City of Woodburn Proposed Biosolids Management Strategy

PREPARED FOR: Randy Scott, City of Woodburn
Curtis Stultz, City of Woodburn

PREPARED BY: Jason Smesrud, CH2M HILL
Lynne Chicoine, CH2M HILL

REVIEWED BY: Mark Madison, CH2M HILL
Greg Brubaker, CH2M HILL

COPIES: Dan Brown, City of Woodburn
Dave Green, CH2M HILL

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1. Purpose

The purpose of this document is to evaluate the short-term and long-term alternatives for biosolids management. Information presented will support 2009 operations planning efforts and will be incorporated into the Facility Plan.

2. Background

In 1999, two new Facultative Sludge Lagoons (FSLs) were constructed to stabilize and store wastewater treatment solids prior to land application. During the preliminary design of the existing poplar tree plantation, biosolids production and utilization rates and required land application areas were assessed to project a biosolids balance through 2025 (CH2M HILL, 1998). The preliminary design report described an initial biosolids implementation plan that involved beginning land application to the poplar tree plantation in 2001 and developing additional poplar irrigation area starting in 2004 to maintain a solids balance in the FSLs.

The limiting factor in preventing an excessive accumulation of FSL solids was the installation of the lagoon dredge. Without the dredge, liquid biosolids could not be removed from the FSLs for transfer to the drying beds or to the day tank for spreading in the tree plantation using the hose-reel system. Consequently, the FSLs have been accumulating solids since 1999 and are at capacity in 2008.

After the installation and successful start-up of the lagoon dredge system in February 2009, all facilities are now in place to allow start-up of the biosolids land application program in 2009. Biosolids management alternatives for future planning need to address both the short-term (ST) need to reduce biosolids volumes in the FSLs and the long-term (LT) need to provide a sustainable system for managing future production and seasonal storage of biosolids.

3. Biosolids Storage, Processing, and Land Application Facilities

The current biosolids management system relies upon the FSLs for seasonal storage and the poplar tree irrigation area for seasonal application of liquid biosolids. The major physical components of this system include:

- FSLs for biosolids stabilization and storage
- Dredge for removing biosolids from the FSLs (installed in 2009)
- Day tank for storing biosolids prior to pumping
- Biosolids screening between the day tank and pump station
- Liquid biosolids pump station
- Drying beds for dewatering a portion of produced solids
- Buried pipe distribution system within the 80-acre poplar tree plantation
- Hose reel irrigation machine and tractor for applying liquid biosolids
- Brown Bear-type auger on tractor for turning drying bed solids
- Tractor-pulled honey pot for liquid biosolids application
- Tractor-pulled manure spreader for dewatered solids application
- Knight sludge truck to haul and apply dewatered solids

The discussion below provides additional details of biosolids storage and handling facilities necessary for calculation of ST and LT biosolids management planning. Detailed calculation tables and figures are presented in Appendix A.

3.1 Facultative Sludge Lagoons (FSLs)

The FSLs provide interim storage for anaerobically-digested biosolids. Table 1 summarizes the dimensions for rectangular FSL 2 (North FSL). Both lagoons have equal volume (8.8 MG each; 17.6 MG total) and it is assumed for the calculations that the volume per foot of depth is equivalent for both lagoons.

TABLE 1
FSL Characteristics

Parameter	Value
Bottom Surface Area, each approximate	65,400 square feet (1.5 acres)
Side-slopes	2:1
Bottom Elevation	168 feet
Overflow Pipe Elevation	182 feet
Top of Berm Elevation	184 feet
Design Minimum Water Cap Depth	3 feet
Design Maximum Top of Solids Elevation	179 feet
Design Total Liquid and Solids Accumulation Depth	14 feet
Design Max Solids Accumulation Depth	11 feet
Storage Volume up to Overflow Pipe	8.8 MG each (2 FSLs at 17.6 MG total)

