Table 3B.1: Capacity Assessment for Agat-Santa Rita STP

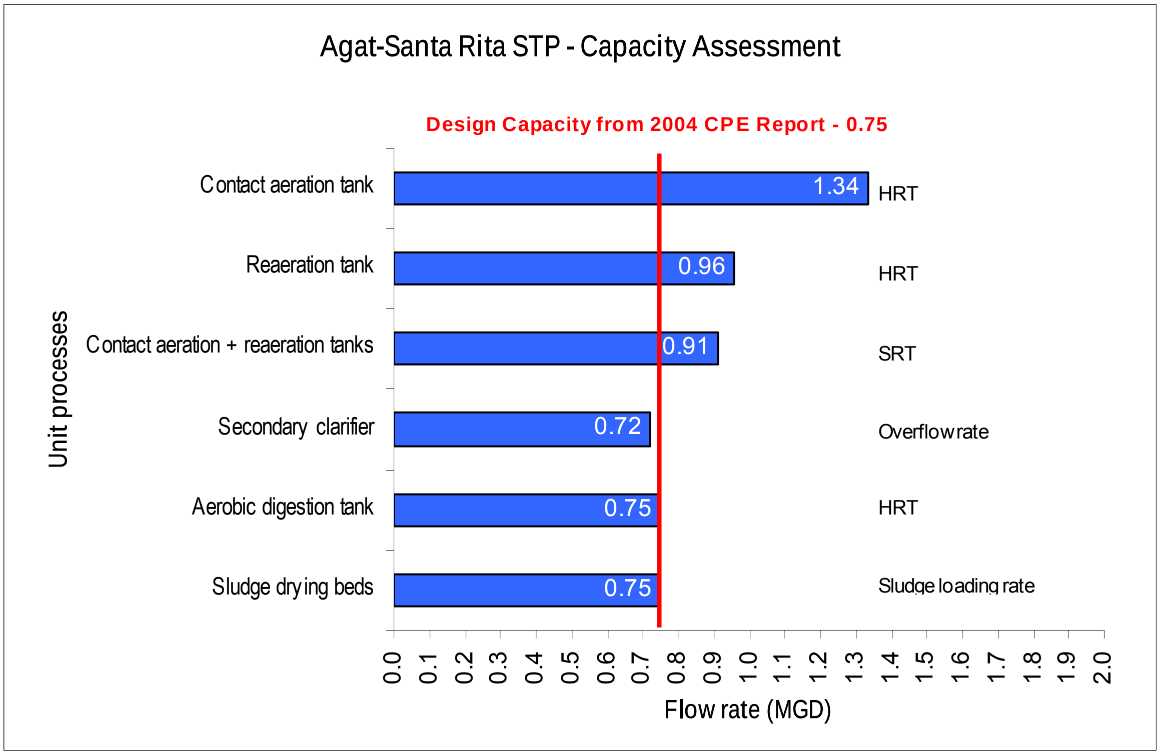
Description	Capacity assessment calculations	Compared with original design (f)	Unit
General			
Assume: System is not restricted by air requirement			
Operating depth(a)	14	N/A(h)	ft
Total volume(a) (See additional calculations for details)	65,753.5	N/A	ft³
	491,870.0	N/A	gal
Aerobic digestion zone			
Arc angle	158.7	N/A	º
Volume	28,986.3	24,600.0	ft³
	216,817.8	184,008.0	gal
Assume: Hydraulic detention time (b - page 837) (Design range = 12-18 day)	17.0	N/A	d
Available maximum incoming flow	12,754.0	N/A	gpd
Select waste sludge flow rate/influent flow rate	0.017	N/A	
Available process capacity of aerobic digester	750,234.5	N/A	gpd
Contact aeration basin			
Arc angle	36.7	N/A	º
Volume	6,703.2	14,300.0	ft³
	50,143.4	106,964.0	gal
Assume: Hydraulic detention time(b - page 550) (Design range = 0.1 - 1.0 hours)	0.9	1.7	hours
Available process capacity of contact aeration basin	1,337,157.7	755,040.0	gpd
Reaeration basin			
Arc angle	145.7	N/A	º
Volume	26,611.9	28,500.0	ft³
	199,070.7	213,180.0	gal
Assume : Hydraulic detention time(b - page 550) (Design range = 3-6 hours)	5	6.8	hours
Available process capacity of reaeration basin	955,539.4	752,400.0	gpd
Contact aeration + reaeration design (c)			
Assume: MLSS in contact aeration tank(b - page 550) (Design range = 1,000 - 3,000 mg/L)	2,500.0	N/A	mg/L
Assume: MLSS in reaeration tank(b - page 550) (Design range = 4,000-9,000 mg/L)	6,000.0	N/A	mg/L
Microorganism concentration in clarifier effluent (d)	20.0	N/A	mg/L
Clarifier flow rate/Influent flow rate	0.983	N/A	
Waste sludge rate/Influent flow rate	0.017	N/A	
Select microorganism concentration of waste sludge	11,000.0	N/A	mg/L
Assume: Solid retention time (SRT) (b - page 550) (Design range = 5-15 days)	7.0	N/A	D
Available process capacity of combined aeration and reaeration tanks	912,321.7	N/A	gpd

Description	Capacity assessment calculations	Compared with original design (f)	Unit
Check return activated sludge flow rate (b - page 550)			
Approach - Mass balance around contact aeration and reaeration tanks			
Microorganism concentration in raw water influent (d)	0.0	N/A	mg/L
Return activated sludge flow rate/influent flow rate	0.29	N/A	
Secondary Clarifier			
Arc angle	360.0	N/A	º
Diameter	40.0	N/A	ft
Operating depth	10.7	N/A	ft
Volume	13,489.1	13,250.0	ft³
Assume: Available overflow surface area (e)	1,203.0	N/A	ft²
Assume: Overflow rate (b - page 588) (Design range = 400-1,200 gpd/ft²)	600.0	565.0	gpd/ft²
Available process capacity of secondary clarifier	721,800.0	743,377.0	gpd
Sludge drying bed			
Total unit = 8			
Operating width (each unit)	22.5	N/A	ft
Operating Length (each unit)	90.0	N/A	ft
Total approximated area (g)	15,945.0	16,300.0	ft²
Approach 1: Area per person			
Assume: Required area of sludge drying beds for one person (b - page 873) (Design range = 1.75-2.50 ft²/person)	2.2	N/A	ft²/ person
Maximum number of people generating wastewater that sludge drying beds can handle	7,248	8,500	persons
Assume: Wastewater flow rate per person (b - page 27) (Design range = 60 - 100 gpd per person for better home)	80.0	N/A	gpd/ person
Available maximum flow capacity	579,818.0	N/A	gpd
Approach 2: Sludge-loading rate			
Assume: Sludge-loading rate (b - 873) (Design range = 12-20 lb dry solids/ft².yr)	14.0	N/A	lb dry solids/ ft².yr
Total approximated area (g)	15,945.0	16,300.0	ft²
Maximum sludge that can be wasted	223,230.0	N/A	lb dry solids/ yr
Maximum sludge that can be wasted	612.0	N/A	lb dry solids/ day
Find digested suspended solid concentration (b - page 838)			
From aerobic digester design, Incoming sludge to aerobic digestion	12,754.0	N/A	gpd
	1,705.0	N/A	ft³/d
Influent suspended solids from secondary clarifier to aerobic digester	11,000.0	N/A	mg/L
Reaction-rate constant (kd)	0.07	N/A	d-1

Description	Capacity assessment calculations	Compared with original design (f)	Unit
Relative fraction of digester SS	0.8		
Solid retention time (25 ºC, 40% volatile solid reduction)	20.0	N/A	day
Aerated digester tank volume	28,986.0	N/A	ft^3
So, digested suspended solid concentration	6,104.9	N/A	mg/L
<u>Find available maximum sludge flow rate to sludge drying bed</u>			
Available maximum sludge flow rate that sludge drying bed can receive	45,441.1	N/A	L/d
	12,006.0	N/A	gpd
Supernatant return flow	748.0	N/A	gpd
So, the selected conditions for aerobic digested design are corresponding to the sludge loading rate requirement for sludge drying beds			
Available process capacity of sludge drying beds	750,234.5	N/A	gpd
Design capacity is restricted by secondary clarifier which its available process capacity is	721,800	743,377	gpd

Note:

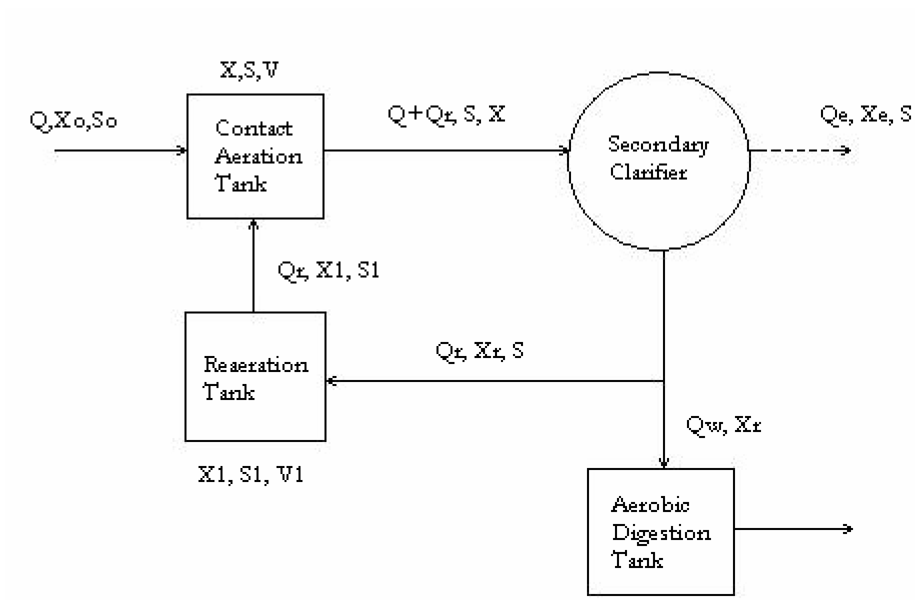
(a) - Total volume for contact aeration zone, aerobic digestion zone, and chlorination zone if operating depth is 14 ft.
The calculated dimensions are based on Sheet #48 - Agat Treatment Tank Plan
(b) - From Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse
(c) - Equation modified from Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse, Page 38
(d) - TSS from NPDES permit ≤ 30 mg/L and assume microorganism concentration is also 30 mg/L;
Select 20 mg/L (for safety of factor)
TSS of raw water influent ~ 102.2 mg/L and assume microorganism concentration is close to zero mg/L;
(e) - Available overflow surface area is approximated from ¶$(19.75^2-2.67^2)$
(f) - Hydraulic detention times of contact aeration and reaeration zones are based on 100% sludge return rate.
(g) – Areas of unit no. 1 to no. 6 are 2,025 ft^2 each. Areas of unit no. 7 and no. 8 are approximated to be 1,960 ft^2 and 1,835 ft^2 respectively.
(h) – Not available



The bar chart above compares the design capacity from the 2004 CPE report versus the calculated capacities.

