Schematic Design Report
Lahaina Wastewater Reclamation Facility

PREPARED FOR:	County of Maui Department of Public Works and Environmental Management
PREPARED BY:	CH2M HILL
DATE:	September 20, 2006
PROJECT NUMBER:	176853.PS.02

Executive Summary

This report summarizes the work completed to date with respect to identifying improvements needed at the Lahaina Wastewater Reclamation Facility (WWRF). A series of studies has been completed to characterize flows and loads currently being treated at the plant, as well as the performance and capacity of the existing facilities. This information was used to identify short-term improvements needed at the plant and to develop implementation strategies for increasing the capacity of the plant if ongoing community planning concludes that there will be growth within the service area.

The Lahaina WWRF currently treats an average dry weather flow of approximately 5 million gallons per day (mgd). The plant is capable of treating approximately 5.5 mgd, although limits to the amount of redundant facilities and opportunities for improving performance may require some short-term improvements regardless of projected growth within the basin. These improvements include the following:

- Replacing existing screens
- Adding a mixed liquor recirculation (MLR) pump
- Filling the notches in the screenings channel
- Adding aeration basin capacity
- Rehabilitating the existing DAFT

Additionally, some odor control for the solids load-out facilities will be needed, but the timing may be based on when nearby land is developed.

Alternative 7A is recommended for expansion, if needed. Alternative 7A includes expanding the existing secondary process such that there will be one common set of secondary clarifiers and a new aeration basin running in parallel with the existing basin. All other liquids processes will be expanded using processes similar to those currently in use at the facility. This plan also limits the amount of reuse water that can be produced to 3 mgd, which is the capacity of the existing ultraviolet (UV) system.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

A Biosolids Master Plan (BMP) completed as part of these studies concluded that the current practice of taking undigested, dewatered biosolids offsite to be composted is the most cost-effective disposal option available to the plant. Additionally, an evaluation of solids processing concluded that thickening prior to dewatering is the most cost-effective option for expansion. Therefore, the solids processing improvements will include additional dissolved air flotation thickeners (DAFTs), centrifuges, holding tanks, and silos. The design will allow for continuous thickening, but dewatering will be done only 8 hours per day, 7 days per week.

The final scope of the first phase of expansion at the plant will be based on the expected growth rate within the service area, as determined by an ongoing study.

Background

The objectives for the schematic design were identified through discussions with County of Maui staff and the results of the Phase 1 and Phase 2 process evaluations. The primary driver relates to capacity issues. The County needs to determine the most cost-effective approach for accommodating potential growth in the service area and the expected rate of that growth, both of which are currently being evaluated by the County Planning Department.

The current regulatory rated capacity of the plant is 9 mgd, allocated between the 1975 and the 1985 plants. Thus, the rated capacity relies on a portion of that capacity being provided by the old 1975 facilities. However, the 1975 facilities have not been in service for several years and may require significant repairs, upgrades, or improvements before they can be placed back in service. Likewise, various limitations such as equipment capacities and hydraulics have prevented the 1985 plant from fully realizing its rated capacity. The purpose of the Phase 1 study was to complete a condition assessment of the existing facilities, estimate the capacity of the existing facilities, and identify alternatives for increasing capacity.

The process evaluation completed as part of the Phase 2 study consisted of developing the process alternatives identified in the Phase 1 study and evaluating them on the basis of cost and non-cost criteria. The results of the Phase 2 evaluation indicated that the most cost-effective alternative for meeting the buildout scenarios was expanding the plant either by (a) using membrane bioreactors (Alternative 4) or (b) replacing the 1975 plant with a new secondary treatment process with a Modified Ludzack-Ettinger (MLE) configuration (Alternative 7).

The original objectives of the Schematic Design were as follows:

- Establish current influent flows and loads to the plant.
- Determine whether to implement Alternative 7 or Alternative 4.
- Prepare a Biosolids Master Plan.
- Establish an implementation plan for increasing the capacity of the plant that is flexible enough to address projected growth, as determined by the County Planning Department.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

The analysis of the flow and load characteristics was completed based on 5 years of influent data. The peaking factors developed as part of this analysis were used in combination with a plant process model to estimate the existing average dry weather (ADW) capacity of the plant.

The results, presented in the Preliminary Findings of the Schematic Design (see Appendix A), indicated that the plant should not be able to meet current permit and reuse requirements. However, the plant is currently not having trouble meeting any discharge requirements.

To determine the source of the discrepancy, the County provided operational data from the past several years. The new operational data indicate that the data gathered during the Phase 1 study that was used to calibrate the model were not accurate. The model was recalibrated on the basis of the new data, and the capacity of the existing facilities was estimated based on an ADW condition. The results of the recalibration of the model are included in Process Model Calibration and Existing Capacity Assessment (see Appendix B).

Based on the results of Preliminary Findings of the Schematic Design, there was no significant difference in costs for implementing Alternative 4 or 7. Because Alternative 4 was based on using a technology that is both relatively new and significantly different than the processes currently being used at any of the County plants, a decision was made to implement Alternative 7.

This report summarizes the most relevant findings of all the previous studies and presents a schematic design for increasing the plant capacity based on the Alternative 7 configuration.

Existing Flows and Loads

Flow and load data were analyzed for the Lahaina WWRF in order to refine the design of the plant upgrade options identified in the Lahaina WWRF Process Study—Steady State Process Modeling and Alternatives Evaluation, Final Phase 2 Report (CH2M HILL, September 2005).

Plant influent (PI) data were obtained from the County of Maui for the past 5 years. The data were used to develop peaking factors for critical design parameters. The peaking factors were used for capacity analysis and to estimate projected flows and loads based on predicted growth in the collection system as determined by the County. The flow and load analysis is more fully described in the Lahaina WWRF Flow and Load Analysis (see Appendix C).

The average range for flows and loads for 2001-2005 is presented in Table 1.

TABLE 1
Estimated Flows and Loads, 2001–2005

	Flow, mgd	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
Average Dry Weather (ADW)	5.0	10,153	8,124	652	1,189	493

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 1
Estimated Flows and Loads, 2001–2005

	Flow, mgd	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
Maximum Month	6.0	12,996	10,398	835	1,521	631
Maximum Week	7.0	19,390	15,514	1,174	2,270	942
Maximum Day	8.3	24,469	16,379	1,304	3,004	945
Peak Hour (estimated)	11.1					

Abbreviations:
mgd = million gallons per day.
TSS = total suspended solids.
lb/d = pounds per day.
CBOD = carbonaceous biochemical oxygen demand.
NH_3 = ammonia.
TKN = total Kjeldahl nitrogen.
TP = total phosphorus.

Design Criteria

The Lahaina WWRF currently consists of preliminary, secondary, tertiary, and disinfection facilities, which are required to meet two discharge requirements. One set of discharge requirements is included in the plant's underground injection control (UIC) permit. This permit applies to all flows that are discharged into injection wells. The second set of discharge requirements applies to the flows that discharge to reuse facilities. The reuse water must meet R-1 requirements of the Hawaii State Department of Health. The discharge limits for each of these criteria that control facilities design are outlined in Table 2.

TABLE 2
Lahaina WWRF Permit Limits

Parameter	UIC Limit	Reuse Limit
BOD_5, mg/L	30	
Total Suspended Solids, mg/L	30	
Total Residual Chlorine, mg/L	0.1 minimum	
Total Nitrogen, mg/L	10	
Turbidity, NTU		2

Abbreviations:
UIC = underground injection control.
BOD_5 = 5-day biochemical oxygen demand.
mg/L = milligrams per liter.
NTU = nephelometric turbidity unit(s).

In addition to the parameters listed in Table 2, R-1 water must at all times be oxidized, filtered, and exposed to a disinfection process and meet specific disinfection requirements

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

for fecal coliform. Also, despite the permit limit of 30 milligrams per liter (mg/L) for total suspended solids (TSS) in the UIC permit, a significantly lower TSS level is required to ensure that the wells do not become plugged.

On the basis of the parameters in Table 2 and the additional limitations on reuse and the limits of the injection wells to take solids, the following process requirements are assumed:

- The secondary system must be designed for nitrification and denitrification to meet the total nitrogen (TN) requirement for the UIC permit.
- Because there is currently no disinfection requirement in the UIC permit, the chlorine contact basins only need to be designed such that the chlorine residual can be met. This may be accomplished with very short detention times. If a disinfection limit is included in future permits, this criterion may need to be reevaluated.
- Flows must be filtered prior to discharge to meet the requirements not to plug the injection wells and to meet the nephelometric turbidity unit (NTU) requirements for reuse.

Table 3 presents the design criteria used in sizing new facilities and estimating the capacity of existing facilities. These criteria are based on industry standards for meeting the process requirements discussed above, discussions with plant staff about the performance of the existing facilities, and stress testing of the existing secondary clarifiers.

In addition to the criteria in Table 3, some redundancy is needed for the aeration basins. Because of the size and configuration of the existing aeration basins in the 1985 plant, it currently is not possible to take the conventional aeration basin (CAB) out of service for inspection and maintenance. Any plant improvements should have, at a minimum, provisions for providing additional aeration basin volume such that the conventional aeration basin can be taken out of service for a limited period of time while allowing the plant to meet permit requirements. It is recommended that the redundant basin be sized such that average annual flows can be treated without the CAB in service while the remaining facilities, including all secondary clarifiers, are operated at a minimum solids retention time (SRT) of 3 days. Operating at this SRT should still allow the plant to meet the TN limit but will increase solids production. Therefore, taking the CAB out of service should be possible for limited periods of time (2–3 weeks).

Existing Capacity

Currently, plant operators try to maintain a relatively constant biomass within the aeration basin and secondary clarifiers. Therefore, the SRT within the basins varies based on the loads and the amount of wasting required to maintain the biomass. Plant data indicate that the minimum SRT at which the plant has operated for at least one month is approximately 8 days. This minimum historical SRT has been used to establish the current capacity. On the basis of the minimum historical SRT and the criteria listed in Table 3, and assuming that the 1975 aeration basin and secondary clarifiers are not in operable condition, the liquid treatment capacity of the Lahaina WWRF is limited by the capacity of the 1985 secondary treatment system, which is provided in Table 4. The capacity is determined by the maximum month solids loading rate on the secondary clarifiers. The ADW capacity is

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

estimated based on the peaking factors developed as part of the flow and load analysis (1.2 for maximum month).

Using the criteria of having one secondary clarifier out of service under maximum month conditions, the reliable plant capacity for liquids treatment is currently approximately 4.5 mgd on an ADW basis. The estimated ADW capacity is below the average observed flow to the plant. It is probable that the plant has not had any problems meeting permit requirements because the third clarifier has been available during peak months. If it is assumed that all secondary clarifiers are in service, the maximum month capacity is 6.6 mgd, which translates to an ADW capacity of 5.5 mgd. Therefore, if the redundancy requirement for the secondary clarifiers is not applied, the plant has approximately 0.5 mgd of excess capacity.

The model results for ADW flows of 5.5 mgd project that the maximum month loading on the DAFT would be 1.2 pounds per hour per square foot (lb/hr/ft2), which is close to the design criteria for maximum day loading. Therefore, it is likely that additional thickening capacity would be required to match the solids processing capacity to the liquids processing capacity at peak loads and for periods where an aeration basin must be taken out of service.

Liquids Process Facilities Expansion

The capacity of the liquids process facilities will be increased by first optimizing the performance of the existing facilities and then adding facilities similar to the existing facilities as needed. The following paragraphs describe the proposed approach for improving performance and increasing capacity for each of the liquids unit processes.

Preliminary Treatment

There are currently plans to replace the existing screens with step screens. These screens will each have a peak hour capacity of 13 mgd. Assuming the manual screen is available if one of the step screens is down, no additional screens will be needed unless the plant reaches an ADW flow of approximately 12 mgd.

Additionally, hydraulic analyses completed as part of the Phase 2 study concluded that the notch in the screenings channel needs to be filled regardless of whether there is a projected increase in flows.

The existing vortex grit removal units each have an ADW capacity of approximately 4.5 mgd. If ADW flows exceed 9 mgd, a third vortex grit removal system will be needed. The third unit will give adequate capacity for ADW flows of up to 13.5 mgd.

Secondary Treatment

The capacity of the secondary system is currently controlled by the need to meet the TN requirement in the UIC permit. The TN removal requirements control the required SRT, which controls the need for aeration basins and secondary clarifiers. In addition to expansion for projected growth, the secondary treatment system requires immediate improvements to improve performance and reliability.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 3

Design Criteria

Unit Process	Value	Design Criteria	Peaking Condition	Reliability and Redundancy	Comments
Screening	3 feet per second (fps)	Approach velocity upstream of screen	Peak hour flow (PHF)	All units in service. Bypass channel available.	Based on Phase 2 study
Grit removal	120,000 gallons per day per square foot (gpd/ft^2)	Surface loading	PHF	All units in service. Bypass channel available.	Based on Phase 2 study
Aeration basins—nitrifying	7 Days	Solids retention time (SRT)	maximum month(MM)	All units in service.	Existing is 10+ days
Aeration blowers					
All basins	2 mg/L	aeration basin dissolved oxygen	maximum week (MW) biochemical oxygen demand (BOD) load	Largest unit out of service.	
1985 basins	21%	standard oxygen transfer efficiency	Peak day BOD load	Largest unit out of service.	Based on exist. basin configuration
New basin		SOTE	Peak day BOD load	Largest unit out of service.	SOTE dependent on final basin design
Secondary clarifiers					
All secondary clarifiers (SCs)	150	solids volume index(SVI)			
1985	1,400 gpd/ft^2	surface overflow rate(SOR)	maximum day (MD)	All units in service.	Based on Phase 2 study
	1,000 gpd/ft^2	SOR	MM	Largest unit out of service.	
	850 gpd/ft^2	SOR	Average dry weather (ADW)	Largest unit out of service.	Based on Phase 1 study
	35 pounds per day per square foot (lb/d/ft^2)	solids loading rate (SLR)	MD	All units in service.	Based on Phase 2 study
	23 lb/d/ft^2	SLR	MM	Largest unit out of service.	
New SCs	1,500 gpd/ft^2	SOR	MD	All units in service.	Based on Phase 2 study
	1,100 gpd/ft^2	SOR	MM	Largest unit out of service.	
	900 gpd/ft^2	SOR	ADW	Largest unit out of service.	Based on Phase 1 study
	40 lb/d/ft^2	SLR	MD	All units in service.	Based on Phase 2 study
	25 lb/d/ft^2	SLR	MM	Largest unit out of service.	
Return activated sludge (RAS) pumps	100% of influent flow		MM	Largest unit out of service.	
Filtration	6 gallons per minute per square foot (gpm/ft^2)	hydraulic loading rate (HLR)	PHF	All units in service.	Phase 2 Study
	2.5 gpm/ ft^2	HLR	ADW	Largest unit out of service.	Phase 1 Study
Ultraviolet (UV) disinfection	120 milliwatt-second per square centimeter (mW-sec/cm^2)	UV dose	PHF	All units in service.	Phase 1 study
Dissolved air flotation thickeners (DAFTs)	1.5 pounds per hour per square foot (lb/hr/ft$^{2)}$	SLR	MD	All units in service.	Assume 24/7 operation
	1.5 gpm/ft^2	HLR	MD	All units in service.	
Centrifuge					
Existing	700 lbs DS/hour	SLR	MW	Largest unit out of service.	Assume 8 hours/day, 7 days/week operation
New	80 gpm	HLR	MW	Largest unit out of service.	Assume 8 hours/day, 7 days/week operation

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 4
Capacity of Existing Facilities

	With Redundant Secondary Clarifier	Without Redundant Secondary Clarifier
ADW Flows and Loads		
Flow (mgd)	4.5	5.5
$CBOD_5$ (lb/day)	7,700	9,600
TSS (lb/day)	9,600	12,000
Maximum Month Flows and Loads		
Flow (mgd)	5.3	6.6
$CBOD_5$ (lb/day)	9,200	11,500
TSS (lb/day)	11,500	14,400
1985 Plant Capacity Design Condition		
SRT (days)	8.0	8.0
MLSS (mg/L)	2,400	2,900
Number of secondary clarifiers	2	3
Diameter of secondary clarifiers	75	75
SLR (lb/d/ft^2)	23	23
RAS Underflow Rate (gpd/ ft^2)	70%	70%
WAS (lb/d)	7,100	8,900

Abbreviations:
ADW = average dry weather.
mgd = million gallons per day.
$CBOD_5$ = carbonaceous biochemical oxygen demand.
lb/day = pounds per day.
TSS = total suspended solids.
SRT = solids retention time.
MLSS = mixed liquor suspended solids.
SLR = solids loading rate.
WAS = waste activated sludge.

Existing Capacity Issues and Process Improvements

Regardless of the potential for increased flows, it is recommended that a minimum of two improvements be made to the secondary system:

- Mixed Liquor Recycle: Addition of a pump to allow for the recycle of mixed liquor to the head of the flexible aeration basin (FAB) provides two benefits. First, it will reduce the concentration of TN in the plant's effluent by improving denitrification. Second, it will add alkalinity to the aeration basin, which should allow the plant to maintain a higher pH, which will improve the biological processes. Normal recycle rates are 250 – 400% of raw sewage flows. Existing piping and tank configurations should be reviewed to maximize the use of the existing before adding new pipes.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

- Increase Aeration Basin Volume: It is recommended that the plant have the ability to take the largest portion of its aeration basins out of service and still be able to meet discharge limits under ADW flow and load conditions. Equipment within aeration basins needs regular inspection and occasionally requires repair or maintenance. With the current configuration, if the CAB were taken out of service, the FAB would be able to treat only approximately 3 mgd of flow. Therefore, it is recommended that additional aeration basin volume be added immediately. The additional aeration basin volume may either be added in parallel with the existing CAB or as part of a new secondary process train in place of the 1975 secondary process (see the process flow diagrams included in Appendix D). To treat current ADW flows of 5 mgd, approximately 0.8 million gallons (MG) of aeration basin volume is required.

Improvements to Increase Capacity

As previously discussed, if the need for redundancy for aeration capacity is not considered, the ADW capacity of the existing system under current operating practices is approximately 4.5 mgd. If the requirement for a redundant secondary clarifier is also not considered, the capacity is 5.5 mgd.

Some increases in capacity of the secondary treatment system can be realized at little or no cost by changing existing operations. First, the SRT of the secondary system can be lowered. The minimum SRT for nitrification is primarily affected by temperature and pH. For the Lahaina WWRF, the estimated minimum SRT needed for nitrification (based on historical temperature and pH data) is approximately 2.5 days, so a 5-day SRT would provide a safety factor of approximately 2 that would allow the plant to deal with daily and diurnal fluctuations in ammonia loading. Therefore, it should be able to achieve the effluent TN limits at the lower SRTs, though solids production would increase. Reducing the SRT to 5 days would increase the plant's ADW capacity by approximately 1 mgd to approximately 5.4 mgd, assuming one redundant secondary clarifier. This is approximately 0.5 mgd more than what the plant currently treats. Depending on the performance of the MLR system, it may be possible to lower the SRT even more. Per discussion with plant staff, long-term operation at such a low SRT is not desirable. Therefore, operating at an SRT of 5 days is considered only a short-term solution that can be used if needed prior to construction of new facilities.

For long-term operation, a minimum SRT of 7 days has been used. Also, it is assumed that the FAB and the new aeration train (as required for Alternative 7) will be operated in step feed mode. Step feed operation increases the capacity for a given aeration basin volume by allowing a higher solids inventory to be stored without increasing the loads on the secondary clarifiers. The FAB was designed to be able to be operated in the step feed mode; however, some minor capital improvements will be needed to relocate the discharge of the return activated sludge (RAS) and to control odors. Currently, RAS is discharged into the influent channel to suppress the odors of the raw sewage. For step feed operation, the discharge must be relocated to the first basin in the FAB. Removing the RAS from the influent channel may increase odors from the channel. If the odors are above acceptable limits, the channel may be covered and an odor control system added.

As previously discussed, it is recommended that new aeration basin capacity be added for redundancy. This additional aeration basin will also be used to increase capacity. Based on

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

the recalibrated model, this expansion may be done by building a second parallel secondary system that is hydraulically separated from the 1985 system (the original Alternative 7) or by expanding the aeration capacity of the 1985 basin and adding additional secondary clarifiers to that plant as needed (Alternative 7A). See Appendix D for process flow diagrams and site layouts showing how each of these alternatives would be implemented. The addition of a 0.8-mg aeration basin would increase plant capacity to approximately 6 mgd. Note that if Alternative 7A is selected, no additional secondary clarifiers will be needed to reach this capacity. If Alternative 7 is selected, two new secondary clarifiers will be needed because the new aeration basin will not be able to take advantage of the excess secondary clarifier capacity in the 1985 treatment facilities.

Additional capacity will be added by balancing the addition of secondary clarifiers and additional aeration basin volume. At a projected ADW flow of 12 mgd, both alternatives result in the same number of aeration basins and secondary clarifiers.

The disadvantage of Alternative 7A is that it may result in more difficult construction because of the need for significant retrofit work.

Although Alternative 7A may result in more difficult, retrofit construction, it is the recommended alternative for expansion of the secondary facilities because of cost savings at lower capacity increases. Early in the next phase of design, the extent of the required retrofit work should be identified, and a review of hydraulics through an expanded 1985 secondary treatment process should be completed (this option was not considered in the hydraulic analysis completed as part of the Phase 2 study).

Tertiary Treatment

The tertiary facilities consist of continuously backwashed, upflow sand filters. The filters are needed to meet the turbidity limits for the reuse water, as well as to remove solids that might otherwise plug the injection wells. The existing facilities have a firm ADW capacity of approximately 7.6 mgd. With all units in service, the capacity is approximately 8.7 mgd.

Although the filters are required for the reuse water, only four filters are currently needed to meet reuse demand.

If it is assumed that reuse could be discontinued on a short-term basis (up to 60 days) in the event of high loadings or equipment failure, it is probable that a mixture of filtered effluent and unfiltered secondary effluent could be sent to the injection wells without significantly increasing the solids loading. Table 5 illustrates how this would work given a flow of 9 mgd and one of the filters out of service. With filters in service, the injection wells usually receive flow with a TSS concentration of 3 mg/L. If a relatively low proportion of secondary effluent (1.4 mgd, in this case) is added to that filtered effluent, the amount of TSS in the water reaching the injection wells is only 4 mg/L. This operating strategy may be used to defer expansion of the tertiary facilities. Before implementation, however, a better evaluation of the effects on the performance of the injection wells and the hydraulic ability and capacity of the existing facilities to operate in this configuration should be completed.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 5
Potential Blending Operation for Underground Injection

	Filter Effluent	Unfiltered Secondary Effluent	Injection Well Influent
Flow, mgd	7.6	1.4	9
TSS, mg/L	3.0	10.0	4.0

Abbreviations:
mgd = million gallons per day.
TSS = total suspended solids.

When additional tertiary facilities are required, additional Dynasand® filters (similar to the existing filters) will be added as needed.

Disinfection

Currently, the UIC permit has a limit for residual chlorine of no less than 0.1 mg/L. There is no contact time requirement. Therefore, the size of the chlorine contact basin does control the capacity. Only the chemical feed system of the chlorine contact basin controls whether the residual can be met. Because of the size and the cost of the chemical feed system, a detailed analysis was not included in this study. Costs for improvements to this system will be better defined during the next phase of design.

The reuse requirement for disinfection is more restrictive and requires a reduction of fecal coliforms to acceptable limits. Therefore, reuse water currently goes to the UV disinfection system after filtration. The capacity of the existing UV disinfection system is 3 mgd, which is more than adequate to meet current demands. Expansion of this system is needed only if reuse demand increases. Similar to the filtration expansion, if a portion of the UV system were off-line for relatively short periods (up to 60 days), the supply of reuse water would decrease and more water would go to the injection wells. On the basis of that operating scenario, the expansion of the UV system is driven strictly by the need to produce reuse water. The UV system does not affect the overall capacity of the plant, and it will be expanded only if reuse demand increases.

Solids Processing Facilities Expansion

A Biosolids Master Plan (see Appendix E) was completed to look at the overall strategy for processing and disposing of biosolids. It is the conclusion of the BMP that the most cost-effective approach is to thicken and dewater biosolids without stabilization prior to being hauled offsite to be composted.

Thickening

The Lahaina WWRF currently has one DAFT unit that has been out of service for more than 10 years. If made functional, the existing the unit will have a maximum day capacity of approximately 5.4 dry tons per day (dtpd). Currently, the plant produces approximately 4 dtpd of waste activated sludge (WAS), and it exceeded 5.4 dtpd one day in the past year.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Therefore, it appears that the existing unit should have enough capacity to treat current flows and loads under the current operating practices.

WAS production will increase as a result of increased loads on the plant, as well as changes in operational practices (i.e., lower SRT). On the basis of the recalibrated process model, at an SRT of 5 days, the Net Observed Yield will be approximately 1.0 pound (lb) WAS/lb carbonaceous biochemical oxygen demand (CBOD). At the minimum SRT at which the plant has been operated, 8 days, the average Net Observed Yield has been approximately 0.76 lb WAS/lb CBOD. Therefore, if the SRT were reduced to 5 days and the plant received the same load that it is currently receiving, the DAFT unit would be near capacity even under average conditions.

Addition of the DAFTs will be based on both increased loads and proposed operational changes. An SRT of 8 days and a Net Observed Yield of 0.76 lb WAS/lb CBOD was used for this study. Thickening capacity will be accomplished by adding similarly sized DAFT units to provide additional capacity and some level of redundancy. Expansion of the dewatering facilities will include a bufferage tank to allow the DAFTs to operate on a continuous basis while the dewatering facilities are operated only during the day shift. It is recommended that the bufferage tank be built for ultimate buildout because it is not cost effective to build smaller modules.