Stage/storage curves for each FSL are provided in Figure A-1 for stored volume and Figure A-2 for stored solids mass with tabular data provided in Table A-1. With an average accumulated solids percentage of 7.2 percent (see Section 4), the total solids mass storage capacity is approximately 3,962,000 pounds (1,981 dT) for one lagoon and 7,924,000 pounds (3,962 dT) for two lagoons. Additional FSL calculations are provided in Table A-2. Using a target maximum solids accumulation level based on maintaining a 3-ft thick water cap plus maintaining the ability to fully drain one FSL periodically, the maximum target accumulation in two lagoons would be 3,971,000 pounds (1,986 dT). Compared to the 7,971,000 pounds (3,986 dT) currently in storage (February 2009), 4,000,000 pounds (2,000 dT) would need to be removed to bring the solids storage down to within the target operational level. Operating within this target level would maintain the average solids accumulation across the two lagoons below an elevation of 173.8 feet (Average 5.2 foot water cap). This would allow the City to maintain the dredge in one lagoon for a period of about 3 to 5 years while the other was being filled and then reverse the filling and draining lagoons, while maintaining both lagoons with no less than the 3-ft design water cap.

3.2 Biosolids Drying Beds

Eight biosolids drying beds are used to dewater biosolids. The beds are equipped with French drains, which recycle flow back to the WWTP. Up to two drying cycles can be performed each year; however, the additional ammonia loading from the recycled drainage may prohibit a second drying cycle during effluent irrigation in July and August. This report assumes one drying cycle will be obtained in the drying beds each summer. Table 2 summarizes the characteristics of the drying beds.

TABLE 2
Sludge Drying Bed Characteristics

Parameter	Value
Number, total	11
Number, available	8
Surface Area	5000 square feet
Depth	1 foot
Influent Solids Concentration	3.4%
Effluent Solids Concentration – Minimum	17% (two drying cycles)
- Maximum	32% (one drying cycle)
Capacity, volume - Each	37,000 gallons
- Total	299,000 gallons
Capacity, mass [a] - Each	10,600 dry pounds (5.3 dT)
- Total	84,900 dry pounds (42 dT)

[a] Mass is based on an influent solids concentration of 3.4 %

In a single drying cycle, approximately 84,900 pounds or 42.5 dry Tons (dT) of air-dried solids can be produced for land application.

4. Biosolids Volume and Characteristics

The quantity and quality of biosolids was assessed for current conditions (2009) and for projected future production rates. These data are used for development of the LT annual solids balance and ST needs for reclaiming storage space within the FSLs.

4.1 2009 Biosolids Characteristics

In February and March 2009, a sampling effort was conducted to characterize the quality and quantity of biosolids accumulated within the FSLs. The lagoon dredge was operated on February 10, 2009 to collect 3 samples of material representative of what will be pumped out of the FSLs. Later, on March 3, 2009, seven samples were collected from the FSLs using a coring device deployed from a boat with samples collected at the approximate mid-depth of solids accumulation within the FSLs. A full suite of nutrient and metals analyses were conducted on the 3 samples in February with supplemental nutrient analyses conducted on the 7 samples from March. Results of these analyses are reported in Tables 3 and 4.

TABLE 3
2009 FSL Sampled Biosolids General Nutrient and Pathogen Characteristics

Parameter	No. of Samples	Value [b]
Total Kjeldahl Nitrogen –TKN	10	49,228 mg/kg (4.9 %)
Ammonia Nitrogen – NH3-N	10	15,645 mg/kg (1.6 %)
Organic Nitrogen – ON [a]	10	33,582 mg/kg (3.4 %)
Nitrate Nitrogen – NO3-N	3	58 mg/kg (0.0058 %)
Total Phosphorous – TP	3	30,343 mg/kg (3.0 %)
Potassium – K	3	3,049 mg/kg (0.3 %)
E. Coli	3	11,944 MPN/g
pH	3	7.0

[a] ON = (TKN) – (NH3-N)

[b] All nutrient concentrations are expressed on a dry weight basis.