Description of Assessment

Agat-Santa Rita STP is a package system providing secondary wastewater treatment. For the calculation, the simplified flow diagram is drawn below:



Note: Q = Influent flow rate (MGD)

Xo	=	Microorganism concentration in influent wastewater (mg/L)
So	=	BOD_5 concentration in influent wastewater (mg/L)
X	=	Mixed liquor suspended solid (MLSS) or microorganism concentrations in contact aeration tank (mg/L)
S	=	BOD_5 concentration in contact aeration tank (mg/L)
V	=	Volume of contact aeration tank (gal)
Qr	=	Recirculation flow rate among contact aeration tank, reaeration tank, and secondary clarifier (MGD)
X1	=	MLSS concentration in reaeration tank (mg/L)
S1	=	BOD_5 concentration in reaeration tank (mg/L)
V1	=	Volume of reaeration tank (gal)
Xr	=	MLSS concentration of sludge return from secondary clarifier to reaeration tank (mg/L)
Qw	=	Waste sludge flow rate (MGD)
Qe	=	Effluent flow rate from secondary clarifier (MGD)
Xe	=	Microorganism concentration in effluent treated wastewater (mg/L)

General approach of flow capacity assessment for Agat-Santa Rita STP can be written below:

1) Assumed information includes the dimensions of existing major unit processes and the average of the monthly average influent BOD_5 and TSS. From the GWA DMRs during the period of January 2004 to March 2005, the averages of monthly average influent BOD_5 and TSS concentrations can be summarized below:
   - BOD_5 influent concentration = 220 mg/L
   - TSS influent concentration = 102 mg/L

2) This package system has a cylinder shape which is partitioned into five compartments. See Figure 5.2 for a schematic diagram. These five compartments consist of a contact aeration tank, a reaeration tank, an aerobic digestion tank, a secondary clarifier, and a chlorination tank. In order to calculate the operating volume of each tank, the total volume of all five compartments is first calculated. By knowing the arc angle of each compartment, each compartment volume is quantified.

3) The capacity assessment determines the available process capacity of the aerobic digestion tank, contact aeration basin, reaeration basin, secondary clarifier, and sludge drying beds. The unit process that has the least available capacity was used to represent the limiting capacity of the whole plant.

4) The assessment begins by selecting an appropriate waste sludge flow rate (Q_w) to suit the size of the existing aerobic digestion tank at an acceptable hydraulic retention time (HRT).
   - Available maximum flow capacity of aerobic digestion tank (Q_w) = Volume/HRT
   - HRT design range = 12-18 Days

5) The hydraulic retention time approach is then used to find the available maximum capacity of contact aeration basin and reaeration basin. Their HRT design ranges are written below:
   - HRT design range for contact aeration basin = 0.1-1.0 Hours
   - HRT design range for reaeration basin = 3-6 Hours

6) The available process capacity based on mean cell-residence or solid retention time (SRT) is also investigated. The SRT is assumed to be the total time that microorganisms stay in the contact aeration and reaeration basins before they are discharged from these basins. The following equation is used to find available maximum flow capacity.
   - Solid retention time (SRT) = $\dfrac{VX + V_1 X_1}{Q_w X_r + Q_e X_e}$

   Design ranges of the parameters required for this approach are shown below:
   - Mixed-liquor suspended solid (MLSS) design range
     -Contact aeration tank = 1,000-3,000 mg/L
     -Reaeration tank = 4,000-9,000 mg/L
   - Typical SRT design range of these combined units = 5-15 Days

   Q_w and Q_e are taken from the calculation for the aerobic digestion system. X_r and X_e are selected based on typical operating conditions for a wastewater treatment system. V and V_1 are calculated based on the existing dimensions.

7) Next, return activated sludge flow rate (Q_r) is calculated by doing mass balance around the contact aeration and the reaeration tank, the equation can be written as follows:

$$Q_r \cdot X_r + Q \cdot X_o = (Q + Q_r) \cdot X$$

8) The last main unit process is the sludge drying beds. It is assumed that they are conventional open sludge drying beds and the type of sludge is categorized as primary and waste activated digested. Two equations below are used to calculate the available capacity:
   - Maximum numbers of people who generate wastewater (N) = (Total sludge drying bed area)/(Area of sludge drying beds for one person)
   - Available maximum capacity flow capacity (Q) = (N)x(Average wastewater generated per one person per day)

   Two parameters used for this calculation are listed below:
   - Design range of required area of sludge drying beds for one person = 1.75-2.50 ft2/person
   - Design range of wastewater flow rate per person for better home = 60-100 gpd per person.

9) Another approach that is usually used as design criteria is sludge loading rate (lb dry weight/ft^2 year). This approach was used to confirm that all parameters selected earlier for the contact aeration tank, reaeration tank, secondary clarifiers, and the aerobic digester are compatible with the sludge-loading rate criteria for the sludge drying bed design. These design parameters include waste sludge concentration from the secondary clarifier to the aerobic digestion tank (mg/L) and waste sludge flow rate to the aerobic digesters (gpd). The procedure used to check whether all parameters used for the aerobic digester unit and sludge drying beds are compatible with each other when all of their dimensions are known are shown below:

- Find available maximum sludge loading rate (lb dry weight solid/year) by multiplying sludge drying bed area (ft^2) by selected sludge loading rate (lb dry solid/ft^2 year). Typical design range is 12-20 lb dry solid/ft^2 year.
- Do mass balance around aerobic digester unit to find digested suspended solid concentrations (mg/L). Refer to Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse, page 838. The equation can be written as follows:

$$V = \frac{Q_i \left(X_i + YS_i \right)}{X \left(K_d P_v + 1/\theta_c \right)}$$

Where V = volume of aerobic digester, ft^3
Q_i = influent average flow rate to digester, ft^3/d
X_i = influent suspended solid concentration, mg/L
Y = fraction of the influent BOD_5 consisting of raw primary sludge (decimal)
S_i = influent BOD_5, mg/L
X = digester suspended solid concentration, mg/L
K_d = reaction-rate constant, d^{-1}
P_v = volatile fraction of digester suspended solids (decimal)
θ_c = solids detention time (sludge age), d

Assume that 1) There is no raw primary sludge, 2) $K_d = 0.07\ d^{-1}$, 3) $P_v = 0.8$, and 4) θ_c = 20 days (based on 25° C and 40% volatile solid reduction)

- Find maximum stabilized sludge flow rate (gpd) to sludge drying beds based on the available maximum sludge loading rate and digested suspended solid concentration found above.

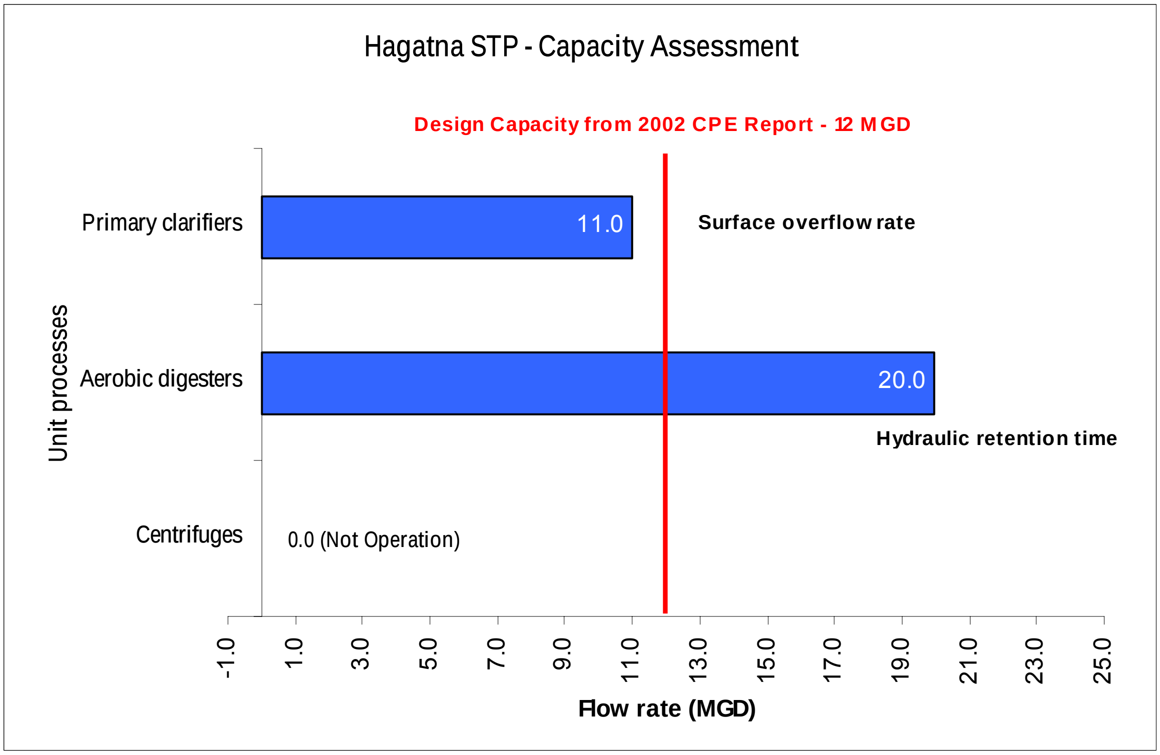
Table 3B.2: Capacity Assessment for Hagatna STP