Dewatering

Dewatering is accomplished using three centrifuges. Based on the BMP, the goal is to operate the centrifuges 7.5 hours per day, 7 days per week. Using this criterion, the existing centrifuges have a capacity of approximately 5.3 dtpd with the largest unit out of service and a DAFT upstream of the centrifuges. This is slightly less than the current sludge production but is probably sufficient given the redundant unit and the equalization capacity of the proposed bufferage tank upstream.

Dewatering capacity will be increased by adding centrifuges with the same capacity as the existing centrifuges.

Additionally, the County has indicated that there is the potential for nearby land to be developed as a resort. When this development happens, additional odor control will be needed. Currently the largest source of uncontrolled odors is the loading of the trucks for hauling the dewatered biosolids. These odors may be controlled by storing the dewatered cake in an enclosed silo with odor control. The cake from the silo can be unloaded in a shorter period of time and therefore create fewer odors. If additional odor control is needed, the load out facilities may be enclosed. The costs developed for this study included enclosing the facilities.

Implementation Strategy

On the basis of the process expansions previously described, two plans for expansion have been developed. Alternative 7 is the same as that described in previous studies, with the construction of a new secondary treatment system that will run in parallel with the 1985 system. Alternative 7A assumes that new aeration basin volume will be added that will run in parallel with the 1985 CAB, but that both aeration basins will discharge to the same

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

secondary clarifiers. Process flow diagrams and site layouts for both alternatives are included in Appendix D.

An implementation strategy has been developed for each alternative that identifies immediate needs, as well as improvements needed to increase capacity. Using the peaking factors developed for existing flows and loads, these implementation strategies increase ADW capacity in 1-mgd increments. The implementation strategies allow accommodation of an ultimate capacity of 12 mgd on the existing site. Note that, based on the current ADW flow, each 1-mgd increase represents an increase of approximately 20 percent over existing flows.

When the ongoing community planning is completed, it is recommended that a phased approach to adding capacity be developed based on the projected rate of growth. For example, each phase of expansion may be designed to provide enough capacity for the plant for 5 years. The phased approach must balance the savings realized by deferring improvements while limiting the risks of exceeding capacity before the next phase of construction is on-line.

Figure 1 represents the implementation strategy for Alternative 7. The implementation strategy assumes that the plant will immediately add additional aeration basin volume to address the lack of capacity if the CAB is taken out of service. Because of the loads expected to go to the new aeration basin, two new secondary clarifiers will be needed for that train. As previously described, all other short-term improvements are those that have been identified either to eliminate hydraulic issues or to improve reliability. Beyond the short-term improvements, each process is expanded (as described above) as needed to meet the flows and loads listed with the ADW flows in the figure.

Figure 1 also includes the de facto population associated with each ADW flow. The de facto population was estimated based on information in the *Socio-Economic Forecast: Phase 1 Report* and is a function of the residential population and its perceived transience, as well as the average number of visitors. The de facto population for the current ADW flow is based on census data from 2000. On the basis of the current flows and de facto population, the per capita flow is approximately 120 gallons per day per person. This per capita loading was used to estimate the de facto population needed to generate the ADW flows shown in the figure.

Figure 2 represents the implementation for Alternative 7A. For most processes, this is identical to Alternative 7. The only difference is in the timing of the addition of secondary clarifiers. Because the new aeration basin can take advantage of the excess capacity in the existing secondary clarifiers, the addition of secondary clarifiers can be deferred until an ADW capacity of 7 mgd is required.

Both implementation strategies assume that the volume of reuse water does not exceed the capacity of the UV system, which is 3 mgd. If there is an increase in reuse demand, additional UV capacity may be needed. Both implementation schedules also assume that 100 percent of the water going to the injection wells will be filtered and that no additional chlorine contact basin volume (CCB) volume will be added. As previously discussed, it is possible that the addition of filtration capacity may be further deferred if it can be shown

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

that the injection wells can be operated with a blended effluent of filtered and unfiltered secondary effluent.

Costs

Tables 6 and 7 summarize present-worth cost estimates for implementing Alternatives 7 and 7A, respectively. As in previous studies, two different ADW flow capacities were selected for comparison.

The cost estimates presented in this study are "order of magnitude" estimates, defined by the American National Standards Institute (ANSI) and the American Association of Cost Engineers (AACE) as "approximate estimates made without detailed engineering data. It is normally expected that estimates of this type will be accurate within plus 50 percent or minus 30 percent." This range implies that there is a high probability that the final project cost will fall within the range.

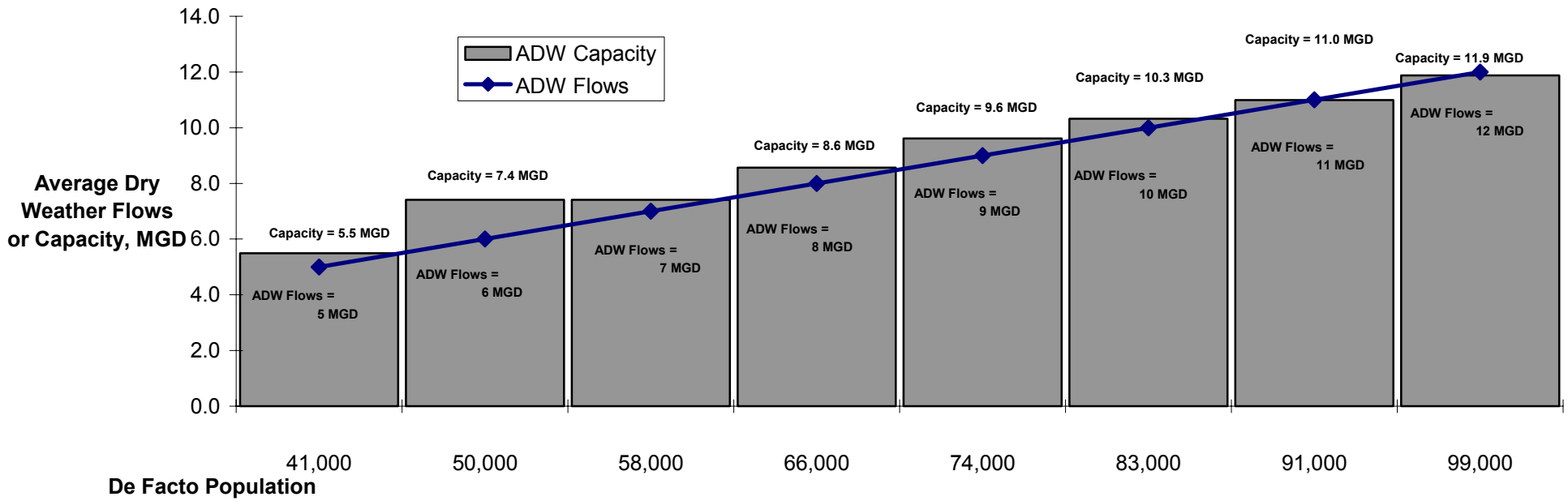
A 30 percent contingency has been included in these cost estimates within the contractor markups as a provision for unforeseeable, additional costs within the general bounds of the project scope, particularly where previous experience has shown that unforeseeable events that will increase costs are likely to occur. The contingency is used as a means to reduce the risk of possible cost overruns. The contingency in these estimates consists of two components: Bid Contingency and Scope Contingency. Bid Contingency covers the unknown costs associated with constructing a given project scope, such as adverse weather conditions, strikes by material suppliers, geotechnical unknowns, and unfavorable market conditions for a particular project scope. Scope Contingency covers scope changes that invariably occur during final design and implementation.

Based on the annual operations and maintenance (O&M) and construction cost for each alternative, a 20-year-life-cycle net present value (NPV) was calculated for each alternative. The NPV for each alternative included the following:

- Annual operations costs for each alternative process evaluated for 20 years were used in the NPV.
- Projected inflation for the four main cost types (Labor, Power, Chemicals, and Maintenance) based on the average inflation of these items over the last 20 years, for the next 20 years, as shown in Table 6.
- NPV calculation was then applied to the anticipated 20-year escalated O&M and construction costs and discounted to present-day value at 3.5 percent.

The 9-mgd expansion for Alternative 7A is slightly lower than for Alternative 7, showing the benefit of constructing one fewer secondary clarifier. At 12 mgd, there is no difference between costs because each alternative requires construction of the same basic facilities. Though there will be some differences, at this level of analysis they cannot be accounted for accurately.

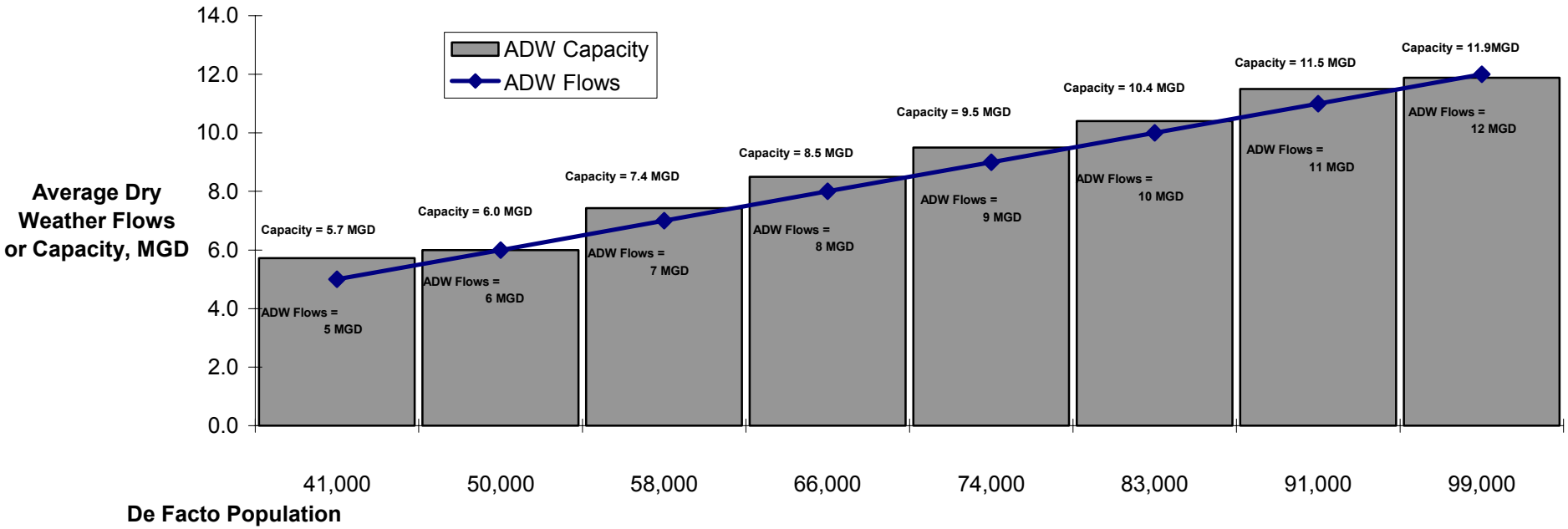
COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL



Short-Term Improvements	1 MGD Additional Capacity	2 MGD Additional Capacity	3 MGD Additional Capacity	4 MGD Additional Capacity	5 MGD Additional Capacity	6 MGD Additional Capacity	7 MGD Additional Capacity
Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 3 New Screens
+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel
+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump
+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add 2 ABs	+ Add 2 ABs
+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT
+ 2 Secondary Clarifiers	+ 2 Secondary Clarifiers	+ 2 Secondary Clarifiers	+ 3 Secondary Clarifiers	+ 4 Secondary Clarifiers	+ 5 Secondary Clarifiers	+ 5 Secondary Clarifiers	+ 5 Secondary Clarifiers
+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT + 1	+ Rehabilitate DAFT +1	+ Rehabilitate DAFT + 1
	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed
	+ 1 Centrifuge	+ 1 Centrifuge	+ 2 Centrifuge	+ 2 Centrifuges	+ 2 Centrifuges	+ 2 Centrifuges	+ 2 Centrifuges
			+ 1 Filter	+ 2 Filters	+ 3 Filters	+ 4 Filters	+ 4 Filters
				+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit

Figure 1 Trigger Schedule for Alternative 7 (note: Assumes that all criteria in Table 3 are met including redundancy for the secondary clarifiers.)

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL



Short-Term Improvements	1 MGD Additional Capacity	2 MGD Additional Capacity	3 MGD Additional Capacity	4 MGD Additional Capacity	5 MGD Additional Capacity	6 MGD Additional Capacity	7 MGD Additional Capacity
Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 2 New Screens	+ 3 New Screens
+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel	+ Fill Notch In Screenings Channel
+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump	+ Add MLR Pump
+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add AB	+ Add 2 ABs	+ Add 2 ABs
+ Reduce SRT to 7 days	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT	+ Reduce SRT
+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT	+ Rehabilitate DAFT +1	+ Rehabilitate DAFT +1	+ Rehabilitate DAFT + 1
	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed	+ Switch to Step Feed
	+ 1 Centrifuge	+ 1 Centrifuge	+ 2 Centrifuge	+ 2 Centrifuges	+ 2 Centrifuges	+ 2 Centrifuges	+ 2 Centrifuges
		+ 1 Secondary Clarifier	+ 2 Secondary Clarifiers	+ 3 Secondary Clarifiers	+ 4 Secondary Clarifiers	+ 4 Secondary Clarifiers	+ 5 Secondary Clarifiers
			+ 1 Filter	+ 2 Filters	+ 3 Filters	+ 4 Filters	+ 4 Filters
				+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit	+ 1 Vortex Grit Unit

Figure 2 Trigger Schedule for Alternative 7A (note: Assumes that all criteria in Table 3 are met including redundancy for the secondary clarifiers.)

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 6
Cost Estimates for Alternative 7 ($million)

Facility		9 MGD	12 MGD
Headworks		2.50	2.5
Aeration Basin		3.05	4.01
Secondary Clarification & RAS/WAS Pumping		3.87	4.73
Disinfection			
Filters		0.85	1.16
Thickening		1.83	3.04
Dewatering		1.46	1.46
Subtotal - Project Costs		**13.56**	**16.90**
Additional Allowances			
Demo	2%	0.27	0.34
Sitework	5%	0.68	0.85
Plant Computer System	1%	0.14	0.17
Yard electrical	2%	0.27	0.34
Yard Piping	20%	2.712	3.38
Subtotal		**17.63**	**21.97**
Contractor Mark-ups	58%	10.16	12.67
Subtotal with Mark-ups		**27.79**	**34.64**
Escalation to Mid Point of Construction	20%	33.24	41.42
Location Adjustment	23%	40.72	50.74
Non Construction Costs			
Engineering	10%	4.07	5.07
Commissioning and Start-up	5%	2.04	2.54
Total Capital Cost		**46.82**	**58.36**
O&M PW Costs			
Labor		0.63	0.69
Maintenance		0.72	0.77
Vehicle Expenses		0.10	0.14
Chemicals		0.19	0.25
Sludge Disposal		0.51	0.66
Utilities		0.86	0.96
O&M Costs		**3.01**	**3.47**
Total Project Costs		**49.83**	**61.83**

Abbreviations:
mgd = million gallons per day.
RAS/WAS = return activated sludge/waste activated sludge.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 7
Cost Estimates for Alternative 7A ($million)

Facility		9 MGD	12 MGD
Headworks		2.50	2.5
Aeration Basin		3.05	4.01
Secondary Clarification & RAS/WAS Pumping		3.00	4.73
Disinfection			
Filters		0.91	1.16
Thickening		1.83	3.04
Dewatering		1.46	1.46
Subtotal - Project Costs		**12.75**	**16.90**
Additional Allowances			
Demo	2%	0.26	0.34
Sitework	5%	0.64	0.85
Plant Computer System	1%	0.13	0.17
Yard electrical	2%	0.26	0.34
Yard Piping	20%	2.55	3.38
Subtotal		**16.58**	**21.97**
Contractor Mark-ups	58%	9.56	12.67
Subtotal with Mark-ups		**26.13**	**34.64**
Escalation to Mid Point of Construction	20%	31.25	41.42
Location Adjustment	23%	38.28	50.74
Non Construction Costs			
Engineering	10%	3.83	5.07
Commissioning and Start-up	5%	1.91	2.54
Total Capital Cost		**44.03**	**58.36**
O&M PW Costs			
Labor		0.63	0.69
Maintenance		0.70	0.77
Vehicle Expenses		0.10	0.14
Chemicals		0.19	0.25
Sludge Disposal		0.51	0.66
Utilities		0.86	0.96
O&M Costs		**2.98**	**3.47**
Total Project Costs		**47.01**	**61.83**

Abbreviations:
mgd = million gallons per day.
RAS/WAS = return activated sludge/waste activated sludge.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Recommendations

A number of items are recommended to improve performance and provide some redundancy regardless of whether increased capacity is needed. These improvements include the following:

- Replace existing screens.
- Add an MLR pump.
- Fill the notches in the screenings channel.
- Add aeration basin capacity.
- Refurbish the existing DAFT.

Additionally, the need for and timing of odor control for solids load out will need to be determined based on the timing of nearby development.

If additional capacity is needed, it is recommended that Alternative 7A be implemented. Alternative 7A is recommended because of the cost savings associated with deferring the addition of secondary clarifiers.

Once community planning is completed and an estimated rate of growth within the basin is established, a phased implementation plan should be developed based on the trigger schedule provided in Figure 2. The phased approach must balance the savings realized by deferring improvements while limiting the risks of exceeding capacity before the next phase of construction is on-line.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

APPENDIX A

Preliminary Findings of the Schematic Design

Preliminary Findings of Schematic Design

PREPARED FOR: Ross Kaneko/HNL

PREPARED BY: Jeff McCormick/PDX

COPIES: Bruce Johnson/BOI

DATE: March 17, 2006

Existing Flows and Loads

Flow and load data were analyzed for the Lahaina Wastewater Reclamation Facility (Lahaina WWRF) in order to refine the design of the plant upgrade options identified in the *Lahaina WWRF Process Study – Steady State Process Modeling and Alternatives Evaluation, Final Phase 2 Report* (CH2M HILL, September 2005).

Plant influent (PI) data were obtained from the County of Maui (the County) for the past 5 years. The data were used to develop peaking factors for critical design parameters. The peaking factors were used to estimate projected flows and loads based on predicted growth in the collection system as determined by the County.

The average range for flows and loads for 2001-2005 are presented in Table 1. Additionally, flows were projected for two development scenarios. One is for 9 MGD which is the equivalent of adding approximately 11,500 equivalent dwelling units (EDUs). The second scenario is for an ADW flow of 12 MGD, which is the equivalent of adding approximately 20,000 EDUs.

Table 2 compares the new flows and loads with those used in the Phase 2 report. The analysis of recent data showed that the although the peaking factors (i.e. the amount of variability) for the flows and loads have been less than what was assumed for the Phase 2 report, the average loads have been higher.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 1

Estimated Flows and Loads

	Flow, MGD	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
2001-2005						
Average Dry Weather (ADW)	5.0	10,153	8,124	652	1,189	493
Maximum Month	6.0	12,996	10,398	835	1,521	631
Maximum Week	7.0	19,390	15,514	1,174	2,270	942
Maximum Day	8.3	24,469	16,379	1,304	3,004	945
Peak Hour (estimated)	11.1					
Projected for 9 MGD ADW						
ADW	9.0	18,200	14,600	1,200	2,100	900
Maximum Month	10.7	23,300	18,700	1,500	2,700	1,200
Maximum Week	12.5	34,800	27,900	2,200	4,000	1,700
Maximum Day	14.9	43,900	29,400	2,400	5,300	1,700
Peak Hour	19.8					
Projected for 12 MGD						
ADW	12.0	24,200	19,400	1,600	2,800	1,200
Maximum Month	14.3	31,000	24,800	2,000	3,600	1,500
Maximum Week	16.6	46,200	37,000	2,900	5,300	2,300
Maximum Day	19.8	58,300	39,100	3,200	7,100	2,300

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 2

Comparison of Flow and Load Projections with Phase 2 Flow and Loads

	Flow, MGD	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
Phase 2						
ADW	9	11,184	10,508	1,051	1,726	300
Maximum Month	13.5	16,776	15,763	1,576	2,590	450
Recommended						
ADW	9.0	18,200	14,600	1,200	2,100	900
Maximum Month	10.7	23,300	18,700	1,500	2,700	1,200
Percent Difference						
ADW	0%	63%	39%	14%	22%	200%
Maximum Month	-21%	39%	19%	-5%	4%	167%

Design Criteria

Table 3 presents the design criteria that will be used in sizing new facilities and estimating the capacity of existing facilities. These criteria are based on industry standards, discussions with plant staff about the performance of the existing facilities, and some stress testing of the existing secondary clarifiers.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 3

Design Criteria for Liquids Treatment

Unit Process	Value	Design Criteria	Peaking Condition	Reliability and Redundancy	Comments
Screening	3 fps	Approach velocity upstream of screen	PHF	All units in service. Bypass channel available.	Based on Phase 2 Study
Grit removal	120,000 gpd/sf	Surface Loading	PHF	All units in service. Bypass channel available.	Based on Phase 2 Study
Aeration basins -- nitrifying	7 Days	SRT	MM	All Units in Service	Existing is 10+ days
Aeration blowers					
All Basins	2	AB DO	MW BOD Load	Largest Unit out of Service	
1985 Basins	21%	SOTE	Peak day BOD load	Largest Unit out of Service	Based on Exist. Basin Configuration
New Basin		SOTE	Peak day BOD load	Largest Unit out of Service	SOTE dependent on final basin design
Secondary Clarifiers					
All SC	150	SVI			
1985	1400 gpd/sf	SOR	MD	All Units in Service	Based on Phase 2 Study
	1000 gpd/sf	SOR	MM	Largest Unit out of Service	
	850 gpd/sf	SOR	ADW	Largest Unit out of Service	Based on Phase 1 Study
	35 lb/d/sf	SLR	MD	All Units in Service	Based on Phase 2 Study
	23 lb/d/sf	SLR	MM	Largest Unit out of Service	
New SCs	1500 gpd/sf	SOR	MD	All Units in Service	Based on Phase 2 Study
	1100 gpd/sf	SOR	MM	Largest Unit out of Service	
	900 gpd/sf	SOR	ADW	Largest Unit out of Service	Based on Phase 1 Study
	40 lb/d/sf	SLR	MD	All Units in Service	Based on Phase 2 Study
	25 lb/d/sf	SLR	MM	Largest Unit out of Service	
MBR Basin	7 Days	SRT	MM	Largest Unit out of Service	
	10,000 mg/L	MLSS	MM	Largest Unit out of Service	
RAS pumps	100% of influent flow		MM	Largest Unit out of Service	
Filtration	6 gpm/sf	HLR	PHF	All Units in Service	Phase 2 Study
	2.5 gpm/sf	HLR	ADW	Largest Unit Out of Service	Phase 1 Study
UV disinfection	120 mW-sec/sq cm	UV dose	PHF	All Units in Service	Phase 1 Study

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 4
Design Criteria for Solids Treatment

Unit Process	Value	Design Criteria	Peaking Condition	Reliability and Redundancy	Comments
DAFTs	1.5 lbs/hr/ft2	SLR	MD	All Units in Service	Assume 24/7 operation
	1.5 gpm/ft2	HLR	MD	All Units in Service	
Aerobic Digestion	30	SRT, with staged aerobic digestion		All Units in Service	
Anaerobic digestion	15 days	Hydraulic/solids retention time	MM	All Units in Service	Assume thickened sludge at 4% solids.
	12 days	Hydraulic/solids retention time	MW	All Units in Service	
Centrifuge					
Without Digestion					
Existing	700 lbs DS/hour	SLR	MW	Largest Unit out of Service	Assume 8 hour/d, 7 days/week operation
New	80 gpm	HLR	MW	Largest Unit out of Service	Assume 8 hour/d, 7 days/week operation
With Digestion					Assume 8 hour/d, 7 days/week operation
Existing	700 lbs DS/hour	SLR	MM	Largest Unit out of Service	Assume 8 hour/d, 7 days/week operation
	700 lbs DS/hour	SLR	MW	All Units in Service	Assume 8 hour/d, 7 days/week operation
New	80 gpm	HLR	MM	Largest Unit out of Service	Assume 8 hour/d, 7 days/week operation
	80 gpm	HLR	MW	All Units in Service	Assume 8 hour/d, 7 days/week operation

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Existing Capacity

Based on the criteria listed in Table 3 and 4 and assuming that the 1975 aeration basin and secondary clarifiers are not in operable condition, the liquid treatment capacity of the Lahaina WWRF is limited by the capacity of 1985 secondary treatment system, which is given in Table 5. The capacity is determined by the maximum month solids loading rate on the secondary clarifiers. The ADW capacity is estimated based on the peaking factors developed as part of the flow and load analysis (1.2 for maximum month).

Using the criteria of having one secondary clarifier out of service, the plant capacity for liquids treatment is currently approximately 3.90 MGD on an average dry weather basis. If it is assumed that all secondary clarifiers are in-service, the capacity is 4.80 MGD.

