Feed Pump No.2	10	Installed spare
Asbrook CQ700 Centrifuge No. 1	165	275 gpm capacity, 125 HP bowl drive, 40 HP scroll drive
Asbrook CQ700 Centrifuge No. 2	165	275 gpm capacity, 125 HP bowl drive, 40 HP scroll drive
Asbrook CQ700 Centrifuge No. 3	165	275 gpm capacity, 125 HP bowl drive, 40 HP scroll drive
Centrate Sump		12'x12'x8'D concrete sump, located inside buidling
Centrate Pump No. 1	15	
Centrate Pump No. 2	15	Installed spare

Appendix D: Cost Estimate Detail

Brown AND Caldwell

Memorandum

6962 Deframe Ct.
Arvada, Colorado 80004
Tel: 303-284-3058
Fax: 303-284-3354

Date: February 11, 2011

To: Stephen McGuire, Nashville

From: Bob Ferguson, Arvada

Reviewed by: Butch Matthews, Jacksonville

Project Number: 139649

Subject: National Renewable Energy Laboratory Wastewater Treatment Evaluation

Conceptual Design Completion

Basis of Estimate of Probable Construction – Revision 4

The Basis of Estimate Report for the subject project is attached. Please call me if you have questions or need additional information.

RAF:bf

Enclosures (2)

1. Summary Estimate
2. Detailed Estimate

BASIS OF ESTIMATE REPORT

NATIONAL RENEWABLE ENERGY LABORATORY WASTEWATER TREATMENT EVALUATION – CONCEPTUAL DESIGN

Introduction

Brown and Caldwell (BC) is pleased to present this estimate of probable construction cost (estimate) prepared for the National Renewable Energy Laboratory Wastewater Treatment, Harris Group, Inc.

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

This estimate evaluates the cost of the revised single option for wastewater treatment for the Harris Group, Inc., National Renewable Energy Laboratory (NREL). The design documents are conceptual in nature and a specific location for the facility is undetermined other than it will be a Greenfield construction site located in the mid-west part of the country. Treatment consists of anaerobic system, membrane bioreactor, dissolved air floatation, and reverse osmosis.

Background of this Estimate

In a previously submitted conceptual estimate dated January 21, 2010, BC's estimating team presented an estimate of probable cost for a high confidence scenario and a low confidence scenario treatment options based on documents furnished to the Estimating and Scheduling Group (ESG), and on the overall market conditions at that time. As a result of refinements in the project, the treatment components have changed and a single revised option has been settled on. These changes are reflected in the current estimate.

The attached estimate of probable construction cost is based on documents dated February 2011, received by the ESG. These documents are described as conceptual design based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 percent to 15 percent complete. Class 4 estimates are used to prepare planning level cost scopes or to evaluate alternatives in design conditions and form the base work for the Class 3 Project Budget or Funding Estimate.
Expected accuracy for Class 4 estimates typically range from -30 percent to +50 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes, and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs, including a shift differential if applicable, and anticipated productivity adjustments to labor, and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of a Windows-based commercial estimating software engine using BC's material and labor database, historical project data, the latest vendor and material cost information, and other costs specific to the project locale.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel), and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and workers compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. For the purpose of this cost comparison an assumed tax rate of 9.75% was used. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data, 2010.

The contractor's cost for builders risk, general liability, and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost, and are added to the net totals after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work except that which will be performed by traditional specialty subcontractors as identified here:
   - Electrical
   - Miscellaneous metalwork
   - Thermal/moisture proofing
   - HVAC systems
   - Painting
   - Plumbing
   - Steel tank erection

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
4. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
5. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
6. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material, is included in the purchase price of major equipment items where so stated in that quotation.
7. Bulk material quantities are based on manual quantity take-offs.
8. There is sufficient electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.
9. Soils are of adequate nature to support the structures. No piles have been included in this estimate.
10. Site work assumes a Greenfield site requiring no clearing and minimal grading for site preparation.
11. Aeration basins are cast-in-place concrete partially buried in the ground (15-foot) and partially aboveground (10-foot).
12. No groundwater or rock is included in the excavations.
13. Equipment not located within buildings will be founded on concrete slab-on-grade with thickened edge for frost protection.

14. Building will be concrete slab-on-grade with thickened edge for frost protection and pre-engineered steel structures.
15. Centrate sump will be in-ground cast-in-place concrete construction.
16. Lift stations at the aeration basins will be precast concrete manholes with rail mounted submersible pumps. Electrical panels will be located in outside enclosures adjacent to the manholes.
17. The biomass boiler/burner building shown on the conceptual drawing is outside the scope of the estimate and is therefore not included in the costs.
18. Equipment pricing is based on quotes from previous projects. Quotes have not been obtained at this conceptual stage.
19. Process piping and yard piping is unknown at this conceptual stage. Allowances are included in the estimate to cover the cost of materials, supports, installation, and testing.
20. It is assumed that the selected site will have adequate space for construction and construction staging and off-site facilities of storage will not be required.
21. Site civil work in unknown at this conceptual stage but is assumed to me minimal including some paving and walkways between process facilities. An allowance was included in the estimate to cover the cost of site work.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

Allowances for Known but Undefined Work

The following allowances were made in the development of this estimate.

1. Site civil and yard piping
2. Process piping
3. HVAC
4. Building electrical
5. Electrical/Instrumentation

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups, February 2011	
Item	Rate, percent
Prime Contractor	
Labor (employer payroll burden)	10
Materials and process equipment	8
Equipment (construction-related)	8
Subcontractor	5
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.)	9.75
Startup, Training, O&M	2
Builder's Risk, Liability, and Vehicle Insurance	2
Material Shipping and Handling	2
Subcontractor Markups	Same as Prime
Escalation to Midpoint of Construction (not included for this estimate)	0
Contingency	30
Performance and Payment Bonds	1.5

Labor Markup. The labor rates used in the estimate were derived chiefly from the latest published State Prevailing Wage Rates. These rates include costs beyond raw labor for such items as Payroll Tax and Insurance (PT&I), FICA, and Workers Compensation Insurance. In addition to these markups, the General Contractor (GC) typically adds a percentage to each raw labor dollar to cover overhead and profit, payroll and accounting costs, additional insurance, retirement, 401k contributions, and sick leave/vacation cost.

Materials and Process Equipment Markup. This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup. This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all of the equipment needed for the job, but in order to recoup their initial purchasing cost they will charge the project an internal rate for

equipment use which is similar to the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup. This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Sales Tax (Materials, Process Equipment and Construction Equipment). This is the tax that the contractor must pay according to state and local tax laws. The percentage is applied to both the material and equipment the GC purchases as well as the cost for rental equipment. The percentage is based on the local rates in place at the time the estimate was prepared.

Contractor Startup, Training, and O&M Manuals. This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup, and O&M Manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and trouble shoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings, and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance. This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity, and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and on the contractor's insurability at the time the project is bid.

Material Shipping and Handling. This can range from 2 percent to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paper work, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the amount of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets, and bolts that may be missing from the equipment or materials shipped.

Escalation to Midpoint for Labor, Materials and Subcontractors. In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material, and equipment costs beyond values at the time the estimate is prepared. For this project escalation was not included in the estimate since the timing of the project is unknown. The estimate is given in today's dollars.

Construction Contingency. The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that can not be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage, and area factors, construction contingency can range from 10 percent to 50 percent.

Range of Accuracy. The amount of contingency in the estimate should not be confused with the accuracy of the estimate. The Expected Accuracy Range defines the window within which the bids are expected to fall based on the project complexity, information available during the estimate process, outside influences (wage rates, material, bidding climate), and includes a level of contingency appropriate to the project definition at the time the estimate was prepared. It is important to understand that AACEI notes on its ranges of accuracy that,

> "The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value [of the ranges] represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope."

While a 50-percent level of confidence in the contingency may seem broad, typically this results in a 90-percent confidence that the actual cost will fall within the bounds of the low and high ranges.

The caution here is that these estimates are not what are often referred to as "bid quality," i.e., estimates prepared by contractors who are receiving competitive bids from subcontractors, equipment vendors, and materials suppliers. In general, we receive reasonable budget values from those willing to provide quotations.

Performance and Payment Bonds. Based on historical and industry data, this can range from 0.75 percent to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity, and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

SUMMARY ESTIMATE REPORT
WITH MARK-UPS ALLOCATED

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION
CONCEPTUAL DESIGN

Project Number:	139646
BC Project Manager:	THOMAS STEINWINDER/STEPHEN McGUIRE
BC Office:	NASHVILLE
Estimate Issue Number:	01
Estimate Original Issue Date:	DECEMBER 17, 2010
Estimate Revision Number:	04
Estimate Revision Date:	FEBRUARY 11, 2011
Lead Estimator:	BOB FERGUSON
Estimate QA/QC Reviewer:	BUTCH MATTHEWS
Estimate QA/QC Date:	DECEMBER 17, 2010

HARRIS GROUP, INC.

NATIONAL RENEWABLE ENERGY LABORATORY WASTEWATER TREATMENT EVALUATION

Description		Total w/ Markups Allocated
NREL WASTEWATER TREATMENT - REVISION 1		98,402,612
NREL WASTEWATER TREATMENT EVALUATION		
02 - Site Construction		3,220,486
03 - Concrete		7,423,342
05 - Metals		1,161,856
08 - Doors & Windows		45,854
09 - Finishes		47,270
10 - Specialties		3,424
11 - Equipment		73,679,853
13 - Special Construction		1,253,915
15 - Mechanical		4,797,683
16 - Electrical		6,768,928
	NREL WASTEWATER TREATMENT EVALUATION Total	98,402,612
	Grand Total	98,402,612

DETAILED ESTIMATE REPORT

NATIONAL RENEWABLE ENERGY LABORATORY WASTEWATER TREATMENT EVALUATION CONCEPTUAL DESIGN

Project Number:	139646
BC Project Manager:	THOMAS STEINWINDER/STEPHEN McGUIRE
BC Office:	NASHVILLE
Estimate Issue Number:	01
Estimate Original Issue Date:	DECEMBER 17, 2010
Estimate Revision Number:	04
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Lead Estimator:	BOB FERGUSON
Estimate QA/QC Reviewer:	BUTCH MATTHEWS
Estimate QA/QC Date:	DECEMBER 17, 2010