Description	Capacity assessment calculations	Compared with other designs (g)	Unit
Primary clarifier			
-Type – Rectangular			
-Number – 3			
-Length (each)	120.0	120.0	ft
-Width (each)	34.0	34.0	ft
-Side water depth	10.0	10.0	ft
-Surface area (total)	12,240.0	12,240.0	ft^2
-Weir length (total) (b)	204.0	204.0	ft
-Volume (total)	122,400.0	N/A(h)	ft^3
	915,552.0	915,613.0	gal
Criteria 1: Surface overflow rates (SOR)			
Assume: Surface overflow rates (SOR) @ AADF (c - page 475) (Design range = 800-1,200 gpd/ft²)	900.0	980.0	gpd/ft²
Available maximum capacity @ AADF	11.0	12.0	MGD
Assume: Surface overflow rates (SOR) @ PHF (c - page 475) (Design range = 2,000-3,000 gpd/ft²)	2,000	1,716	gpd/ft²
Available maximum capacity @ PHF	24.5	21.0	MGD
Criteria 2: Hydraulic retention time (HRT)			
Assume: Hydraulic retention time (HRT) @ AADF (c - page 475) (Design range = 1.50-2.50 hours)	1.90	1.83	hours
Available maximum capacity @ AADF	11.6	12.0	MGD
Criteria 3: Weir overflow rate (WOR)			
Assume: Weir overflow rate @ AADF (c - page 475) (Design range = 10,000-40,000 gpd/ft)	38,000.0	58,824.0	gpd/ft
Available maximum capacity @ AADF (d)	7.7	12.0	MGD
Find: Primary sludge volume per Mgal			
Assume: Removal efficiency of suspended solid	0.6	N/A	
Average influent TSS (Data from Jan 04 to Mar 05)	94.0	N/A	mg/L
Dry solid (e)	471.0	N/A	lb
Assume: Specific gravity of sludge (c - page 485)	1.05	N/A	
Assume: Solid concentration (c - page 485) (Design range = 4-12%)	4.7	N/A	%
Primary sludge volume per Mgal (f)	1,145.0	N/A	gal
Aerobic digesters			
Assume: Oxygen requirement is not restricted.			
-Number - 4			
-Type - Square			
-Length (each)	36.0	32.0	ft
-Max. sludge water depth (SWD)	18.0	18.0	ft
-Avg. working SWD	14.0	15.0	ft

Description	Capacity assessment calculations	Compared with other designs (g)	Unit
Assume: 20% of volume occupied by settled grit			
-Active volume fraction	80.0	80.0	%
-Active volume (total)	58,061.0	N/A	ft³
	434,295.0	367,682.0	gal
Assume: Hydraulic retention time (HRT) (c - page 837) (Design range = 15-20 days)	19.0	27.9	d
Available max. capacity (primary sludge)	22,857.6	13,200.0	gpd
Assume: Solid concentration = 4.7%			
Available max. capacity (raw wastewater)	20.0	N/A	MGD
Design capacity is restricted by primary clarifier system which its available maximum flow is	11.0	12.0	MGD

Note:

(a) - Firm pump capacity with largest unit out of service (OOS) should equal or exceed PHF (EPA Class I reliability).
(b) - Effluent weirs are on both side of the effluent trough.
(c) - From Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse
(d) - Weir loading has little effect on the performance of primary clarifiers. Therefore it may be used larger than 40,000 gpd/ft.
(e) - Dry solid = (removal efficiency of total suspended solid)(avg. inf. TSS)((8.34 lb/Mgal)(mg/L))(1.0 Mgal)
(f) - Primary sludge volume per Mgal = (dry solid, lb)(100)/((specific gravity)(solid concentration, %)(62.4 lb/ft3)/(7.48 gal/ft3))
(g) - Compared with comprehensive performance evaluation of the Hagatna STP report prepared by Duenas & Associates, Inc. and Boyle Engineering Corporation
(h) - Not available



The bar chart above represents the design capacity from the 2002 CPE report versus the calculated capacities.

Description of Assessment

For the Hagatna STP, the unit operations selected for the process capacity assessment were three primary clarifiers and four aerobic digesters. Stabilized sludge from the sludge decant tank is not treated at this STP but it is currently sent to the Northern District STP for disposal. It is assumed that the pumping and blower systems function properly and do not restrict the capacity of treatment plant. The process unit that provides the least available capacity will be used to represent the design capacity of the whole plant.

General steps of the capacity assessment are as follows:

1) Below are the averages of the monthly average influent BOD_5 and TSS concentrations taken from the DMR during the period of January 2004 to March 2005.
   - Average of monthly average influent BOD_5 concentration = 209 mg/L
   - Average of monthly average influent TSS concentration = 93 mg/L

2) The primary clarifiers capacity is assessed based on three criteria including surface overflow rates (SOR), hydraulic retention time (HRT), and weir overflow rate (WOR). In general, WOR has little effect on the design of primary clarifiers. Therefore, the calculated flow capacity based on WOR is used as supplementary information for design purposes. Below are the design ranges for the basic parameters of this primary clarifier designs.
   - SOR design ranges =800-1,200 (average flow) gpd/ft^2
     =2,000-3,000 (peak flow) gpd/ft^2

- HRT design range =1.5-2.5 (average flow) Hours
- WOR design range =10,000-40,000 (average flow) gpd/ft

3) Primary sludge volume per MGD of wastewater influent is determined next. This calculated volume ratio of primary sludge and wastewater influent is used to assess the available capacity of the aerobic digesters. The following parameters and their design ranges were used for this assessment:
    - Removal efficiency: No design range (65% removal efficiency is assumed.)
    - Average influent TSS concentration (mg/L) (The average of monthly average influent TSS concentrations reported in the GWA DMRs during January 2004 to March 2005 were used.)
    - Specific gravity of sludge: Typical design = 1.05
    - Solid concentration: Design range = 4-12%

    Dry solids were calculated by the equation written in note (f) above. The calculated value of dry solids is then used to calculate the primary sludge volume per MGD of wastewater influent.

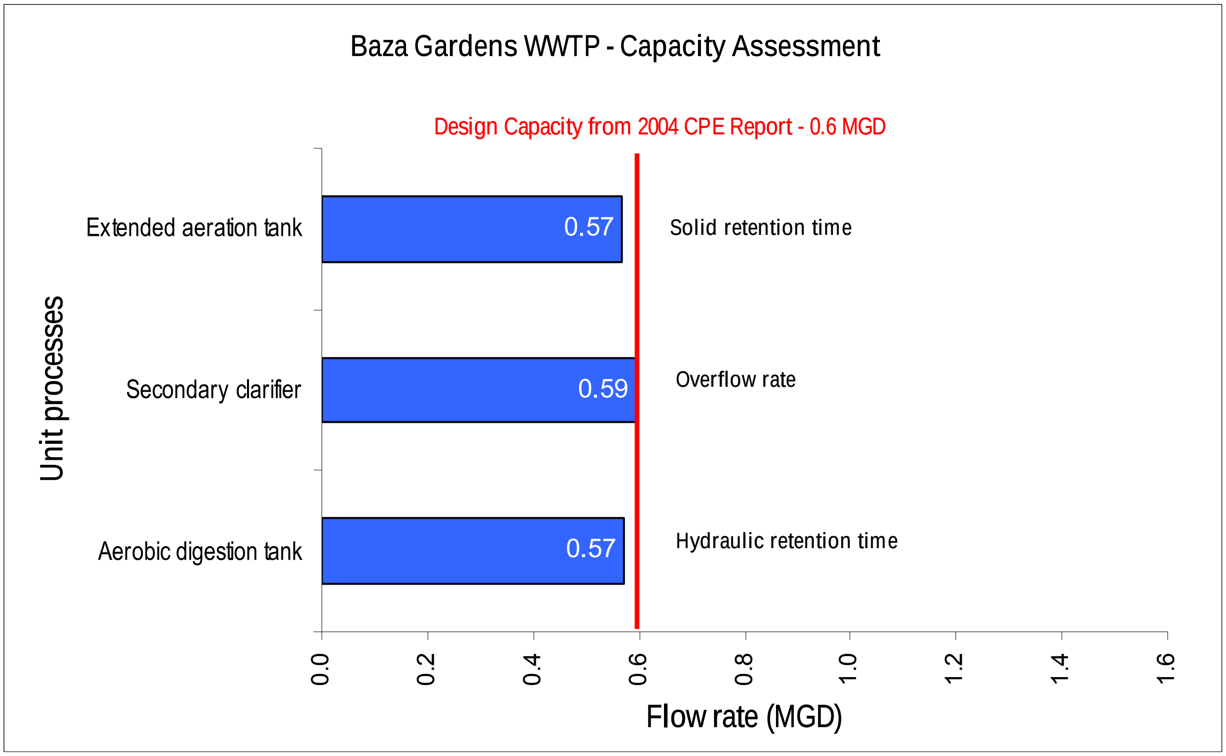
4) Hydraulic retention time is used as a criteria to calculate the available maximum primary sludge flow rate that enters the four aerobic digesters. Then, the available capacity (in terms of influent wastewater flow) of the aerobic digesters can be calculated by using the ratio found in item 3).