TABLE 5
Capacity of Existing Facilities

	With Redundant Secondary Clarifier	Without Redundant Secondary Clarifier
ADW Flows and Loads		
Flow (mgd)	3.90	4.80
CBOD5 (lbs/day)	6,700	8,400
TSS (lbs/day)	8,400	10,500
Max Month Flows and Loads		
Flow (mgd)	4.60	5.75
CBOD5 (lbs/day)	8,018	10,023
TSS (lbs/day)	10,013	12,516
1985 Plant Capacity		
SRT (days)	7.00	7.00
MLSS (mg/L)	3,069	3,837
# of Secondary Clarifiers	2	3
Diameter of Secondary Clarifiers	75	75
SLR (lb/d/sf)	23	23
RAS Underflow Rate (gpd/sq.ft.)	50%	50%
WAS (lb/d)	10,361	12,960

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Capacity with Operational Improvements

Table 6 presents estimate for the capacity of the existing liquids treatment facilities that can be realized with changes in current operations. The changes in operation that were analyzed were operating the secondary treatment system and reducing the solids retention time (SRT) from 7 days to 5 days. Switching to step feed operation increases the ADW capacity to 4.40 to 5.50 MGD depending on assumptions about the number of secondary clarifiers in service. Reducing the SRT to 5 days will increase the capacity by another 0.6 -0.8 MGD.

TABLE 6
Plant Capacity with Operational Improvements

	7-day SRT		5-day SRT	
	With Redundant Secondary Clarifier	**Without Redundant Secondary Clarifier**	**With Redundant Secondary Clarifier**	**Without Redundant Secondary Clarifier**
Plant Capacity at ADW Flows and Loads				
Flow (mgd)	4.40	5.50	5.00	6.30
CBOD5 (lbs/day)	7,700	9,500	8,800	11,000
TSS (lbs/day)	9,600	11,900	11,000	13,700
Plant Capacity at Max Month Flows and Loads				
Flow (mgd)	5.25	6.50	6.00	7.50
CBOD5 (lbs/day)	9,151	11,330	10,458	13,073
TSS (lbs/day)	11,428	14,149	13,060	16,326
1985 Plant Design Criteria and Operating Assumptions				
SRT (days)	7.00	7.00	5.00	5.00
MLSS (mg/L)	2,794	3,449	2,385	2,969
# of Secondary Clarifiers	2	3	2	3
Diameter of Secondary Clarifiers	75	75	75	75
SLR (lb/d/sf)	23	23	23	23
RAS Underflow Rate (gpd/sq.ft.)	50%	50%	50%	50%
WAS (lb/d)	11,676	14,473	13,935	17,436

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Alternatives Analysis for Plant Expansion

The Phase 2 Summary report recommended that Alternatives 4 and 7 be evaluated for expanding the Lahaina WWRF. The purpose of the Schematic Design was to refine these design concepts to provide the County with the information needed to select a preferred alternative.

The alternatives analysis consists of the following:

- Development of a process flow diagram for the plant showing the improvements necessary for implanting the selected alternative
- Sizing of facilities based on the updated flows and loads.
- Development of preliminary site layouts to show how the improvements can fit within the existing site
- Development of a trigger schedule for just-in-time expansion based on incremental development within the basin.
- Estimating costs for plant expansions necessary to meet 9 MGD ADW flows and 12 MGD ADW flows.

The trigger schedules that have been developed are shown in 1 MGD increments. The schedules also show the estimated number of equivalent dwelling units (EDUs) that the would be needed the generate the increase in flows.

Note that the alternatives comparison show only the improvements needed to treat increased flows. The alternatives do not account for repair and rehabilitation projects that may be needed, but are not critical for increasing capacity. The alternatives analysis also does not include expansion of the effluent reuse program, which will require additional expansion of the UV disinfection system.

The cost estimates presented in this study are "order of magnitude" estimates, as defined by the American National Standards Institute (ANSI) and the American Association of Cost Engineers (AACE) as "approximate estimates made without detailed engineering data. It is normally expected that estimates of this type will be accurate within plus 50 percent or minus 30 percent." This range implies that there is a high probability that the final project cost will fall within the range.

A 20% contingency has been included in these cost estimates as a provision for unforeseeable, additional costs within the general bounds of the project scope; particularly where previous experience has shown that unforeseeable events that will increase costs are likely to occur. The contingency is used as a means to reduce the risk of possible cost overruns. The contingency in these estimates consists of two components: Bid Contingency and Scope Contingency. Bid Contingency covers the unknown costs associated with constructing a given project scope, such as adverse weather conditions, strikes by material suppliers, geotechnical unknowns, and unfavorable market conditions for a particular project scope. Scope Contingency covers scope changes that invariably occur during final design and implementation.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

The cost estimates have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimates. The final cost for the project will depend on such criteria as actual labor and material costs, competitive market conditions, actual site conditions, final project scope, and other variables. As a result, the final project cost will vary from this estimate. The proximity to actual costs will depend on how close the assumptions of this estimate match final project conditions. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help assure proper project evaluation and adequate funding.

The final Schematic Design Report will also have a present worth costs analysis which will include estimates for operation and maintenance costs.

Alternative 4

This alternative involves retrofitting membrane bioreactors (MBRs) in a portion of the 1975 plant and include nitrification/denitrification capabilities. Significant modifications include:

- Rehab or upgrade transfer pump station to provide needed capacity, or provide capability to gravity to 1975 Plant from influent box.
- Add fine screen for flows to the MBR.
- Retrofit MBRs in 1975 secondary clarifiers. Provide diffused aeration and internal recycles for N-removal as needed.
- Add a secondary clarifier for the 1985 secondary process train.
- Add new screenings channel and grit removal unit.

As shown in the trigger schedule in Figure 1, it is assumed that initially, a new secondary clarifier would be added to the 1985 process train. Subsequent expansion of the secondary processes would be accomplished by retrofitting MBRs in the 1975 aeration basins and secondary clarifiers as shown in the attached site layout. Other unit processes such as screenings, grit removal, and solids processing equipment would be added as needed.

A process flow diagram and a site layout that show illustrating improvements needed for to treat 12 MGD are also attached.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

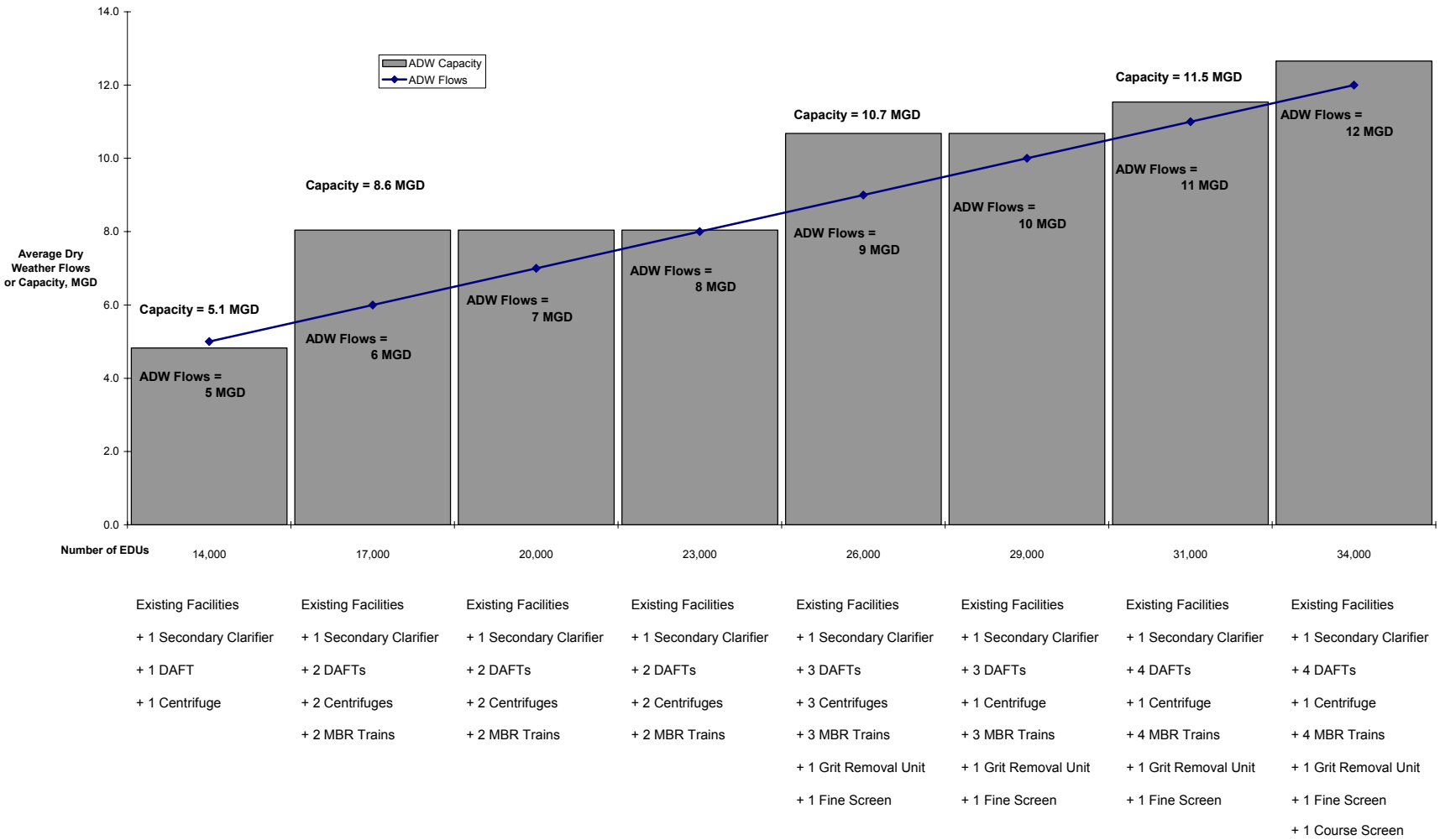


FIGURE 1
Trigger Schedule for Alternative 4 Expansion

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 7
Cost Estimates for Alternative 4 ($million)

Facility		9 MGD	12 MGD
Headworks		1.46	2.65
Pump Station		1.00	1.00
MBRs & Blowers		8.36	11.96
Secondary Clarification & RAS/WAS Pumping		1.55	1.91
Disinfection			
Filters			
Thickening		1.83	2.43
Dewatering		3.75	5.00
Subtotal - Project Costs		17.95	24.95
Additional Allowances			
Demo	0.1	1.80	2.50
Sitework	0.02	0.36	0.50
Plant Computer System	0.03	0.54	0.75
Yard electrical	0.03	0.54	0.75
Yard Piping	0.02	0.36	0.50
Subtotal		21.54	29.94
Contractor Mark-ups	0.4553	9.81	13.63
Subtotal with Mark-ups		31.35	43.57
Escalation to Mid Point of Construction	0.1959	37.49	52.11
Location Adjustment	1.225	45.92	63.83
Max Construction Costs		64.29	89.36
Non Construction Costs			
Engineering	0.1	6.43	8.94
Commissioning and Start-up	0.05	3.21	4.47
Total Project Cost		73.94	102.77

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Alternative 7 Summary

In this alternative, the 1975 plant is demolished and the land space recovered for a new expansion of secondary treatment capacity. The new secondary treatment system would be configured as an MLE-type system to provide adequate nitrogen removal.

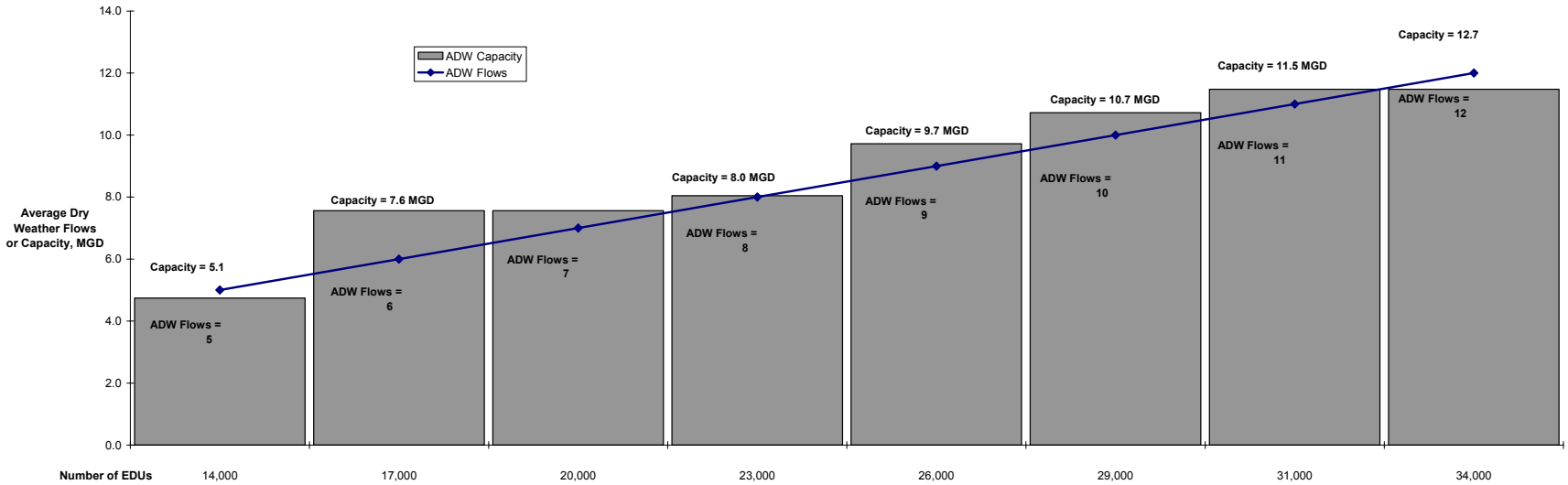
The Alternative 7, 12-mgd plant includes the following capital improvements:

- A new 75′ diameter clarifier for the 1985 plant
- Demolition of 1975 plant
- A new 3.25 MG MLE aeration basin
- Four new 75′ diameter secondary clarifiers
- New Filters

A process flow diagram and a site layout that show illustrating improvements needed for to treat 12 MGD are also attached.

As shown in the trigger schedule in Figure 1, it is assumed that initially, a new secondary clarifier would be added to the 1985 process train. Subsequent expansion of the secondary processes would be require demolishing the existing 1975 aeration basins, 1975 secondary clarifiers, 1975 blower building, and the 1975 DAFT prior to constructing the new aeration basins, blower building, and secondary clarifiers. Additionally, the road between the aeration basins and secondary clarifiers would need to be relocated as shown in the attached site layout. Other unit processes such as screenings, grit removal, and solids processing equipment would be added as needed.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL



14,000	17,000	20,000	23,000	26,000	29,000	31,000	34,000
Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
+ 1 Secondary Clarifier	+ 3 Secondary Clarifiers	+ 3 Secondary Clarifiers	+ 4 Secondary Clarifiers	+ 4 Secondary Clarifiers	+ 5 Secondary Clarifiers	+ 5 Secondary Clarifiers	+ 5 Secondary Clarifiers
+ 1 DAFT	+ 2 DAFTs	+ 2 DAFTs	+ 2 DAFTs	+ 3 DAFTs	+ 3 DAFTs	+ 4 DAFTs	+ 4 DAFTs
+ 1 Centrifuge	+ 2 Centrifuges	+ 2 Centrifuges	+ 2 Centrifuges	+ 3 Centrifuges	+ 3 Centrifuges	+ 3 Centrifuges	+ 3 Centrifuges
	+ 1 Aeration Basins	+ 1 Aeration Basins	+ 2 Aeration Basins	+ 2 Aeration Basins	+ 3 Aeration Basins	+ 3 Aeration Basins	+ 3 Aeration Basins
	+ New Blower Building	+ New Blower Building	+ New Blower Building	+ 1 Grit Removal Unit	+ 1 Grit Removal Unit	+ 1 Grit Removal Unit	+ 1 Grit Removal Unit
							+ 1 Screen

FIGURE 2
Trigger Schedule for Alternative 7

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 8
Cost Estimates for Alternative 7

Facility		9 MGD	12 MGD
Headworks		0.73	2.5
Pump Station		1.00	1.26
MBRs & Blowers		5.25	6.92
Secondary Clarification & RAS/WAS Pumping		3.75	4.5
Disinfection			
Filters		1.55	2.13
Thickening		1.83	2.43
Dewatering		3.75	5
Subtotal - Project Costs		17.86	24.74
Additional Allowances			
Demo	0.1	1.79	2.47
Sitework	0.05	0.89	1.24
Plant Computer System	0.01	0.18	0.25
Yard electrical	0.02	0.36	0.49
Yard Piping	0.02	0.36	0.49
Subtotal		21.43	29.69
Contractor Mark-ups	0.4553	9.76	13.52
Subtotal with Mark-ups		31.19	43.20
Escalation to Mid Point of Construction	0.1959	37.30	51.67
Location Adjustment	1.225	45.69	63.29
Max Construction Costs		63.97	88.61
Non Construction Costs			
Engineering	0.1	6.40	8.86
Commissioning and Start-up	0.05	3.20	4.43
Total Project Cost		73.57	101.90

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

APPENDIX B

Process Model Calibration and Existing Capacity Assessment

Lahaina WWRF
Process Model Calibration and Existing Capacity Assessment

PREPARED FOR: Ross Kaneko/HNL

PREPARED BY: Jeff McCormick/PDX

COPIES: Bruce Johnson/DEN

DATE: May 18, 2006

As part of the Schematic Design for the Lahaina WWRF, an analysis of the flow and load a characteristics was completed based on 5 years of influent data. The results of this analysis were used in combination with a plant process model to estimate the existing average dry weather (ADW) capacity of the plant.

The results indicated that the plant should be unable to meet current permit and reuse requirements. However, the plant is not having trouble meeting any discharge requirements.

To determine the source of the error, the County provided operational data from the past several years. The new operational data indicates that the data gathered during the Phase 1 study to calibrate the model was not accurate. The model has been recalibrated based on the new data and the existing capacity of the existing facilities has been estimated based on an average dry weather condition.

Phase 1 Data Collection and Model Calibration

As part of the Phase 1 study, the model was calibrated to customize model parameters to conditions specific to the Lahaina WWRF. The process of calibration involved adjusting one or more of the model parameters such that the model inputs and outputs both match actual measured performance data. A detailed description of the model calibration is included in the Phase 1 Final Report dated November 2003.

A targeted sampling and analysis campaign was planned and implemented during February 2003 to provide the data for calibration. As can be seen in the sampling schedule for gathering this data is presented in Table 1, the focused sampling was a thorough evaluation of the operation of the whole plant. Although many of the samples were grab samples, the combined plant influent was a composite sample and should match the flow and load data routinely gathered by the County.

TABLE 1
Sampling Plan for the Phase I Process Model Calibration

SAMPLE LOCATION	Total CBOD5	Soluble CBOD5	Total COD	Soluble COD	TSS	VSS	TKN	Soluble TKN	NH_3-N	Nitrate-Nitrite-N	DO	pH	Temp	Alkalinity
Lahaina P.S. #1 (LHI)	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab 1W	Grab	Grab	Grab	Grab
Napili P.S. #1 (NPI)	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Centrate (CNT)	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab				
Filter Backwash (FRW)	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab				
Combined plant influent with recycles (PI)	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Grab	Grab	Grab	Comp
FAB (effluent end of zone F-2)									Grab	Grab				
CAB1 (effluent end of zone C-3)									Grab	Grab				
CAB2 (effluent end of zone C-4)									Grab	Grab				
Aeration Basin ML (clarifier splitter box) (ML)					Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	
RAS Clarifier #3 (RAS3)					Grab	Grab				Grab				
RAS Clarifier #4 (RAS4)					Grab	Grab				Grab				
RAS Clarifier #5 (RAS5)					Grab	Grab				Grab				
WAS (WAS)					Grab	Grab								
Secondary Effluent (Filter Influent) (SE/FI)	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp		Grab		Grab
Final Effluent (FE/FW)	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp		Grab		Grab
Dewatered Sludge (DWS)					Grab	Grab								

A comparison of the of the Phase 1 data and the data provided by the County for the flow and load analysis for the same period in February 2003 is presented in Table 2. Based on the data presented in Table 2, there is a significant difference in the data generated for the Phase 1 study and the data routinely collected by the plant staff. The data used for the Phase 1 calibration is significantly lower than the plant data with the flows approximately 7% lower and the TSS and CBOD concentrations lower by 40% and 25%, respectively. This results in TSS and CBOD loads that are lower by 51% and 34%, respectively. Currently, the cause of the difference in the raw wastewater characterizations has not been identified.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 2
Comparison of Data Sets

	Phase 3 Flow and Load (Data Received 1/06)			Phase 1 Study (2003 Model Calibration)		
	PI Flow, MGD	**PI TSS, mg/L**	**PI CBOD, mg/L**	**PI Flow, MGD**	**PI TSS, mg/L**	**PI CBOD, mg/L**
2/1/2003	4.77	290				
2/2/2003	4.97	244		4.6	136	
2/3/2003	4.81	208		4.4	146	110
2/4/2003	4.85	238		4.7	126	
2/5/2003	4.85	192	146	4.4	144	110
2/6/2003	4.85	382		4.5	372	
2/7/2003	4.68	320		4.4	148	113
2/8/2003	4.87	226		4.4	152	
2/9/2003	4.93	242		4.4	172	
2/10/2003	5.12	224		4.6	222	155
2/11/2003	4.87	218		4.5	158	
2/12/2003	4.71	24	196	4.6	254	166
2/13/2003	4.98	260		4.6	404	
2/14/2003	7.19	342		4.8	192	148
2/15/2003	3.51	236		5.4	168	
2/16/2003	5.36	342		4.9	152	
2/17/2003	5.26	376		5.1	262	138
2/18/2003	5.22	158		4.9	162	
2/19/2003	5.35	368	187	4.8	174	146
2/20/2003	5.23	302		4.8	180	
2/21/2003	5.26	424		4.8	280	124
2/22/2003	5.13	330		4.8	214	
2/23/2003	5.03	254		4.7	198	
2/24/2003	5.27	308		4.8	148	142
2/25/2003	4.97	216		4.5	154	
2/26/2003	4.8	220	166	4.5	172	161
2/27/2003	4.92	256		4.4	160	
2/28/2003	4.75	360		4.5	158	160
Average	**5.02**	**270**	**174**	**4.66**	**193**	**139**

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Recalibration of the Plant Process Model

The County provided CH2M HILL with plant data from October 1, 2004 through May 31, 2006. The data included raw wastewater characterization, liquids process information, and solids production and processing data. Two periods of time were selected for calibration, November 2005 and March 2006. These two months were selected because both had the most complete set of data and they represented relatively steady-state conditions. Additionally, during the two periods, the plant was operated at significantly different solids retention times (SRTs), which allowed estimation of how solids yield changes under different operating conditions.

Table 3 presents the results of the calibration completed for March 2006. During this period, the average CBOD loads were 9,372 lbs/d and the plant was operated at an SRT of 8.7 days Table 4 presents the results of the calibration completed for November 2006. During this period, the average CBOD loads were 8,851 lbs/d, approximately 6% less than what was observed in March. During November, the SRT was 12.3 days. Note that the process model uses an SRT based only on the solids in the aeration basin, so all SRTs discussed in this TM were calculated using that method.

The parameters that are critical to determining the capacity of the plant are mixed liquor suspended solids (MLSS) concentration, waste activated sludge (WAS) production and effluent total nitrogen (TN) concentration. The MLSS is critical because the solids loading rate on the secondary clarifiers is used to determine the limit of the capacity of the secondary system. WAS production is critical because it determines the loading on both the DAFT and the dewatering centrifuges. MLSS and WAS production are both determined by adjusting raw sewage characteristic and kinetic variables within the model that are used to calculate the yield. The effluent TN is critical for determining whether the secondary system is configure correctly to reduce TN to the permit level of 10 mg/L in the UIC permit.

For the March 2006 data, the estimate yield is within 1% of the actual yield resulting in close approximation of both MLSS and WAS. For November 2005, the estimated yield was 17% higher than the observed resulting in high estimated MLSS and WAS. Although the accuracy of the yield varied, as shown in Figure 1, the estimated yields for both months are well within the variability been observed for their respective SRTs.

The effluent TN for both model calibrations is within 7% of the observed effluent TN.