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	NREL WASTEWATER TREATMENT - REVISION 1									
	NREL WASTEWATER TREATMENT EVALUATION									60,723,062
	02000 - Site Civil Work									
	02000000 - General Civil Work									
0990	Allowance - Site Work	1.0	lsum	69,600.00	69,600.00		24,000.00		163,200.00	163,200
	Site Civil Work Total									163,200
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	**Backfill, structural, common earth, 200 H.P. dozer, 300' haul**	**115.3**	**L.C.Y.**	**0.80**			**1.53**		**2.33**	**269**
5420	**Backfill, structural, common earth, 300 H.P. dozer, 300' haul**	**20,793.5**	**L.C.Y.**	**0.43**			**1.09**		**1.53**	**31,730**
	02315310 - Compaction, General									
7000	**Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate**	**20,950.7**	**E.C.Y.**	**1.77**			**0.17**		**1.94**	**40,651**
7500	**Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**103.8**	**E.C.Y.**	**1.40**			**0.36**		**1.77**	**184**
7520	**Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**306.0**	**E.C.Y.**	**2.07**			**0.54**		**2.61**	**798**
7540	**Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**652.5**	**E.C.Y.**	**2.76**			**0.72**		**3.48**	**2,272**
	02315424 - Excavating, Bulk Bank Measure									
4400	**Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum**	**72,043.6**	**B.C.Y.**	**4.78**			**7.13**		**11.91**	**858,061**
	02315492 - Hauling									
0009	**Loading Trucks, F.E. Loader, 3 C.Y.**	**70,889.9**	**cuyd**	**0.59**			**1.06**		**1.65**	**117,070**
4298	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**73,894.7**	**L.C.Y.**	**1.65**			**3.17**		**4.83**	**356,618**
4498	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**1,628.7**	**L.C.Y.**	**1.84**			**3.52**		**5.35**	**8,720**
	02315610 - Excavating, Trench									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0060	**Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering**	**1,591.4**	**B.C.Y.**	**3.79**			**1.79**		**5.58**	**8,886**
	02315640 - Utility Bedding									
0100	**Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction**	**5,381.9**	**L.C.Y.**	**7.21**	**43.50**		**2.04**		**52.76**	**283,925**
	Earthwork Total									**1,709,182**
	02600 - Drainage & Containment									
	02630400 - Storm Drainage Manholes, Frames & Covers									
1210	Storm Drainage Manholes, Frames, and Covers, concrete, precast, 6' inside diameter, 8' deep, excludes footing, excavation, backfill, frame and cover	4.0	EA	1,085.14	2,375.00		306.13		3,766.27	15,065
1500	Storm Drainage Manholes, Frames, and Covers, precast concrete, 6' diameter manhole, 8" thick top	4.0	EA	154.83	595.00		43.73		793.56	3,174
4100	Storm Drainage Manholes, Frames, and Covers, steps, standard sizes, aluminum	42.0	EA	10.95	25.50				36.45	1,531
	Drainage & Containment Total									**19,770**
	03100 - Concrete Forms & Accessories									
	03110445 - Forms In Place, Slab On Grade									
3050	**C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**3,812.0**	**sfca**	**3.67**	**0.74**				**4.41**	**16,795**
3550	C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning	4,944.0	LF	9.01	0.76				9.77	48,300
	03110455 - Forms In Place, Walls									
2550	**C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning**	**124,368.0**	**sfca**	**6.20**	**0.78**				**6.98**	**867,565**
	03150860 - Waterstop									
0600	**Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide**	**4,992.0**	**LF**	**3.29**	**4.50**				**7.79**	**38,869**
	Concrete Forms & Accessories Total									**971,529**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0602	Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	995,378.9	lb	0.46	0.44				0.90	897,066
0702	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	595,381.8	lb	0.33	0.44				0.77	456,063
2000	Reinforcing steel, unload and sort, add to base	819.7	ton	32.63			8.22		40.86	33,490
2210	Reinforcing steel, crane cost for handling, average, add	819.7	ton	35.30			8.95		44.25	36,271
2450	Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add	47,941.5	lb	1.34	0.55				1.89	90,532
	Concrete Reinforcement Total									1,513,422
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments	12,454.0	CY		106.00				106.00	1,320,124
	03310700 - Placing Concrete									
4650	Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibrating, excludes material	7,862.0	CY	16.14			4.44		20.59	161,861
5350	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	4,592.0	CY	24.88			6.87		31.75	145,800
	03350300 - Finishing Floors									
0150	Concrete finishing, floors, manual screed, bull float, manual float, broom finish	112,147.2	SF	0.65					0.65	72,613
	03350350 - Finishing Walls									
0150	Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids	89,424.0	SF	2.40					2.40	214,232
	Cast-In-Place Concrete Total									1,914,629
	05050 - Basic Metal Materials & Methods									
	05090340 - Drilling									
0400	Concrete impact drilling, for anchors, up to 4" D, 5/8" dia, in concrete or brick walls and floors, incl bit & layout, excl anchor	47.0	EA	10.64	0.08				10.72	504
	05090540 - Machinery Anchors									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0800	Machinery anchor, heavy duty, 1" dia stud & bolt, incl sleeve, floating base nut, lower stud & coupling nut, fiber plug, connecting stud, washer & nut	10.0	EA	52.58	98.50		6.97		158.06	1,581
	Basic Metal Materials & Methods Total									**2,085**
	05100 - Structural Metal Framing									
	05120640 - Structural Steel Members									
0302	Structural steel member, 100-ton project, 1 to 2 story building, W8x10, A992 steel, shop fabricated, incl shop primer, bolted connections	1,648.0	LF	5.39	16.50		3.02		24.91	41,048
	Structural Metal Framing Total									**41,048**
	05500 - Metal Fabrications									
	05514500 - Ladder									
0400	Ladder, shop fabricated, aluminum, 20" W, bolted to concrete, excl cage	75.0	vlft	23.29	64.50		1.64		89.44	6,708
	05517700 - Stair									
0400	Stair, shop fabricated, steel, 3'-6" W, incl pipe railing, stringers, cast iron treads w/ safety nosing, per riser	68.0	Riser	56.86	600.00		3.99		660.85	44,937
1500	Stair landing, shop fabricated, steel, conventional, incl framing, metal fan forms, excl concrete for pan forms	64.0	SF	12.40	75.00		0.87		88.27	5,650
	05520700 - Railing, Pipe									
0210	Railing, pipe, aluminum, clear finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/2" dia, shop fabricated	3,090.0	LF	14.45	71.00		1.02		86.47	267,206
	05530300 - Floor Grating, Aluminum									
0132	Floor grating, aluminum, 1-1/2" x 3/16" bearing bars @ 1-3/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	6,180.0	SF	2.84	41.50		0.20		44.53	275,219
	05530360 - Grating Frame									
0020	Grating frame, aluminum, 1" to 1-1/2" D, field fabricated	3,090.0	LF	6.89	2.88				9.77	30,199
	Metal Fabrications Total									**629,919**
	08100 - Metal Doors And Frames									
	08110200 - Commercial Steel Doors									
0100	**Doors, hollow metal, commercial, steel, flush, full panel, hollow core, 1-3/8" thick, 20 ga., 3'-0" x 7'-0"**	**11.0**	**EA**	**48.02**	**295.00**				**343.02**	**3,773**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	08110250 - Door Frames									
0100	**Door frames, steel channels with anchors and bar stops, 6" channel@ 8.2 lb/LF, 3' x 7' door, weighs 150 lb**	**5.0**	**EA**	**152.08**	**270.00**		**10.72**		**432.80**	**2,164**
0200	**Door frames, steel channels with anchors and bar stops, 8" channel@ 11.5 lb/LF, 6' x 8' door, weighs 275 lb**	**3.0**	**EA**	**220.58**	**495.00**		**15.51**		**731.09**	**2,193**
	Metal Doors And Frames Total									**8,131**
	08300 - Specialty Doors									
	08310350 - Floor, Industrial									
3020ds	Doors, specialty, access, floor, industrial, aluminum, Gas/Watertight, H-20, single leaf, 3' x 3'	4.0	Opng	160.84	1,147.00				1,307.84	5,231
	08360550 - Overhead, Commercial									
2700	Doors, overhead, commercial, stock, steel, heavy duty, sectional, manual, 24 gauge, 12' x 12' high	2.0	EA	544.26	1,175.00				1,719.26	3,439
	Specialty Doors Total									**8,670**
	08700 - Hardware									
	08710300 - Door Closers									
0015	**Door hardware, door closer, rack and pinion**	**11.0**	**EA**	**62.75**	**148.00**				**210.75**	**2,318**
	08710340 - Doorstops									
0020	**Door hardware, doorstops, holder and bumper, floor or wall**	**11.0**	**EA**	**12.81**	**33.50**				**46.31**	**509**
	08710520 - Hinges									
0100	**Door hardware, hinges, full mortise, average frequency, steel base, USP, 5" x 5"**	**16.5**	**pair**		**41.00**				**41.00**	**677**
	08710550 - Kick Plate									
0020	**Door hardware, kick plate, stainless steel, 6" high for 3' door**	**11.0**	**EA**	**27.53**	**31.00**				**58.53**	**644**
	08710700 - Mortise Lockset									
0020	**Door hardware, mortise lockset, commercial, wrought knobs and full escutcheon trim, non-keyed, passage, minimum**	**11.0**	**EA**	**45.46**	**175.00**				**220.46**	**2,425**
	08720300 - Weatherstripping, Window									
2300	**Weatherstripping, doors, metal frame, spring type, bronze, for 3' x 7' door**	**11.0**	**Opng**	**137.02**	**35.50**				**172.52**	**1,898**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	08720800 - Thresholds									
0500	**Thresholds, bronze**	**33.0**	**LF**	**6.85**	**38.50**				**45.35**	**1,497**
	Hardware Total									**9,967**
	09900 - Paints & Coatings									
	09910640 - B & C coating specification									
0030bc	Coatings & paints	18,500.0	sqft	0.65	0.86				1.51	27,905
	Paints & Coatings Total									**27,905**
	10100 - Visual Display Boards									
	10160100 - Toilet Partitions, Metal									
1700	Toilet cubicles, floor mounted, painted metal	1.0	EA	146.47	545.00				691.47	691
7800	Urinal screen, wedge type, painted metal	1.0	EA	102.45	128.00				230.45	230
	Visual Display Boards Total									**922**
	10800 - Toilet/Bath/Laundry Accessories									
	10810100 - Commercial Toilet Accessories									
0610	Toilet Accessories, dispenser units, towel dispenser & waste receptacle, 18 gallon capacity	1.0	EA	51.22	395.00				446.22	446
0900	Toilet Accessories, grab bars, straight, stainless steel, 24" long	1.0	EA	22.25	32.00				54.25	54
1100	Toilet Accessories, grab bars, straight, stainless steel, 36" long	1.0	EA	25.61	36.00				61.61	62
3200	Toilet Accessories, mirror, 48" x 24", with stainless steel 3/4" square frame	1.0	EA	51.22	173.00				224.22	224
4600	Toilet Accessories, soap dispenser, chrome, surface mounted, liquid	1.0	EA	25.61	47.50				73.11	73
6000	Toilet Accessories, toilet seat cover dispenser, stainless steel, recessed	1.0	EA	25.61	143.00				168.61	169
6200	Toilet Accessories, toilet tissue dispenser, stainless steel, surface mounted, double roll	1.0	EA	21.29	24.00				45.29	45
	Toilet/Bath/Laundry Accessories Total									**1,073**
	11000 - Equipment									
	11000100 - Process Equipment									
0130do	Pump, Submersible Lift, 2500 gpm, rail mounted	4.0	each	6,272.00	51,600.00				57,872.00	231,488