Nitrogen content of the biosolids presented in Table 3 is used in following sections for determining the allowable liquid biosolids loading rates. Nitrogen content of drying bed processed biosolids has been estimated (Table A-5) using the beginning and ending TS concentrations of 3.4 and 32 percent over one drying cycle during the summer period and assuming N loss through the drying process was limited to ammonia loss in liquid drained from the biosolids. The estimated ammonia-N is then reduced from 1.6 to 0.17 percent with TKN reduced from 4.9 to 3.5 percent. These concentrations should be verified in 2009 at the completion of the first drying bed processing cycle.

TABLE 4
2009 Biosolids Metals Concentrations

Parameter	No. of Samples	Value (mg/kg)	Concentration Limits for Class B PC Biosolids (mg/kg) per 40 CFR Part 503
Arsenic – As	3	16	41
Cadmium – Cd	3	2.9	39
Chromium – Cr	3	28	-
Copper – Cu	3	465	1500
Lead – Pb	3	39	300
Mercury – Hg	1	2.8	17
Molybdenum – Mo	3	18	-
Nickel – Ni	3	21	420
Selenium – Se	3	10	100
Zinc – Zn	3	1,501	2,800

Based on the analytical data presented in Tables 3 and 4, the FSL biosolids meet the Class B requirements with E. Coli less than 2 Million MPN (Mean Probable Number) per gram of total solids. Total metals concentrations are also well below both the maximum allowable ceiling concentrations and more stringent pollutant concentration (PC) limits for land application.

Previous evaluations have determined that the total volatile solids reduction requirements for vector attraction control have been met with the solids treatment process at Woodburn. However, these calculations should be performed again using current operational data and verified prior to land application in 2009.

4.2 2009 Biosolids Mass/Volume in Storage.

During the February 2009 sampling effort, the total solids (TS) content averaged 3.4 percent for material pumped out of the lagoon using the dredge. This is representative of the solids contents that will be pumped to the biosolids day tank and pump station for liquid biosolids land application and is representative of the solids content of material initially pumped to the drying beds for processing.

During the March 2009 sampling effort, the TS content averaged 7.2 percent for material collected in-place at the approximate mid-depth of solids accumulation within the FSLs. This value was assumed to be representative of the average solids content across the entire solids accumulation depth for use in mass storage estimates.

Depths to the top of solids were also assessed during the March 2009 sampling effort. With an average water cap thickness of 5-ft for the North FSL and 1-ft for the South FSL and total water depth of 14 feet, the resulting solids accumulation depth ranges from 9 to 13 feet. The

South FSL has solids accumulation to about 2 feet above the design maximum level, which was set to maintain a 3-foot water cap. Consequently, the dredge is now installed within the South FSL and this should be the first lagoon to be drawn down in 2009 to, at a minimum, reclaim the design water cap depth.

The mass of solids accumulated in storage was estimated using the geometry of the FSLs, average solids accumulation thickness, and average TS content. Table A-2 details those calculations and is based on the FSL stage/storage rating curves presented in Table A-1 and Figures A-1 and A-2. These calculations estimate a total accumulation of 1,609 dT in the North FSL and 2,376 dT in the South FSL for a total mass of 3,986 dT in storage as of March 2009.

4.3 Projected Biosolids Production and Characteristics

Biosolids production rates were estimated for both actual and allocated industrial scenarios using CH2M HILL's Pro2D process model. A volatile solids content of the digested sludge discharged to the FSLs was assumed to be 71% of total solids based on model results. A 15% volatile solids destruction rate in the lagoon was assumed. It was also assumed that the destruction would take place in the first year of storage and that the solids would be in the lagoon for at least one year. The resulting biosolids production rate out of the FSLs is summarized in Table 5.

TABLE 5
Projected Biosolids Production

Year	Projected Biosolids Production (dT/year)
	Municipal with Actual Industrial Flow
2008	455
2020	585
2030	696
	Municipal with Allocated Industrial Flow
2008	526
2020	657
2030	764

Year by year projections of biosolids production rates are presented in Table A-3 for allocated industrial flows and in Table A-4 for actual industrial flows.