Based on these critical calibration factors, it appears that the model is able to reasonably estimate the performance of the Lahaina WWRF under a variety of load conditions and operating scenarios and will increase the estimated capacity of the plant.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 3
Calibration Data for March 2006

	Difference	Model	Plant Data
RS			
Flow (mgd)		5.6	5.6
CBOD5 (lbs/day)		9,372.0	9,372
TSS (lbs/day)		11,493.0	11,493
%VSS		89%	89%
TKN (lbs/d)		1,384.0	1,384
Ammonia (lbs/d)		828.0	828
TP (lbs/d)		602.0	602
1985 Plant			
SRT (days)		8.70	8.60
MLSS (mg/L)	11.1%	2,567	2,311
MLVSS (mg/L)	3.5%	1,963	1,897
WAS (lb/d)	1.0%	7,091	7,019
Observed Yield, lbs WAS/lb BOD applied	1.0%	0.76	0.75
SE			
TSS (mg/L)	0.0%	9.6	9.6
VSS (mg/L)	-6.3%	7.3	7.8
FE			
CBOD5 (mg/L)	-44.2%	1.8	3.2
TSS (mg/L)	9.1%	5.9	5.4
VSS (mg/L)	7.9%	4.5	4.2
Ammonia (mg/L)	-70%	0.4	1.3
Nitrate (mg/L)	17.1%	6.6	5.7
TN (mg/L)	-6.7%	8.1	8.7
Sludge to Disposal (lbs/d)	1.1%	6,666	6595

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 4
Calibration Data for November 2005

	Difference	Model	Plant Data
RS			
Flow (mgd)		4.9	4.9
CBOD5 (lbs/day)		8,851.0	8,851
TSS (lbs/day)		10,175.0	10,175
%VSS		91%	91%
TKN (lbs/d_		1,131.0	1,131
Ammonia (lbs/d)		649.0	649
TP (lbs/d)		457.0	457
1985 Plant			
SRT (days)		12.30	12.30
ML pH		6.60	6.60
MLSS (mg/L)	21.3%	3,097	2,554
MLVSS (mg/L)	15.3%	2,428	2,105
WAS (lb/d)	17.4%	6,194	5,278
Observed Yield, lbs WAS/lb BOD applied	17.4%	0.70	0.60
SE			
TSS (mg/L)	-1.3%	6.0	6.1
VSS (mg/L)	-3.4%	4.7	4.9
FE			
CBOD5 (lbs/day)	-65.9%	1.1	3.2
TSS (lbs/day)	9.2%	3.5	3.2
VSS (lbs/d)	12.7%	2.7	2.4
Ammonia (mg/L)	21.8%	0.4	0.3
Nitrate (mg/L)	-5.9%	5.1	5.4
TN (mg/L)	-6.7%	6.5	7.0
Sludge to Disposal (lbs/d)	16.7%	5,760	4934

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

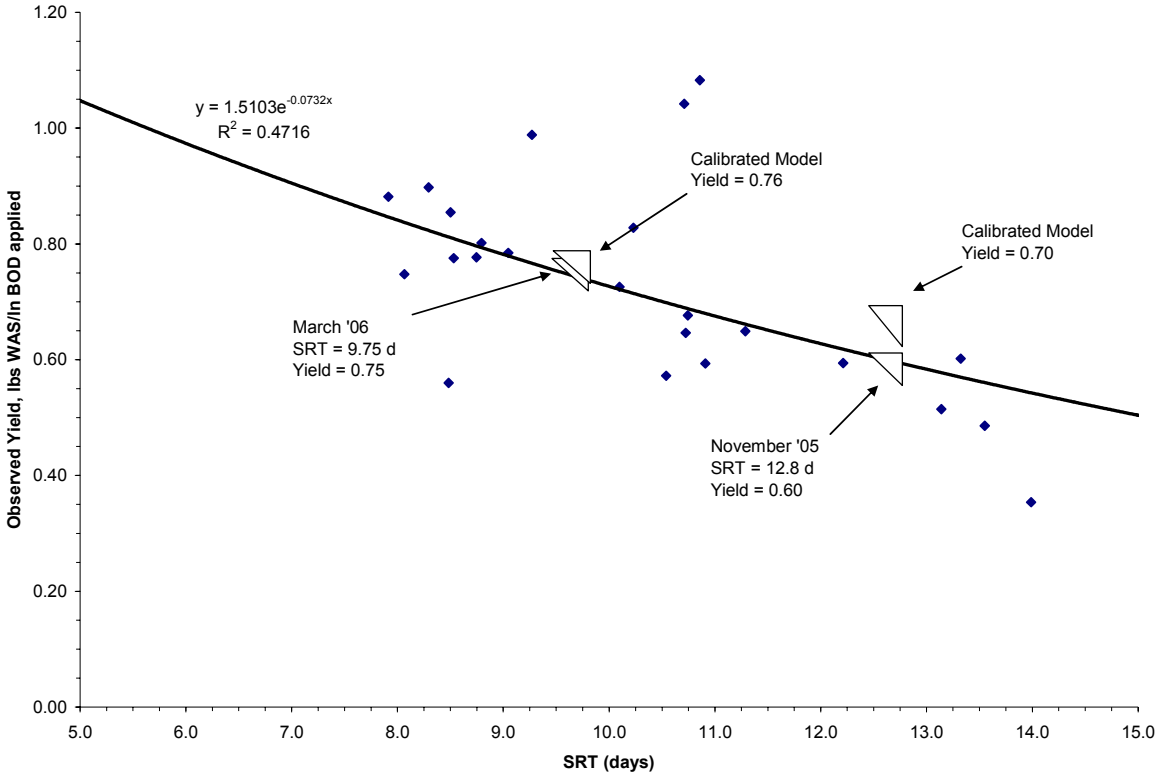


FIGURE 1
Observed Yields and SRTs

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Design Criteria

Table 3 presents the design criteria that will be used in sizing new facilities and estimating the capacity of existing facilities. These criteria are the same criteria presented in the Preliminary Findings of the Schematic Design.

Because the results of the model recalibration have resulted in significantly lower observed yields, additional design criteria should be considered to address the capacity of the aeration basins and the most cost effective way to implement Alternative 7. One additional consideration should be the maximum MLSS concentration within the aeration basin. A commonly used criteria for MLSS concentrations is 3500 mg/L in the effluent from the aeration basin, however this is can very from plant to plant based on operational experience.

A second consideration is redundancy for the aeration basin. The lower yields will allow the existing aeration basin to treat higher flows and loads than previously estimated potentially allowing the plant to increase capacity significantly by adding secondary clarification capacity. Although having one aeration basin out of service for maximum month conditions may be overly conservative, it is not overly conservative to assume that an aeration basin will need to be taken out of service for maintenance. To properly evaluate this alternative, a scenario for taking a portion of the aeration system out of service should be established.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 3

Design Criteria for Liquids Treatment

Unit Process	Value	Design Criteria	Peaking Condition	Reliability and Redundancy	Comments
Screening	3 fps	Approach velocity upstream of screen	PHF	All units in service. Bypass channel available.	Based on Phase 2 Study
Grit removal	120,000 gpd/sf	Surface Loading	PHF	All units in service. Bypass channel available.	Based on Phase 2 Study
Aeration basins -- nitrifying	7 Days	SRT	MM	All Units in Service	
Aeration blowers					
	2	AB DO	MW BOD Load	Largest Unit out of Service	
	21%	SOTE	Peak day BOD load	Largest Unit out of Service	Based on Exist. Basin Configuration
Secondary Clarifiers					
	150	SVI			
	1400 gpd/sf	SOR	MD	All Units in Service	Based on Phase 2 Study
	1000 gpd/sf	SOR	MM	Largest Unit out of Service	
	850 gpd/sf	SOR	ADW	Largest Unit out of Service	Based on Phase 1 Study
	35 lb/d/sf	SLR	MD	All Units in Service	Based on Phase 2 Study
	23 lb/d/sf	SLR	MM	Largest Unit out of Service	
RAS pumps	100% of influent flow		MM	Largest Unit out of Service	
Filtration	6 gpm/sf	HLR	PHF	All Units in Service	Phase 2 Study
	2.5 gpm/sf	HLR	ADW	Largest Unit Out of Service	Phase 1 Study
UV disinfection	120 mW-sec/sq cm	UV dose	PHF	All Units in Service	Phase 1 Study
DAFTs	1.5 lbs/hr/ft2	SLR	MD	All Units in Service	Assume 24/7 operation
	1.5 gpm/ft2	HLR	MD	All Units in Service	
Centrifuges	700 lbs DS/hour	SLR	MW	Largest Unit out of Service	Assume 8 hour/d, 7 days/week operation

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Existing Capacity Estimation

Based on the criteria listed in Table 3 and 4 and assuming that the 1975 aeration basin and secondary clarifiers are not in operable condition, the liquid treatment capacity of the Lahaina WWRF is limited by the capacity of 1985 secondary treatment system, which is given in Table 5. The capacity is determined by the maximum month solids loading rate on the secondary clarifiers. The ADW capacity is estimated based on the peaking factors developed as part of the flow and load analysis (1.2 for maximum month).

The recalibration of the resulted in increasing the estimated capacity of the plant by 0.5 – 1.0 MGD depending on the assumptions made reliability requirements for secondary clarification

Using the criteria of having one secondary clarifier out of service, the plant capacity for liquids treatment is currently approximately 4.40 MGD on an average dry weather basis. The estimated ADW capacity is below the average observed flow to the plant. It is probable that the plant has not had any problems meeting permit requirements because the third clarifier has been available during peak months. If it is assumed that all secondary clarifiers are in-service, the maximum month capacity is 7.0 MGD which translate to an ADW capacity is 5.80 MGD. Therefore, if the redundancy requirement for the secondary clarifiers is not applied, the plant has approximately 0.8 MGD of excess capacity.

Note that these capacities do not account for the capacity of the solids processing equipment. The model results for ADW flows of 5.8 MGD project that the maximum month loading on the DAFT would be 1.3 lb/hr/sf which is close to the design criteria for maximum day loading. Therefore, it is probable that additional thickening capacity would be required to match the solids processing capacity to the liquids processing capacity.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 5
Capacity of Existing Facilities

	With Redundant Secondary Clarifier	Without Redundant Secondary Clarifier
ADW Flows and Loads		
Flow (mgd)	4.4	5.8
CBOD5 (lbs/day)	9,000	10,200
TSS (lbs/day)	11,300	12,700
Max Month Flows and Loads		
Flow (mgd)	5.2	7.0
CBOD5 (lbs/day)	10,800	12,200
TSS (lbs/day)	13,500	15,200
1985 Plant Capacity		
SRT (days)	7.00	7.00
MLSS (mg/L)	2500	2,700
# of Secondary Clarifiers	2	3
Diameter of Secondary Clarifiers	75	75
SLR (lb/d/sf)	23	23
RAS Underflow Rate (gpd/sq.ft.)	70%	70%
WAS (lb/d)	8,600	9,400

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Capacity with Operational Improvements

Table 6 presents estimate for the capacity of the existing liquids treatment facilities that can be realized with changes in current operations. The changes in operation that were analyzed were operating the secondary treatment system and reducing the solids retention time (SRT) from 7 days to 5 days. The minimum SRT for nitrification is primarily affected by temperature and pH. For the Lahaina WWRF, the estimated minimum SRT needed for nitrification based on historical temperature and pH data is approximately 2.5 days, so a 5-day SRT would provide a safety factor of approximately 2 which will allow the plant to deal with daily and diurnal fluctuations in ammonia loading. Therefore the effluent TN limits should be able to be achieved at the lower SRTs, though solids production will increase.

Switching to step feed operation increases the ADW capacity by approximately 0.9 MGD to 5.3 - 6.7 MGD depending on assumptions about the number of secondary clarifiers in service. Reducing the SRT to 5 days will increase the capacity by another 0.8 -1.3 MGD. Note that solids processing facilities will need to be expanded to meet the liquids treatment process capacity.

In addition to process changes to increase capacity, additional operational changes may improve process reliability and performance. One improvement would be to add the ability to recycle the mixed liquor. Recycling the mixed liquor to the head of the aeration basin would improve denitrification and increase alkalinity. The improved denitrification should lower the TN in the final effluent and decrease aeration requirements. The increase in alkalinity will increase the pH in the aeration basin. Currently, the aeration basins operate at a pH of approximately 6.60, which is below the optimal pH for nitrification and increases the minimum SRT required for nitrification

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 6
Plant Capacity with Operational Improvements

	7-day SRT		5-day SRT	
	With Redundant Secondary Clarifier	**Without Redundant Secondary Clarifier**	**With Redundant Secondary Clarifier**	**Without Redundant Secondary Clarifier**
Plant Capacity at ADW Flows and Loads				
Flow (mgd)	5.3	6.7	6.1	9.0
CBOD5 (lbs/day)	9,200	11,600	10,500	13,100
TSS (lbs/day)	11,400	14,500	13,200	16,300
Plant Capacity at Max Month Flows and Loads				
Flow (mgd)	6.3	8.00	7.3	9.0
CBOD5 (lbs/day)	11,000	13,900	12,600	15,700
TSS (lbs/day)	13,700	17,400	15,800	19,600
1985 Plant Design Criteria and Operating Assumptions				
SRT (days)	7.00	7.00	5.00	5.00
MLSS (mg/L)	2,000	2,569	1,800	2,219
# of Secondary Clarifiers	2	3	2	3
Diameter of Secondary Clarifiers	75	75	75	75
SLR (lb/d/sf)	23	23	23	23
RAS Underflow Rate (gpd/sq.ft.)	70%	70%	70%	70%
WAS (lb/d)	8,600	10,900	10,600	13,179

Conclusions and Recommendations

It appears that the data used for the process model calibration in Phase 1 may have been inaccurate. The model was recalibrated based on data from two recent months. The recalibrated model showed good correlation with recent plant operational data.

The recalibrated model resulted in significantly increasing the estimated capacity of the plant. However, although the plant has been able to meet permit requirements to date, it appears to be operating very close to capacity. Without any growth within the basin, the plant should be able to continue to meet permit limits by keeping all secondary clarifiers on-

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

line. If a secondary clarifier is out of service, the plant may need to alter operating practices to meet permit requirements. One option is to reduce SRT. The plant should be able to operate at SRTs as low as 5-days and still be able to fully nitrify. A second option would be to operate the plant in the step feed configuration. The combination of these two operational changes should allow the plant to treat maximum month flows up to 6.1 MGD. To match the solids processing capacity with the liquids treatment capacity, additional thickening capacity will be required.

The recalibrated model also indicates that the capacity of the 1985 secondary system may be increased significantly by adding secondary clarification capacity which may effect the most cost effective approach to expansion based on the Alternative 7 scenario previously developed. Design criteria for the maximum MLSS concentration and redundancy for the aeration system need to be established to fully evaluate Alternative 7.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

APPENDIX C

Lahaina WWRF Flow and Load Analysis

Lahaina Wastewater Reclamation Facility Flow and Load Analysis (Modification Stage 1A)

PREPARED FOR: County of Maui Department of Public Works and Waste, Wastewater Reclamation Division

PREPARED BY: Jeff McCormick/CH2M HILL

DATE: September 18, 2006

PROJECT NUMBER: 176853.PS.02

1.0 Introduction

Flow and load data were analyzed for the Lahaina Wastewater Reclamation Facility (Lahaina WWRF) in order to carry out the predesign of two plant upgrade options identified in the *Lahaina WWRF Process Study – Steady State Process Modeling and Alternatives Evaluation, Final Phase 2 Report* (CH2M HILL, September 2005).

Plant influent (PI) data were obtained from the County of Maui (the County). The data were used to develop peaking factors for critical design parameters. The peaking factors were used to estimate projected flows and loads based on predicted growth in the collection system as determined by the County.

2.0 Definitions

The following critical design periods were analyzed as part of this study:

- Average Dry Weather (ADW): Average flows and loads for the dry weather period that includes May 1 through October 30 for each year
- Maximum Month (MM): Maximum 30-day running average
- Maximum Week (MW): Maximum 7-day running average
- Maximum Day (MD): Maximum average day

Peaking factors for MM, MW, and MD conditions are based on the ratio of the maximum observed flows or loads to the ADW flow or load for a given year.

3.0 Historical Flow and Load Analysis

To determine the characteristics of the existing raw sewage at the Lahaina WWRF, 5 years of PI data were analyzed to determine average loadings and the variability of flows and loads at the plant. These data will be used to project the range of flows and loads that may be seen at the plant as increased development in the basin occurs.

3.1 Data Collection

The County provided daily PI flows and loads for total suspended solids (TSS), carbonaceous biochemical oxygen demand (CBOD), ammonia (NH_3), total Kjeldahl nitrogen (TKN), and total phosphorous (TP) from January 2001 through December 2005. Plant flow and TSS concentration were measured daily, while the remaining parameters were measured approximately once per week.

Influent flows are calculated based on the sum flows measured by the flowmeters on the Napili and Lahaina force mains. Influent flows represent all raw sewage flows entering the plant and include no internal plant recycle flows.

3.2 Data Analysis

As stated in Section 3.1, daily data are available for plant flow and TSS, and weekly data are available for the remaining constituents. Owing to the limited data for CBOD, TKN, NH_3, and TP, the calculated loads for MW and MM were not considered to be accurate enough for use in determining peaking factors. Therefore, peaking factors for these parameters were based on the observed peaking factors for TSS. Based on the available data, the variability of all loads appeared similar to TSS. Table 1 summarizes the observed peaking factors and the peaking factors recommended for estimating future flows and loads.

TABLE 1
Peaking Factors

Parameter	Design Condition	Historical Data			Recommended Peaking Factor
		Minimum	Maximum	Average	
	ADW	1.00	1.00	1.00	1
	Maximum Month	1.08	1.19	1.12	1.19
	Maximum Week	1.11	1.38	1.19	1.38
	Maximum Day	1.20	1.65	1.43	1.65
TSS	ADW	1.00	1.00	1.00	1
	Maximum Month	1.16	1.42	1.26	1.28
	Maximum Week	1.45	1.91	1.59	1.91
	Maximum Day	1.90	2.85	2.33	2.85
CBOD	ADW	1.00	1.00	1.00	1
	Maximum Month	1.22	1.47	1.36	1.28
	Maximum Week	1.47	2.02	1.70	1.91
	Maximum Day	1.47	2.02	1.70	2.02
NH_3	ADW	1.00	1.00	1.00	
	Maximum Month	1.19	1.29	1.24	1.28
	Maximum Week	1.31	1.42	1.37	1.80
	Maximum Day	1.31	1.42	1.37	2.00
TKN	ADW	1.00	1.00	1.00	
	Maximum Month	1.16	1.61	1.37	1.28
	Maximum Week	1.25	2.53	1.77	1.91
	Maximum Day	1.25	2.53	1.77	2.53
TP	ADW	1.00	1.00	1.00	1
	Maximum Month	1.36	1.44	1.21	1.28

TABLE 1
Peaking Factors

Parameter	Design Condition	Historical Data			Recommended Peaking Factor
		Minimum	Maximum	Average	
	Maximum Week	1.54	1.92	1.31	1.91
	Maximum Day	1.54	1.92	1.31	1.92

To complete the Phase 2 study, a MM peaking factor of 1.5 was used for both flows and loads based on previous work. The analysis of recent data included in Table 1 reduces this peaking factor to 1.19 for flows and 1.28 for loads.

Table 2 summarizes the ADW flows and loads observed during the past 5 years and provides estimates of MM, MW, and MD flows and loads for the past 5 years based on the recommended peaking factors listed in Table 1. Figures 1 through 6 present the observed data and estimates for ADW, MM, and MW.

TABLE 2
Lahaina WWRF Plant Influent Flows and Loads

Design Condition	Flow, mgd	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
Plant Influent						
ADW	5.0	10,153	8,124	652	1,189	493
Maximum Month	6.0	12,996	10,398	835	1,521	631
Maximum Week	7.0	19,390	15,514	1,174	2,270	942
Maximum Day	8.3	28,944	16,379	1,304	3,004	945