Table 3B.3: Capacity Assessment for Baza Gardens STP

Description	Capacity assessment calculations	Compared with Other Design (d)	Unit
General			
Assume: System is not restricted by air requirement			
Inside tank diameter	98.5	N/A[e]	ft
Inside tank radius	49.2	N/A	ft
Inside tank circumference	309.6	N/A	ft
Clarifier inside tank diameter	36.1	N/A	ft
Clarifier inside tank radius	18.1	N/A	ft
Clarifier inside tank circumference	113.5	N/A	ft
Aerobic digestion tank			
Internal tank circumference (a)	56.0	N/A	ft
Operating depth	15.3	15.3	ft
Volume	18,196.7	N/A	ft³
	136,111.1	N/A	gal
Assume: Hydraulic detention time (b - page 837) (Design range = 12 - 18 days)	17.0	N/A	d
Available maximum incoming sludge flow	8,006.5	N/A	gpd
Select waste sludge flow rate/influent flow rate	0.014		
Available maximum capacity	571,895.2	N/A	gpd
Extended aeration tank			
Approach 1 - Based on HRT			
Internal tank circumference (a)	240.4	N/A	ft
Operating depth	15.3	15.3	ft
Volume	78,138.6	78,000.0	ft³
	584,476.9	N/A	gal
Assume: Hydraulic retention time(b - page 550) (Design range = 18-36 hours)	24	23.3	hours
Available maximum flow capacity	584,476.9	600,000.0	gpd
Approach 2 - Based on solid retention time (SRT) (b - page 387)			
Assume: MLSS in extended aeration tank(b - page 550) (Design range = 1,500-5,000 mg/L)	2,700.0	N/A	mg/L
Microorganism concentration in clarifier effluent (c)	20.0	N/A	mg/L
Clarifier flow rate/Influent flow rate	0.986	N/A	
Waste sludge rate/Influent flow rate	0.014	N/A	
Select microorganism concentration of waste sludge	8,000.0	N/A	mg/L
Assume: Solid retention time (SRT) (b - page 550) (Design range = 20-30 days)	21.0	N/A	d
Available maximum capacity	566,267.0	N/A	gpd
Check return activated sludge flow rate to extended aeration tank (b - page 550) (Design range = 0.5-1.50)			

Description	Capacity assessment calculations	Compared with Other Design (d)	Unit
Approach - Mass balance around extended aeration tank			
Microorganism concentration in raw water influent (c)	0.00	N/A	mg/L
Return activated sludge flow rate/influent flow rate	0.51	N/A	
Secondary clarifier			
Feed Well Diameter	7.00	N/A	ft
Feed Well Radius	3.50	N/A	ft
Operating depth	15.3	15.3	ft
Volume	15,049.8	15,600.0	ft^3
	112,572.2	N/A	gal
Available overflow surface area	986.9	1,020.0	ft^2
Assume: Overflow rate (b - page 588) (Design range = 200-800 gpd/ft^2)	600.0	600.0	gpd/ft^2
Available maximum capacity	592,121.6	600,000.0	gpd
Design capacity is restricted by extended aeration tank which its available maximum capacity is	566,267	600,000	gpd

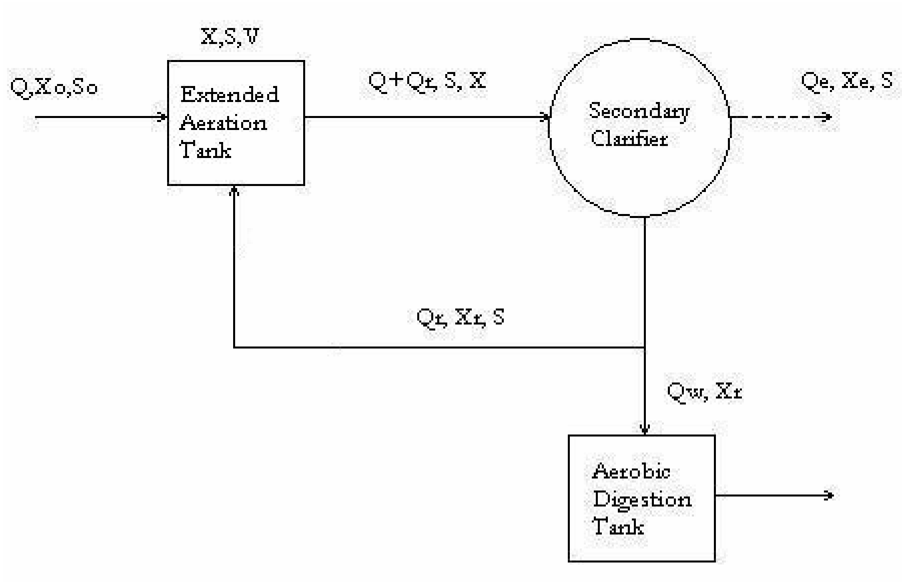
Note:
(a) - There are 47 front spray header nozzles. Based on tank inner wall, distance (arc length) between nozzles is 6.584 ft. There are 36.5, 2, and 8.5 nozzles within extended aeration, chlorination contact, and aerobic sludge digestion zones respectively.
(b) - Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse
(c) - TSS from NPDES permit ≤ 30 mg/L and assume microorganism concentration is also 30 mg/L; Select 20 mg/L (for safety factor). TSS of raw water influent ~ 104.7 mg/L and assume microorganism concentration is close to zero mg/L.
(d) - Data from Winzler & Kelly Consulting Engineers (2004). Comprehensive Performance Evaluation Baza Gardens Wastewater Treatment Plant
(e) - Not available



Bar chart above represents the comparison of the design capacity from 2004 CPE report versus the calculated capacities from Brown and Caldwell.

Description of Assessment

Baza Gardens STP is a package system that has a "donut" shape consisting of an extended aeration tank, an aerobic sludge digester, and chlorine contact tank around the perimeter with the secondary clarifier in the middle. For the purpose of design calculation, a simplified flow diagram is presented below:



Note:	Q	=	Influent flow rate (MGD)
	Xo	=	Microorganism concentration in influent wastewater (mg/L)
	So	=	BOD5 concentration in influent wastewater (mg/L)
	X	=	Mixed liquor suspended solid (MLSS) or microorganism concentrations in extended aeration tank (mg/L)
	S	=	BOD5 concentration in extended aeration tank (mg/L)
	V	=	Volume of extended aeration tank (gal)
	Qr	=	Sludge return flow rate (MGD)
	Xr	=	MLSS concentration of sludge return from secondary clarifier to extended aeration tank or to aerobic digestion tank (mg/L)
	Qw	=	Waste sludge flow rate (MGD)
	Qe	=	Effluent flow rate from secondary clarifier (MGD)
	Xe	=	Microorganism concentration in effluent (mg/L)

Main unit processes selected for the capacity assessment include the extended aeration tank, aerobic digestion tank, and secondary clarifier. It is assumed that pumping and blower systems are working properly and do not restrict the capacity. Facility headworks including a bar screen, aerated grit chamber, and comminutor are assumed to function and do not restrict the treatment capacity. The unit operation that provides the least available capacity will represent the maximum available capacity of the whole plant. Below are steps to evaluate the available capacity for each unit operation.

1) Assumed information includes dimensions of the existing major unit processes and the average of the monthly average influent BOD_5 and TSS. The averages of monthly average influent BOD_5 and TSS concentrations were taken from GWA's DMRs during the time period of January 2004 to March 2005:
   - Average of monthly average influent BOD_5 concentration = 187 mg/L
   - Average of monthly average influent TSS concentration = 105 mg/L

   Tank volumes for each unit process can be found by using similar calculation methods applied for the Agat-Santa Rita STP assessment.

2) The available capacity of the aerobic digestion tank is evaluated first by selecting a waste sludge flow rate appropriate for its size (volume). The assessment will be based on an appropriate hydraulic retention time, the design range is shown below:
   - HRT design range for the aerobic digestion tank = 12-18 Days

3) Next, the capacity of the extended aeration tank is assessed based on two design criteria, HRT and SRT.

   Approach 1 – Based on HRT
   The following steps are used to calculate the capacity:
   - HRT for an extended aeration tank is selected. (Design range is 18-36 hours.)
   - Available maximum capacity = Volume of extended aeration tank/HRT

   Approach 2 - Based on SRT
   SRT equation below:

$$SRT = \frac{VX}{Q_w X_r + Q_e X_e}$$

   When all other variables and parameters including tank volume, Q_w/Q, Q_e/Q, X, and SRT are known (or assumed), the available maximum flow capacity can be calculated. Below summarizes the design parameters used in this calculation:
   - MLSS design range = 1,500-5,000 mg/L
   - SRT design range = 20-30 Days

   The Q_w/Q, and Q_e/Q, values applied here correspond to the capacity assessment for the aerobic digestion system. The MLSS concentration, X_r is selected based on a typical operating range.