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0300IK	Dewatering Polymer Feed System (includes pumps)	1.0	each	651.46	8,500.00		150.40		9,301.86	9,302
0522do	Flare	1.0	each	2,714.40	30,000.00		240.64		32,955.04	32,955
0950	Belt conveyor, complete w/ walkway, supports,e-stop	1.0	each	7,000.00	7,000.00		1,000.00		15,000.00	15,000
1270	Pump, Aeration Basin Feed, centrifugal	4.0	each	4,800.00	16,200.00				21,000.00	84,000
1270	Pump, Anaerobic Wasteage, rotary lobe	6.0	each	4,800.00	10,750.00				15,550.00	93,300
1270	Pump, MBR RAS, centrifugal	6.0	each	4,800.00	24,750.00				29,550.00	177,300
1270	Pump, Centrate, submersible centrifugal	2.0	each	4,800.00	30,600.00				35,400.00	70,800
1270	Pump, Centrifuge Feed, centrifugal	2.0	each	4,800.00	25,800.00				30,600.00	61,200
1270	Pump, caustic feed	4.0	each	700.00	5,000.00				5,700.00	22,800
NREL01	Anaerobic Treatment System	1.0	lsum					27,000,000.00	27,000,000.00	27,000,000
NREL02	Membrane Bioreactor	1.0	lsum	356,250.00	4,750,000.00		142,500.00		5,248,750.00	5,248,750
NREL04	Reverse Osmosis Unit	6.0	each	24,997.50	333,500.00		9,999.00		368,496.50	2,210,979
NREL06	Blowers	1.0	lsum	128,310.00	1,150,000.00		50,385.00		1,328,695.00	1,328,695
NREL09	Centrifuge	3.0	each	156,000.00	1,950,000.00		58,500.00		2,164,500.00	6,493,500
NREL10	Aeration Grid and Air Piping	1.0	lsum	200,000.00	2,500,000.00				2,700,000.00	2,700,000
	11001900 - Laboratory equipment									
0320	Laboratory equip & furnishing, allowance	350.0	sqft			60.00			60.00	21,000
	Equipment Total									**45,801,069**
	13120 - Pre-Engineered Structures									
	13128700 - Pre-Engineered Steel Buildings									
0400	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 30' to 40' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	800.0	SF	7.83	9.65		4.37		21.85	17,483
0900	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 50' to 100' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	6,000.0	SF	4.43	8.40		2.48		15.31	91,866
	Pre-Engineered Structures Total									**109,349**
	13200 - Storage Tanks									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	13201200 - Elevated Storage Tanks									
3300	Aboveground Storage Tanks, Steel, 380,000 gallons, incl. painting	1.0	EA			684,000.00			684,000.00	684,000
	Storage Tanks Total									**684,000**
	15100 - Building Services Piping									
	15140800 - Water Hammer Arrestors / Shock Absorbers									
0500	Water hammer arrester/shock absorber, copper, for 1 to 11 fixtures, 3/4" male I.P.S.	1.0	EA	52.89	17.00				69.89	70
	Building Services Piping Total									**70**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0400B	Allowance - Process Piping	1.0	lsum	837,400.00	1,675,000.00		120,000.00		2,632,400.00	2,632,400
0400C	Allowance - small bore piping	1.0	lsum	23,000.00	23,000.00				46,000.00	46,000
	Process Piping Total									**2,678,400**
	15400 - Plumbing Fixtures & Equipment									
	15411700 - Urinals									
3120	Urinal, wall hung, vitreous china, with hanger & self-closing valve, blowout type	1.0	EA	401.97	385.00				786.97	787
3300	Urinal, wall hung, rough-in, supply, waste and vent	1.0	EA	426.02	240.00				666.02	666
	15418450 - Lavatories									
0640	Lavatory, vanity top, porcelain enamel on cast iron, white, oval, 33" x 19", includes trim	1.0	EA	188.96	505.00				693.96	694
	15418600 - Sinks									
6790	Sink, service, floor, rough-in, supply, waste and vent	1.0	EA	738.67	705.00				1,443.67	1,444
	15418900 - Water Closets									
0400	Water closet, tank type, vitreous china, wall hung, close coupled, two piece, includes seat, supply pipe with stop	1.0	EA	226.75	555.00				781.75	782
0960	Water closet, tank type, vitreous china, wall hung, rough-in, supply, waste, vent and carrier	1.0	EA	441.48	630.00				1,071.48	1,071
	15480200 - Water Heaters									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1100	Water heater, residential, electric, glass lined tank, double element, 5 year, 52 gallon	1.0	EA	317.36	560.00				877.36	877
	Plumbing Fixtures & Equipment Total									**6,321**
	15700 - Heating/Ventilating/Air Conditioning Equipment									
	15700100 - HVAC Allowance									
0010	**HVAC heating, cooling allowance**	**6,800.0**	**sqft**			**10.00**			**10.00**	**68,000**
	Heating/Ventilating/Air Conditioning Equipment Total									**68,000**
	16000 - Electrical and Instrumentation									
	16000000 - Electrical and Instrumentation									
0001	**Electrical, building wiring, switches, outlets**	**6,800.0**	**sqft**			**8.00**			**8.00**	**54,400**
0001	Electrical and Instrumentation Subcontract	1.0	lsum			4,300,000.00			4,300,000.00	4,300,000
	Electrical and Instrumentation Total									**4,354,400**

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Grand Total									**60,723,062**

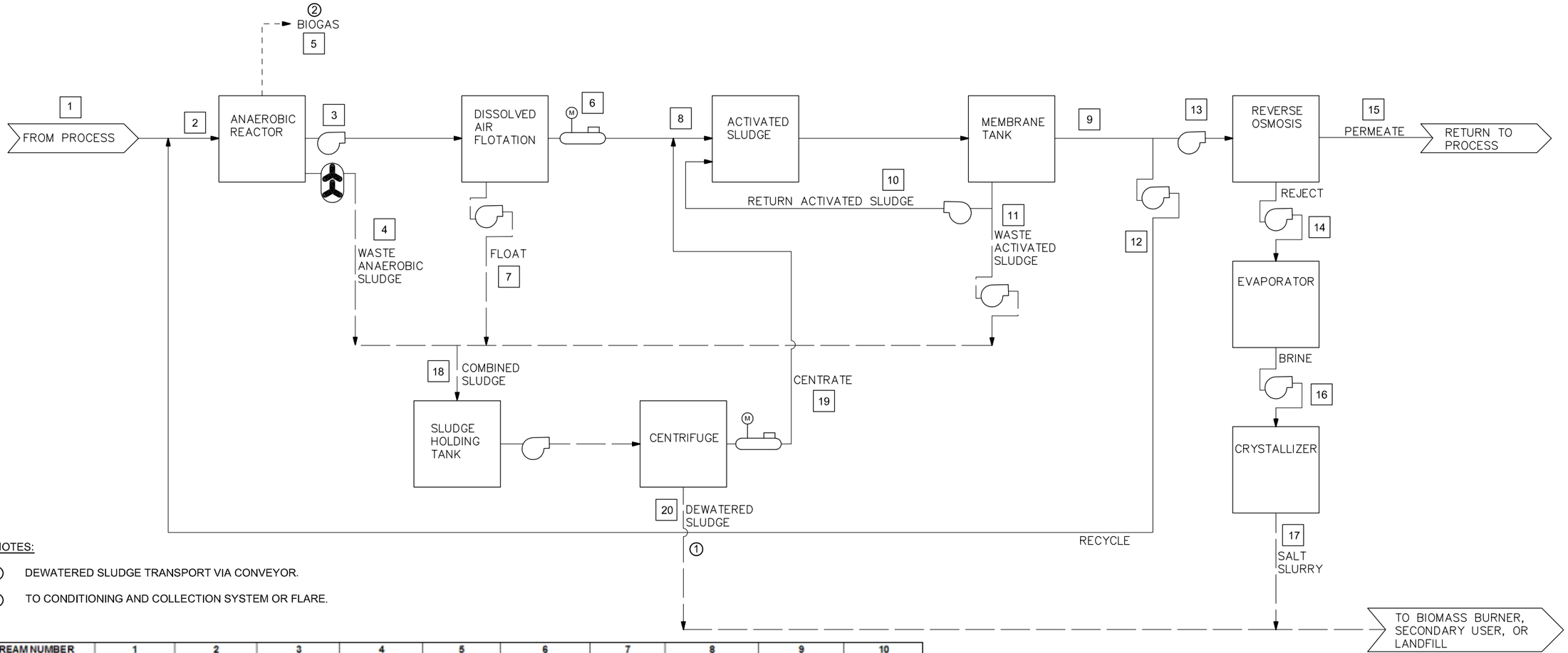
NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION

Category	Percent	Amount	Hours
NREL WASTEWATER TREATMENT - REVISION 1 Totals			
Labor	**8.69 %**	**5,278,840**	**82,361.9**
Material	**35.84 %**	**21,762,787**	
Subcontractor	**8.44 %**	**5,127,400**	
Equipment	**2.56 %**	**1,554,035**	**32,313.7**
Other	**44.46 %**	**27,000,000**	
User			
Net Costs		**60,723,062**	
Labor Mark-up	10.00 %	527,884	
Material/Process Equipment Mark-up	8.00 %	1,741,023	
Subcontractor Mark-up	5.00 %	256,370	
Construction Equipment Mark-up	8.00 %	124,323	
Sales tax	9.75 %	2,273,390	
Material Shipping & Handling	2.00 %	373,464	
Contractor General Conditions	10.00 %	6,601,952	
Subtotal		**72,621,468**	
Start-up, training, O & M	2.00 %	491,946	
Subtotal		**73,113,413**	
Construction Contingency	30.00 %	21,934,024	
Subtotal		**95,047,437**	
Bldg Risk, Liability Auto Ins.	2.00 %	1,900,949	

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT
EVALUATION

Category	Percent	Amount	Hours
Subtotal		**96,948,386**	
Bonds	1.50 %	1,454,226	
Subtotal		**98,402,612**	
Total NREL WASTEWATER TREATMENT - REVISION 1		**98,402,612**	

Appendix E: Draft Design Basis Supporting Data



NOTES:

① DEWATERED SLUDGE TRANSPORT VIA CONVEYOR.

② TO CONDITIONING AND COLLECTION SYSTEM OR FLARE.

STREAM NUMBER	1	2	3	4	5	6	7	8	9	10
STREAM NAME	Influent	Anaerobic Influent	Anaerobic Effluent	Waste Anaerobic Sludge	Biogas	Dissolved Air Flotation Effluent	Dissolved Air Flotation Sludge	Activated Sludge Influent	Membrane Tank Effluent	Return Activated Sludge
TEMPERATURE, °C	50	40	35	35	35	25	25	25	30	30
FLOW, MGD	2.15	2.86	2.65	0.20	177	2.42	0.23	3.43	2.81	17.2
SCOD, LBS/DAY	705,944	717,708	345,774	26,321	-	315,801	29,974	379,538	46,827	286,431
TSS, LBS/DAY	388,415	388,415	48,682	67,421	-	696	47,986	8,704	0	1,432,155
TDFS, LBS/DAY	176,411	234,275	217,703	16,572	-	198,832	18,872	281,799	230,349	1,408,997
DENSITY, LBS/GAL	8.3	8.3	8.3	8.5	4.9E-04	8.3	8.4	8.3	8.3	8.3

STREAM NUMBER	11	12	13	14	15	16	17	18	19	20
STREAM NAME	Waste Activated Sludge	System Recycle	Reverse Osmosis Influent	Reverse Osmosis Reject	Final Effluent	Evaporator Effluent	Crystallizer Effluent	Sludge Holding Tank Influent	Centrate	Dewatered Sludge
TEMPERATURE, °C	30	30	30	25	25	50	50	30	25	25
FLOW, MGD	0.63	0.71	2.10	0.42	1.68	0.042	0.0042	1.06	1.01	0.05
SCOD, LBS/DAY	10,459	11,763	35,064	35,064	0	35,064	35,064	66,754	63,738	3,016
TSS, LBS/DAY	52,330	0	0	0	0	-	-	167,737	8,008	159,729
TDFS, LBS/DAY	51,450	57,865	172,484	163,860	8,624	163,860	163,860	86,894	82,968	3,926
DENSITY, LBS/GAL	8.3	8.3	8.3	8.3	8.3	-	-	8.3	8.3	9.2

LIQUID STREAM ———
SOLID STREAM — —
BIOGAS – – – –

Brown AND Caldwell
NASHVILLE, TENNESSEE

SUBMITTED: _____ DATE: _____ (PROJECT MANAGER)
APPROVED: _____ DATE: _____ (BROWN AND CALDWELL)

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2" - SCALE ACCORDINGLY)

DESIGNED: M. MECREDY
DRAWN: M. MECREDY
CHECKED: T. STEINWINDER
CHECKED: E. GILL
APPROVED:

EXTERNAL REFERENCE FILES: Border.dwg

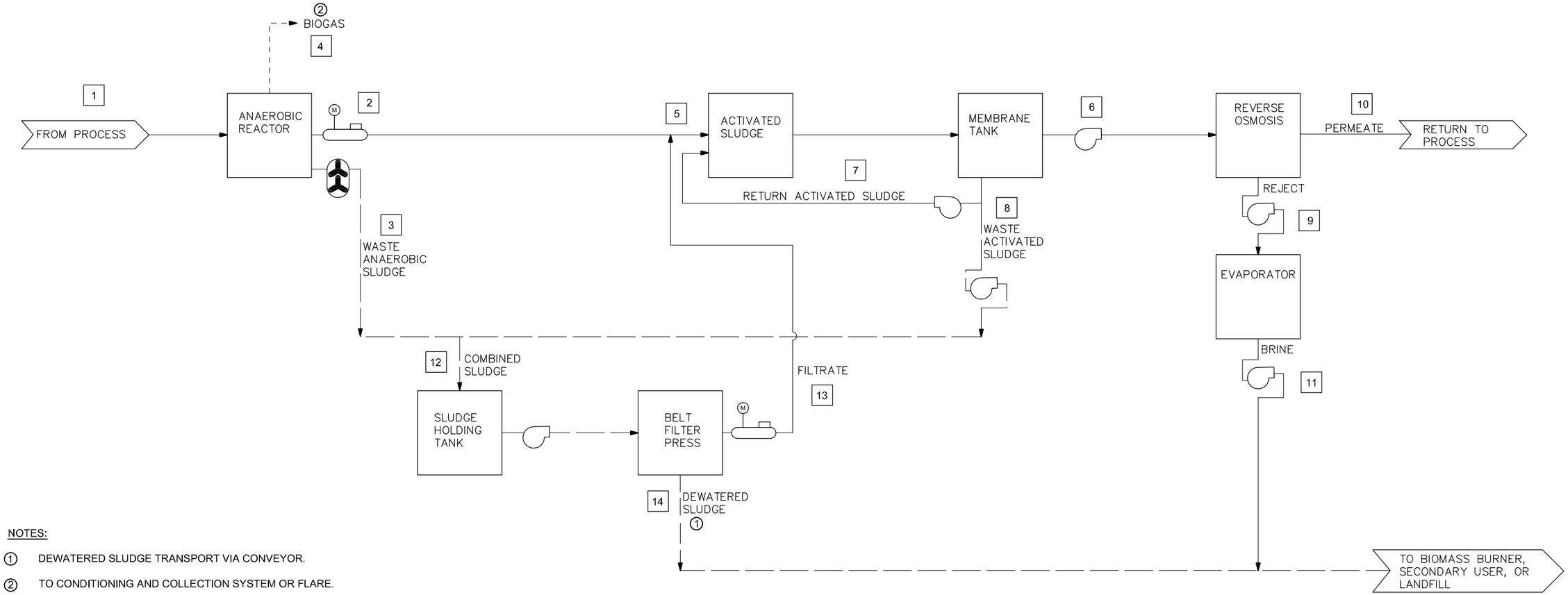
REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

NATIONAL RENEWABLE ENERGY LABORATORY

WASTEWATER TREATMENT CONCEPTUAL DESIGN

HIGH CONFIDENCE SCENARIO

FILENAME
BC PROJECT NUMBER 139646
CLIENT PROJECT NUMBER ____



NOTES:

① DEWATERED SLUDGE TRANSPORT VIA CONVEYOR.

② TO CONDITIONING AND COLLECTION SYSTEM OR FLARE.

STREAM NUMBER	1	2	3	4	5	6	7
STREAM NAME	Influent	Anaerobic Effluent	Waste Anaerobic Sludge	Biogas	Activated Sludge Influent	Membrane Tank Effluent	Return Activated Sludge
TEMPERATURE, °C	50	35	35	35	30	30	30
FLOW, MGD	2.15	1.95	0.20	152	2.68	2.06	13.4
SCOD, LBS/DAY	705,944	253,869	26,321	-	286,463	34,356	223,313
TSS, LBS/DAY	388,415	35,742	67,421	-	41,692	0	1,116,567
TDFS, LBS/DAY	176,411	159,839	16,572	-	219,702	169,001	1,098,512
DENSITY, LBS/GAL	8.3	8.3	8.5	4.9E-04	8.3	8.3	8.3

STREAM NUMBER	8	9	10	11	12	13	14
STREAM NAME	Waste Activated Sludge	Reverse Osmosis Reject	Final Effluent	Evaporator Effluent	Sludge Holding Tank Influent	Belt Filter Press Filtrate	Dewatered Sludge
TEMPERATURE, °C	30	30	25	50	30	25	25
FLOW, MGD	0.62	0.42	1.64	0.41	0.82	0.73	0.09
SCOD, LBS/DAY	10,307	34,356	0	34,356	36,628	32,594	4,034
TSS, LBS/DAY	51,568	0	0	-	118,989	5,949	113,039
TDFS, LBS/DAY	50,701	160,551	8,450	160,551	67,273	59,864	7,409
DENSITY, LBS/GAL	8.3	8.3	8.3	-	8.3	8.3	8.8

LIQUID STREAM ———
SOLID STREAM — —
BIOGAS - - - -

Brown AND Caldwell
NASHVILLE, TENNESSEE

SUBMITTED: _____ DATE: _____ PROJECT MANAGER
APPROVED: _____ DATE: _____ BROWN AND CALDWELL

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2" - SCALE ACCORDINGLY)

DESIGNED: M. MECREDY
DRAWN: M. MECREDY
CHECKED: T. STEINWINDER
CHECKED: E. GILL
APPROVED:

EXTERNAL REFERENCE FILES: Border.dwg

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

NATIONAL RENEWABLE ENERGY LABORATORY

WASTEWATER TREATMENT CONCEPTUAL DESIGN

LOW COST SCENARIO

FILENAME
BC PROJECT NUMBER 139646
CLIENT PROJECT NUMBER ____

Dec 20, 2010, 10:53am
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mthorpe

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
High Confidence Major Equipment List

Equipment Name	HP	Notes
Lift Station No. 1		
Lift Station No. 2		
Lift Station No. 3		
Lift Station No. 4		
Anaerobic Basin		Includes cover, recycle pumps, biogas blowers, and flare
Waste Anaerobic sludge (WANS) Pump No. 1	3.0	
WANS Pump No. 2	3.0	
WANS Pump No. 3	3.0	
WANS Pump No. 4	3.0	
WANS Pump No. 5	3.0	
WANS Pump No. 6	3.0	
DAF Feed Pump No. 1	15.0	
DAF Feed Pump No. 2	15.0	
DAF Feed Pump No. 3	15.0	
DAF No. 1		304SS Tank and frame / 385 sf
DAF No. 2		304SS Tank and frame / 385 sf
Skimmer Motor No. 1	1.0	
Skimmer Motor No. 2	1.0	
DAF Recycle Pump No. 1	30.0	
DAF Recycle Pump No. 2	30.0	
DAF Effluent Wetwell		
DAF Float Pump No. 1	1.5	
DAF Float Pump No. 2	1.5	
Aeration Basin Feed Pump No. 1	9.0	
Aeration Basin Feed Pump No. 2	9.0	
Aeration Basin Feed Pump No. 3	9.0	
Aeration Basin Feed Pump No. 4	9.0	
Aeration Basin No. 1		25 ft H x 119 ft x 357 ft / 2 ft floor and wall thickness / 132,698 cf concrete

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
High Confidence Major Equipment List

Equipment Name	HP	Notes
Aeration Basin No. 2		25 ft H x 119 ft x 357 ft / 2 ft floor and wall thickness / 132,698 cf concrete
Aeration Basin No. 3		25 ft H x 119 ft x 357 ft / 2 ft floor and wall thickness / 132,698 cf concrete
Membrane Tank No. 1		Vendor Package
Membrane Tank No. 2		Vendor Package
Membrane Tank No. 3		Vendor Package
Blower System		13 x 1000 HP Blower
RAS Pump No. 1	10.0	
RAS Pump No. 2	10.0	
RAS Pump No. 3	10.0	
RAS Pump No. 4	10.0	
RAS Pump No. 5	10.0	
RAS Pump No. 6	10.0	
Recycle Wetwell		
Recycle Pump No. 1	20.0	
Recycle Pump No. 2	20.0	
Recycle Pump No. 3	20.0	
Reverse Osmosis Feed Pump		Part of vendor package.
Reverse Osmosis		
Evaporator Feed Pump		Part of vendor package.
Evaporator		
Crystallizer Feed Pump		Part of vendor package.
Crystallizer		
Conveyor		
Polymer Addition System		
Sludge Holding Tank		Bolted Steel. H=30', Dia=57'.
Centrifuge Feed Pump No.1	7.5	
Centrifuge Feed Pump No.2	7.5	
Asbrook CQ700 Centrifuge No. 1	145.0	275 gpm capacity.

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
High Confidence Major Equipment List

Equipment Name	HP	Notes
Asbrook CQ700 Centrifuge No. 2	145.0	275 gpm capacity.
Asbrook CQ700 Centrifuge No. 3	145.0	275 gpm capacity.
Centrate Pump No. 1	10.0	
Centrate Pump No. 2	10.0	

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
High Confidence Major Equipment List

Equipment Name	HP	Notes

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
Low Cost Major Equipment List

Equipment Name	HP	Notes
Lift Station No. 1		
Lift Station No. 2		
Lift Station No. 3		
Lift Station No. 4		
Anaerobic Basin		Includes cover, recycle pumps, biogas blowers, and flare
Waste Anaerobic Sludge (WANS) Pump No. 1	3.0	
WANS Pump No. 2	3.0	
WANS Pump No. 3	3.0	
WANS Pump No. 4	3.0	
WANS Pump No. 5	3.0	
WANS Pump No. 6	3.0	
Anaerobic Effluent Wetwell		
Aeration Basin Feed Pump No. 1	12.0	
Aeration Basin Feed Pump No. 2	12.0	
Aeration Basin Feed Pump No. 3	12.0	
Aeration Basin Feed Pump No. 4	12.0	
Aeration Basin No. 1		25 ft H x 110 ft x 331 ft / 2 ft floor and wall thickness / 117,013 cf concrete
Aeration Basin No. 2		25 ft H x 110 ft x 331 ft / 2 ft floor and wall thickness / 117,013 cf concrete
Aeration Basin No. 3		25 ft H x 110 ft x 331 ft / 2 ft floor and wall thickness / 117,013 cf concrete
Membrane Tank No. 1		Vendor package
Membrane Tank No. 2		Vendor package
Membrane Tank No. 3		Vendor package
Blower System		14 x 1000 HP Blower
RAS Pump No. 1	7.0	
RAS Pump No. 2	7.0	
RAS Pump No. 3	7.0	
RAS Pump No. 4	7.0	
RAS Pump No. 5	7.0	
RAS Pump No. 6	7.0	
Reverse Osmosis Feed Pump		Part of vendor package.

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
Low Cost Major Equipment List

Equipment Name	HP	Notes
Reverse Osmosis		
Evaporator Feed Pump		Part of vendor package.
Evaporator		
Conveyor		
Polymer Addition System		
Sludge Holding Tank		Bolted Steel. H=25', Dia=27'.
Belt Filter Press Feed Pump No.1	5.0	
Belt Filter Press Feed Pump No.2	5.0	
Phoenix WX-3.0H8 Belt Filter Press No. 1	12.0	
Phoenix WX-3.0H8 Belt Filter Press No. 2	12.0	
Phoenix WX-3.0H8 Belt Filter Press No. 2	12.0	
Filtrate Pump No. 1	8.0	
Filtrate Pump No. 2	8.0	

Harris Group, Inc.
NREL Wastewater Treatment Evaluation
Low Cost Major Equipment List

Equipment Name	HP	Notes

Brown AND Caldwell

Memorandum

6962 Deframe Ct.
Arvada, Colorado 80004
Tel: 303-284-3058
Fax: 303-284-3354

Date: December 17, 2010

To: Thomas Steinwinder, Nashville

From: Bob Ferguson, Arvada

Reviewed by: Butch Matthews, Jacksonville

Project Number: 139649

Subject: National Renewable Energy Laboratory Wastewater Treatment Evaluation

Conceptual Design Completion

Basis of Estimate of Probable Construction

The Basis of Estimate Report for the subject project is attached. Please call me if you have questions or need additional information.