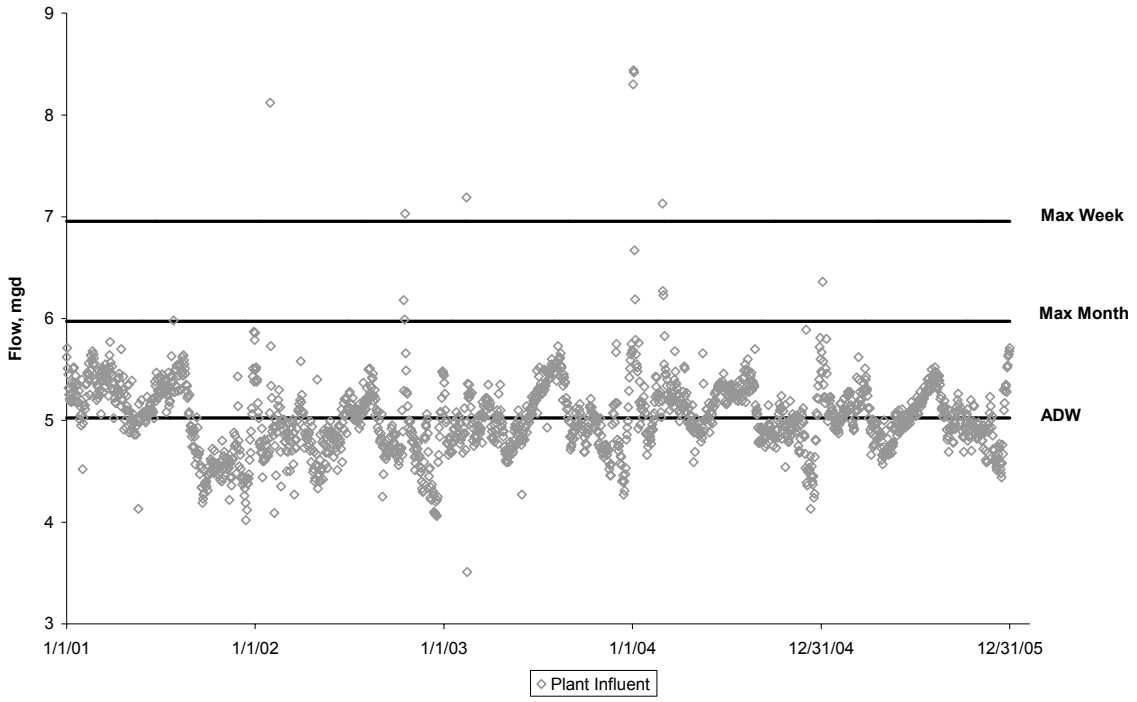


FIGURE 1
Lahaina WWRF Flows 2001 - 2004

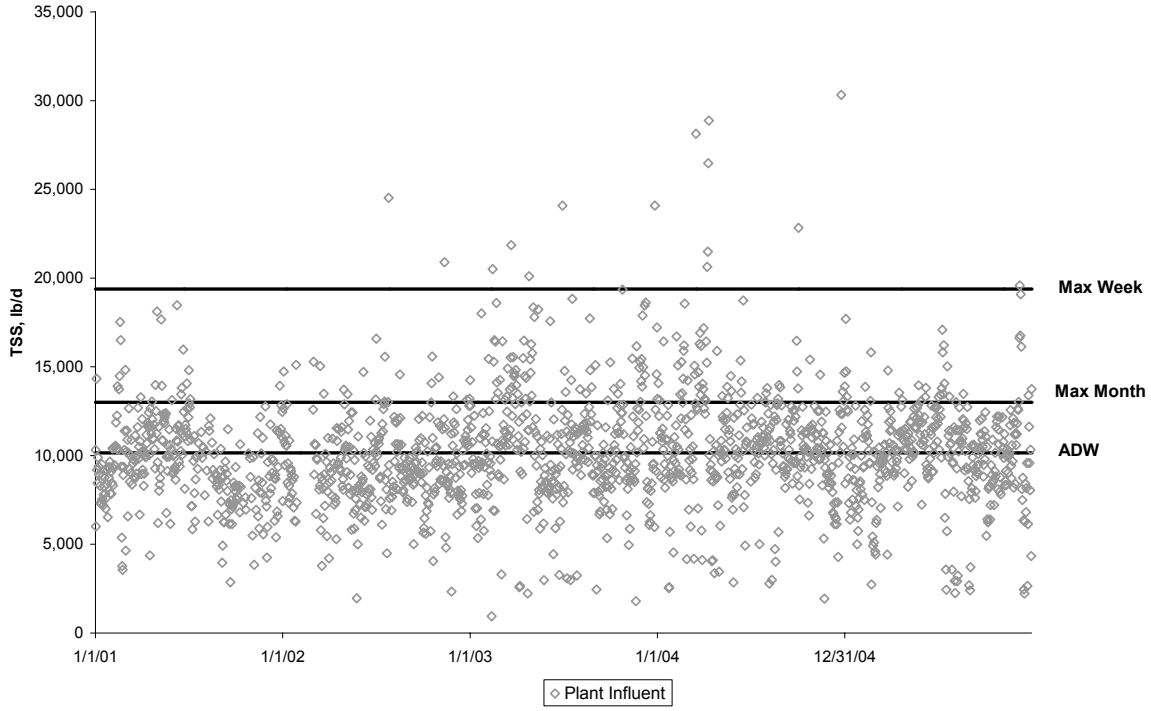


FIGURE 2
Lahaina WWRF TSS Loads 2001 - 2004

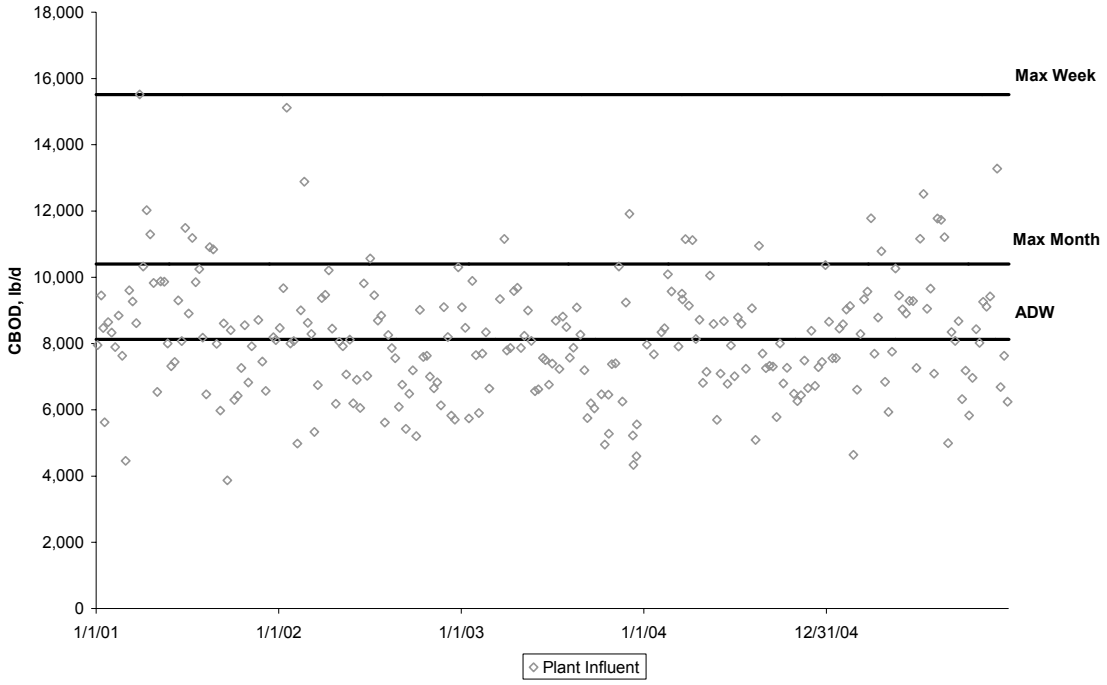


FIGURE 3
Lahaina WWRF CBOD Loads 2001 - 2004

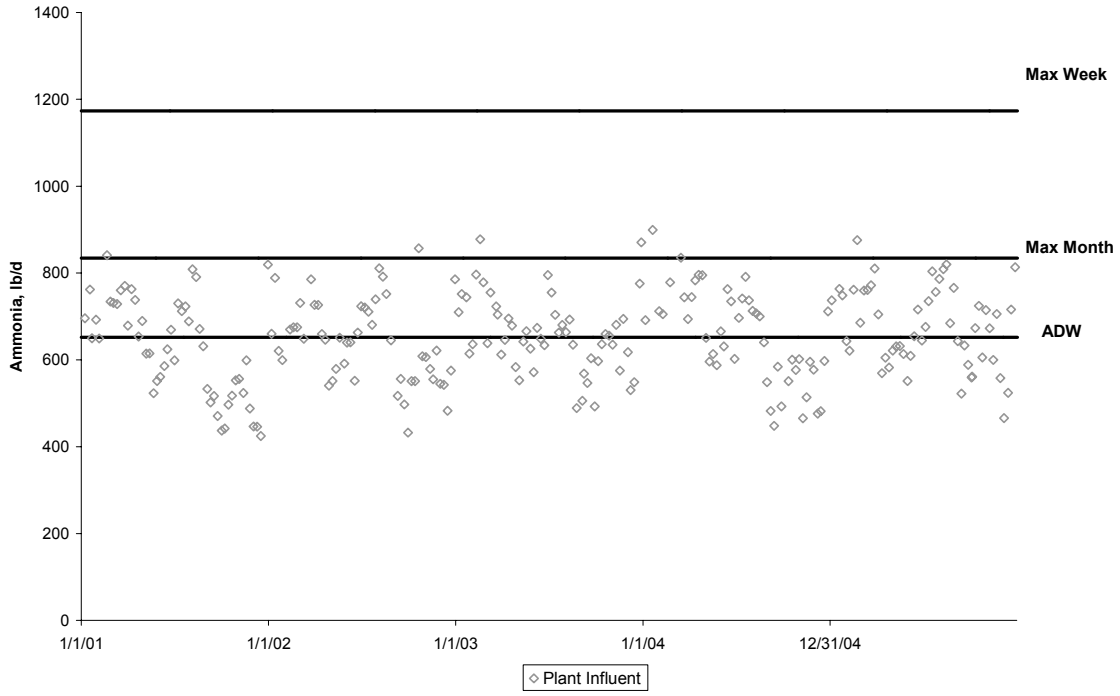


FIGURE 4
Lahaina WWRF Ammonia Loads 2001 - 2004

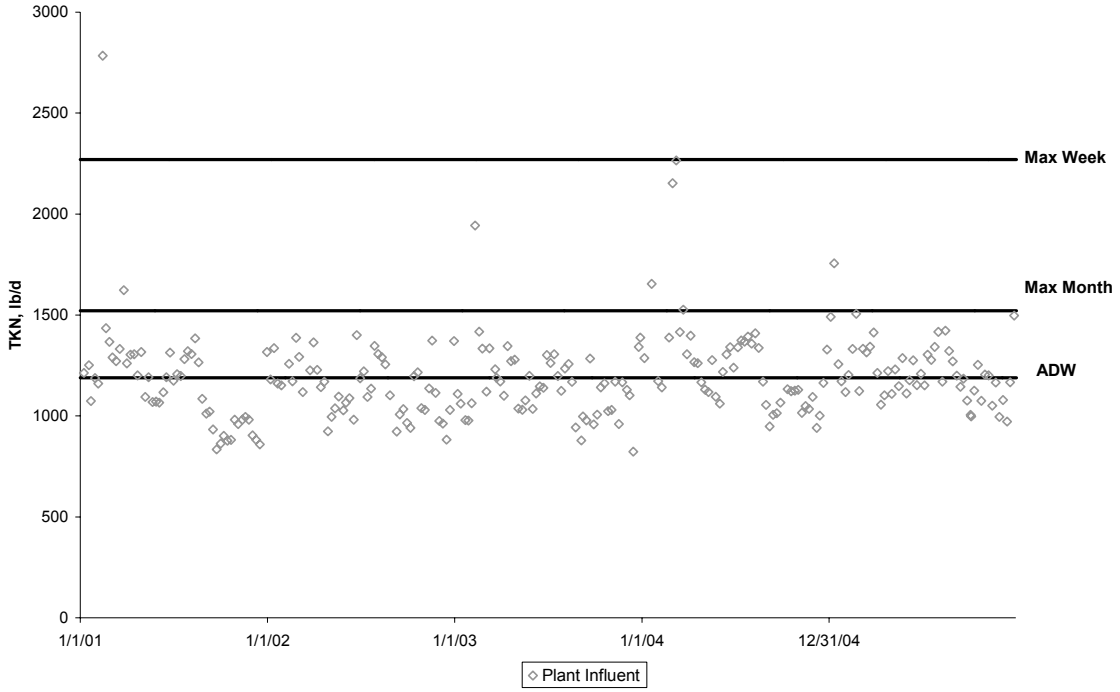


FIGURE 5
Lahaina WWRF TKN Loads 2001 - 2004

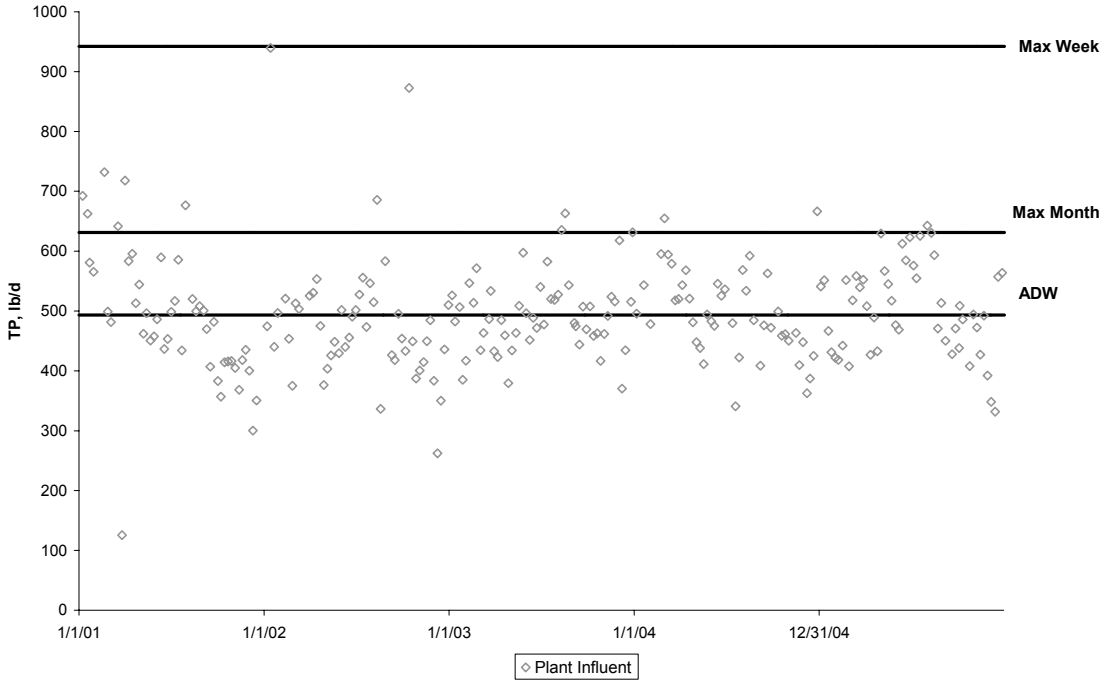


FIGURE 6
Lahaina WWRF TP Loads 2001 - 2004

4.0 Projected Flows and Loads

Flows and loads were projected for two build-out scenarios based on total ADW flows of 9 and 12 mgd (million gallons per day). For both scenarios, it was assumed that the ADW loads increased proportionately to the ADW flows. The peaking factors given in Section 3 were used to project MM, MW, and MD condition. The results of the analysis are given in Table 3.

TABLE 3
Projected Flows and Loads

Design Condition	Flow, mgd	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
9 mgd						
ADW	9.0	18,200	14,600	1,200	2,100	900
Maximum Month	10.7	23,300	18,700	1,500	2,700	1,200
Maximum Week	12.5	34,800	27,900	2,200	4,000	1,700
Maximum Day	14.9	43,900	29,400	2,400	5,300	1,700
12 mgd						
ADW	12.0	24,200	19,400	1,600	2,800	1,200
Maximum Month	14.3	31,000	24,800	2,000	3,600	1,500
Maximum Week	16.6	46,200	37,000	2,900	5,300	2,300
Maximum Day	19.8	58,300	39,100	3,200	7,100	2,300

Table 4 compares the results of the flow and load analysis with the flows and loads used in the Phase 2 study. Although the peaking factors that were developed based on recent data were lower than those for the Phase 2 study, the ADW developed based on recent data are substantially higher than what was used for the Phase 2 study. The flows and loads in the Phase 2 study were based on information from previous designs and did not include an analysis of recent flows and loads. The detailed analysis based on recent data indicates a decrease in the projected MM flows of 2.8 mgd. However, projected MM TSS loads are approximately 39 percent higher and MM CBOD loads are approximately 19 percent higher.

TABLE 4
Comparison of Flows and Loads for Phases 2 and 3

Design Condition	Flow, mgd	TSS, lb/d	CBOD, lb/d	NH3, lb/d	TKN, lb/d	TP, lb/d
Phase 2						
ADW	9	11,184	10,508	1,051	1,726	300
MM	13.5	16,776	15,763	1,576	2,590	450
Recommended Based on 2001-2005 Data						
ADW	9.0	18,200	14,600	1,200	2,100	900
MM	10.7	23,300	18,700	1,500	2,700	1,200
Percent Difference						
ADW	0%	63%	39%	14%	22%	200%
MM	-21%	39%	19%	-5%	4%	167%

5.0 Conclusion

It is recommended that the projected flows and loads in Table 3 be used in the predesign of two plant upgrade options, identified in the *Lahaina WWRF Process Study*. The projections in Table 3 are based on the flows and loads observed at the plant over the past five years and the variability of those flows and loads. Although the projections in Table 3 are substantially different than data used in the *Lahaina WWRF Process Study* study, the projections should be more accurate due the amount of data reviewed and the fact the this data is current.

ATTACHMENT 1

Data Summary Tables

FLOW PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS Flow, mgd	5.00	4.95	5.09	5.11	5.05
	Max of 30-Day Avg. RS Flow, mgd	5.47	5.24	5.52	5.38	5.37
	Max of 7-Day Avg. RS Flow, mgd	5.55	5.85	5.63	5.44	5.43
	Max of RS Flow, mgd	5.98	7.03	5.73	5.70	5.52
W	Average of RS Flow, mgd	5.11	4.81	4.93	5.17	5.04
	Max of 30-Day Avg. RS Flow, mgd	5.44	5.09	5.05	5.76	5.36
	Max of 7-Day Avg. RS Flow, mgd	5.62	5.63	5.55	7.07	5.73
	Max of RS Flow, mgd	5.87	8.12	7.19	8.44	6.36

Peaking Factors - ADF

		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS CBOD, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 30-Day Avg. RS CBOD, lb/d	1.10	1.06	1.08	1.05	1.06	1.05	1.10	1.07
	Max of 7-Day Avg. RS CBOD, lb/d	1.11	1.18	1.11	1.07	1.08	1.07	1.18	1.11
	Max of RS CBOD, lb/d	1.20	1.42	1.13	1.12	1.09	1.09	1.42	1.19
W	Average of RS CBOD, lb/d	1.02	0.97	0.97	1.01	1.00	0.97	1.02	0.99
	Max of 30-Day Avg. RS CBOD, lb/d	1.09	1.03	0.99	1.13	1.06	0.99	1.13	1.06
	Max of 7-Day Avg. RS CBOD, lb/d	1.12	1.14	1.09	1.38	1.14	1.09	1.38	1.17
	Max of RS CBOD, lb/d	1.17	1.64	1.41	1.65	1.26	1.17	1.65	1.43

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.10	1.06	1.08	1.13	1.06	1.06	1.13	1.09
Max Week	1.12	1.18	1.11	1.38	1.14	1.11	1.38	1.19
Max Day	1.20	1.64	1.41	1.65	1.26	1.20	1.65	1.43

CBOD PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS CBOD, lb/d	8,380	7,497	7,287	7,610	8,700
	Max of 30-Day Avg. RS CBOD, lb/d	10,868	9,392	8,873	8,697	10,597
	Max of 7-Day Avg. RS CBOD, lb/d	11,493	10,568	9,085	10,949	12,517
	Max of RS CBOD, lb/d	11,493	10,568	9,085	10,949	12,517
W	Average of RS CBOD, lb/d	8,702	8,305	7,903	8,375	8,518
	Max of 30-Day Avg. RS CBOD, lb/d	12,291	10,339	10,250	10,052	10,605
	Max of 7-Day Avg. RS CBOD, lb/d	15,516	15,115	11,914	11,152	13,281
	Max of RS CBOD, lb/d	15,516	15,115	11,914	11,152	13,281

Peaking Factors

		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS CBOD, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 30-Day Avg. RS CBOD, lb/d	1.30	1.25	1.22	1.14	1.22	1.14	1.30	1.23
	Max of 7-Day Avg. RS CBOD, lb/d	1.37	1.41	1.25	1.44	1.44	1.25	1.44	1.38
	Max of RS CBOD, lb/d	1.37	1.41	1.25	1.44	1.44	1.25	1.44	1.38
W	Average of RS CBOD, lb/d	1.04	1.11	1.08	1.10	0.98	0.98	1.11	1.06
	Max of 30-Day Avg. RS CBOD, lb/d	1.47	1.38	1.41	1.32	1.22	1.22	1.47	1.36
	Max of 7-Day Avg. RS CBOD, lb/d	1.85	2.02	1.64	1.47	1.53	1.47	2.02	1.70
	Max of RS CBOD, lb/d	1.85	2.02	1.64	1.47	1.53	1.47	2.02	1.70

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.47	1.38	1.41	1.32	1.22	1.22	1.47	1.36
Max Week	1.85	2.02	1.64	1.47	1.53	1.47	2.02	1.70
Max Day	1.85	2.02	1.64	1.47	1.53	1.47	2.02	1.70

TSS PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS TSS, lb/d	7,594	9,026	10,202	10,117	10,153
	Max of 30-Day Avg. RS TSS, lb/d	12,015	10,551	12,662	11,604	12,088
	Max of 7-Day Avg. RS TSS, lb/d	12,872	12,267	15,523	14,075	14,331
	Max of RS TSS, lb/d	18,460	24,525	24,084	22,833	17,087
W	Average of RS TSS, lb/d	8,689	7,242	10,950	10,744	9,785
	Max of 30-Day Avg. RS TSS, lb/d	10,774	9,939	13,053	14,652	11,782
	Max of 7-Day Avg. RS TSS, lb/d	12,477	12,008	15,247	20,315	16,253
	Max of RS TSS, lb/d	17,529	20,889	24,080	30,324	19,581

Peaking Factors

		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS TSS, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 30-Day Avg. RS TSS, lb/d	1.58	1.17	1.24	1.15	1.19	1.15	1.58	1.27
	Max of 7-Day Avg. RS TSS, lb/d	1.70	1.36	1.52	1.39	1.41	1.36	1.70	1.48
	Max of RS TSS, lb/d	2.43	2.72	2.36	2.26	1.68	1.68	2.72	2.29
W	Average of RS TSS, lb/d	1.14	0.80	1.07	1.06	0.96	0.80	1.14	1.01
	Max of 30-Day Avg. RS TSS, lb/d	1.42	1.10	1.28	1.45	1.16	1.10	1.45	1.28
	Max of 7-Day Avg. RS TSS, lb/d	1.64	1.33	1.49	2.01	1.60	1.33	2.01	1.62
	Max of RS TSS, lb/d	2.31	2.31	2.36	3.00	1.93	1.93	3.00	2.38

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.58	1.17	1.28	1.45	1.19	1.17	1.58	1.33
Max Week	1.70	1.36	1.52	2.01	1.60	1.36	2.01	1.64
Max Day	2.43	2.72	2.36	3.00	1.93	1.93	3.00	2.49

NH3 PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS NH3, lb/d	599	641	629	634	669
	Max of 30-Day Avg. RS NH3, lb/d	753	773	729	780	795
	Max of 7-Day Avg. RS NH3, lb/d	809	857	795	795	820
	Max of RS NH3, lb/d	809	857	795	791	820
W	Average of RS NH3, lb/d	660	644	638	676	658
	Max of 30-Day Avg. RS NH3, lb/d	769	756	762	821	776
	Max of 7-Day Avg. RS NH3, lb/d	841	819	828	899	876
	Max of RS NH3, lb/d	841	789	878	899	876

Peaking Factors

		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS NH3, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 7-Day Avg. RS NH3, lb/d	1.26	1.21	1.16	1.23	1.19	1.16	1.26	1.21
	Max of 30-Day Avg. RS NH3, lb/d	1.35	1.34	1.26	1.25	1.22	1.22	1.35	1.29
	Max of RS NH3, lb/d	1.35	1.34	1.26	1.25	1.22	1.22	1.35	1.28
W	Average of RS NH3, lb/d	1.10	1.00	1.01	1.07	0.98	0.98	1.10	1.03
	Max of 7-Day Avg. RS NH3, lb/d	1.28	1.18	1.21	1.29	1.16	1.16	1.29	1.23
	Max of 30-Day Avg. RS NH3, lb/d	1.40	1.28	1.32	1.42	1.31	1.28	1.42	1.35
	Max of RS NH3, lb/d	1.40	1.23	1.39	1.42	1.31	1.23	1.42	1.35

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.28	1.21	1.21	1.29	1.19	1.19	1.29	1.24
Max Week	1.40	1.34	1.32	1.42	1.31	1.31	1.42	1.36
Max Day	1.40	1.34	1.39	1.42	1.31	1.31	1.42	1.37

TKN PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS TKN, lb/d	1,102	1,118	1,115	1,200	1,201
	Max of 30-Day Avg. RS TKN, lb/d	1,323	1,300	1,267	1,382	1,338
	Max of 7-Day Avg. RS TKN, lb/d	1,385	1,400	1,305	1,410	1,422
	Max of RS TKN, lb/d	1,385	1,400	1,305	1,410	1,422
W	Average of RS TKN, lb/d	1,250	1,166	1,108	1,311	1,243
	Max of 30-Day Avg. RS TKN, lb/d	1,719	1,278	1,302	1,936	1,458
	Max of 7-Day Avg. RS TKN, lb/d	2,784	1,387	1,943	2,265	1,756
	Max of RS TKN, lb/d	2,784	1,387	1,943	2,265	1,756

Peaking Factors

		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS TKN, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 7-Day Avg. RS TKN, lb/d	1.20	1.16	1.14	1.15	1.11	1.11	1.20	1.15
	Max of 30-Day Avg. RS TKN, lb/d	1.26	1.25	1.17	1.17	1.18	1.17	1.26	1.21
	Max of RS TKN, lb/d	1.26	1.25	1.17	1.17	1.18	1.17	1.26	1.21
W	Average of RS TKN, lb/d	1.13	1.04	0.99	1.09	1.03	0.99	1.13	1.06
	Max of 7-Day Avg. RS TKN, lb/d	1.56	1.14	1.17	1.61	1.21	1.14	1.61	1.34
	Max of 30-Day Avg. RS TKN, lb/d	2.53	1.24	1.74	1.89	1.46	1.24	2.53	1.77
	Max of RS TKN, lb/d	2.53	1.24	1.74	1.89	1.46	1.24	2.53	1.77

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.56	1.16	1.17	1.61	1.21	1.16	1.61	1.34
Max Week	2.53	1.25	1.74	1.89	1.46	1.25	2.53	1.77
Max Day	2.53	1.25	1.74	1.89	1.46	1.25	2.53	1.77

TP PEAKING FACTORS

		Year				
Season	Data	2001	2002	2003	2004	2005
D	Average of RS TP, lb/d	477	490	505	483	533
	Max of 30-Day Avg. RS TP, lb/d	591	564	614	545	633
	Max of 7-Day Avg. RS TP, lb/d	677	873	663	592	643
	Max of RS TP, lb/d	677	873	663	592	643
W	Average of RS TP, lb/d	505	473	450	510	474
	Max of 30-Day Avg. RS TP, lb/d	649	707	537	625	556
	Max of 7-Day Avg. RS TP, lb/d	732	940	618	667	667
	Max of RS TP, lb/d	732	940	631	667	564

Peaking Factors

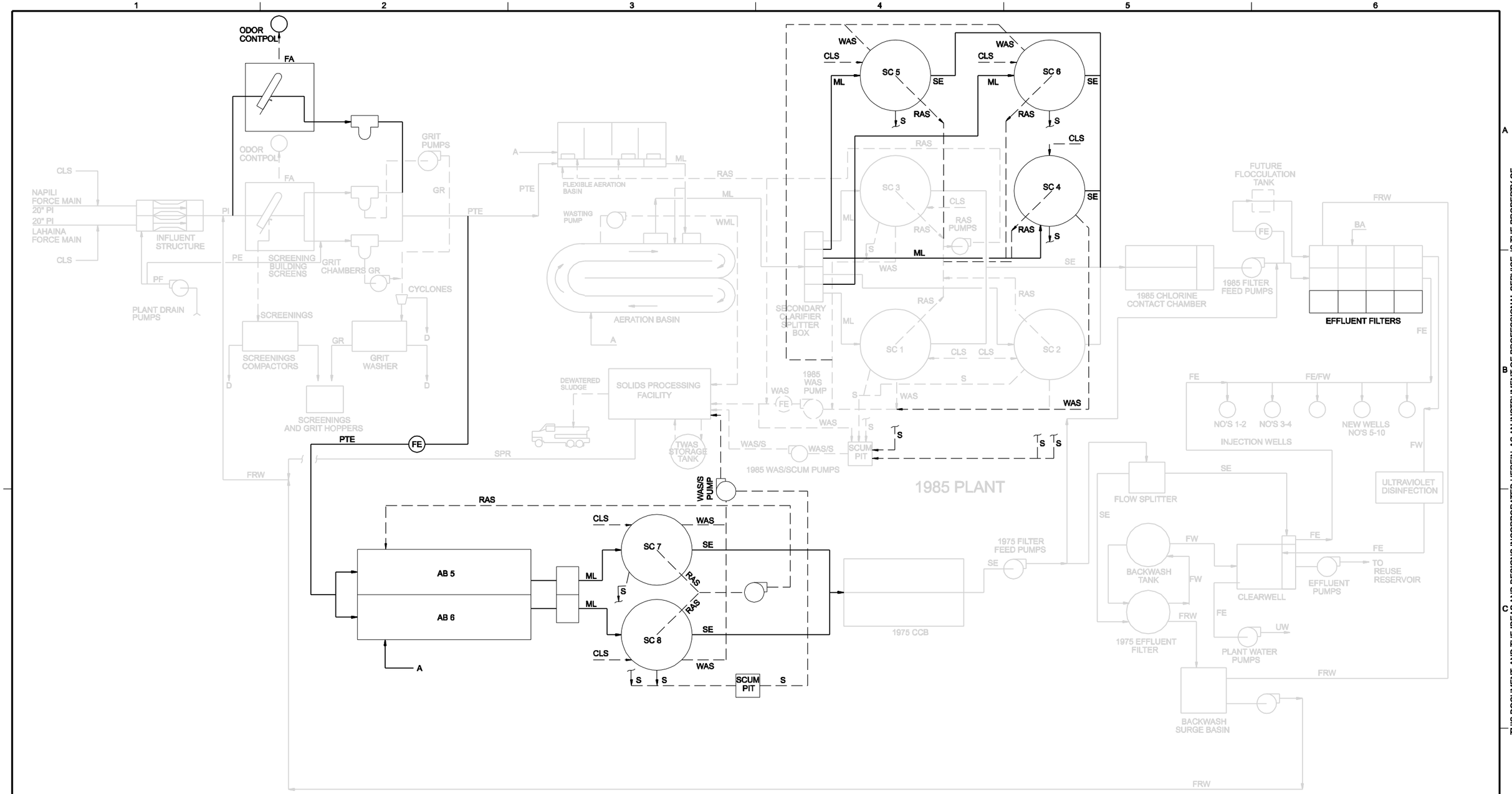
		2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
D	Average of RS TP, lb/d	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Max of 30-Day Avg. RS TP, lb/d	1.24	1.15	1.21	1.13	1.19	1.13	1.24	1.18
	Max of 7-Day Avg. RS TP, lb/d	1.42	1.78	1.31	1.23	1.21	1.21	1.78	1.39
	Max of RS TP, lb/d	1.42	1.78	1.31	1.23	1.21	1.21	1.78	1.39
W	Average of RS TP, lb/d	1.06	0.96	0.89	1.05	0.89	0.89	1.06	0.97
	Max of 30-Day Avg. RS TP, lb/d	1.36	1.44	1.06	1.29	1.04	1.04	1.44	1.24
	Max of 7-Day Avg. RS TP, lb/d	1.54	1.92	1.22	1.38	1.25	1.22	1.92	1.46
	Max of RS TP, lb/d	1.54	1.92	1.25	1.38	1.06	1.06	1.92	1.43