   In order to confirm that the above capacity assessment is properly performed, the return activated sludge ratio (Q_r/Q) is calculated. This is to confirm whether this ratio is in the design range. A mass balance of microorganisms around the extended aeration tank is performed, based on the equation below:

$$(Q_r)(X_r) + (Q)(X_0) = (Q_r + Q)(X)$$

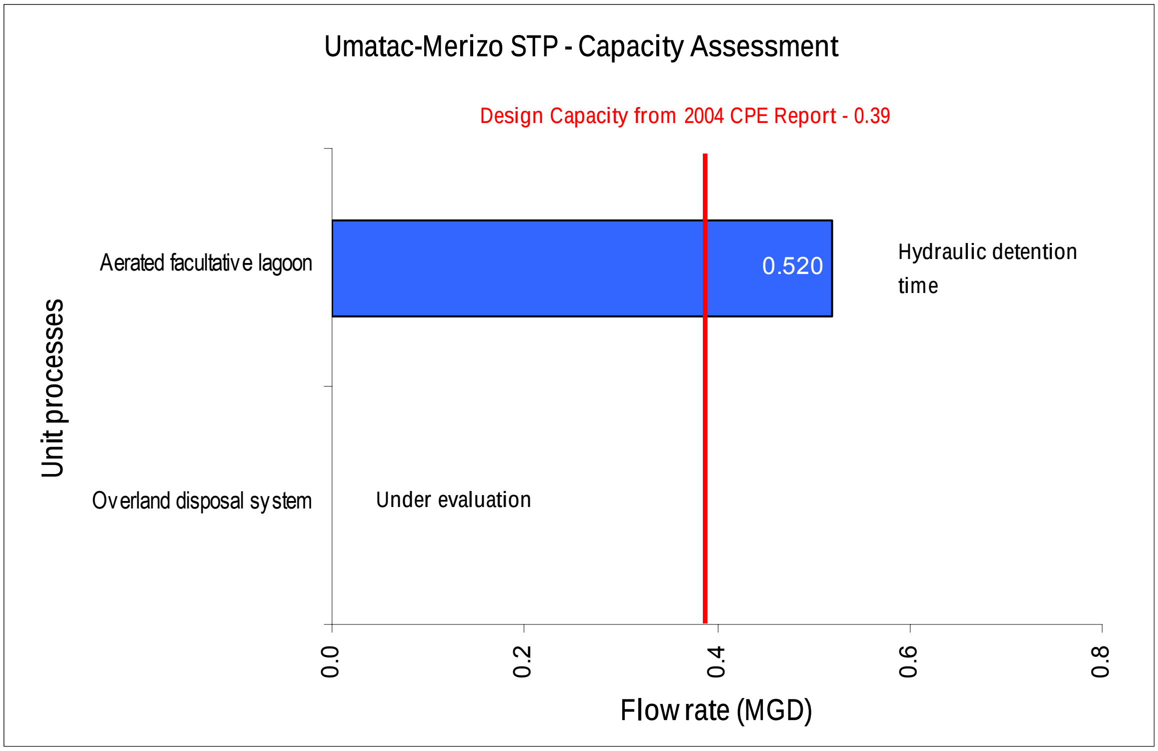
   The design range of return activated sludge ratio for an extended aeration system is 0.5 to 1.5.

4) The next process unit to consider for the capacity assessment is the secondary clarifier. An overflow rate design range of 200-800 gpd/ft^2 is used as a criteria, in conjunction with the known existing surface area of the secondary clarifier, to determine the available maximum capacity for this process unit.

Table 3B.4: Capacity Assessment for Umatac-Merizo STP

Description	Capacity assessment calculations	Compared with Other Design (c)	Unit
Aerated facultative lagoon			
Lagoon surface width	166.7	N/A[c]	ft
Lagoon surface length	300.0	N/A	ft
Lagoon Bottom width	80.6	N/A	ft
Lagoon bottom length	208.3	N/A	ft
Depth	15.0	N/A	ft
Slope	0.34	N/A	ft
Total volume (a)	500,880.5	N/A	ft
Select operating depth	12.5	12.5	ft
Operating volume	417,400.4	436,000.0	ft^3
	3,122,155.0	3,261,280.0	gal
Approach: Detention time			
Assume: Detention time (b – Table 8-4, page 533) (Design range = 5-20 days)	6.0	7.0	d
Available maximum capacity	520,359.2	465,897.1	gal
Overland flow/Treatment disposal system			
Information is not available.			
Recirculation pond			
Information is not available.			
Design flow capacity based on aerated facultative lagoon is	520,359	391,000	gpd

Note:
(a) - Total volume can be found from sum of rectangular volume based on the bottom area of lagoon and half of the difference of rectangular volume based on surface area of lagoon and rectangular volume based on bottom area of lagoon.
(b) – From Crites and Tchobanoglous, Small and Decentralized Wastewater Management Systems
(c) - Not available



The bar chart above is a comparison of the design capacity from the 2004 CPE report versus the calculated capacity of the aerated facultative lagoon.

Description of Assessment

According to available current information, only the aerated facultative lagoon was evaluated for the capacity assessment. Unit processes including pumps and surface aerators are assumed to function properly and provide enough capacities. The dimension of the lagoon is known. The averages of monthly average influent BOD_5 and TSS concentrations, 216 and 70 mg/L, respectively are taken from GWA's DMRs during the time period of January 2004 to March 2005.

Detention time is selected as the criteria to determine the available maximum capacity for this unit process. The typical design range is from 5 to 20 days. Full-scale stress testing is recommended to assess the capacity of the overland flow/treatment disposal system.

Table 3B.5: Capacity Assessment for Northern District STP

Description	Capacity assessment calculations	Compared with other designs (d)	Unit
Aerated grit chamber and grit classifier			
-Width (each)	22.0	N/A[f]	ft
-Length	54.3	N/A	ft
-Operating depth	14.0	N/A	ft
-Volume (each)	16,709.0	16,650.0	ft^3
-Volume (total)	33,418.0	33,300.0	ft^3
	249,967.0	249,084.0	gal
Assume: Hydraulic retention time (HRT) @ PHF (a - page 462) (Design range = 2-5 minutes)	3.0	N/A	min
Available maximum capacity @ PHF	12.0	N/A	mgd
Primary clarifier			
-Type – Circular			
-Number – 2			
-Diameter (each)	130.0	130.0	ft
-Side water depth (each)	7.0	7.0	ft
-Surface area (total)	26,546.0	26,546.0	ft^2
-Weir length (total)	817.0	817.0	ft
-Volume (total)	185,822	N/A	ft^3
	1,389,949.0	1,390,065.0	gal
Criteria 1: Surface overflow rates (SOR)			
Assume: Surface overflow rates (SOR) @ AADF (a - page 475) (Design range = 800-1,200 gpd/ft²)	900.0	1,000.0	gpd/ft²
Available maximum capacity @ AADF	12.0	13.0	MGD
Assume: Surface overflow rates (SOR) @ PHF (a - page 475) (Design range = 2,000-3,000 gpd/ft²)	2,000.0	2,000.0	gpd/ft²
Available maximum capacity @ PHF	26.6	26.6	MGD
Criteria 2: Hydraulic retention time (HRT)			
Assume: Hydraulic retention time (HRT) @ AADF (a - page 475) (Design range = 1.5-2.5 hours)	2.0	2.8	hours
Available maximum capacity @ AADF	16.7	N/A	MGD
Criteria 3: Weir overflow rate			
Assume: Weir overflow rate @ AADF (a - page 475) (Design range = 10,000-40,000 gpd/ft2)	16,000.0	14,691.0	gpd/ft
Available maximum capacity @ AADF	13.0	N/A	MGD
Find: Primary sludge volume per Mgal			
Assume: Removal efficiency of suspended solid	0.6	N/A	
Assume: Average influent TSS (based on the average of monthly average DMR during Jan 04 - Mar 05))	108.0	N/A	mg/L
Dry solid (b)	542.0	N/A	lb