5. Biosolids Land Application Rates

The current Biosolids Management Plan (BMP) was produced in May 2000 and obtained final DEQ approval in May 2001. However, biosolids land application has not yet been conducted under this BMP. As part of the NPDES permit renewal process (current permit expires in November 2009), a new BMP will be required and will need to be brought into compliance with the 2005 DEQ Internal Management Directive (IMD) for Implementing Oregon's Biosolids Program (DEQ, 2005).

Biosolids land application rates are primarily driven by nitrogen (N) management considerations. Agronomic nitrogen utilization rates are set for the crop being grown and plant available nitrogen (PAN) is assessed for the biosolids being applied to determine the mass of biosolids that can be applied per unit land area.

For ST and LT planning purposes, the PAN accounting procedures and agronomic loading rates for poplar tree production were re-evaluated using the recommended references identified within the 2005 DEQ IMD. For PAN accounting procedures, an organic N mineralization decay series approach was used to account for organic N availability as presented in Table A-5. Following procedures of PNW 511 (Cogger and Sullivan, 1999), mineralization rates of organic N were assumed to be 20% in the first year for liquid applied biosolids and 35% in the first year for drying bed processed biosolids. Mineralization of originally applied biosolids in subsequent years was assumed at 8% in year 2, 3% in year 3, and 1% per year in years 4 and 5. Over a 5 year period, it is estimated that 33% of organic N in liquid applied biosolids will be mineralized to PAN and that 48% of drying bed processed biosolids will be mineralized to PAN. Furthermore, availability of ammonia-N was assumed as 95% for liquid applied biosolids and 85% for drying bed processed biosolids with 100% availability of nitrate-N. Using these PAN accounting procedures, PAN is estimated to be 52 lbs PAN/dT of liquid biosolids and 34 lbs PAN/dT of drying bed processed biosolids (Table A-5). This accounts for 53 percent of liquid applied biosolids total N becoming available as PAN And 48 percent of drying bed processed biosolids total N becoming available as PAN over a 5- year period.

Under the approved BMP, it is assumed that 100% of organic and nitrate-N in biosolids becomes plant available in the first year of application and 50% of ammonia-N is available. Some adjustment for ST organic N buildup is also utilized, but is not a significant factor in the calculations over the LT. Using these PAN accounting procedures and the current biosolids quality data, the PAN would be 83 lbs PAN/dT of liquid biosolids (Table A-5), compared to the 52 lbs PAN/dT calculated using the proposed new accounting procedures. The new accounting procedures assume a 37% lower PAN availability and hence would allow a 37% higher biosolids application rate to meet the same target PAN application. Consequently, it would be beneficial to get the new PAN accounting procedures approved prior to biosolids application in 2009, if possible.

Poplar tree agronomic N rates with accounting for understory grass cover effects are presented in Table 6 per recommendations within WDE (1999). Accounting for a 12-year harvest rotation, a plantation averaged agronomic N rate would be 215 lb/ac/yr. With average effluent nitrate-N concentrations of 10 mg/L, the PAN contribution from effluent irrigation is about 65 lbs/ac/yr. The effluent PAN contribution is subtracted from the agronomic N rate to determine the PAN required from biosolids applications.

TABLE 6
Proposed Nitrogen Agronomic Application Rates for the Poplar Tree Plantation

Year of Growth	Total Agronomic N Rate (lb/ac/yr)		
	Trees	Understory	Total
1	50	70 [a]	120
2	120	0	120
3	200	0	200
4	220	0	220
5-12	240	0	240

[a] assumes 70% of the field is covered by a grass cover

The pre-design, design, and BMP for Woodburn were based on a maximum agronomic N rate of 260 lb of PAN. Rates proposed in Table 6 are slightly lower, but are based on the published guidance recommended in the 2005 DEQ IMD.

6. Biosolids Management Solutions

Several independent biosolids management solutions are evaluated below. Most of these are not stand-alone options and require combination of two or more solutions to provide a viable alternative to address both short-term (ST) and long-term (LT) biosolids management needs.