Peaking Factors

	2001	2002	2003	2004	2005	**Min**	**Max**	**Average**
ADW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Month	1.36	1.44	1.21	1.29	1.19	1.19	1.44	1.30
Max Week	1.54	1.92	1.31	1.38	1.25	1.25	1.92	1.48
Max Day	1.54	1.92	1.31	1.38	1.21	1.21	1.92	1.47

APPENDIX D

Process Flow Diagrams and Site Layouts for Alternatives 7 and 7A



SCHEMATIC DESIGN
JULY 2006

NOT FOR CONSTRUCTION

DRAWN BY: VED PARKASH				
DESIGNED BY: DJG				
CHECKED BY: JFM	REV	DATE	REVISION	APVD

PROJECT MANAGER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

DEPARTMENT OF PUBLIC WORKS
COUNTY OF MAUI, HAWAII

LAHAINA
WASTE WATER RECLAMATION FACILITES
ADDITIONS AND MODIFICATIONS

SCALE
NA

PROJ NUMBER
176853

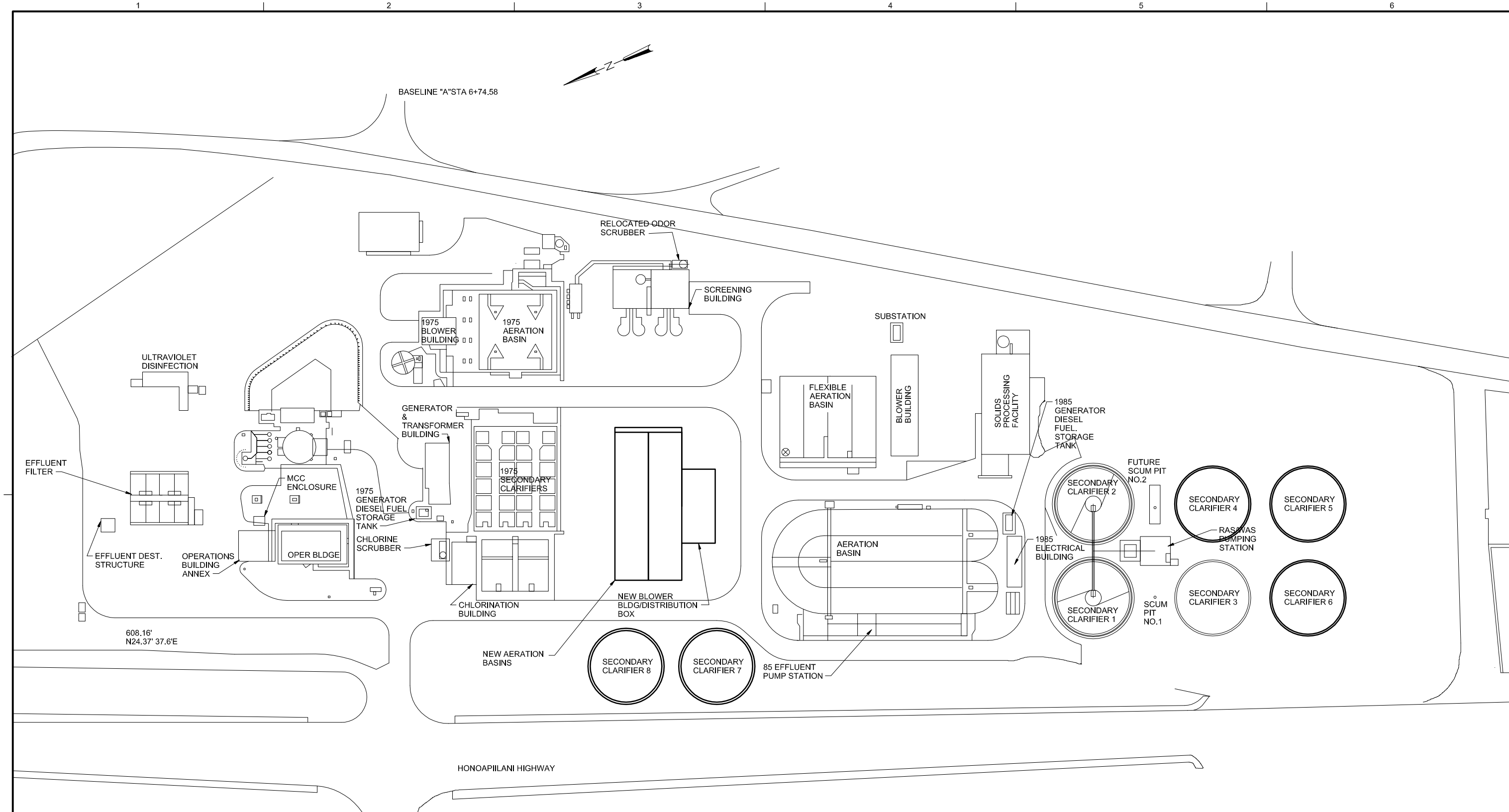
ALTERNATIVE 7
PROCESS FLOW DIAGRAM

SHEET

DRAWING NO.
PFD ALT. 7

FILENAME: PLOT DATE: PLOT TIME:

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2MHILL. ©CH2M HILL



REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2MHILL.

SCHEMATIC DESIGN
JULY 2006

NOT FOR CONSTRUCTION

DRAWN BY: VED PARKASH				
DESIGNED BY: DJG				
CHECKED BY: JFM	REV	DATE	REVISION	APVD

PROJECT MANAGER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

DEPARTMENT OF PUBLIC WORKS
COUNTY OF MAUI, HAWAII

LAHAINA
WASTE WATER RECLAMATION FACILITES
ADDITIONS AND MODIFICATIONS

SCALE 1"=50'

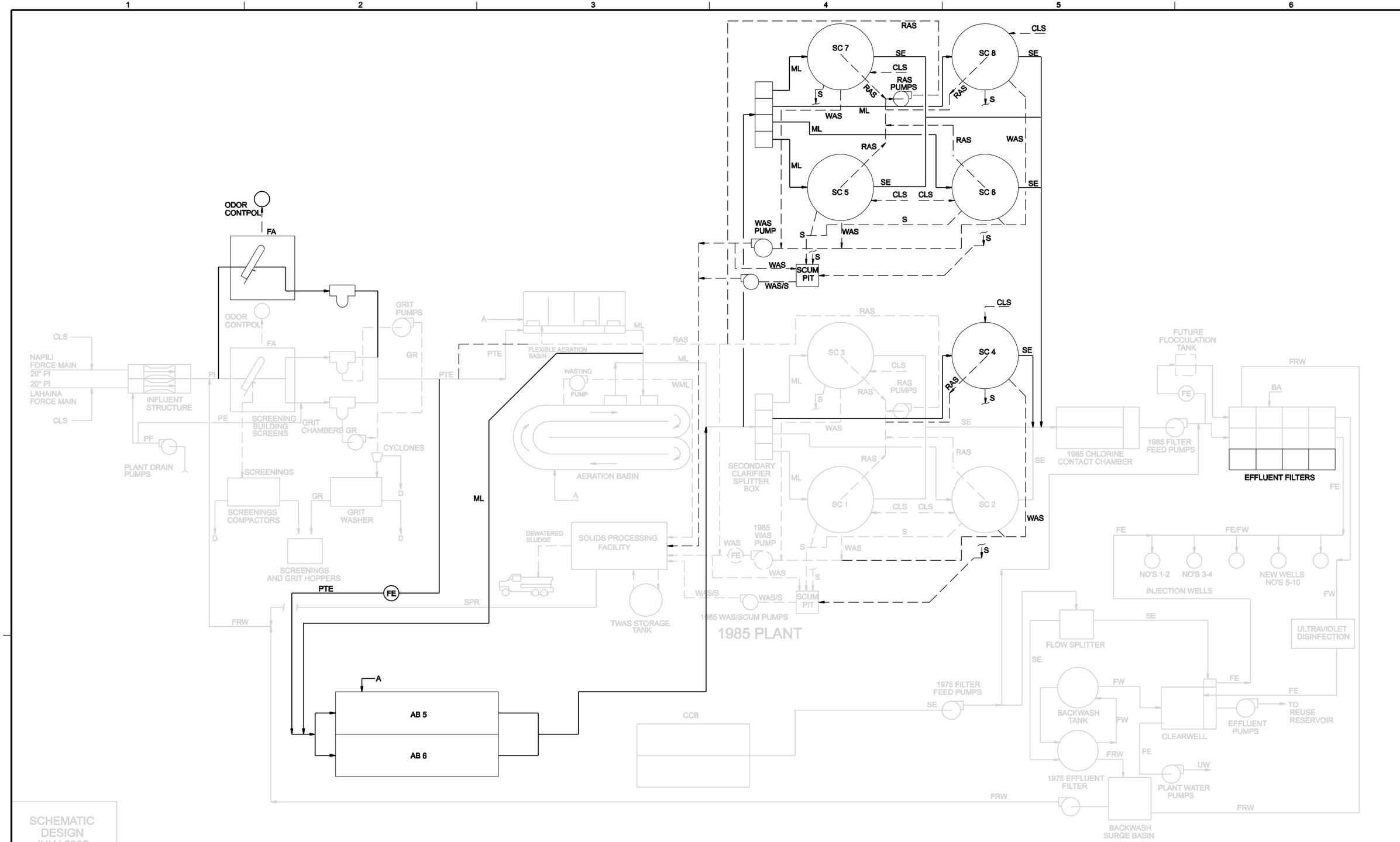
PROJ NUMBER 176853

FACILITY
ALTERNATIVE 7
SITE LAYOUT PLAN

SHEET

DRAWING NO.

FILENAME: Site layout plan alt7.dwg PLOT DATE: 18-JUL-2006 PLOT TIME: 17:30:06



SCHEMATIC DESIGN
JULY 2006

NOT FOR CONSTRUCTION

DRAWN BY: VED PARKASH				
DESIGNED BY: DJG				
CHECKED BY: JFM	REV	DATE	REVISION	APVD

PROJECT MANAGER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

DEPARTMENT OF PUBLIC WORKS
COUNTY OF MAUI, HAWAII

LAHAINA
WASTE WATER RECLAMATION FACILITES
ADDITIONS AND MODIFICATIONS

SCALE: NA

PROJ NUMBER: 176853

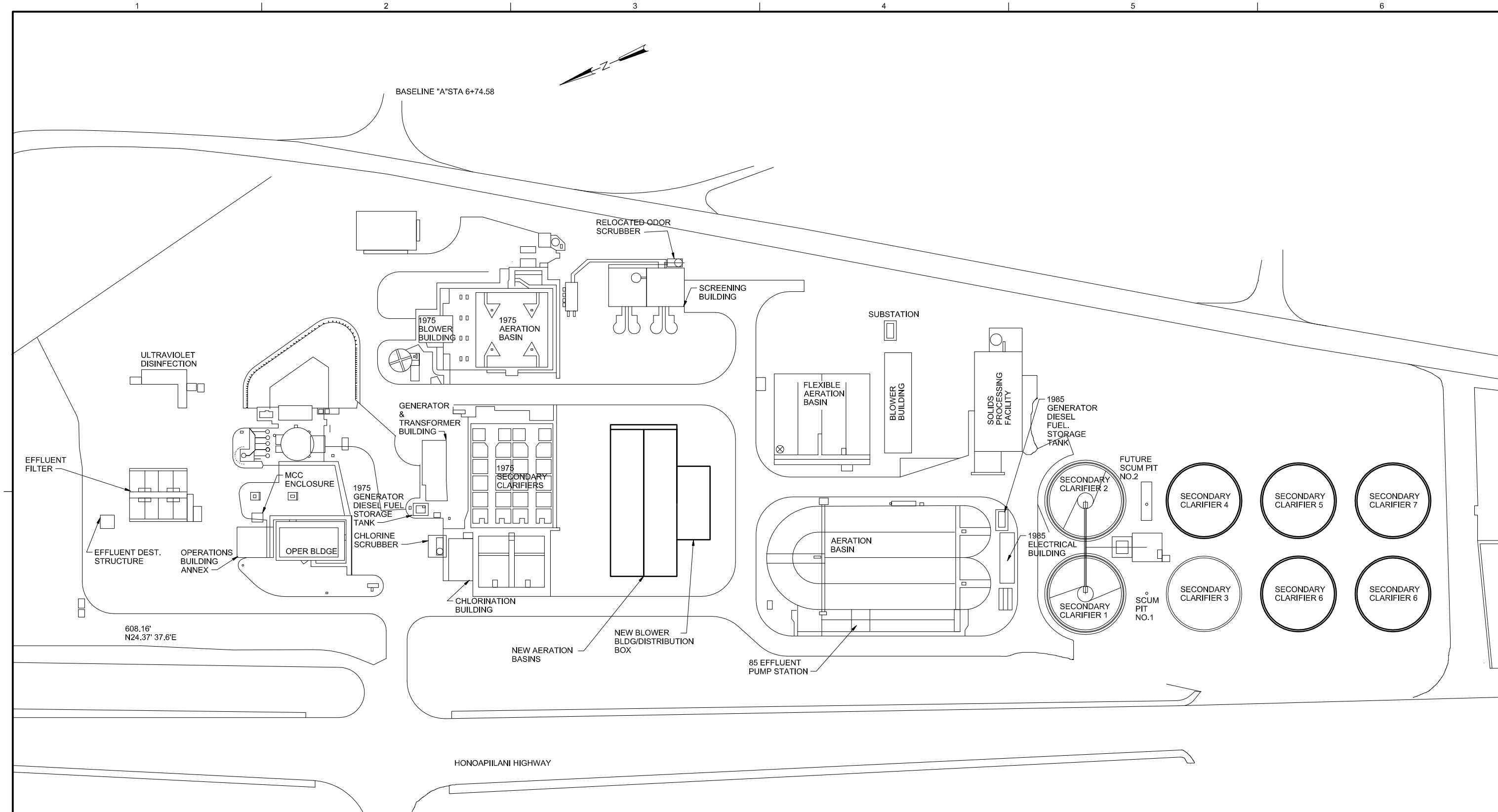
ALTERNATIVE 7A
PROCESS FLOW DIAGRAM

SHEET

DRAWING NO. PFD ALT. 7A

FILENAME: PLOT DATE: PLOT TIME:

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF © CH2M HILL. CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2MHILL.



REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2MHILL. ©CH2M HILL

SCHEMATIC DESIGN
JULY 2006

NOT FOR CONSTRUCTION

DRAWN BY: VED PARKASH				
DESIGNED BY: DJG				
CHECKED BY: JFM	REV	DATE	REVISION	APVD

PROJECT MANAGER

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

DEPARTMENT OF PUBLIC WORKS
COUNTY OF MAUI, HAWAII

LAHAINA
WASTE WATER RECLAMATION FACILITES
ADDITIONS AND MODIFICATIONS

SCALE 1"=50'

PROJ NUMBER 176853

FACILITY
ALTERNATIVE 7A
SITE LAYOUT PLAN

SHEET

DRAWING NO.

FILENAME:Site layout plan alt7a.dwg PLOT DATE: 18-JUL-2006 PLOT TIME: 17:30:06

APPENDIX E
Biosolids Master Plan

Biosolids Master Plan—County of Maui Lahaina Wastewater Reclamation Facility

PREPARED FOR:	County of Maui, Hawaii, Department of Public Works and Environmental Management, Wastewater Division
PREPARED BY:	CH2M HILL
COPIES:	Bruce Johnson/CH2M HILL Ross Kaneko/CH2M HILL Jeff McCormick/CH2M HILL Tim Shea/CH2M HILL
DATE:	September 19, 2006
PROJECT NUMBER:	176853.PS.02

Introduction

This technical memorandum (TM) summarizes the development of the Biosolids Master Plan (BMP) for the Lahaina Wastewater Reclamation Facility (WWRF), County of Maui, Hawaii. The BMP summarizes the evaluation of the solids processing and biosolids management needs of the Lahaina WWRF for two cases of ultimate build-out capacity, 9 mgd and 12 mgd, by the year 2030.

The objectives of this TM are to describe:

- Evaluation of thickening and dewatering facilities.
- Development of three alternatives for solids processing and biosolids management using the results of the thickening and dewatering evaluation, for each build-out capacity.
- Identification of the subjective preferences of the staff of the Wastewater Division for each alternative, as a means of determining the benefits to the County of Maui from the selected project.
- Preparation of preliminary relative cost estimates for the alternatives, at a level allowing differentiation among the alternatives.
- Population of the decision prioritization model in the CH2M HILL BMP Tool Kit.
- Operation of the model to develop the relative costs and benefits of each alternative.
- Review of the findings with the staff of the Wastewater Division.
- Recommendation of an alternative for each build-out capacity.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

The priority of this document is to develop the basis for differentiation among the alternatives, leading to the selection of a specific alternative.

Existing Conditions

The existing treatment train consists of preliminary treatment, aeration basins, secondary clarifiers, effluent filters and effluent injection wells. The waste activated sludge (WAS) produced is taken directly to dewatering by centrifuge on a single-shift-per-day, 7-day-per-week basis. The three centrifuges are each capable of dewatering WAS at 0.8 percent dry solids (DS) at a rate of 85 gallons per minute (gpm). The dewatered cake is hauled 25 miles to the Maui EKO merchant composting facility.

There is an existing, out-of service dissolved air flotation thickener (DAFT) unit at the WWRF as well as the three dewatering centrifuges. The DAFT has a surface area of 300 square feet and a capacity of 450 pounds of dry solids per hour.

The present truck-loading operation takes place in an open-air staging area, as the cake is produced. Typical loading times vary from 6 to 8 hours, corresponding to the length of the dewatering operation. The loaded trucks are then driven to Maui EKO.

The present annual average daily wastewater flow rate is approximately 5.5 mgd, with a corresponding solids production rate of 3 dry tons per day (DTPD).

Design Assumptions and Criteria

The development of this TM is based primarily upon the following documents and meetings:

- Documents:
  - CH2M HILL. Final Phase 2 Report. Lahaina WWRR Process Study. Steady State Process Model ling and Alternatives Evaluation. Prepared for County, Department of Public Works and Environmental Management. September 2005
  - Brown and Caldwell. Basis of Design Report for Lahaina WWRF Additions and Modifications. January 25, 1991.
  - Brown and Caldwell. Basis of Design Appendices for Lahaina WWRF Additions and Modifications. January 25, 1991.
  - Brown and Caldwell. State Revolving Fund Process Evaluation for Lahaina WWRF. July 1, 1991.
- Teleconferences:
  - Teleconference, January 18, 2006.
  - Teleconference, March 10, 2006
- Draft Biosolids Master Plan, dated March 31, 2006 (CH2M HILL).
- Draft Schematic Design Report, Lahaina Wastewater Reclamation Facility, dated July 24, 2006 (CH2M HILL).

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

These sources were used to establish the following baseline assumptions:

- Tourist accommodations will be located across the highway from the WWRF in the next few years, requiring careful attention to odor control at the WWRF.
- There are no unique regulatory drivers from the state or U.S. Environmental Protection Agency (USEPA) for a solids processing program at the WWRF.
- At present, the dewatered cake production from Lahaina WWRF is hauled to the Maui EKO composting facility where it is converted to a Class A biosolids product. This facility is open on a 7-day-per-week basis and is located about 25 miles from the Lahaina WWRF.
- The Maui EKO facility has been under contract with the County of Maui for 15 years, and is assumed to be available to serve as the outlet for biosolids production at least through the year 2030.
- The Maui EKO facility has extensive experience with the processing of unstabilized cake and aerobically digested cake, but not with anaerobically digested biosolids.
- The resultant priorities for the solids processing train are to provide adequate solids processing capacity and containment of odor releases from the Lahaina WWRF in the foreseeable future.
- For study purposes it is assumed that either the 9-mgd capacity or the 12-mgd capacity will be needed by 2030, and that the required capital investment for solids processing capacity for each would be made starting in the year 2007, but may be spread over a number of phases of construction.

The opening of tourist accommodations opposite the site of the Lahaina WWRF will necessitate an upgrade of the solids processing, cake loading, and truck staging areas to contain odor release. To address this need, the County may wish to consider the following options:

- An enclosed building to eliminate the open-air loading and staging operations.
- A cake silo to accumulate the cake and allow truck loading in 1 hour or less and permit the departure of the truck as soon as loaded.
- An odorous air collection and treatment system for the building to minimize the risk of odor release from this area.

The projected WAS production used for the development of the alternatives at capacities of 9 mgd and 12 mgd is presented in Table 1. The solids production rates are presented for the annual average (AA), maximum month (MM), maximum week (MW) and maximum day (MD) for 9 mgd and 12 mgd. Additionally, Table 2 presents the design criteria used for new and existing processing facilities.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 1
Projected WAS Production

	WAS Production	
	(Lb/hour)	(GPM)
Production at 9 MGD:		
Annual Average (AA)	475	95
Maximum Month (MM)	675	135
Maximum Week (MW)	792	158
Maximum Day (MD, estimated @ 125% of MW)	950	190
Production at 12 MGD:		
Annual Average (AA)	708	141
Maximum Month (MM)	1,010	202
Maximum Week (MW)	1,180	236
Maximum Day (MD, estimated @ 125% of MW)	1,480	296

TABLE 2
Design Criteria

Unit Process	Value	Design Criteria	Peaking Condition	Reliability and Redundancy	Comments
Dissolved air flotation thickeners (DAFTs)	1.5 pounds per hour per square foot (lb/hr/ft$^{2)}$	SLR	MD	All units in service	Assume 24/7 operation
	1.5 gpm/ft^2	HLR	MD	All units in service	
Centrifuge					
	700 lbs DS/hour	SLR	MW	Largest unit out of service	Assume 8 hours/day, 7 days/week operation
	85 gpm	HLR	MW	Largest unit out of service	Assume 8 hours/day, 7 days/week operation

Thickening and Dewatering Alternatives Analysis

As previously discussed, the plant currently dewaters unthickened sludge, bypassing the existing DAFT. The existing DAFT has been out of service for more than 10 years and will require some rehabilitation before it can be returned to service.

An analysis has been completed comparing the current process of dewatering without thickening to thickening using DAFTs prior to dewatering. The evaluation was based on the solids production and design criteria given in Tables 1 and 2, along with the assumptions in Table 3.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 3
Thickening and Dewatering Design Assumptions

WAS solids	0.80%
TWAS solids	4%
DAFT capture rate	98%
DAFT polymer consumption	5 lb/DT
DAFT power consumption	25 kWh/DT
DAFT OMRR*	$10/DT
Centrifuge polymer consumption without thickening	32 lb/DT
Centrifuge polymer consumption with thickening	28 lb/DT
Centrifuge power consumption	100 kWh/DT
Centrifuge OMRR*	$25/DT
Polymer cost	$1.60/lb
DAFT rehabilitation cost	$50,000
New DAFT cost	$500,000
New centrifuge cost	$625,000

* OMRR = operations, maintenance, rehabilitation, and repair.

Table 4 presents a brief summary of results of the analysis. A more detailed presentation and discussion of the results is given in Appendix A. Although the combined use of DAFTs and centrifuges results in slightly higher annual operation and maintenance (O&M) costs, the number of centrifuges needed under the "no DAFT" scenario to process projected unthickened sludge is significantly higher, resulting in higher capital cost. The net present worth (NPW) analysis shows that the combined use of DAFTs and centrifuges will result in lower lifetime costs to the county.

TABLE 4
Thickening and Dewatering Evaluation Results

9 MGD	DAFT and Centrifuge	Centrifuge Only
Facilities		
Number of DAFTs	1 existing + 1 new	zero + zero
Number of Centrifuges	3 existing + 2 new	3 existing + 5 new
Costs		
Capital	$1.800 million	$3.125 million
O&M	$358,630	$348.20
Total NPW Cost	$8.403 million	$8.900 million

Based on this analysis it is recommended that the County proceed with the addition of DAF thickening capacity on a 24-hour-per-day, 7-day-per-week basis. This recommendation could be implemented by building a new DAFT unit and refurbishing the existing unit,

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

which has been out of service for over 10 years, then adding new centrifuges in 2016 and 2024.

For completion of the biosolids management alternatives evaluation, it is assumed that this recommendation is acceptable to the County. All biosolids management alternatives will assume that the DAF process is to be used for thickening of WAS, with additional DAFT and centrifuge capacity to be provided as needed. This would allow the dewatering of the thickened waste activated sludge (TWAS) and cake haul-out to be done on a single-shift basis. Buffer storage capacity for liquid sludge would also be required to support the one-shift dewatering operation.

Biosolids Management Alternatives

In addition to accommodating increased WAS production and improving odor control, the County needs to determine whether to add a solids stabilization process to the existing process train. A solids stabilization process will reduce the volatile solids content of TWAS, resulting in fewer solids to be conditioned, dewatered, hauled to the composting operation, and composted. Solids stabilization was investigated using aerobic digestion and anaerobic digestion, the former energy-intensive and the latter with biogas recovery assuming a combined heat and power (CHP) system.