RAF:bf

Enclosures (2)

1. Summary Estimate
2. Detailed Estimate

BASIS OF ESTIMATE REPORT

NATIONAL RENEWABLE ENERGY LABORATORY WASTEWATER TREATMENT EVALUATION – CONCEPTUAL DESIGN

Introduction

Brown and Caldwell (BC) is pleased to present this estimate of probable construction cost (estimate) prepared for the National Renewable Energy Laboratory Wastewater Treatment, Harris Group, Inc.

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

This estimate evaluates the cost of two wastewater treatment options, Low Cost Scenario and High Confidence Scenario, for the Harris Group, Inc., National Renewable Energy Laboratory (NREL). The design documents are conceptual in nature and a specific location for the facility is undetermined other than it will be a Greenfield construction site located in the mid-west part of the country. Treatment consists of anaerobic system, membrane bioreactor, and reverse osmosis treatment for both scenarios with the inclusion of dissolved air floatation for the high confidence scenario.

Background of this Estimate

The attached estimate of probable construction cost is based on documents dated December 2010, received by the ESG. These documents are described as conceptual design based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 percent to 15 percent complete. Class 4 estimates are used to

prepare planning level cost scopes or to evaluate alternatives in design conditions and form the base work for the Class 3 Project Budget or Funding Estimate.
Expected accuracy for Class 4 estimates typically range from -30 percent to +50 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes, and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs, including a shift differential if applicable, and anticipated productivity adjustments to labor, and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of a Windows-based commercial estimating software engine using BC's material and labor database, historical project data, the latest vendor and material cost information, and other costs specific to the project locale.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel), and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and workers compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. For the purpose of this cost comparison an assumed tax rate of 9.75% was used. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data, 2010.

The contractor's cost for builders risk, general liability, and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost, and are added to the net totals after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.

4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work except that which will be performed by traditional specialty subcontractors as identified here:
   - Electrical
   - Miscellaneous metalwork
   - Thermal/moisture proofing
   - HVAC systems
   - Painting
   - Plumbing
   - Steel tank erection

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
4. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
5. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
6. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material, is included in the purchase price of major equipment items where so stated in that quotation.
7. Bulk material quantities are based on manual quantity take-offs.
8. There is sufficient electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.
9. Soils are of adequate nature to support the structures. No piles have been included in this estimate.
10. Site work assumes a Greenfield site requiring no clearing and minimal grading for site preparation.
11. Aeration basins are cast-in-place concrete partially buried in the ground (15-foot) and partially aboveground (10-foot).
12. No groundwater or rock is included in the excavations.
13. Equipment not located within buildings will be founded on concrete slab-on-grade with thickened edge for frost protection.
14. Building will be concrete slab-on-grade with thickened edge for frost protection and pre-engineered steel structures.
15. DAF wetwell will be in-ground cast-in-place concrete construction.
16. Lift stations at the aeration basins will be precast concrete manholes with rail mounted submersible pumps. Electrical panels will be located in outside enclosures adjacent to the manholes.

17. The biomass boiler/burner building shown on the conceptual drawings is outside the scope of the estimate and is therefore not included in the costs.
18. Equipment pricing is based on quotes from previous projects. Quotes have not been obtained at this conceptual stage.
19. Process piping and yard piping is unknown at this conceptual stage. Allowances are included in the estimate to cover the cost of materials, supports, installation, and testing.
20. It is assumed that the selected site will have adequate space for construction and construction staging and off-site facilities of storage will not be required.
21. Site civil work in unknown at this conceptual stage but is assumed to me minimal including some paving and walkways between process facilities. An allowance was included in the estimate to cover the cost of site work.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

Allowances for Known but Undefined Work

The following allowances were made in the development of this estimate.

1. Site civil and yard piping
2. Process piping
3. HVAC
4. Building electrical
5. Electrical/Instrumentation

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups, December 2010

Item	Rate, percent
Prime Contractor	
Labor (employer payroll burden)	10
Materials and process equipment	8
Equipment (construction-related)	8
Subcontractor	5

Table 1. Estimate Markups, December 2010	
Item	Rate, percent
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.)	9.75
Startup, Training, O&M	2
Builder's Risk, Liability, and Vehicle Insurance	2
Material Shipping and Handling	2
Subcontractor Markups	Same as Prime
Escalation to Midpoint of Construction (not included for this estimate)	0
Contingency	30
Performance and Payment Bonds	1.5

Labor Markup. The labor rates used in the estimate were derived chiefly from the latest published State Prevailing Wage Rates. These rates include costs beyond raw labor for such items as Payroll Tax and Insurance (PT&I), FICA, and Workers Compensation Insurance. In addition to these markups, the General Contractor (GC) typically adds a percentage to each raw labor dollar to cover overhead and profit, payroll and accounting costs, additional insurance, retirement, 401k contributions, and sick leave/vacation cost.

Materials and Process Equipment Markup. This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup. This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all of the equipment needed for the job, but in order to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is similar to the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup. This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Sales Tax (Materials, Process Equipment and Construction Equipment). This is the tax that the contractor must pay according to state and local tax laws. The percentage is applied to both the material and equipment the GC purchases as well as the cost for rental equipment. The percentage is based on the local rates in place at the time the estimate was prepared.

Contractor Startup, Training, and O&M Manuals. This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup, and O&M Manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and trouble shoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings, and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance. This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity, and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and on the contractor's insurability at the time the project is bid.

Material Shipping and Handling. This can range from 2 percent to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paper work, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the amount of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets, and bolts that may be missing from the equipment or materials shipped.

Escalation to Midpoint for Labor, Materials and Subcontractors. In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material, and equipment costs beyond values at the time the estimate is prepared. For this project escalation was not included in the estimate since the timing of the project is unknown. The estimate is given in today's dollars.

Construction Contingency. The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that can not be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage, and area factors, construction contingency can range from 10 percent to 50 percent.

Range of Accuracy. The amount of contingency in the estimate should not be confused with the accuracy of the estimate. The Expected Accuracy Range defines the window within which the bids are expected to fall based on the project complexity, information available during the estimate process, outside influences (wage rates, material, bidding climate), and includes a level of contingency appropriate to the project definition at the time the estimate was prepared. It is important to understand that AACEI notes on its ranges of accuracy that,

> "The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value [of the ranges] represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope."

While a 50-percent level of confidence in the contingency may seem broad, typically this results in a 90-percent confidence that the actual cost will fall within the bounds of the low and high ranges.

The caution here is that these estimates are not what are often referred to as "bid quality," i.e., estimates prepared by contractors who are receiving competitive bids from subcontractors, equipment vendors, and materials suppliers. In general, we receive reasonable budget values from those willing to provide quotations.

Performance and Payment Bonds. Based on historical and industry data, this can range from 0.75 percent to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity, and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

SUMMARY ESTIMATE REPORT
WITH MARK-UPS ALLOCATED

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION
CONCEPTUAL DESIGN

Project Number:	139646
BC Project Manager:	THOMAS STEINWINDER
BC Office:	NASHVILLE
Estimate Issue Number:	01
Estimate Original Issue Date:	DECEMBER 17, 2010
Lead Estimator:	BOB FERGUSON
Estimate QA/QC Reviewer:	BUTCH MATTHEWS
Estimate QA/QC Date:	DECEMBER 17, 2010

INDEX

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION

Description		Gross Total Costs
LOW COST SCENARIO		99,989,724
NREL WASTEWATER TREATMENT EVALUATION		
02 - Site Construction		3,212,585
03 - Concrete		7,421,833
05 - Metals		1,158,339
08 - Doors & Windows		60,060
09 - Finishes		47,270
10 - Specialties		3,424
11 - Equipment		74,956,723
13 - Special Construction		663,396
15 - Mechanical		5,210,917
16 - Electrical		7,255,176
	NREL WASTEWATER TREATMENT EVALUATION Total	99,989,724
HIGH CONFIDENCE SCENARIO		142,211,223
NREL WASTEWATER TREATMENT EVALUATION		
02 - Site Construction		3,349,014
03 - Concrete		7,493,963
05 - Metals		1,158,339
08 - Doors & Windows		60,060
09 - Finishes		49,825
10 - Specialties		3,424
11 - Equipment		109,759,430
13 - Special Construction		2,597,197
15 - Mechanical		7,375,787
16 - Electrical		10,364,182
	NREL WASTEWATER TREATMENT EVALUATION Total	142,211,223

DETAILED ESTIMATE REPORT

NATIONAL RENEWABLE ENERGY LABORATORY WASTEWATER TREATMENT EVALUATION CONCEPTUAL DESIGN

Project Number:	139646
BC Project Manager:	THOMAS STEINWINDER
BC Office:	NASHVILLE
Estimate Issue Number:	01
Estimate Original Issue Date:	DECEMBER 17, 2010
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INDEX