6.1 Solution 1 – Contract dredge, haul, and land application (ST and LT)

With the FSLs full to capacity and annual solids production rates exceeding the land application capacity of City-owned land, one option that draws down solids storage and removes solids from the site is initiating a contract dredge, haul, and land application program. Under this program, an outside contractor would be hired to dredge and haul biosolids off-site for spreading on approved land application sites. Preliminary discussions with Parker Ag Services, a major contract land application contractor in the Western U.S., yielded the following information for use in planning for this management solution:

- An order-of-magnitude unit cost for contract services is $0.10 per gallon pumped from the FSL.
- If land application sites can be identified within 50 miles, liquid biosolids pumped at 3.4 percent solids could be directly hauled at those TS concentrations. More lead time is required to identify sites within 50 miles in the Willamette Valley as opposed to Central and Eastern Oregon sites.
- For land application sites at distances greater than 50 miles, liquid biosolids would be dewatered using a belt filter press, returning liquids to the FSLs. A site in Wasco, OR is available for immediate use under this scenario.

As part of the DEQ approval for this operation, a site approval letter obtained by the contractor would be amended to the BMP to allow hauling to the identified land application sites.

6.2 Solution 2 – Construct additional FSL (ST)

Constructing a third FSL would provide additional biosolids storage capacity. Based on the rate that the existing FSLs were filled, a third lagoon would provide an additional 2-4 years of storage. The cost of an FSL with the same volume as each of the existing lagoons is estimated to be $1.2M.

Constructing the FSL would not provide a solution for the ST biosolids capacity issue as solids would still need to be hauled off site in 2009 until construction of the lagoon could be completed.

In the LT, the additional FSL would forestall hauling biosolids off site or expanding poplar acreage for the purpose of land application for a few years following its completion. However, once the lagoon was filled, the City would still have to dispose of the biosolids stored in the new FSL. Alternatively, the $1.2M cost spent towards contract hauling could remove 1,700 dT of solids from storage, which would empty one of the existing FSLs.

The only potential cost advantage of constructing an additional FSL might be in the ability to finance the capital improvement over time to spread out the contract hauling expenses, which are drawn from annual O&M budgets.

6.3 Solution 3 – Expand biosolids application onto McNulty property (ST and LT)

The City-owned McNulty property lies adjacent to the eastern border of the existing poplar tree plantation and is the first poplar expansion area identified within the Facility Plan recommended alternative. Prior to application of biosolids on this property, a site approval issued by DEQ is required. This involves providing DEQ with a characterization of the site and conducting a neighbor notification process to allow public input. This process takes a minimum of 2 months.

Some biosolids could be utilized on this property in 2009 following the site approval process. Since infrastructure is not currently in place to support liquid biosolids application with the hose-reel system on this property, the City would haul drying bed-processed or liquid biosolids for application. The two upper terrace fields that are most suitable for poplar tree development and biosolids application are currently cropped to winter wheat. Current plans involve harvesting the wheat in Summer 2009 followed by replanting of winter wheat in Fall 2009. Replanting plans will need to be revisited if the fields can be prepared and planted for poplar tree expansion in early 2010. Other potential tree expansion areas on this property are located in the floodplain area where constructed wetlands will be developed. Biosolids application in this area would likely require tillage for incorporation prior to the wet season. Following the wetland delineation and preliminary design of floodplain constructed wetlands, poplar tree irrigation areas can be identified. It is possible that these areas could be cultivated and cropped in 2009 to receive biosolids. Additional discussions with City staff are necessary to develop a detailed cropping and biosolids management plan for this property in preparation for 2009 activities.

6.4 Solution 4 – Develop poplar tree expansion area based on biosolids capacity (LT)

Under this LT solution, poplar tree expansion areas would be sized and developed to provide for on-site utilization of 100 percent of biosolids produced. Because the poplar tree expansion area needed to address July/August ammonia discharge limitations is smaller than if sized for biosolids utilization, a fraction of poplar expansion area would need to be justified solely upon the cost advantage of using an on-site poplar tree biosolids management solution against other potential solutions.