Also, the Maui EKO composting facility has had extensive prior experience in the composting of cakes from both unstabilized solids and aerobically digested solids, but no prior experience with composting of anaerobically digested sludge. Accordingly, an anaerobically digested cake would require an adjustment in the blend formula for composting now used by Maui EKO.

The benchmarks for evaluation were as follows:

- All WAS is to be thickened using DAFT and dewatered by centrifuge.
- All dewatered solids production, whether unstabilized as at present or digested aerobically or anaerobically, is to be hauled to the Maui-EKO composting facility through the year 2030.
- DAF thickening in lieu of additional dewatering capacity is to be on-line in 2008 to avoid a two-shift dewatering operation. Other facilities will also be needed to support the solids processing operations in each alternative.

The three long-term alternatives evaluated in consideration of these benchmarks were:

- **Alternative 1.** Continue the status quo—add more thickening, buffer storage, dewatering centrifuges, dewatering cake storage and outloading capacity to maintain a one-shift solids dewatering operation. Haul to Maui EKO for composting.
- **Alternative 2.** Add aerobic digestion to Alternative 1.
- **Alternative 3.** Add anaerobic digestion with CHP to Alternative 1.

The processes included in the alternatives are described in more detail in Table 5 and illustrated in Figures 1 to 3.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 5
Description of Biosolids Management Alternatives

Alternative No.	Suggested Name	Key Features	Process Train
1	Status Quo—Thickening, Dewatering, and Contract Composting	Retains current processing and outlet for cake	Expand thickening, centrifuge dewatering and outloading (first expansion in 2007); add odor control where needed
2	Thickening, Aerobic Digestion, Dewatering, and Contract Composting	Adds an energy-intensive process (aerobic digestion); retains current outlet	Adds aerobic digestion to Alt. 1
3	Thickening, Anaerobic Digestion, Dewatering, and Contract Composting	Substitutes an energy-yielding process (anaerobic digestion) for aerobic digestion and recycles reduced nitrogen; retains current outlet	Adds anaerobic digestion to Alt. 1

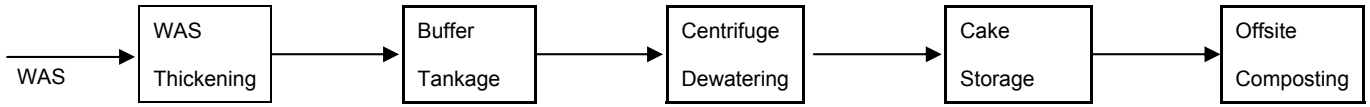
Notes:

1. Interim projects common to all alternatives (2007): additional WAS thickening capacity by DAFT; buffer storage tanks for liquid sludge to support a dewatering operation on an 8-hour-per-day, 7-day-per-week schedule; additional dewatering capacity by centrifuge; a cake silo to support the removal of cake on an 8-hour-per-day, 7-day-per-week schedule; and an enclosed solids processing and truck loading building with odorous air collection and treatment.
2. Anaerobic digestion complex to include: heating and mixing systems; and gas collection, treatment, and storage systems
3 All alternatives assume the continued operation of the Maui EKO plant through study period

Solids processing models were used to develop the comparison of input and output quantities in each process train for year 2030, which are given in Tables 6 and 7. The quantities were calculated for an average daily TWAS production rate of 5.7 DTPD at 9 mgd, and 8.5 DTPD at 12 mgd. In comparison of the three alternatives, at the build-out capacity of 9 mgd, the average day cake production without stabilization (Alternative 1) is 21.2 wet tons per day (WTPD) versus 16.5 WTPD after aerobic digestion and 12.6 WTPD after anaerobic digestion. The cake production rates are based upon assumed cake DS content of 25 percent for unstabilized sludge and 22 percent DS for the aerobically or anaerobically digested biosolids. The biogas production from anaerobic digestion will amount to about 85,800 standard cubic feet per day (SCFD) on an average day basis.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

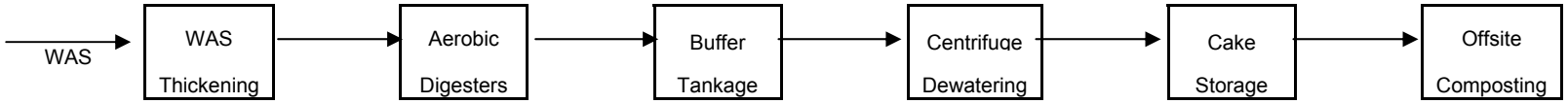
FIGURE 1
Alternative #1 Thickening, Dewatering, and Contract Composting



Note:

1. It is assumed that additional thickening and dewatering capacity will be added to avoid second shift dewatering (2007).

FIGURE 2
Alternative #2 Thickening, Aerobic Digestion, Dewatering and Contract Composting

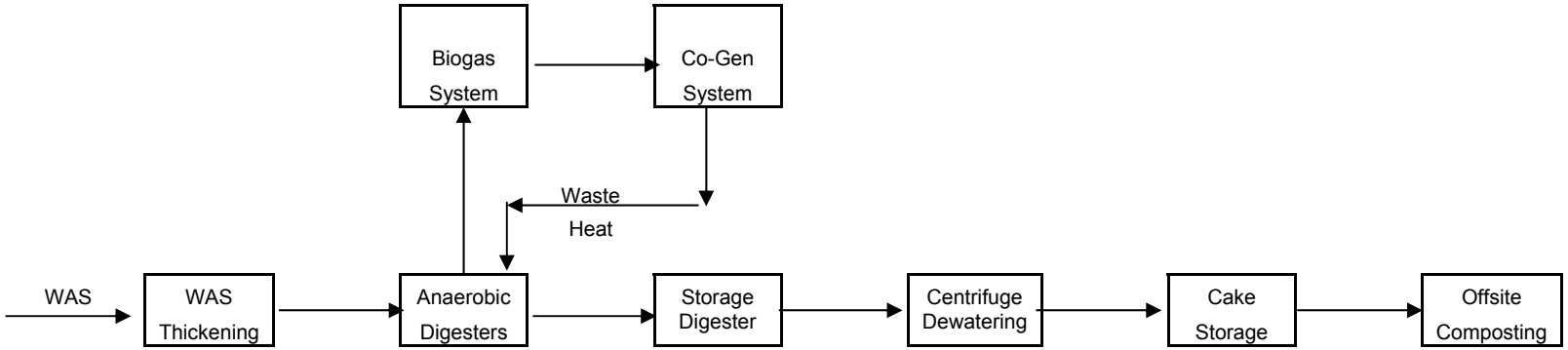


Note:

1. It is assumed that additional thickening and dewatering capacity will be added to avoid second shift dewatering (2007)

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

FIGURE 3
Alternative #3 Thickening, Anaerobic Digestion, Dewatering, and Contract Composting



Notes:

1. It is assumed that additional thickening and dewatering capacity will be added to avoid second shift dewatering (2007).
2. Biogas System—assume installation consists of minimal gas treatment, fueling of a combined heat and power unit, waste heat recovery from exhaust system, hot water boilers and flares.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 6
Comparison Of Input and Output Quantities—9 Mgd

	TWAS (DAF)			After Aerobic Digestion			After Anaerobic Digestion		
Parameter	**Average Day**	**Maximum Month**	**Maximum Week**	**Maximum Day**	**Maximum Month**	**Maximum Week**	**Average Day**	**Maximum Month**	**Maximum Week**
Liquid									
VSD, %	na	na	na	40	40	40	60	60	60
VF	0.8	0.8	0.8	0.71	0.71	0.71	0.62	0.62	0.62
Ratio to raw feed	0.98	0.98	0.98	0.67	0.67	0.67	0.51	0.51	0.51
DTPD	5.59	7.94	9.31	3.82	5.43	6.37	2.91	4.13	4.85
TS, %	4	4	4	2.67	2.67	2.67	2.4	2.4	2.4
WTPD	140	199	233	143	203	239	121	172	202
GPD	33,600	47,800	55,900	34,300	48,800	57,300	29,000	41,300	48,500
GPM	23.3	33.1	38.8	23.8	33.9	39.8	20.1	28.7	33.7
DTPD Destroyed-VS	na	na	na	1.79	2.54	2.98	2.68	3.81	4.47
Biogas (SCFD)	na	na	na	Na	na	na	85,800	122,000	143,000
Cake After Dewatering									
DTPD	5.3	7.53	10.6	3.62	5.16	6.05	2.76	3.92	4.61
Ratio to raw feed	0.93	0.93	0.93	0.64	0.64	0.64	0.48	0.48	0.48
TS, %	25	25	25	22	22	22	22	22	22
WTPD	21.2	30.1	42.4	16.5	23.5	27.5	12.6	17.8	20.9

Assumed cake DS:

TWAS cake = 25%; aerobically or anaerobically digested = 22%

Code:

VSD = volatile solids destruction efficiency, %
VF = volatile fraction, ratio

Assumptions:

Total solids production as WAS
Volatile fraction of blended sludge = 80%
Total solids content of TWAS = 4%
98% recovery of solids through DAF thickening
95% recovery of solids through dewatering centrifuges
Digester gas production = 16 SCFD/lb VSD

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 7
Comparison Of Input and Output Quantities—12 Mgd

Parameter	TWAS (DAF)			After Aerobic Digestion			After Anaerobic Digestion		
	Average Day	Maximum Month	Maximum Week	Average Day	Maximum Month	Maximum Week	Average Day	Maximum Month	Maximum Week
Liquid									
VSD, %	na	na	na	40	40	40	60	60	60
VF	0.8	0.8	0.8	0.71	0.71	0.71	0.62	0.62	0.62
Ratio to raw feed	0.98	0.98	0.98	0.67	0.67	0.67	0.51	0.51	0.51
DTPD	8.33	11.86	13.9	5.7	8.11	9.51	4.34	6.17	7.24
TS, %	4	4	4	2.67	2.67	2.67	2.4	2.4	2.4
WTPD	209	296	348	213	304	356	181	257	302
GPD	50,000	71,100	83,400	51,200	72,900	85,500	43,400	61,700	72,400
GPM	34.7	49.4	57.9	35.5	50.6	59.4	30.1	42.9	50.3
DTPD Destroyed-VS	na	na	na	2.72	3.87	4.54	4.08	5.81	6.82
Biogas (SCFD)	na	na	na	na	na	na	131,000	186,000	218,000
Cake After Dewatering									
DTPD	7.91	11.3	13.2	5.44	7.74	9.09	4.08	5.81	6.82
Ratio to raw feed	0.93	0.93	0.93	0.64	0.64	0.64	0.48	0.48	0.48
TS, %	25	25	25	22	22	22	22	22	22
WTPD	31.6	45	52.8	24.7	35.2	41.3	18.5	26.4	31

Assumed cake DS:

TWAS cake = 25%; aerobically or anaerobically digested = 22%

Code:

VSD = volatile solids destruction efficiency, %
VF = volatile fraction, ratio

Assumptions:

Total solids production as WAS
Volatile fraction of blended sludge = 80%
Total solids content of TWAS = 4%
98% recovery of solids through DAF thickening
95% recovery of solids through dewatering centrifuges
Digester gas production = 16 SCFD/lb VSD
Anaerobic digestion by two-phase (acid-gas)

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Tables 8 through 10 are listings of the facilities required for implementation of each alternative. The listings are specific to alternative and the build-out capacity as indicated.

TABLE 8
Alternative #1 System Requirements

	DAFT	Buffer Tankage	Centrifuges	Cake Silo
9 MGD Requirements				
Existing				
Number of Units	1	0	3	0
Capacity	450 lb DS/hr		700 lbs DS/hr	
New				
Number of Units	1	1	2	1
Capacity	450 lb DS/hr	50,000 gallons	35 gpm	75 cubic yards
12 MGD Requirements				
Existing				
Number of Units	1	0	3	0
Capacity	450 lb DS/hr		700 lbs DS/hr	
New				
Number of Units	2	1	3	1
Capacity	450 lb DS/hr	50,000 gallons	35 gpm	75 cubic yards

TABLE 9
Alternative #2 System Requirements

	DAFT	Aerobic Digesters	Buffer Tankage	Centrifuges	Cake Silo
9 MGD Requirements					
Existing					
Number of Units	1	0	0	3	0
Capacity	450 lb DS/hr			700 lbs DS/hr	
New					
Number of Units	1	2	1	2	1
Capacity	450 lb DS/hr	250,000 gallons	50,000 gallons	35 gpm	75 cubic yards
12 MGD Requirements					
Existing					
Number of Units	1	0	0	3	0
Capacity	450 lb DS/hr			700 lbs DS/hr	
New					
Number of Units	2	3	1	3	1
Capacity	450 lb DS/hr	250,000 gallons	50,000 gallons	35- gpm	75 cubic yards

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 10
Alternative #3 System Requirements

	DAFT	Anaerobic Digesters	Buffer Tankage	Centrifuges	Cake Silo
9 MGD Requirements					
Existing					
Number of Units	1	0	0	3	0
Capacity	450 lb DS/hr			700 lbs DS/hr	
New					
Number of Units	1	2	1	2	1
Capacity	450 lb DS/hr	60,000 gallons	50,000 gallons	35 gpm	75 cubic yards
12 MGD Requirements					
Existing					
Number of Units	1	0	0	3	0
Capacity	450 lb DS/hr			700 lbs DS/hr	
New					
Number of Units	2	2	1	3	1
Capacity	450 lb DS/hr	320,000 gallons	50,000 gallons	35 gpm	75 cubic yards

The three solids processing alternatives, noted above, are under consideration and are being evaluated in concert with the liquid treatment alternatives as described in the Schematic Design Report. The result of this evaluation indicated that either digestion alternative can be accommodated on the site, with no adverse impact upon the liquid treatment train.

Selection of the aerobic digestion alternative would result in a significant increase in electrical energy consumption. The increased energy would be required for aeration and mixing of the digesting sludge over an estimated 30-day hydraulic retention time (HRT). Because the Wastewater Division has aerobic digestion facilities at its other two wastewater treatment facilities, it has personnel who are familiar with the requirements of this energy-dependent stabilization process. This was assumed to place an operational preference in the Wastewater Division toward this alternative over anaerobic digestion.

The anaerobic digestion alternative would result in the production of a biogas stream and an additional reduction in the volume and mass of biosolids to be dewatered, hauled, and composted, relative to the aerobic digestion alternative. It is assumed that the biogas from anaerobic digestion will be used to fuel a CHP system capable of generating electricity, with the waste heat used to heat the anaerobic digestion system. For study purposes a two-phase anaerobic digestion system has been considered because it can complete the digestion process in a 12- to 15-day HRT and with greater volatile solids destruction (VSD) efficiency than is possible with a conventional high rate anaerobic digestion system. However, a side effect of any of the anaerobic digestion processes is a greater level of ammonia nitrogen in the centrate (reject water). The reject water is produced upon dewatering of the digested solids. This will add to the cost of liquid treatment and possibly necessitate a larger centrate equalization (EQ) tank.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Note that the anaerobic digestion process has not been incorporated previously at any of the County's wastewater treatment facilities, and therefore would represent a new process system differing from those in place at present. It is not likely that the County would select this alternative based on prior experience, but the results are included because they are useful for comparison purposes.

Procedure for Evaluation of Biosolids Management Alternatives

This section contains the procedures used to develop the alternatives for a BMP for the Lahaina WWRF. The initial biosolids management alternatives were developed using the results of the telecom of January 18, 2006, as noted above. After evaluation of the liquid treatment alternatives, it was found that all three solids processing alternatives could be accommodated on the existing site, and therefore all were evaluated.

Considerable work is required to fully develop and evaluate the alternatives. This effort would usually take the form of several face-to-face meetings and workshops with departmental staff and other stakeholders in the biosolids management process. However, in the present project the subjective preferences of County staff were identified from conference calls and follow-up calls. These contacts resulted in the recommendation by CH2M HILL of the evaluation criteria, weightings for each criterion, and scales for performance of each alternative, as discussed subsequently.

The solids production rates for the analysis and the basis for the facilities required for each alternative are presented in Table 2. The assumed operating schedule for the solids processing operation is of particular importance. This assumption was that the upstream solids processing operations (thickening, and digestion if applicable) are 24-hour-per-day, 7-day-per-week operations, and the dewatering and cake haul operations are on an 8-hour-per-day, 7-day-per-week basis.

Order of magnitude costs were developed for comparative purposes between the alternatives. The cost estimates presented in this study are "order of magnitude" estimates, defined by the American National Standards Institute (ANSI) and the American Association of Cost Engineers (AACE) as "approximate estimates made without detailed engineering data. It is normally expected that estimates of this type will be accurate within plus 50 percent or minus 30 percent." This range implies that there is a high probability that the final project cost will fall within the range.

The capital cost estimates presented in Table 11 can be used to characterize the relative cost differences among the alternatives for each build-out capacity, but not the absolute cost of the solids upgrade and expansion program. This is because no estimates were made for the common elements of the project that are assumed to have the same capital cost for all the alternatives. The relative capital costs at the 9-mgd build-out capacity vary from $2.50 million for Alternative 1 to $8.50 million for Alternative 2 (aerobic digestion) and $14.85 million for Alternative 3 (anaerobic digestion with CHP). Similarly the relative capital costs at the 12-mgd build-out capacity vary from $3.63 million for Alternative 1 to $12.63 million for Alternative 2 (aerobic digestion) and $22.10 million for Alternative 3 (anaerobic digestion with CHP).

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 11
Order of Magnitude Costs Estimates for each Alternative

	Alternative 1	Alternative 2	Alternative 3
Estimate for 9 MGD			
DAFT	0.55	0.55	0.55
Aerobic Digestion		6.00	
Anaerobic Digestion			12.31
Buffer Tank	0.20	0.20	0.20
Centrifuge	1.25	1.25	1.25
Silo	0.50	0.50	0.50
Total	2.50	8.50	14.85
Estimate for 12 MGD			
DAFT	1.05	1.05	1.05
Aerobic Digestion		9.00	
Anaerobic Digestion			18.47
Buffer Tank	0.20	0.20	0.20
Centrifuge	1.880	1.88	1.88
Silo	0.50	0.50	0.50
Total	3.63	12.63	22.10

Table 12 contains the unit cost parameters for the unit processes and operations in each of the alternatives. These cost factors are used to develop annual O&M cost estimates by alternatives as discussed later. The O&M cost estimates are again relative rather than absolute, because the cost differential is more important at this stage of the evaluation.

The unit costs for aerobic digestion include a component based upon the mechanical equipment (primarily blowers and pumps) required and a separate component based upon electricity. The cost of electricity is based upon a minimum aeration rate in the digesters, as measured by the energy input (20 watts/m^3), and an assumed all-in electricity cost of $0.25/kWh. The total unit O&M cost for aerobic digestion is $305/DT.

The unit cost of anaerobic digestion also has two components, one based upon mechanical equipment excepting the biogas elements and the second based upon the biogas system. The total unit cost of anaerobic digestion with biogas energy recovery is $150/DT (118+32), as compared with $305/DT for aerobic digestion.

The energy value of digester gas was developed for a CHP system sized on the basis of the annual average daily biogas production of 85,800 SCFD at the 9-mgd capacity (Table 6), and 131,000 SCFD at the 12-mgd capacity (Table 7). This gas flow can support electricity production while providing waste heat for digester heating. It is assumed that the electricity would be used to offset the electricity consumption at Lahaina WWRF, and that it would have a value of $0.25/kWh. On this basis the unit credit for energy production from biogas is estimated at $50/DT.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 12
Unit Cost Parameters for Unit Operations and Processes

Unit Operation or Process	Average Loading, DTPD	Unit O&M Cost, $ per DT or WT	Rationale
Common Projects		$0	O&M cost of DAF thickening, buffer tankage and cake storage are assumed to be equal for all alternatives
Aerobic Digestion	5 to 15	$305/DT	Unit cost excluding electricity taken as 10% per year of capital investment, of 4 tanks @ 250,000 gallons each, @ $12 gallon, for a capital cost of $12,000,000. Units O&M cost = (0.10)(12,000,000)/(13.1)(365) = $251/DT. Cost of electricity taken @ 20 watts/m^3, or 75 watts/1,000 gal, at 30-day HRT, and $0.25/kWh, = $54.00/DT, or: Total unit O&M cost of aerobic digestion = $251+54= $305/DT
Anaerobic Digestion	5 to 15	$118/DT	Unit cost is based upon 3% of capital investment during time horizon, or (0.03)(18,855,000)/(13.1)(365) = $118/DT
Biogas System	5 to 15	$32/DT	Unit cost is based upon 10% of capital investment during time horizon, or (0.10)(1,508,400)/(13.1)(365) = $32/DT
Energy Value of Digester Gas		$50/DT	Assumes a CHP unit yielding electricity for the WRF & waste heat for digester heating. Net electricity yield is 0.11 megawatt. At $0.25/kWh, 0.11 MW is worth $242,000/year or $51/DT digested anaerobically
Dewatering Cost Haul to Maui EKO Composting,		$100/DT $120 or 136/DT	Centrifuge dewatering, including polymer conditioning, energy, etc. Assumes 25-mile haul cake at $30/WT, or $120/DT (unstabilized @ 25% DS), or $136/DT @ 22% DS (digested)
Composting fee		$140 or 159/DT	Assumes $35/wet ton, or $140/DT of cake (unstabilized @ 25% DS), and $159/DT (digested @ 22% DS)

Note: Unit cost parameters are applicable to quantities into the process, not to the loadings of WAS

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

As noted earlier the dewatering, haul, and composting costs are all dependent upon the throughput quantities. From experience, the centrifuge dewatering of unstabilized sludge will yield a cake of 25 percent as compared with 22 percent for digested biosolids, whether aerobic or anaerobic. For this reason the unit cost of hauling (taken as $30/WT) is equivalent to $120/DT of unstabilized sludge and $136/DT of digested biosolids. Similarly, the tipping fee at the composting facility (taken as $35/WT) is equivalent to $140/DT of unstabilized sludge and $159/DT of digested biosolids.

The annual O&M costs by alternative for year 2030 are presented in Tables 13 and 14, using the unit cost factors of Table 12 and the quantities of Table 6. The relative annual O&M costs at the 9-mgd capacity (Table 13) vary from $707,000 for Alternative 1 to $1,105,000 for Alternative 2 (aerobic digestion) and $553,000 for Alternative 3 (anaerobic digestion with CHP). The energy credit association with Alternative 3 is worth an estimated $280/day or $102,000/year, reducing the annual cost by about 16 percent. The remainder of the $552,000/year O&M cost difference between anaerobic and aerobic digestion at the 9-mgd capacity is associated with the lesser quantities of digested biosolids to be dewatered, hauled out, and composted. A similar pattern of relative annual O&M cost differences exists for the alternatives at the 12-mgd build-out capacity (Table 14).

TABLE 13
Relative O&M Costs by Alternative Solids Processing and Biosolids Management—9 mgd Basis

	Alt. 1 Status Quo ($/day)	Alt. 2 Aerobic Digestion ($/day)	Alt. 3 Anaerobic Digestion ($/day)
Parameter			
Aerobic digestion	na	1,705	na
Anaerobic digestion	na	na	839
Dewatering	559	382	240
Haul	636	434	331
Composting	742	507	386
Energy Credit	na	na	-280
Total OM ($/day)	1,937	3,028	1,516
Total OM ($/year)	707,000	1,105,000	553,000

Notes:

Assumed cake DS: TWAS cake = 25%; aerobically or anaerobically digested = 22%

OM costs for DAFT thickening, buffer tankage and cake storage are assumed equal for all alternatives and therefore not included

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 14
Relative O&M Costs by Alternative Solids Processing and Biosolids Management—12 mgd Basis

	Alt. 1 Status Quo ($/day)	Alt. 2 Aerobic Digestion ($/day)	Alt. 3 Anaerobic Digestion ($/day)
Parameter			
Aerobic digestion	na	2,541	na
Anaerobic digestion	na	na	1,250
Dewatering	833	570	434
Haul	949	653	490
Composting	742	507	386
Energy Credit	na	na	-417
Total OM ($/day)	2,524	4,271	2,143
Total OM ($/year)	921,000	1,560,000	782,000

Notes:

Assumed cake DS: TWAS cake = 25%; aerobically or anaerobically digested = 22%

OM costs for DAFT thickening, buffer tankage and cake storage are assumed equal for all alternatives and therefore not included

In order to evaluate the alternatives it is necessary to establish the relative annual O&M cost by year, alternative and build-out capacity for the 24-year period from 1907 to 2030. This is established in Tables 15 and 16, in which the annual O&M cost is pro rated on the basis of the AA solids production rate, assuming a linear increase from beginning to end.