NATIONAL RENEWABLE ENERGY LABORATORY
WASTEWATER TREATMENT EVALUATION

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	LOW COST SCENARIO									
	NREL WASTEWATER TREATMENT EVALUATION									**62,118,617**
	02000 - Site Civil Work									
	02000000 - General Civil Work									
0990	Allowance - Site Work	1.0	lsum	69,600.00	69,600.00		24,000.00		163,200.00	163,200
	Site Civil Work Total									**163,200**
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	**Backfill, structural, common earth, 200 H.P. dozer, 300' haul**	**73.6**	**L.C.Y.**	**0.78**			**1.53**		**2.31**	**170**
5420	Backfill, structural, common earth, 300 H.P. dozer, 300' haul	20,258.2	L.C.Y.	0.43			1.09		1.52	30,857
	02315310 - Compaction, General									
7000	**Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate**	**20,550.7**	**E.C.Y.**	**1.77**			**0.17**		**1.93**	**39,702**
7500	**Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**66.2**	**E.C.Y.**	**1.38**			**0.36**		**1.74**	**115**
7520	**Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**328.5**	**E.C.Y.**	**2.06**			**0.54**		**2.60**	**855**
7540	**Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**666.4**	**E.C.Y.**	**2.76**			**0.72**		**3.48**	**2,316**
	02315424 - Excavating, Bulk Bank Measure									
4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	71,615.5	B.C.Y.	4.77			7.13		11.90	852,454
	02315492 - Hauling									
0009	**Loading Trucks, F.E. Loader, 3 C.Y.**	**71,039.4**	**cuyd**	**0.59**			**1.06**		**1.65**	**117,315**
4298	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**73,894.5**	**L.C.Y.**	**1.65**			**3.17**		**4.83**	**356,617**
4498	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**1,778.2**	**L.C.Y.**	**1.83**			**3.52**		**5.35**	**9,514**
	02315610 - Excavating, Trench									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0060	**Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering**	**1,693.7**	**B.C.Y.**	**3.78**			**1.79**		**5.57**	**9,435**
	02315640 - Utility Bedding									
0100	**Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction**	**5,404.6**	**L.C.Y.**	**7.21**	**43.50**		**2.04**		**52.75**	**285,112**
	Earthwork Total									**1,704,462**
	02600 - Drainage & Containment									
	02630400 - Storm Drainage Manholes, Frames & Covers									
1210	Storm Drainage Manholes, Frames, and Covers, concrete, precast, 6' inside diameter, 8' deep, excludes footing, excavation, backfill, frame and cover	4.0	EA	1,085.14	2,375.00		306.13		3,766.27	15,065
1500	Storm Drainage Manholes, Frames, and Covers, precast concrete, 6' diameter manhole, 8" thick top	4.0	EA	154.83	595.00		43.73		793.56	3,174
4100	Storm Drainage Manholes, Frames, and Covers, steps, standard sizes, aluminum	42.0	EA	10.95	25.50				36.45	1,531
	Drainage & Containment Total									**19,770**
	03100 - Concrete Forms & Accessories									
	03110445 - Forms In Place, Slab On Grade									
3050	**C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**3,956.0**	**sfca**	**3.64**	**0.74**				**4.38**	**17,339**
3550	C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning	4,944.0	LF	9.01	0.76				9.77	48,300
	03110455 - Forms In Place, Walls									
2550	C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning	123,600.0	sfca	6.19	0.78				6.97	861,027
	03150860 - Waterstop									
0600	**Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide**	**4,944.0**	**LF**	**3.28**	**4.50**				**7.78**	**38,456**
	Concrete Forms & Accessories Total									**965,122**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0602	**Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**1,002,892.5**	**lb**	**0.46**	**0.44**				**0.90**	**903,694**
0702	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	591,518.0	lb	0.33	0.44				0.77	452,791
2000	**Reinforcing steel, unload and sort, add to base**	**820.7**	**ton**	**32.60**			**8.22**		**40.82**	**33,505**
2210	**Reinforcing steel, crane cost for handling, average, add**	**820.7**	**ton**	**35.26**			**8.95**		**44.21**	**36,287**
2450	**Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**46,591.1**	**lb**	**1.33**	**0.55**				**1.88**	**87,545**
	Concrete Reinforcement Total									**1,513,822**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments**	**12,497.9**	**CY**		**106.00**				**106.00**	**1,324,772**
	03310700 - Placing Concrete									
4650	**Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibrating, excludes material**	**7,920.1**	**CY**	**16.14**			**4.44**		**20.58**	**163,028**
5350	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	4,577.8	CY	24.86			6.87		31.73	145,260
	03350300 - Finishing Floors									
0150	**Concrete finishing, floors, manual screed, bull float, manual float, broom finish**	**113,335.8**	**SF**	**0.65**					**0.65**	**73,358**
	03350350 - Finishing Walls									
0150	Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids	88,992.0	SF	2.39					2.39	212,939
	Cast-In-Place Concrete Total									**1,919,358**
	05100 - Structural Metal Framing									
	05120640 - Structural Steel Members									
0302	Structural steel member, 100-ton project, 1 to 2 story building, W8x10, A992 steel, shop fabricated, incl shop primer, bolted connections	1,648.0	LF	5.39	16.50		3.02		24.91	41,048
	Structural Metal Framing Total									**41,048**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	05500 - Metal Fabrications									
	05514500 - Ladder									
0400	Ladder, shop fabricated, aluminum, 20" W, bolted to concrete, excl cage	75.0	vlft	23.29	64.50		1.64		89.44	6,708
	05517700 - Stair									
0400	Stair, shop fabricated, steel, 3'-6" W, incl pipe railing, stringers, cast iron treads w/ safety nosing, per riser	68.0	Riser	56.86	600.00		3.99		660.85	44,937
1500	Stair landing, shop fabricated, steel, conventional, incl framing, metal fan forms, excl concrete for pan forms	64.0	SF	12.40	75.00		0.87		88.27	5,650
	05520700 - Railing, Pipe									
0210	Railing, pipe, aluminum, clear finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/2" dia, shop fabricated	3,090.0	LF	14.45	71.00		1.02		86.47	267,206
	05530300 - Floor Grating, Aluminum									
0132	Floor grating, aluminum, 1-1/2" x 3/16" bearing bars @ 1-3/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	6,180.0	SF	2.84	41.50		0.20		44.53	275,219
	05530360 - Grating Frame									
0020	Grating frame, aluminum, 1" to 1-1/2" D, field fabricated	3,090.0	LF	6.89	2.88				9.77	30,199
	Metal Fabrications Total									**629,919**
	08100 - Metal Doors And Frames									
	08110200 - Commercial Steel Doors									
0100	**Doors, hollow metal, commercial, steel, flush, full panel, hollow core, 1-3/8" thick, 20 ga., 3'-0" x 7'-0"**	**15.0**	**EA**	**48.02**	**295.00**				**343.02**	**5,145**
	08110250 - Door Frames									
0100	**Door frames, steel channels with anchors and bar stops, 6" channel@ 8.2 lb/LF, 3' x 7' door, weighs 150 lb**	**7.0**	**EA**	**152.08**	**270.00**		**10.72**		**432.80**	**3,030**
0200	**Door frames, steel channels with anchors and bar stops, 8" channel@ 11.5 lb/LF, 6' x 8' door, weighs 275 lb**	**4.0**	**EA**	**220.58**	**495.00**		**15.51**		**731.09**	**2,924**
	Metal Doors And Frames Total									**11,099**
	08300 - Specialty Doors									
	08310350 - Floor, Industrial									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
3020ds	Doors, specialty, access, floor, industrial, aluminum, Gas/Watertight, H-20, single leaf, 3' x 3'	4.0	Opng	160.84	1,147.00				1,307.84	5,231
	08360550 - Overhead, Commercial									
2700	**Doors, overhead, commercial, stock, steel, heavy duty, sectional, manual, 24 gauge, 12' x 12' high**	**3.0**	**EA**	**544.26**	**1,175.00**				**1,719.26**	**5,158**
	Specialty Doors Total									**10,389**
	08700 - Hardware									
	08710300 - Door Closers									
0015	**Door hardware, door closer, rack and pinion**	**15.0**	**EA**	**62.75**	**148.00**				**210.75**	**3,161**
	08710340 - Doorstops									
0020	**Door hardware, doorstops, holder and bumper, floor or wall**	**15.0**	**EA**	**12.81**	**33.50**				**46.31**	**695**
	08710520 - Hinges									
0100	**Door hardware, hinges, full mortise, average frequency, steel base, USP, 5" x 5"**	**22.5**	**pair**		**41.00**				**41.00**	**923**
	08710550 - Kick Plate									
0020	**Door hardware, kick plate, stainless steel, 6" high for 3' door**	**15.0**	**EA**	**27.53**	**31.00**				**58.53**	**878**
	08710700 - Mortise Lockset									
0020	**Door hardware, mortise lockset, commercial, wrought knobs and full escutcheon trim, non-keyed, passage, minimum**	**15.0**	**EA**	**45.46**	**175.00**				**220.46**	**3,307**
	08720300 - Weatherstripping, Window									
2300	**Weatherstripping, doors, metal frame, spring type, bronze, for 3' x 7' door**	**15.0**	**Opng**	**137.02**	**35.50**				**172.52**	**2,588**
	08720800 - Thresholds									
0500	**Thresholds, bronze**	**45.0**	**LF**	**6.85**	**38.50**				**45.35**	**2,041**
	Hardware Total									**13,592**
	09900 - Paints & Coatings									
	09910640 - B & C coating specification									
0030bc	Coatings & paints	18,500.0	sqft	0.65	0.86				1.51	27,905
	Paints & Coatings Total									**27,905**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	10100 - Visual Display Boards									
	10160100 - Toilet Partitions, Metal									
1700	Toilet cubicles, floor mounted, painted metal	1.0	EA	146.47	545.00				691.47	691
7800	Urinal screen, wedge type, painted metal	1.0	EA	102.45	128.00				230.45	230
	Visual Display Boards Total									**922**
	10800 - Toilet/Bath/Laundry Accessories									
	10810100 - Commercial Toilet Accessories									
0610	Toilet Accessories, dispenser units, towel dispenser & waste receptacle, 18 gallon capacity	1.0	EA	51.22	395.00				446.22	446
0900	Toilet Accessories, grab bars, straight, stainless steel, 24" long	1.0	EA	22.25	32.00				54.25	54
1100	Toilet Accessories, grab bars, straight, stainless steel, 36" long	1.0	EA	25.61	36.00				61.61	62
3200	Toilet Accessories, mirror, 48" x 24", with stainless steel 3/4" square frame	1.0	EA	51.22	173.00				224.22	224
4600	Toilet Accessories, soap dispenser, chrome, surface mounted, liquid	1.0	EA	25.61	47.50				73.11	73
6000	Toilet Accessories, toilet seat cover dispenser, stainless steel, recessed	1.0	EA	25.61	143.00				168.61	169
6200	Toilet Accessories, toilet tissue dispenser, stainless steel, surface mounted, double roll	1.0	EA	21.29	24.00				45.29	45
	Toilet/Bath/Laundry Accessories Total									**1,073**
	11000 - Equipment									
	11000100 - Process Equipment									
0130do	Pump, Submersible Lift, 2500 gpm, rail mounted	4.0	each	6,272.00	51,600.00				57,872.00	231,488
0300IK	Dewatering Polymer Feed System (includes pumps)	1.0	each	651.46	8,500.00		150.40		9,301.86	9,302
0950	Belt conveyor, complete w/ walkway, supports,e-stop	1.0	each	7,000.00	7,000.00		1,000.00		15,000.00	15,000
1270	Pump, Aeration Basin Feed, submersible centrifugal	3.0	each	4,800.00	17,850.00				22,650.00	67,950
1270	Pump, Anaerobic Wasteage, rotary lobe	6.0	each	4,800.00	10,750.00				15,550.00	93,300
1270	Pump, MBR RAS, centrifugal	6.0	each	4,800.00	19,950.00				24,750.00	148,500
1270	Pump, MBR WAS, centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300
1270	Pump, Filtrate, submersible centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1270	Pump, Belt Filter Press, centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300
NREL01	Anaerobic Treatment System	1.0	lsum					30,000,000.00	30,000,000.00	30,000,000
NREL02	Membrane Bioreactor	1.0	lsum	262,500.00	3,500,000.00		105,000.00		3,867,500.00	3,867,500
NREL03	Belt Filter Press	3.0	each	22,500.00	300,000.00		9,000.00		331,500.00	994,500
NREL04	Reverse Osmosis Unit	5.0	each	24,997.50	333,300.00		9,999.00		368,296.50	1,841,483
NREL05	Evaporator	1.0	lsum	243,750.00	3,250,000.00		97,500.00		3,591,250.00	3,591,250
NREL06	Blowers	1.0	lsum	225,000.00	3,000,000.00		90,000.00		3,315,000.00	3,315,000
NREL10	Aeration Grid and Air Piping	1.0	lsum	200,000.00	2,500,000.00				2,700,000.00	2,700,000
	11001900 - Laboratory equipment									
0320	Laboratory equip & furnishing, allowance	350.0	sqft					59.25	59.25	20,738
	Equipment Total									**47,031,910**
	13120 - Pre-Engineered Structures									
	13128700 - Pre-Engineered Steel Buildings									
0400	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 30' to 40' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	800.0	SF	7.83	9.65		4.37		21.85	17,483
0900	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 50' to 100' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	6,600.0	SF	4.43	8.40		2.48		15.31	101,053
1100	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 50' to 100' W x 60' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	1,000.0	SF	5.35	29.95		3.00		38.30	38,297
	Pre-Engineered Structures Total									**156,833**
	13200 - Storage Tanks									
	13201200 - Elevated Storage Tanks									
3300	Aboveground Storage Tanks, Steel, 100,000 gallons, incl. painting	1.0	EA			250,000.00			250,000.00	250,000
	Storage Tanks Total									**250,000**
	15100 - Building Services Piping									
	15140800 - Water Hammer Arrestors / Shock Absorbers									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0500	Water hammer arrester/shock absorber, copper, for 1 to 11 fixtures, 3/4" male I.P.S.	1.0	EA	52.89	17.00				69.89	70
	Building Services Piping Total									**70**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0400B	Allowance - Process Piping	1.0	lsum	910,200.00	1,820,400.00		120,000.00		2,850,600.00	2,850,600
0400C	Allowance - small bore piping	1.0	lsum	25,000.00	25,000.00				50,000.00	50,000
	Process Piping Total									**2,900,600**
	15400 - Plumbing Fixtures & Equipment									
	15411700 - Urinals									
3120	Urinal, wall hung, vitreous china, with hanger & self-closing valve, blowout type	1.0	EA	401.97	385.00				786.97	787
3300	Urinal, wall hung, rough-in, supply, waste and vent	1.0	EA	426.02	240.00				666.02	666
	15418450 - Lavatories									
0640	Lavatory, vanity top, porcelain enamel on cast iron, white, oval, 33" x 19", includes trim	1.0	EA	188.96	505.00				693.96	694
	15418600 - Sinks									
6790	Sink, service, floor, rough-in, supply, waste and vent	1.0	EA	738.67	705.00				1,443.67	1,444
	15418900 - Water Closets									
0400	Water closet, tank type, vitreous china, wall hung, close coupled, two piece, includes seat, supply pipe with stop	1.0	EA	226.75	555.00				781.75	782
0960	Water closet, tank type, vitreous china, wall hung, rough-in, supply, waste, vent and carrier	1.0	EA	441.48	630.00				1,071.48	1,071
	15480200 - Water Heaters									
1100	Water heater, residential, electric, glass lined tank, double element, 5 year, 52 gallon	1.0	EA	317.36	560.00				877.36	877
	Plumbing Fixtures & Equipment Total									**6,321**
	15700 - Heating/Ventilating/Air Conditioning Equipment									
	15700100 - HVAC Allowance									
0010	**HVAC heating, cooling allowance**	**8,400.0**	**sqft**			**10.00**			**10.00**	**84,000**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	Heating/Ventilating/Air Conditioning Equipment Total									**84,000**
	16000 - Electrical and Instrumentation									
	16000000 - Electrical and Instrumentation									
0001	**Electrical, building wiring, switches, outlets**	**8,400.0**	**sqft**			**8.00**			**8.00**	**67,200**
0001	Electrical and Instrumentation Subcontract	1.0	lsum			4,600,000.00			4,600,000.00	4,600,000
	Electrical and Instrumentation Total									**4,667,200**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	HIGH CONFIDENCE SCENARIO									
	NREL WASTEWATER TREATMENT EVALUATION									**86,123,159**
	02000 - Site Civil Work									
	02000000 - General Civil Work									
0990	Allowance - Site Work	1.0	lsum	96,000.00	96,000.00		33,600.00		225,600.00	225,600
	Site Civil Work Total									**225,600**
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	**Backfill, structural, common earth, 200 H.P. dozer, 300' haul**	**184.4**	**L.C.Y.**	**0.78**			**1.53**		**2.31**	**427**
5420	Backfill, structural, common earth, 300 H.P. dozer, 300' haul	20,258.2	L.C.Y.	0.43			1.09		1.52	30,857
	02315310 - Compaction, General									
7000	**Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate**	**20,550.7**	**E.C.Y.**	**1.77**			**0.17**		**1.93**	**39,702**
7500	**Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**166.0**	**E.C.Y.**	**1.38**			**0.36**		**1.74**	**289**
7520	**Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**385.0**	**E.C.Y.**	**2.06**			**0.54**		**2.60**	**1,002**
7540	**Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**887.0**	**E.C.Y.**	**2.76**			**0.72**		**3.48**	**3,083**
	02315424 - Excavating, Bulk Bank Measure									
4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	71,615.5	B.C.Y.	4.77			7.13		11.90	852,454
	02315492 - Hauling									
0009	**Loading Trucks, F.E. Loader, 3 C.Y.**	**71,338.4**	**cuyd**	**0.59**			**1.06**		**1.65**	**117,809**
4298	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**73,894.5**	**L.C.Y.**	**1.65**			**3.17**		**4.83**	**356,617**
4498	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 20 CY truck, cycle 20 miles, 45 MPH, no loading equipment**	**2,077.2**	**L.C.Y.**	**1.83**			**3.52**		**5.35**	**11,113**
	02315610 - Excavating, Trench									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0060	**Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering**	**2,060.2**	**B.C.Y.**	**3.78**			**1.79**		**5.57**	**11,476**
	02315640 - Utility Bedding									
0100	**Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction**	**5,640.3**	**L.C.Y.**	**7.21**	**43.50**		**2.04**		**52.75**	**297,544**
	Earthwork Total									**1,722,373**
	02600 - Drainage & Containment									
	02630400 - Storm Drainage Manholes, Frames & Covers									
1210	Storm Drainage Manholes, Frames, and Covers, concrete, precast, 6' inside diameter, 8' deep, excludes footing, excavation, backfill, frame and cover	4.0	EA	1,085.14	2,375.00		306.13		3,766.27	15,065
1500	Storm Drainage Manholes, Frames, and Covers, precast concrete, 6' diameter manhole, 8" thick top	4.0	EA	154.83	595.00		43.73		793.56	3,174
4100	Storm Drainage Manholes, Frames, and Covers, steps, standard sizes, aluminum	42.0	EA	10.95	25.50				36.45	1,531
	Drainage & Containment Total									**19,770**
	03100 - Concrete Forms & Accessories									
	03110445 - Forms In Place, Slab On Grade									
3050	**C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**5,108.0**	**sfca**	**3.64**	**0.74**				**4.38**	**22,388**
3550	C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning	4,944.0	LF	9.01	0.76				9.77	48,300
	03110455 - Forms In Place, Walls									
2550	C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning	123,600.0	sfca	6.19	0.78				6.97	861,027
	03150860 - Waterstop									
0600	**Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide**	**4,944.0**	**LF**	**3.28**	**4.50**				**7.78**	**38,456**
	Concrete Forms & Accessories Total									**970,171**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
0602	**Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**1,020,558.3**	**lb**	**0.46**	**0.44**				**0.90**	**919,612**
0702	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	591,518.0	lb	0.33	0.44				0.77	452,791
2000	**Reinforcing steel, unload and sort, add to base**	**829.9**	**ton**	**32.60**			**8.22**		**40.82**	**33,879**
2210	**Reinforcing steel, crane cost for handling, average, add**	**829.9**	**ton**	**35.26**			**8.95**		**44.21**	**36,692**
2450	**Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**46,591.1**	**lb**	**1.33**	**0.55**				**1.88**	**87,545**
	Concrete Reinforcement Total									**1,530,519**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**Structural concrete, ready mix, normal weight, 4000 PSI, includes local aggregate, sand, Portland cement and water, delivered, excludes all additives and treatments**	**12,646.1**	**CY**		**106.00**				**106.00**	**1,340,492**
	03310700 - Placing Concrete									
4650	**Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibrating, excludes material**	**8,068.4**	**CY**	**16.14**			**4.44**		**20.58**	**166,080**
5350	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	4,577.8	CY	24.86			6.87		31.73	145,260
	03350300 - Finishing Floors									
0150	**Concrete finishing, floors, manual screed, bull float, manual float, broom finish**	**116,427.5**	**SF**	**0.65**					**0.65**	**75,359**
	03350350 - Finishing Walls									
0150	Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids	88,992.0	SF	2.39					2.39	212,939
	Cast-In-Place Concrete Total									**1,940,131**
	05100 - Structural Metal Framing									
	05120640 - Structural Steel Members									
0302	Structural steel member, 100-ton project, 1 to 2 story building, W8x10, A992 steel, shop fabricated, incl shop primer, bolted connections	1,648.0	LF	5.39	16.50		3.02		24.91	41,048
	Structural Metal Framing Total									**41,048**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	05500 - Metal Fabrications									
	05514500 - Ladder									
0400	Ladder, shop fabricated, aluminum, 20" W, bolted to concrete, excl cage	75.0	vlft	23.29	64.50		1.64		89.44	6,708
	05517700 - Stair									
0400	Stair, shop fabricated, steel, 3'-6" W, incl pipe railing, stringers, cast iron treads w/ safety nosing, per riser	68.0	Riser	56.86	600.00		3.99		660.85	44,937
1500	Stair landing, shop fabricated, steel, conventional, incl framing, metal fan forms, excl concrete for pan forms	64.0	SF	12.40	75.00		0.87		88.27	5,650
	05520700 - Railing, Pipe									
0210	Railing, pipe, aluminum, clear finish, 3 rails, 3'-6" high, posts @ 5' O.C., 1-1/2" dia, shop fabricated	3,090.0	LF	14.45	71.00		1.02		86.47	267,206
	05530300 - Floor Grating, Aluminum									
0132	Floor grating, aluminum, 1-1/2" x 3/16" bearing bars @ 1-3/16" O.C., cross bars @ 4" O.C., up to 300 S.F., field fabricated from panels	6,180.0	SF	2.84	41.50		0.20		44.53	275,219
	05530360 - Grating Frame									
0020	Grating frame, aluminum, 1" to 1-1/2" D, field fabricated	3,090.0	LF	6.89	2.88				9.77	30,199
	Metal Fabrications Total									**629,919**
	08100 - Metal Doors And Frames									
	08110200 - Commercial Steel Doors									
0100	**Doors, hollow metal, commercial, steel, flush, full panel, hollow core, 1-3/8" thick, 20 ga., 3'-0" x 7'-0"**	**15.0**	**EA**	**48.02**	**295.00**				**343.02**	**5,145**
	08110250 - Door Frames									
0100	**Door frames, steel channels with anchors and bar stops, 6" channel@ 8.2 lb/LF, 3' x 7' door, weighs 150 lb**	**7.0**	**EA**	**152.08**	**270.00**		**10.72**		**432.80**	**3,030**
0200	**Door frames, steel channels with anchors and bar stops, 8" channel@ 11.5 lb/LF, 6' x 8' door, weighs 275 lb**	**4.0**	**EA**	**220.58**	**495.00**		**15.51**		**731.09**	**2,924**
	Metal Doors And Frames Total									**11,099**
	08300 - Specialty Doors									
	08310350 - Floor, Industrial									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
3020ds	Doors, specialty, access, floor, industrial, aluminum, Gas/Watertight, H-20, single leaf, 3' x 3'	4.0	Opng	160.84	1,147.00				1,307.84	5,231
	08360550 - Overhead, Commercial									
2700	**Doors, overhead, commercial, stock, steel, heavy duty, sectional, manual, 24 gauge, 12' x 12' high**	**3.0**	**EA**	**544.26**	**1,175.00**				**1,719.26**	**5,158**
	Specialty Doors Total									**10,389**
	08700 - Hardware									
	08710300 - Door Closers									
0015	**Door hardware, door closer, rack and pinion**	**15.0**	**EA**	**62.75**	**148.00**				**210.75**	**3,161**
	08710340 - Doorstops									
0020	**Door hardware, doorstops, holder and bumper, floor or wall**	**15.0**	**EA**	**12.81**	**33.50**				**46.31**	**695**
	08710520 - Hinges									
0100	**Door hardware, hinges, full mortise, average frequency, steel base, USP, 5" x 5"**	**22.5**	**pair**		**41.00**				**41.00**	**923**
	08710550 - Kick Plate									
0020	**Door hardware, kick plate, stainless steel, 6" high for 3' door**	**15.0**	**EA**	**27.53**	**31.00**				**58.53**	**878**
	08710700 - Mortise Lockset									
0020	**Door hardware, mortise lockset, commercial, wrought knobs and full escutcheon trim, non-keyed, passage, minimum**	**15.0**	**EA**	**45.46**	**175.00**				**220.46**	**3,307**
	08720300 - Weatherstripping, Window									
2300	**Weatherstripping, doors, metal frame, spring type, bronze, for 3' x 7' door**	**15.0**	**Opng**	**137.02**	**35.50**				**172.52**	**2,588**
	08720800 - Thresholds									
0500	**Thresholds, bronze**	**45.0**	**LF**	**6.85**	**38.50**				**45.35**	**2,041**
	Hardware Total									**13,592**
	09900 - Paints & Coatings									
	09910640 - B & C coating specification									
0030bc	Coatings & paints	19,500.0	sqft	0.65	0.86				1.51	29,414
	Paints & Coatings Total									**29,414**