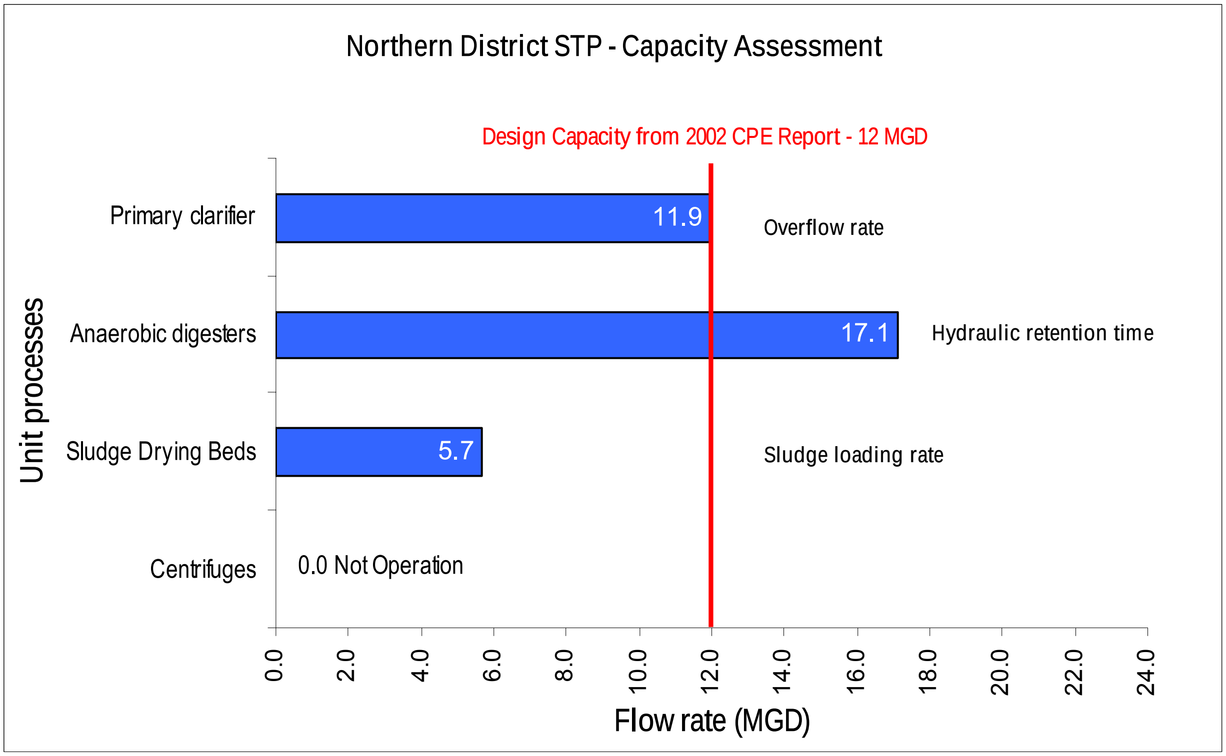
Description	Capacity assessment calculations	Compared with other designs (d)	Unit
Assume: Specific gravity of sludge (a - page 485)	1.05	N/A	
Assume: Solid concentration (a - page 485) (Design range = 4-12 %)	4.7	N/A	%
Primary sludge volume per Mgal (c)	1,316.36.0	N/A	gal/Mgal
Anaerobic digesters			
-Number – 2			
-Type – Circular			
-Diameter (each)	80.0	80.0	ft
-Max. sludge water depth (SWD)	21.0	21.0	ft
-Avg. working SWD	18.0	18.0	ft
Assume: The primary anaerobic digester provides degradation process and the secondary anaerobic digester provides sedimentation process.			
-Volume of primary digester	90,514.0	90,514.0	ft³
	677,047.0	677,047.0	gal
Appraoch 1: Population basis - hydraulic retention time			
Assume: The primary anaerobic digester is operated between high rate and standard rate digestion mode and mesophilic condition.			
Assume: Hydraulic retention time (HRT) (a - page 823) (Design range = 30-60 days - stand rate and 15-20 days - high -rate)	40.0	N/A	d
Available max. capacity (primary sludge)	16,926.2	N/A	gpd
Assume: Solid concentration = 4.7%			
Available max. capacity (raw wastewater)	12.9	N/A	MGD
Approach 2: Volatile solid loading factor			
Assume: The primary anaerobic digester is operated between high rate and standard rate digestion mode and mesophic condition.			
Volume of primary anaerobic digestion tank	90,514.00	N/A	ft³
Selected volatile sludge loading factor (lb/ft3 d) (a - page 821) (Based on sludge concentration = 4.7% and hydraulic retention time = 20 days)	0.11	N/A	lb/ft³.d
Volatile sludge loading	9,956.5	N/A	lb/d
Total solid (Assume - 60% of total solid is volatile solids.)	16,594.2	N/A	lb/d
Sludge concentration (based on 4.7%)	47,000.0	N/A	mg/L
	0.1	N/A	lb/L
Incoming sludge flow rate	160,485.8	N/A	L/d
	42,395.5	N/A	gpd
Primary sludge volume per Mgal	1,316.4	N/A	gal/Mgal
Available maximum capacity (raw wastewater)	32.2	N/A	MGD
Sludge Drying Beds			
Type - Rectangular concrete drying beds with center drainage trench			

Description	Capacity assessment calculations	Compared with other designs (d)	Unit
Number of beds	8	8	beds
Width (each)	30.0	30.0	ft
Length (each)	105.0	105.0	ft
Area (each)	3,150.0	3,150.0	ft²
Total area	25,200.0	25,200.0	ft²
Approach 1: Area per person			
Assume: Required area of sludge drying beds for one person (a - page 873) (Design range = 1.0-1.5 ft²/person)	1.25	N/A	ft²/ person
Maximum number of people generating wastewater that sludge drying bed can handle	20,160	8,500	persons
Assume: Wastewater flow rate per person (a - page 27) (design range = 60-100 gpd per person for better home)	80.0	N/A	gpd/ person
Available maximum flow capacity	1.6	N/A	MGD
Approach 2: Sludge-loading rate			
2.1) Find max. sludge that can be wasted			
Assume: Sludge loading rate (a - 873) (Design range = 25-30 lb dry solids/ft².yr)	27.0	N/A	lb dry solids/ ft².yr
Total area	25,200.0	N/A	ft²
Maximum sludge that can be wasted	680,400.0	N/A	lb dry weight/yr
Maximum sludge that can be wasted	1,864.0	N/A	lb dry weight/day
2.2) Find the relationship between sludge flow from secondary anaerobic digester (lb dry solids/day) and wastewater flow influent (e - page 1262-1263)			
For the calculation purpose, assume - sludge flow from primary clarifiers	1.0	N/A	MGD
Sludge concentration (from primary clarifiers)	47,000.0	N/A	mg/L
Sludge mass flow (from primary clarifiers)	391,980.0	N/A	lb/d
VSS fraction in sludge flow (from primary clarifiers)	0.60	N/A	
Sludge mass flow (fixed solids) (from primary clarifiers)	156,792.0	N/A	lb/d
Total solid concentrations of sludge from primary anaerobic digester	36,000.0	N/A	mg/L
Sludge mass flow (from primary anaerobic digester)	300,240.0	N/A	lb/d
Volumetric flow balance: Total sludge hydraulic flow (from primary clarifiers) (Q) = Supernatant hydraulic flow (from secondary anaerobic digester) (Qs) + Sludge hydraulic flow (from secondary anaerobic digester) (Qsdb)……Equation 1			
So, Qs = 1-Qsdb			
Total solid concentrations of supernatant from secondary anaerobic digester	20,000.0	N/A	mg/L

Description	Capacity assessment calculations	Compared with other designs (d)	Unit
Total solid concentrations of sludge from secondary anaerobic digester	43,000.0	N/A	mg/L
Mass balance of secondary anaerobic digester: (Q)(36,000)(8.34) = (Qs)(20,000)(8.34) + (Qsdb)(43,000)(8.34) …….. Equation 2			
From Equation 1 and 2,			
Qsdb	0.70	N/A	MGD
Qs	0.30	N/A	MGD
So, sludge mass flow (from secondary anaerobic digester to sludge drying beds) =	249,475.0	N/A	lb/d
Therefore, 1 MGD of sludge flow from primary clarifier will generate sludge mass flow to sludge drying beds =	249,475.0	N/A	lb/d
But primary sludge volume per 1 MGD of raw wastewater influent =	1,316.0	N/A	gpd
Therefore, 1 MGD of raw wastewater influent will generate sludge mass flow to sludge drying beds =	328.0	N/A	lb/d
2.3) Find available maximum flow capacity			
Available maximum capacity	5.7	N/A	MGD
Note: Available maximum flow capacity for sludge drying beds is selected based on approach 2 because it is believed that it provides more accurate calculation than approach 1.			
Design flow capacity is restricted by sludge drying beds which its available maximum capacity is	5.7	12.0	MGD

Note:

(a) - From Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse
(b) - Dry solid = (removal efficiency of total suspended solid)(avg. inf. TSS)((8.34 lb/Mgal)(mg/L))(1.0 Mgal)
(c) - Primary sludge volume per Mgal = (dry solid, lb)(100)/((specific gravity)(solid concentration, %)(62.4 lb/ft3)/(7.48 gal/ft3))
(d) - Compared with comprehensive performance evaluation of the Northern District STP report prepared by Duenas & Associates, Inc. and Boyle Engineering Corporation
(e) - Design of Municipal Wastewater Treatment Plants Handbook, WEF, ASCE, 1992
(f) - Not available



The bar chart above is a comparison of the design capacity from 2002 CPE report versus the calculated capacities.

Description of Assessment

The Northern District STP is a primary sewage treatment plant. Capacity assessments are performed on its main unit processes including the aerated grit removal system, primary clarifiers, anaerobic digesters, and sludge drying beds. Currently, centrifuges for dewatering are not in service, eight sludge drying beds are used instead. They receive sludge wastes not only from Northern District STP but also Hagatna STP and Baza Gardens STP. Below is a step-by-step approach to perform the capacity assessment of each main unit process (note redundant and spare tankage and equipment were not part of the assessment).

1) Given information of sizes of each unit process from existing drawings and the raw water characteristics from the GWA's DMRs. Raw wastewater parameters used for this assessment are the averages of monthly average of BOD_5 and TSS taken during the time period beginning from January 2004 to March 2005.
   - Average of monthly average BOD_5 influent concentration = 222 mg/L
   - Average of monthly average TSS influent concentration = 105 mg/L

2) The available maximum capacity of aerated grit chamber was assessed based on HRT. The HRT design ranges of pre-aeration tanks and aerated grit chambers are 10 to 45 minutes and 2-5 minutes respectively.

3) Next, three approaches were selected to calculate the available maximum capacity of the primary clarifiers, including SOR, HRT, and WOR.

Approach 1 - SOR

Both average flow and peak flow are investigated. The available maximum process capacity can be found by multiplying SOR and the total surface area of the primary clarifiers. Typical SOR design ranges are 800-1,200 gpd/ft^2 for average flow and 2,000-3,000 gpd/ft^2 for peak hourly flow.

Approach 2 – HRT

Typical HRT design range is 1.5 to 2.5 hours for average flow. The available maximum capacity can be calculated by the following equation:

Available maximum capacity = Total primary clarifier volumes/HRT

Approach 3 – WOR

Typical weir rate design range is 10,000 to 40,000 gpd/ft^2. The available maximum capacity can be calculated based on the equation written below:

Available maximum capacity = (Total weir length) x (Weir overflow rate)

4) The capacity assessment for the anaerobic digestion tanks is determined by first calculating the available primary sludge treatment capacity. Then, the available maximum influent wastewater flow can be calculated, which can be shown by the following equation:

Available influent wastewater capacity = (Available primary sludge treatment capacity) x (Primary sludge volume per Mgal of raw wastewater influent)

The primary sludge treatment capacity is calculated based on the hydraulic retention time (HRT) - design range of 30 to 60 days.