TABLE 15
Lahaina WWRF BMP—Relative OM Cost by Year and Alternative 9 mgd Basis

Year	Ratio	Alt. 1 ($/year)	Alt. 2($/year)	Alt. 3 ($/year)	AA Rate (DTPD)
2006	0.56	$393,191	$614,535	$307,546	3.17
2007	0.58	$406,835	$635,860	$318,218	3.28
2008	0.59	$419,239	$655,246	$327,919	3.38
2009	0.61	$432,882	$676,570	$338,591	3.49
2010	0.63	$445,286	$695,956	$348,293	3.59
2011	0.63	$447,767	$699,833	$350,233	3.61
2012	0.65	$461,411	$721,158	$360,905	3.72
2013	0.67	$475,054	$742,482	$371,577	3.83
2014	0.69	$488,698	$763,807	$382,249	3.94
2015	0.71	$502,342	$785,132	$392,921	4.05
2016	0.73	$515,986	$806,456	$403,593	4.16
2017	0.75	$528,389	$825,842	$413,295	4.26
2018	0.76	$540,793	$845,228	$422,996	4.36
2019	0.78	$553,196	$864,614	$432,698	4.46
2020	0.80	$566,840	$885,939	$443,370	4.57
2021	0.82	$579,244	$905,325	$453,072	4.67

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 15
Lahaina WWRF BMP—Relative OM Cost by Year and Alternative 9 mgd Basis

2022	0.84	$592,888	$926,649	$463,744	4.78
2023	0.86	$606,532	$947,974	$474,416	4.89
2024	0.88	$620,175	$969,298	$485,088	5
2025	0.89	$632,579	$988,684	$494,789	5.1
2026	0.92	$647,463	$1,011,947	$506,432	5.22
2027	0.94	$662,347	$1,035,211	$518,074	5.34
2028	0.96	$677,232	$1,058,474	$529,716	5.46
2029	0.98	$692,116	$1,081,737	$541,358	5.58
2030	1.00	$707,000	$1,105,000	$553,000	5.7

TABLE 16
Lahaina WWRF BMP—OM Cost by Year and Alternative 12 mgd Basis

Year	Ratio	Alt. 1 ($/year)	Alt. 2 ($/year)	Alt. 3 ($/year)	AA Rate (DTPD)
2006	0.37	$343,479	$589,247	$291,640	3.17
2007	0.40	$367,316	$630,141	$311,880	3.39
2008	0.42	$391,154	$671,035	$332,120	3.61
2009	0.45	$416,075	$713,788	$353,280	3.84
2010	0.48	$439,913	$754,682	$373,520	4.06
2011	0.50	$463,751	$795,576	$393,760	4.28
2012	0.53	$487,588	$836,471	$414,000	4.5
2013	0.56	$511,426	$877,365	$434,240	4.72
2014	0.57	$525,512	$901,529	$446,200	4.85
2015	0.61	$560,185	$961,012	$475,640	5.17
2016	0.63	$584,022	$1,001,906	$495,880	5.39
2017	0.66	$607,860	$1,042,800	$516,120	5.61
2018	0.69	$631,698	$1,083,694	$536,360	5.83
2019	0.71	$656,619	$1,126,447	$557,520	6.06
2020	0.74	$680,456	$1,167,341	$577,760	6.28
2021	0.76	$704,294	$1,208,235	$598,000	6.5
2022	0.79	$728,132	$1,249,129	$618,240	6.72
2023	0.82	$751,969	$1,290,024	$638,480	6.94
2024	0.84	$776,891	$1,332,776	$659,640	7.17
2025	0.87	$800,728	$1,373,671	$679,880	7.39
2026	0.90	$824,566	$1,414,565	$700,120	7.61
2027	0.92	$848,404	$1,455,459	$720,360	7.83
2028	0.95	$872,241	$1,496,353	$740,600	8.05
2029	0.97	$897,162	$1,539,106	$761,760	8.28
2030	1.00	$921,000	$1,580,000	$782,000	8.5

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Evaluation of Alternatives

The evaluation procedure was done using the decision prioritization model in the BMP Tool Kit developed by CH2M HILL. The model uses the information contained in Tables 11 to 16, as well as the decision criteria presented in Table 17, to calculate (1) the cost on a net present worth basis, and (2) the benefits associated with each alternative. The time period of the evaluation was 24 years (from 2007 to 2030) and the assumed interest rate was 5.5 percent.

The decision criteria listed in Table 17 include entries for performance measures of interest to the engineering and operating staff of the County as well as to the public at large. The weightings were selected subjectively and place extra weight in the benefit scoring for odor protection and control, worker health and safety, and public health and safety.

The performance of each alternative relative to each criterion was ranked as shown in Table 17. The rankings represent CH2M HILL's interpretation of the intent of the engineering and operating staff of the County. The criteria assignments are easily adjusted for re-run of the cost-benefit analysis as presented later, should this be desired by the Wastewater Division.

The lowest performance rankings were assigned to Alternative 1 (Status Quo) in reference to stabilization of solids, mass and volume reduction, public health and safety. Contrariwise the highest scores were assigned to Alternative 1 in terms of experience in handling unstabilized cake solids at the composting facility, worker health and safety, project phasing, operations and maintenance simplicity, stakeholder acceptance and sidestream treatment. As noted below, Alternative 1 out-performed the other alternatives in terms of benefit ranking.

The results of the decision prioritization modeling are presented in three charts:

Figure 4 illustrates the total benefit values (cumulative criteria scores) for each alternative on a relative scale. The results clearly assign the highest cumulative criteria score to Alternative 1 (Status Quo), and the least to Alternative 2 (adding aerobic digestion). There is not much difference in the cumulative criteria scores for Alternative 2 and Alternative 3 (adding anaerobic digestion), but the difference does favor Alternative 3 (anaerobic digestion). This distinction would become important if at a future date the operation of the Maui-EKO facility were to cease, mandating a stabilization process for all of the County's wastewater reclamation facilities and a re-visit to the biosolids master planning process.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

TABLE 17
Decision Matrix Score Sheet

Criterion **Note:** Each alternative is ranked by criterion on a scale of 1 (least desirable) to 10 (most desirable)	**Weight**	**Alt. # 1 Status Quo-Dewatering - 100% to Composting**	**Alt. # 2 Aerobic Digestion & Dewatering-100% to Composting**	**Alt. # 3 Anaerobic Digestion & Dewatering-100% to Composting**	**Rationale for Ranking**
1. Stabilization of solids	25	1	7	10	Alts #2 & #3 eliminate removal of unstabilized solids from WWRF site
2. Mass & Volume Reduction	25	1	7	10	Greatest reduction is with Alt #3 and least with Alt #1
3. Energy requirements	50	6	1	10	Greatest reduction is with Alt #3 and least with Alt #2
4. Composting experience	75	10	6	1	No experience with composting of anaerobically digested sludge
5. Odor Protection & Control	100	6	6	10	Less odor control effort required with more stabilized biosolids
6. Facility Permitting	50	10	3	1	Less permitting effort with simpler systems
7. Worker Health	100	6	6	6	Less health risk with less complex & with closed systems
8. Worker Safety	100	10	1	5	Greater risk with more complex systems (Alts #2 & 3)
9. Project Phasing	50	10	3	1	Phasing easiest with least complex system
10. Operations Complexity (Low complexity=higher rank)	75	10	5	1	Greater operations effort with more complex systems of Alt #2 & 3
11. Maintenance Complexity (Low complexity=higher rank)	75	10	3	1	Greater maintenance effort with more complex systems of Alt #2 & 3
12. Contracting Complexity	75	10	3	1	Contracting complexity increases with greater processing complexity
13. Public Health & Safety	100	1	7	10	Less risk to public health with greater stabilization of solids
14. Stakeholder Acceptance	50	10	4	1	Greatest acceptance with least complex system
15. Sidestream Treatment	25	10	4	1	Greater treatment effort required with Alt # 3 than others

Notes:

Rankings developed from discussion during telecom of March 10, 2006

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

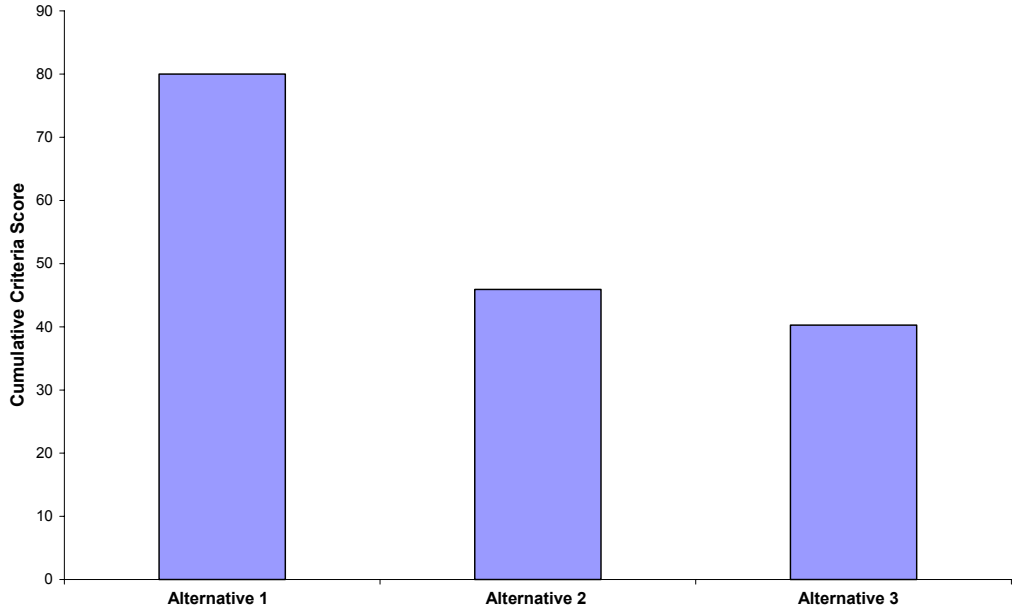


FIGURE 4
Alternatives Comparison of Cumulative Criteria

Figure 5 shows the sum of the capital and annual O&M costs on a net present worth (NPW) basis. The NPW costs are presented in terms of $1,000,000 units. At the 9-mgd capacity, the NPW cost for Alternative 1 (Status Quo) is $8,894,000 as compared $19,110,000 for Alternative 2 (adding aerobic digestion) and $19,390,000 for Alternative 3 (adding anaerobic digestion). The results illustrate clearly the benefit to the County of its access to the Maui-EKO facility and of its long track record in hauling unstabilized cake solids from its wastewater reclamation facilities to this facility.

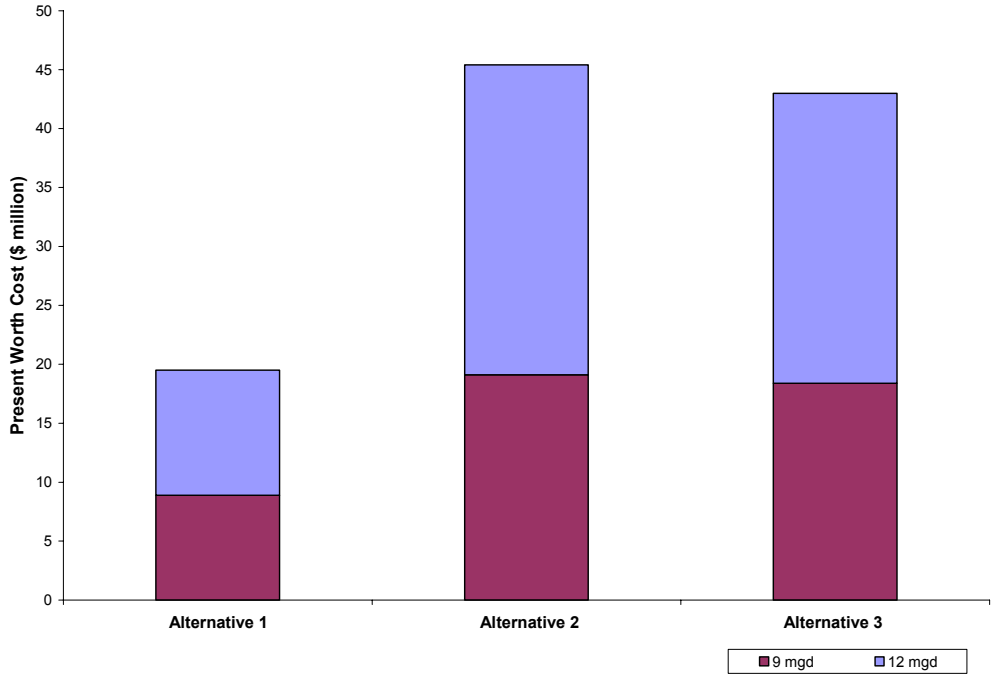


FIGURE 5
Alternatives Comparison by Present Worth Cost

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

Figure 6 shows the ***relative*** benefit-cost score by alternative. Clearly, at the 9 mgd capacity, Alternative 1 (Status Quo) is ranked the highest with a score of 7,573, versus a score of 1,743 for Alternative 2 (adding aerobic digestion) and 1,639 for Alternative 2 (adding anaerobic digestion).

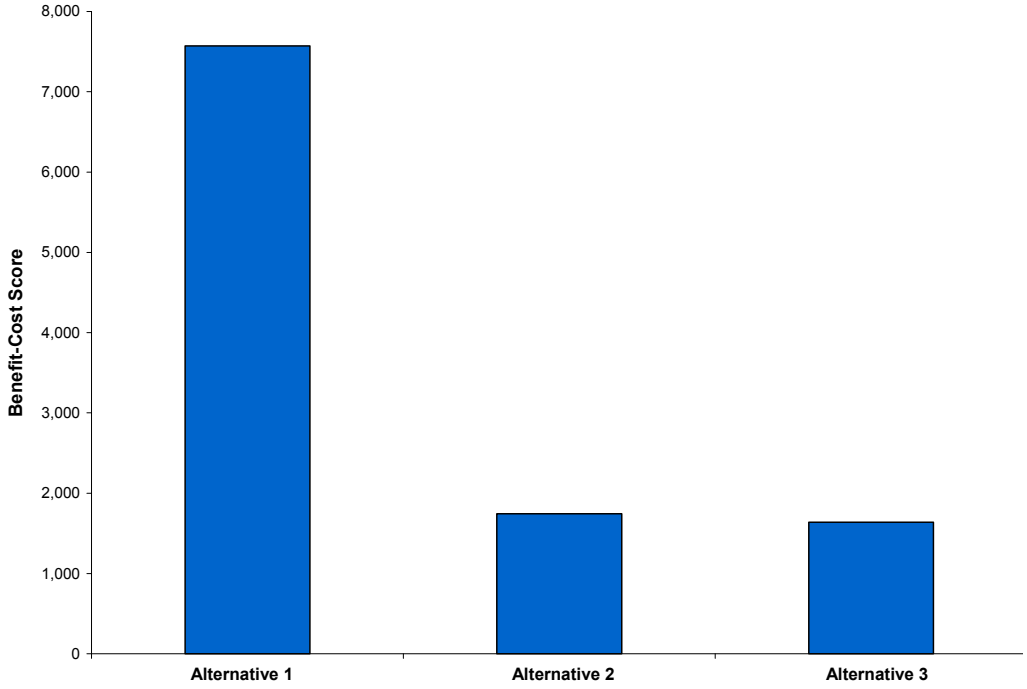


FIGURE 6
Alternatives Comparison By Benefit-Cost Score

Similar trends among the alternatives can be noted at the 12 mgd build-out capacity.

Recommendation

On the basis of this analysis it is recommended that the County proceed with Alternative 1 for solids processing and disposal. Alternative 1 is dependent upon the sustained operation of the Maui-EKO composting facility through the Year 2030. Alternative 1 will include new WAS thickening capacity by DAFT, buffer storage tanks for liquid sludge to support a dewatering operation on an 8-hour-per-day, 7-day-per-week schedule; additional centrifuge dewatering capacity; a cake silo to support the removal of cake on an 8-hour-per-day, 7-day-per-week schedule; and an enclosed solids processing and truck loading building with odorous air collection and treatment.

COPYRIGHT 2006 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

APPENDIX A

Evaluation of Dewatering With and Without DAF Thickening

The Lahaina WWRF has an existing DAF unit that has been out of service for over 10 years, and three centrifuges available for dewatering. As the flow rate into the WWRF increases it is useful to examine the tradeoffs between two sub-alternatives for the handling of WAS, namely:

1. DAF thickening of WAS followed by centrifugation of TWAS.
2. Centrifugation of WAS directly.

The economic analysis was done assuming that the present single-shift dewatering operation each day of the week would continue as the wastewater flow rate increased to 9 mgd by 2030. These boundary conditions are needed for the economic analysis, and resulted in the flow and mass balances and facility requirements for each alternative (see Table A-1). Also shown in Table A-1 is similar information for a 2030 wastewater flow rate of 12 mgd.

The results of the analysis show that, holding to a single shift of dewatering, and no thickening of WAS beforehand, five new centrifuges (total of eight) would be required for a 9-mgd operation, and eight new centrifuges (total of 11) for a 12-mgd operation. In comparison, one additional DAFT unit and two additional centrifuges would be required for a 9-mgd operation, and two additional DAFT units and three new centrifuges for a 24-hour operation. The DAFT operation is assumed to be 24 hours/day, 7 days per week, and would require the availability of a TWAS storage tank to hold the blend during the daily period of no dewatering. It is assumed that such capacity exists at the WWRF at present.

The assumptions made for the economic analysis are presented in Table A-2, and pertain to cost, performance, consumables, and labor. These factors are used to develop the unit OMRR (operation, maintenance, repair, and replacement) costs shown in Table A-3. From Table A-3 the estimated OMRR costs for the DAF plus centrifuge alternative are $358.63/DT, as compared with $348.20/DT for the centrifuge-only alternative.

The life cycle cost analysis was conducted for the case of the 9 mgd wastewater flow rate by 2030, as this is viewed as the most likely scenario. The capital costs of the facility requirements developed from the analysis of Table A-1 are summarized in Table A-4.

Table A-5 shows the OMRR annual costs for the two alternatives, 9-mgd basis, as input to the economic analysis. The OMRR costs are developed assuming a linear increase in the solids production rate from 2006 to 2030. The analysis shows that for 2030 the annual OMRR cost for the DAF + centrifuge alternative amounts to $746,000 as compared with $724,000 for the centrifuge-only alternative. Note that these costs do not represent all the costs of the operation but rather those that are different as a result of the alternatives.

A life cycle cost analysis was then performed using the economic data of Tables A-4 and A-5. The analysis extended from 2007 to 2030. The analysis shows that the DAF+centrifuge alternative has an net present worth (NPW) of $8.403 million as compared with $8.900 million for the centrifuge-only alternative.

On this basis a DAFT system is assumed in the process flow train used for the three alternatives evaluated as part of this BMP.

TABLE A-1
Solids Processing Comparison of Solids Processing With and Without DAF Thickening
Lahaina WWRF

Category	9 mgd	9 mgd	12 mgd	12 mgd
Solids production rates, DTPD as WAS @ 0.8% DS from secondary clarifier:	**DTPD**		**DTPD**	
AA (Annual Average)	5.7		8.5	
MM (Maximum Month)	8.1		12.1	
MW (Maximum Week)	9.5		14.2	
MD (Maximum Day) (estimated @ 125% of MW)	11.4		17.8	
Liquid Sludge Flow Rate, Lb/hour and GPM as WAS @ 0.8% DS:	**Lb/hour**	**GPM**	**Lb/hour**	**GPM**
AA (Annual Average)	475	119	708	176
MM (Maximum Month)	675	169	1,010	253
MW (Maximum Week)	792	198	1,180	295
MD (Maximum Day) (estimated @ 125% of MW)	950	238	1,480	370
Existing Facilities:				
DAFT—1 unit at 300 sq ft (450 Lb DS/hour capacity)				
Centrifuge—3 units @ 85 gpm each				
DAFT Modules for production of TWAS @ 4% DS:	**Modules**	**GPM**	**Modules**	**GPM**
Provide for 24/7 operation at MD (Maximum Day) loading rate with all units in service				
Add DAFT capacity in 300 sq ft (450 Lb DS/hour) - modules needed:	1		2	
Year(s) in which DAFT capacity is assumed to be added:	2008		2008 2019	
TWAS flows @ 4% DS:				
AA (Annual Average)		23.3		34.7
MM (Maximum Month)		33.1		49.4
MW (Maximum Week)		38.8		57.9
MD (Maximum Day) (estimated @ 125% of MW)		46.7		72.6
Centrifuge Dewatering of TWAS after DAFT	**GPM**	**Modules**	**GPM**	**Modules**
Each of the 3 existing unit can handle 35 gpm of TWAS @ 4% DS (assumed)				
Size dewatering for MW (Maximum Week) and for 8/7 operation, then add one spare	116	4+1	174	5+1
Number of additional centrifuges required		2		3
Year in which an additional centrifuge is assumed to be added		2008 2016		2008 2016 2024

TABLE A-1
Solids Processing Comparison of Solids Processing With and Without DAF Thickening
Lahaina WWRF

Category	9 mgd	9 mgd	12 mgd	12 mgd
Centrifuge Dewatering of WAS at 0.8% DS without DAFT				
Each of the 3 existing units can handle 85 gpm of WAS @ 0.8% DS (assumed)				
Size dewatering for MW (Maximum Week) and for 8/7 operation, then add one spare	594	7+1	885	11+1
Number of additional centrifuges required		5		8
Year in which an additional centrifuge is assumed to be added		2007 2012 2016 2020 2024		2007 2011 2014 2017 2020 2023 2025 2028

TABLE A-2
Solids Processing Assumptions for Economic Analysis for DAF Versus No-DAF Operation
Lahaina WWRF

Assumed flow rate at Year 2030—9 mgd and 12 mgd
WAS is produced at 0.8% DS (dry solids content)
DAFT capacity—450 lb DS/hour per unit of 300 square feet
DAFT operation—24/7
New DAFT capacity—$500,000 per module of 300 square feet, installed
TWAS from DAFT produced at 4% DS and 98% solids capture efficiency
DAFT polymer consumption—5 lb/DT
DAFT power consumption—25 kWh per DT
DAFT OMRR operation, maintenance, repair and replacement)—$10/DT
New centrifuge capacity—$625,000 per unit, installed
Centrifuge operation without thickening—85 gpm of feed at 0.8% DS
Centrifuge polymer consumption—32 lb/DT
Centrifuge cake—25% DS
Centrifuge cake with DAFT thickening—35 gpm of feed at 4.0% DS
Centrifuge polymer consumption—28 lb/DT
Centrifuge cake—25% DS
Centrifuge solids capture efficiency—95%
Centrifuge power consumption—100 kWh/DT
Centrifuge OMRR—$25/DT
Polymer cost—$1.60/Lb

TABLE A-3
Solids Processing OMRR Unit Cost Factors—DAF versus No-DAF Operation
Lahaina WWRF

Case	Factors	Total $/DT
DAF + Centrifuge Alternative		
DAF		
Polymer cost = 5 Lb/DT x $1.60/Lb = $8.00/DT		
Electricity cost = 25 kWh/DT x $0.25/kWh = $6.25/DT		
OMRR cost = $10.00/dt		$24.25
Centrifuge		
Polymer cost = $28.00 x $1.60/Lb = $44.20/DT		
Electricity cost = 100 kWh/DT x $0.25/kWh = $25.00/DT		
OMRR cost = $25.00/DT		
Capture efficiency = 98%		
Total cost per input DT = 0.98 x [44.20+25.00+25.00] =		**$92.32**
Haul and Compost		
Haul cost = $120/DT		
Composting cost = $140/DT		
Capture efficiency = 95%		
Total cost per input DT = 0.95 x 0.98 x [120.00+140.00] =		$242.06
Total of unit costs = $24.25 + 92.32 + 242.06 =		**$358.63**
Centrifuge-only Alternative		
Centrifuge		
Polymer cost = $32.00 x $1.60/Lb = $51.20/DT		
Electricity cost = 100 kWh/DT x $0.25/kWh = $25.00/DT		
OMRR cost = $25.00/DT		
Total cost per input DT = [51.20+25.00+25.00] =		**$101.20**
Haul and Compost		
Haul cost = $120/DT		
Composting cost = $140/DT		
Capture efficiency = 95%		
Total cost per input DT = 0.95 x [120.00+140.00] =		$247.00
Total of unit costs = $101.20 + 247.00 =		**$348.20**

TABLE A-4
Facility Requirements by Alternative—9 mgd Basis

Alternative DAF+Centrifuge	
Capital Needs by Year	
2008	One new DAF @ $500,000
2009	Refurbish existing DAF @ $50,000
2016	One new centrifuge @ $625,000
2024	One new centrifuge @ $625,000
Alternative: Centrifuge Dewatering Without Thickening	
Capital Needs by Year	
2007	New centrifuge @ $625,000
2012	New centrifuge @ $625,000
2016	New centrifuge @ $625,000
2020	New centrifuge @ $625,000
2024	New centrifuge @ $625,000

Notes:

Facility requirements from Table A-1.

TABLE A-5
Solids Processing OMRR Annual Cost—DAF versus No-DAF Operation—9 mgd Basis
LAHAINA WWRF BMP

Year	Ratio	AA Rate (DTPD)	DAF+Cent ($1,000/year)	Cent Only ($1,000/year)
2006	0.56	3.17		
2007	0.58	3.28	$429	$417
2008	0.59	3.38	$442	$430
2009	0.61	3.49	$456	$443
2010	0.63	3.59	$470	$456
2011	0.63	3.61	$479	$464
2012	0.65	3.72	$487	$473
2013	0.67	3.83	$502	$487
2014	0.69	3.94	$516	$501
2015	0.71	4.05	$531	$515
2016	0.73	4.16	$545	$529
2017	0.75	4.26	$558	$542
2018	0.76	4.36	$571	$554
2019	0.78	4.46	$585	$568
2020	0.80	4.57	$598	$581
2021	0.82	4.67	$612	$595
2022	0.84	4.78	$626	$608
2023	0.86	4.89	$641	$622
2024	0.88	5	$655	$636
2025	0.89	5.1	$669	$650
2026	0.92	5.22	$683	$663
2027	0.94	5.34	$699	$679
2028	0.96	5.46	$715	$694
2029	0.98	5.58	$730	$710
2030	1.00	5.7	$746	$724

Note: 2006 AA solids production rate is taken as ratio of present (5 mgd) flow rate to assumed 2030 (9 mgd) flow rate, or 0.555 x 5.7 DTPD, or 3.17 DTPD.