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	10100 - Visual Display Boards									
	10160100 - Toilet Partitions, Metal									
1700	Toilet cubicles, floor mounted, painted metal	1.0	EA	146.47	545.00				691.47	691
7800	Urinal screen, wedge type, painted metal	1.0	EA	102.45	128.00				230.45	230
	Visual Display Boards Total									**922**
	10800 - Toilet/Bath/Laundry Accessories									
	10810100 - Commercial Toilet Accessories									
0610	Toilet Accessories, dispenser units, towel dispenser & waste receptacle, 18 gallon capacity	1.0	EA	51.22	395.00				446.22	446
0900	Toilet Accessories, grab bars, straight, stainless steel, 24" long	1.0	EA	22.25	32.00				54.25	54
1100	Toilet Accessories, grab bars, straight, stainless steel, 36" long	1.0	EA	25.61	36.00				61.61	62
3200	Toilet Accessories, mirror, 48" x 24", with stainless steel 3/4" square frame	1.0	EA	51.22	173.00				224.22	224
4600	Toilet Accessories, soap dispenser, chrome, surface mounted, liquid	1.0	EA	25.61	47.50				73.11	73
6000	Toilet Accessories, toilet seat cover dispenser, stainless steel, recessed	1.0	EA	25.61	143.00				168.61	169
6200	Toilet Accessories, toilet tissue dispenser, stainless steel, surface mounted, double roll	1.0	EA	21.29	24.00				45.29	45
	Toilet/Bath/Laundry Accessories Total									**1,073**
	11000 - Equipment									
	11000100 - Process Equipment									
0130do	Pump, Submersible Lift, 2500 gpm, rail mounted	4.0	each	6,272.00	51,600.00				57,872.00	231,488
0300IK	Dewatering Polymer Feed System (includes pumps)	1.0	each	651.46	8,500.00		150.40		9,301.86	9,302
0950	Belt conveyor, complete w/ walkway, supports,e-stop	1.0	each	7,000.00	7,000.00		1,000.00		15,000.00	15,000
1270	Pump, Aeration Basin Feed, submersible centrifugal	4.0	each	4,800.00	13,050.00				17,850.00	71,400
1270	Pump, Anaerobic Wasteage, rotary lobe	6.0	each	4,800.00	10,750.00				15,550.00	93,300
1270	Pump, MBR RAS, centrifugal	6.0	each	4,800.00	21,900.00				26,700.00	160,200
1270	Pump, MBR WAS, centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300
1270	Pump, Filtrate, submersible centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1270	Pump, Centrifuge Feed, centrifugal	2.0	each	4,800.00	17,850.00				22,650.00	45,300
1270	Pump, DAF Float, centrifugal	2.0	each	4,800.00	10,200.00				15,000.00	30,000
1270	Pump, Plant Recycle, centrifugal	3.0	each	4,800.00	13,500.00				18,300.00	54,900
1270	Pump, DAF Feed, centrifugal	3.0	each	4,800.00	17,850.00				22,650.00	67,950
NREL01	Anaerobic Treatment System	1.0	lsum					30,000,000.00	30,000,000.00	30,000,000
NREL02	Membrane Bioreactor	1.0	lsum	356,250.00	4,750,000.00		142,500.00		5,248,750.00	5,248,750
NREL04	Reverse Osmosis Unit	6.0	each	24,997.50	333,300.00		9,999.00		368,296.50	2,209,779
NREL05	Evaporator	1.0	lsum	257,925.00	3,439,000.00		103,170.00		3,800,095.00	3,800,095
NREL06	Blowers	1.0	lsum	262,500.00	3,500,000.00		105,000.00		3,867,500.00	3,867,500
NREL07	Dissolved Air Flotation Unit	2.0	each	22,500.00	300,000.00		9,000.00		331,500.00	663,000
NREL08	Crystallizer	1.0	each	913,500.00	12,180,000.00		365,400.00		13,458,900.00	13,458,900
NREL09	Centrifuge	5.0	each	48,750.00	650,000.00		19,500.00		718,250.00	3,591,250
NREL10	Aeration Grid and Air Piping	1.0	lsum	200,000.00	2,500,000.00				2,700,000.00	2,700,000
	11001900 - Laboratory equipment									
0320	Laboratory equip & furnishing, allowance	350.0	sqft			60.00			60.00	21,000
	Equipment Total									**66,429,714**
	13120 - Pre-Engineered Structures									
	13128700 - Pre-Engineered Steel Buildings									
0400	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 30' to 40' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	800.0	SF	7.83	9.65		4.37		21.85	17,483
0900	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 50' to 100' W x 16' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	6,600.0	SF	4.43	8.40		2.48		15.31	101,053
1100	Pre-Eng Steel Bldg, clear span rigid frame, 30 psf roof and 20 psf wind load, 50' to 100' W x 60' eave H, incl. 26 ga. colored ribbed roofing & siding, excl. footings, slab, anchor bolts	1,000.0	SF	5.35	29.95		3.00		38.30	38,297
	Pre-Engineered Structures Total									**156,833**
	13200 - Storage Tanks									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
	13201200 - Elevated Storage Tanks									
3700	Aboveground Storage Tanks, Steel, 830,000 gallons, incl. painting	1.0	EA			1,494,000.00			1,494,000.00	1,494,000
	Storage Tanks Total									**1,494,000**
	15100 - Building Services Piping									
	15140800 - Water Hammer Arrestors / Shock Absorbers									
0500	Water hammer arrester/shock absorber, copper, for 1 to 11 fixtures, 3/4" male I.P.S.	1.0	EA	52.89	17.00				69.89	70
	Building Services Piping Total									**70**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0400B	Allowance - Process Piping	1.0	lsum	1,303,200.00	2,605,800.00		180,000.00		4,089,000.00	4,089,000
0400C	Allowance - small bore piping	1.0	lsum	25,000.00	25,000.00				50,000.00	50,000
	Process Piping Total									**4,139,000**
	15400 - Plumbing Fixtures & Equipment									
	15411700 - Urinals									
3120	Urinal, wall hung, vitreous china, with hanger & self-closing valve, blowout type	1.0	EA	401.97	385.00				786.97	787
3300	Urinal, wall hung, rough-in, supply, waste and vent	1.0	EA	426.02	240.00				666.02	666
	15418450 - Lavatories									
0640	Lavatory, vanity top, porcelain enamel on cast iron, white, oval, 33" x 19", includes trim	1.0	EA	188.96	505.00				693.96	694
	15418600 - Sinks									
6790	Sink, service, floor, rough-in, supply, waste and vent	1.0	EA	738.67	705.00				1,443.67	1,444
	15418900 - Water Closets									
0400	Water closet, tank type, vitreous china, wall hung, close coupled, two piece, includes seat, supply pipe with stop	1.0	EA	226.75	555.00				781.75	782
0960	Water closet, tank type, vitreous china, wall hung, rough-in, supply, waste, vent and carrier	1.0	EA	441.48	630.00				1,071.48	1,071
	15480200 - Water Heaters									