The equations used to find primary sludge volume per Mgal of raw wastewater influent are shown below:

Primary sludge volume per Mgal = (Dry solid, lb)(100)/((Specific gravity)(Solid concentration, %)(62.4 lb/ft3)/(7.48 gal/ft3))

Dry solid = (Removal efficiency of total suspended solid)(Avg. inf. TSS)((8.34 lb/Mgal)(mg/L))(1.0 Mgal)

The assumptions used to calculate the primary sludge volume include:

- Removal efficiency of suspended solid = 60 %
- Average of monthly average TSS concentration = 108 mg/L
- Specific gravity = 1.05

Design range of solids concentration is 4 to 12%.
Two approaches used to investigate the available maximum capacity of the anaerobic digesters include population basis HRT and volatile solids loading factor.

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Given data -Tank dimensions and raw wastewater influent TSS and BOD5 concentrations
-Design ranges of all parameters were selected from Wastewater Engineering, Treatment, Disposal, and Reuse by Metcalf & Eddy, 3rd Edition.

Approach 1 – Population basis - HRT
Assume 1) The primary anaerobic digester is operated between high rate and standard rate and in mesophilic conditions.
2) HRT is selected based on two design ranges (30 to 60 days for stand rate, and 15 to 20 days for high rate).
3) Solid concentration = 4.7%

Approach 2 – Volatile solids loading factor
Assume 1) The volatile sludge loading factor (lb/ft^3d) is selected based on a: sludge concentration = 4.7%, and hydraulic retention time = 20 days.
2) 60% of the total solids from the primary clarifier are volatile solids.
3) Sludge concentration from primary clarifiers = 4.7%

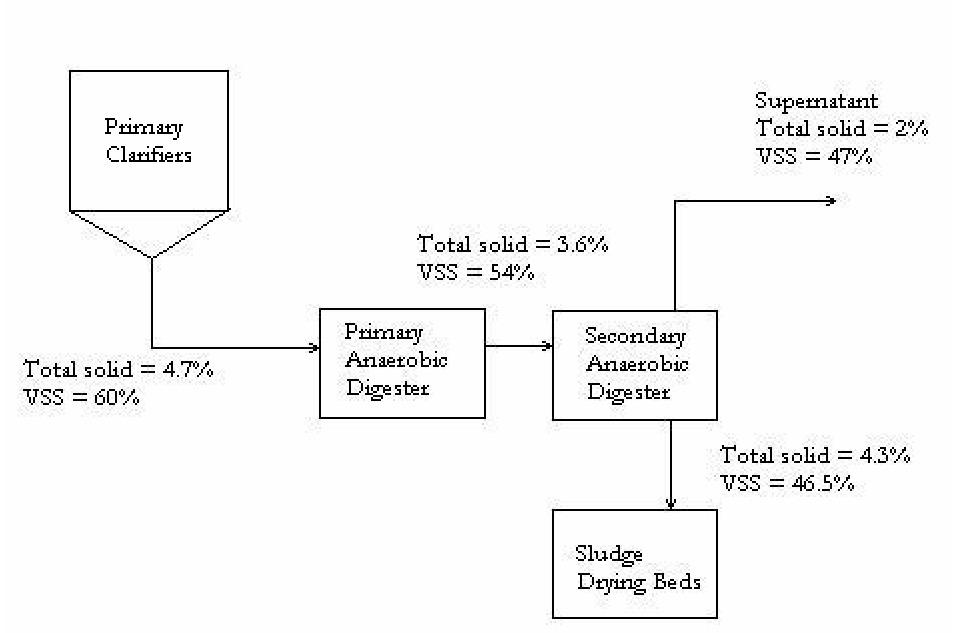
Steps to calculate the available maximum flow capacity are as follows:
1) Volatile sludge loading = (Volatile sludge loading factor) x (Volume of primary anaerobic digestion tank)
2) Find total solids mass flow = (Volatile sludge loading from step 1)/(0.6)
3) Find sludge volumetric flow from primary clarifier = (Total solids)/(Sludge concentration)
4) Available maximum capacity = (Sludge flow from primary clarifier)/(primary sludge volume/Mgal)

5) For the sludge drying beds, two approached are used as follows:

Approach 1 - Area per person
Known – Size of sludge drying beds
Assume –
1) Required area of sludge drying beds per person (Design range = 1 to 1.5 ft^2/person)
2) Wastewater flow generated from 1 person (Design range = 60 – 100 gpd per person)

Steps to find available maximum wastewater flow capacity are
1) Find maximum number of people generating wastewater that sludge drying beds can handle.
2) Find available maximum capacity (MGD)

Approach 2 – Sludge loading rate approach
Given – Size of sludge drying beds



Three major steps used to find the available maximum capacity are written below:

1) Find the maximum quantity of sludge that can be wasted (lb dry solids/day)
2) Find the relationship between sludge flow from the secondary anaerobic digester (lb dry solids/day) and wastewater influent flow.
3) Find the available maximum capacity based on sludge drying beds (MGD)

Step 1 – Find maximum amount of sludge that can be wasted
Assume – Select sludge loading rate (Design range = 25 – 30 lb dry solids/ft^2yr)
Maximum sludge that can be wasted = (Selected sludge loading rate) x (Total area)

Step 2 – Find the relationship between sludge flow from the secondary anaerobic digester (lb dry solids/day) and wastewater influent flow to the wastewater treatment plant

Assume 1) All percent total solids and volatile solids of digester feed, primary digester outlet, and secondary digester supernatant and sludge outlet were selected based on the Design of Municipal Wastewater Treatment Plants Handbook by WEF and ASCE, 1992.

For the calculation:
Select sludge flow = 1 MGD from primary clarifiers
Sludge concentration = 47,000 mg/L
Sludge flow from primary clarifiers = (1)(47,000)(8.34) = 391,980 lb/d
% volatile suspended solids (VSS) = 60 %
Fixed suspended solids = 156,792 lb/d

Sludge from primary anaerobic digester = (1)(36,000)(8.34) = 300,240 lb/d
Give Qs = Supernatant flow from secondary anaerobic digester
Qsdb = Sludge flow to sludge drying beds
Q = Sludge flow from primary clarifiers
So, Q = 1 = Qs + Qsdb ----------------(1)

Mass balance around secondary anaerobic digester system,
(1)(36,000)(8.34) = Qs(20,000)(8.34) + Qsdb(43,000)(8.34) ------------(2)

From Equation (1) and (2),

Qsdb = 0.70 MGD
Qs = 0.30 MGD

Therefore, the sludge flow to the sludge drying beds per 1 MGD of sludge flow from the primary clarifiers = (0.7)(43,000)(8.34) = 249,475 lb/d
But primary sludge volume = 1,316.36 gal/1Mgal of raw wastewater
So, 1 MGD of raw wastewater will generate sludge flow to sludge drying beds,
= (249,475)(1,316.36)/1,000,000 = 328 lb/d

Step 3 – Find available maximum capacity that the sludge drying beds can receive.
1 MGD of raw wastewater can generate 328 lb/d of sludge flow to sludge drying beds.
Maximum sludge that sludge drying beds can handle from step 1 is 1,864 lb/d/,
Therefore, available maximum influent wastewater capacity = 1,864/328 = 5.68 MGD

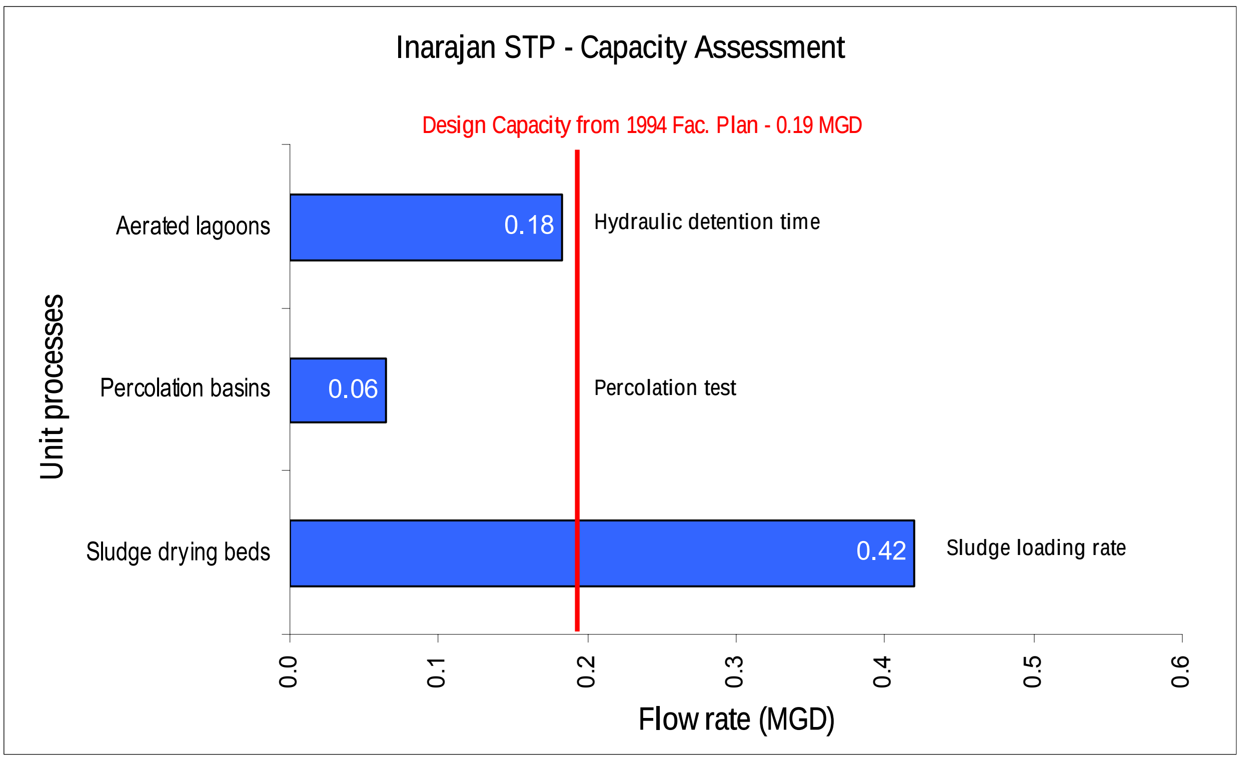
Table 3B.6: Capacity Assessment for Inarajan STP