Item	Item Description	Qty	Unit	Labor $/Unit	Materials $/Unit	Subs $/Unit	Equip $/Unit	Other $/Unit	Total $/Unit	Total Net Cost $
1100	Water heater, residential, electric, glass lined tank, double element, 5 year, 52 gallon	1.0	EA	317.36	560.00				877.36	877
	Plumbing Fixtures & Equipment Total									**6,321**
	15700 - Heating/Ventilating/Air Conditioning Equipment									
	15700100 - HVAC Allowance									
0010	**HVAC heating, cooling allowance**	**8,400.0**	**sqft**			**10.00**			**10.00**	**84,000**
	Heating/Ventilating/Air Conditioning Equipment Total									**84,000**
	16000 - Electrical and Instrumentation									
	16000000 - Electrical and Instrumentation									
0001	**Electrical, building wiring, switches, outlets**	**8,400.0**	**sqft**			**8.00**			**8.00**	**67,200**
0001	Electrical and Instrumentation Subcontract	1.0	lsum			6,600,000.00			6,600,000.00	6,600,000
	Electrical and Instrumentation Total									**6,667,200**

Category	Percent	Amount	Hours
LOW COST SCENARIO Totals			
Labor	**3.49 %**	**5,174,468**	**80,544.2**
Material	**13.78 %**	**20,425,519**	
Subcontractor	**3.37 %**	**5,001,200**	
Equipment	**1.01 %**	**1,496,692**	**30,533.3**
Other	**20.25 %**	**30,020,738**	
User			
Net Costs		**62,118,617**	
Labor Mark-up	10.00 %	517,447	
Material/Process Equipment Mark-up	8.00 %	1,634,042	
Subcontractor Mark-up	5.00 %	250,060	
Construction Equipment Mark-up	8.00 %	119,735	
Sales tax	9.75 %	2,137,416	
Material Shipping & Handling	2.00 %	346,507	
Subtotal		**67,123,823**	
Contractor General Conditions	10.00 %	6,712,382	
Subtotal		**73,836,205**	
Start-up, training, O & M	2.00 %	456,437	
Subtotal		**74,292,642**	
Construction Contingency	30.00 %	22,287,793	
Subtotal		**96,580,434**	
Bldg Risk, Liability Auto Ins.	2.00 %	1,931,609	
Subtotal		**98,512,043**	

Category	Percent	Amount	Hours
Bonds	1.50 %	1,477,681	
Subtotal		**99,989,724**	
Total LOW COST SCENARIO		**99,989,724**	
HIGH CONFIDENCE SCENARIO Totals			
Labor	**4.70 %**	**6,965,006**	**109,271.6**
Material	**26.17 %**	**38,799,875**	
Subcontractor	**5.58 %**	**8,266,200**	
Equipment	**1.41 %**	**2,092,078**	**47,044.3**
Other	**20.24 %**	**30,000,000**	
User			
Net Costs		**86,123,159**	
Labor Mark-up	10.00 %	696,501	
Material/Process Equipment Mark-up	8.00 %	3,103,990	
Subcontractor Mark-up	5.00 %	413,310	
Construction Equipment Mark-up	8.00 %	167,366	
Sales tax	9.75 %	3,986,965	
Material Shipping & Handling	2.00 %	712,757	
Subtotal		**95,204,048**	
Contractor General Conditions	10.00 %	9,520,405	
Subtotal		**104,724,453**	
Start-up, training, O & M	2.00 %	938,879	
Subtotal		**105,663,333**	

Category	Percent	Amount	Hours
Construction Contingency	30.00 %	31,699,000	
Subtotal		**137,362,332**	
Bldg Risk, Liability Auto Ins.	2.00 %	2,747,247	
Subtotal		**140,109,579**	
Bonds	1.50 %	2,101,644	
Subtotal		**142,211,223**	
Total HIGH CONFIDENCE SCENARIO		**142,211,223**	