Description	Capacity assessment calculations	Compared with Original Designs	Unit
Aerated lagoons			
Width (each) (cell 1)	90.0	N/A[(d)]	ft
Width (each) (cell 2 - 4)	92.0	N/A	ft
Bottom lagoon width (cell 1)	30.0	N/A	ft
Bottom lagoon width (cell 2-4)	27.0	N/A	ft
Assume: Operating depth	8.0	N/A	ft
Volume (each) (cell 1)	36,000.0	N/A	ft^3
Volume (each) (cell 2-4)	36,772.0	N/A	ft^3
Volume (total)	146,316.0	N/A	ft^3
	1,094,444.0	N/A	gal
Approach: Hydraulic detention time			
Assume: Hydraulic detention time (b – Table 8-4, page 533) (Design range = 5-20 days)	6.0	N/A	d
Available maximum capacity	182,407.0	191,000.0	gpd
Percolation basins			
Width (each)	70.0	N/A	ft
Length (each)	180.0	N/A	ft
Area (each)	12,600.0	N/A	ft^2
Area (total)	37,800.0	N/A	ft^2
	0.87	N/A	ac
Approach – Percolation test			
Percolation rate – location 1	2.25	N/A	in/hr
Percolation rate – location 2	3.75	N/A	in/hr
Percolation rate – location 3	2.50	N/A	in/hr
Average percolation rate from three locations	2.83	N/A	in/hr
	5.67	N/A	ft/d
Clean water loading rate	214,200.0	N/A	ft^3/d
	1,602,216.0	N/A	gpd
Assume that allowable application rate is 2-4% of clean water loading rate			
Available maximum capacity based on 2%	32,044.3	N/A	gpd
Available maximum capacity based on 4%	64,088.6	N/A	gpd
Sludge drying beds			
Width (each)	22.0	N/A	ft
Length (each)	80.0	N/A	ft
Area (each)	1,760.0	N/A	ft^2
Area (total)	10,560.0	N/A	ft^2
Approach 1 - Area per person			
Assume: Required area of sludge drying beds for one person (a - page 873) (Design range = 1.75-2.50 ft^2/person)	2.3	N/A	ft^2/ person

Description	Capacity assessment calculations	Compared with Original Designs	Unit
Maximum number of people generating wastewater that sludge drying beds can handle	4,591	N/A	Persons
Assume: Wastewater flow rate per person (a- page 27) (Design range = 60-100 gpd per person per home)	80.0	N/A	gpd/ person
Available maximum capacity	367,304.0	N/A	gpd
Approach 2 - Sludge loading rate			
Step 1 - Find maximum sludge that can be wasted (lb/d)			
Assume: Sludge from aerated lagoons to sludge drying beds is similar to primary and waste activated digested (Design range = 12-20 lb dry solids/ft² yr)	16.0	N/A	lb/ft² yr
Total area	10,560.0	N/A	ft²
Available maximum amount of sludge that sludge drying beds can receive	168,960.0	N/A	lb/yr
	463.0	N/A	lb/d
Step 2 - Find how much sludge is generated			
2.1) Find total TSS (mg/L) from aerated lagoons before they settle			
TSS =Influent SS (not degraded) + Total biological solids			
Total biological solids = Volatile biological solids (VBS) + Fixed biological solids (FBS)			
Assume - Fixed TSS	25.0	N/A	mg/L
Assume - Volatile BOD5	168.0	N/A	mg/L
Find effluent soluble BOD (S) (a - page 376, equation 8-28)			
Assumed parameters (a - page 394, Table 8-7)			
K	6.0	N/A	d-1
Kd	0.07	N/A	d-1
Ks	70.0	N/A	mg/L BOD5
Y	0.7	N/A	mg VSS/mg BOD5
$\Theta = \Theta c$ (a - page 605)	5.0	N/A	days
S (soluble)	4.8	N/A	mg/L
Find soluble biological solid concentration, X	84.6	N/A	mg/L
Assume: soluble biological solid fraction	0.8	N/A	
Total biological solids	105.8	N/A	mg/L
Total suspended solids	132.0	N/A	mg/L
2.2) Find total suspended solids mass in aerated lagoons (lb/d) per 1 MGD of raw wastewater			
Total suspended solids mass in aerated lagoons	1,102.7	N/A	lb/d/ MGD

Description	Capacity assessment calculations	Compared with Original Designs	Unit
Step 3 - Find available maximum flow capacity			
Available maximum capacity	419,802.4	N/A	gpd
Design flow capacity is restricted by percolation basins which its available maximum capacity is	32,044 - 64,089	191,000	gpd

Note:
(a) - From Metcalf and Eddy, Inc., 3rd Edition, Wastewater Engineering - Treatment, Disposal, and Reuse
(b) - From Crites and Tchobanoglous, Small and Decentralized Wastewater Management Systems
(c) – BOD effluent required in NPDES permit is less than 30 mg/L.
(d) - Not available



The bar chart above is a comparison of the design capacity from the 1994 Guam Islandwide Wastewater Facilities Plan versus the calculated capacities.

Description of Assessment

Main unit processes of the Inarajan STP for the capacity assessment includes aerated lagoons, percolation basins, and sludge drying beds. Since this STP is operated at zero discharge to the river (or flows to the river were not monitored) no DMR data was available. The capacity assessment of each unit process was carried out as following:

1) All sizing information for main unit processes was based on the system drawings.

2) Two approaches are applied to find the available maximum capacity of the aerated lagoons. Available maximum capacity for this case can be found by dividing the total lagoon volumes with the hydraulic detention time, with a design range of 5 to 20 days.

3) Three percolation basins are used to receive effluent water after biologically treated by aerated lagoons and distributed by the dosing chamber. Effluent water is divided into three lines in parallel and sent to these three percolation basins. The average percolation rate from percolation testing at three locations closing to the percolation basins was determined. Then, typically 2-4% of the average percolation rate would be used as a reliable application rate for disposal.

4) The last unit process for the capacity assessment of this STP was the sludge drying beds. Six sludge drying beds are used to dry wet sludge which is pumped from the four aerated lagoons where stabilized sludge is settled at the bottom of each cell. Based on information from existing drawings, these sludge drying beds are the conventional sand drying bed type. The capacity assessment is based on the required area used to treat generated wastewater by one person. Because aerated lagoons provide a secondary treatment, the type of sludge selected for this assessment is primary and waste activated digested. The design range of the required sludge drying bed area per person is, 1.75-2.50 ft^2/ person, for this type of sludge. In order to find the available maximum capacity of this unit process, two calculation steps were carried out.
   - Finding the maximum number of people that the sludge drying beds can employ (N). N = (Total area of sludge drying beds) x (Required sludge drying area per person)
   - Determining the maximum available flow capacity (Q) by assuming the amount of wastewater that is generated by one person each day. Wastewater amounts depend upon the sources. For this case, the source is assumed to be individual residences. Design range of wastewater flow rates for this type of source is 60-100 gallon/person · day and a typical number of 80 gallon/person · day was assumed.

5) Another approach selected to find the capacity of the sludge drying beds is sludge loading rate. Three main steps to attain the available maximum raw wastewater flow that sludge drying beds can receive are

   <u>Step 1</u> Find maximum sludge that sludge drying beds can handle based on a design range of 12-20 lb dry solids/ft^2yr. It is assumed that the sludge from aerated lagoons to drying beds can be categorized as primary and waste activated type digested sludge.

   Available maximum sludge loading = (Selected sludge loading rate) x (Total area of sludge drying beds)

   <u>Step 2</u> Find how much sludge is generated in the aerated lagoons (lb/d) per 1 MGD of incoming raw wastewater.

   2.1) Find total mixed liquor suspended solids (MLSS) (X) (mg/L) in the aerated lagoons before they settle.

Total MLSS = Influent suspended solids (not degraded) + Total biological solids
Total biological solids = Volatile biological solids + Fixed biological solids

Assume:
Fixed TSS concentration = 25 mg/L
Soluble BOD_5 concentration = 168 mg/L

Find soluble effluent BOD_5 concentration (S) = $$\frac{K_s(1+\theta k_d)}{\theta(Yk-k_d)-1}$$

Then, find X = $$\frac{Y(S_0-S)}{1+k_d\theta}$$

Where, K_s = Half-velocity constant, mg/L BOD_5
Θ = Hydraulic retention time, days
k_d = Endogeneous decay coefficient, d^{-1}
Y = Maximum yield coefficient, mg VSS/mg BOD_5
k = Maximum rate of substrate utilization per unit mass of microorganisms, d^{-1}
S_0 = Soluble BOD_5 influent concentration, mg/L
S = Soluble BOD_5 effluent concentration, mg/L

Assume: 80% of total biological solids are volatile:
Then, total biological solid concentration = X/0.8 mg/L
Total mixed liquor suspended solids (TMLSS) = X/0.8 + Influent suspended solids (fixed)

2.2) Find sludge mass (lb/d) per 1 MGD of incoming raw wastewater
Sludge mass generated from aerated lagoons = (TMLSS) x (1) x (8.34) lb/d

Step 3: Find the available maximum influent wastewater flow rate that sludge drying beds can receive

Available maximum influent wastewater flow rate = (1,000,000) x (maximum sludge flow that can be generated from aerated lagoons (from step 1), lb/d)/(Sludge mass generated from aerated lagoons per 1 MGD (from step 2), lb/d/MGD)

Approach 2 is believed to be more accurate than approach 1. Population basis generally provides only a rough design calculation. Therefore, the calculated available maximum raw wastewater flow capacity from approach 2 will be selected as a criteria for the capacity assessment of the sludge drying beds.