A simple cost benefit comparison of Solutions 1 and 4 was conducted to determine which solution would be most cost-effective. The combined land acquisition and poplar plantation development cost used in the facility planning work is $43,000/acre. On average, each acre of poplar tree plantation has the capacity to utilize 2.9 dT/ac/yr or about 20,335 gallons/ac/yr of liquid biosolids. At a contract hauling rate of $0.10 per gallon, the annual cost of contract hauling the same volume would be $2,036/ac/yr. Considering a 3 percent discount rate, it would take 32 years to pay back the investment in additional poplar tree development on the basis of biosolids management alone. This analysis also ignores the additional O&M cost incurred by the City for Solution 4.

6.5 Solution 5 – Develop poplar tree expansion area based on hydraulic capacity for July and August effluent irrigation (LT)

The recommended plan presented within the facility plan sizes the future poplar tree expansion areas based upon the sizing criteria for July and August effluent irrigation to meet Pudding River ammonia discharge criteria. Using these criteria, land would be developed up to the limits that it could be utilized for both irrigation and biosolids management purposes. The long payback period and need for more up-front capital to utilize Solution 4 drove the decision to utilize Solution 5 for LT planning purposes.

7. Recommended Alternative

The recommended alternative to address both ST and LT needs is a combination of solution 1 (Contract dredge, haul, and land application), solution 3 (Expand biosolids application onto McNulty property), and solution 5 (Develop poplar tree expansion area based on hydraulic capacity for July and August effluent irrigation). This approach is carried out through the Facility Plan recommended alternative for LT planning with ST planning considerations discussed below.

The annual solids balance for the recommended alternative, including estimated annual O&M costs for contract dredge/haul operations is presented in Table A-6 and Figure A-3. The O&M costs presented in Table A-6 are subsequently used for the rate study work within the facility plan. An alternative solids balance for the actual industrial flow alternative is also presented in Table A-7 for comparative purposes.

In planning for contract dredge and haul operations, the first year cost was set to not exceed $250,000 in order to keep the wastewater annual O&M budget within the debt service requirements and to avoid the need for a rate increase in 2009. After 2009, the contract operations were set to draw down the FSLs to within the target maximum solids storage over a 3-year period, after which contract operations would proceed on an annual basis to balance projected shortfalls of biosolids utilization capacity.

Additional activities that need to be completed to enable a successful startup of the biosolids management program in 2009 include:

- Revise the BMP to follow the 2005 DEQ IMD and to add the McNulty property as a new permitted application site. Incorporation of the new PAN accounting procedures will allow higher application rates than approved under the existing BMP.
- In 2008, abnormally high nitrate concentrations were produced during the July/August irrigation period. One possible explanation is that higher ammonia content supernatant from the overfull South FSL is returning to the plant through the recycling process. However, this has not been entirely confirmed with plant operational data. The cause for the 2008 high nitrate concentrations needs to be positively diagnosed and corrected prior to the 2009 irrigation season in order to prevent a reduction in the allowable N loading rates for biosolids in 2009.
- Clear trees out of every third tree row within the poplar coppice MUs to allow access by the hose-reel cart for liquid biosolids application. Consider removing just enough trees leaning into rows to provide cart access, and chipping trees with mobile operation down rows leaving chips on ground. Since these MUs will be harvested and replanted before the 2010 growing season, preparation for the 2009 season should be kept to a minimum.
- Begin transfer of liquid biosolids to the drying beds in early May to allow sufficient time for drainage of liquids back to the WWTP prior to the July/August effluent irrigation season. This will also allow startup and testing of the biosolids pump station
- Request quotes from contractors for a fixed price rate for biosolids dredging and contract hauling for land application to other permitted sites. Initiate hauling as soon as possible.
- Develop a cropping and N management plan for the McNulty property so 2009 biosolids applications can be planned. Initial projections for 2009 are presented in Table A-8 for the poplar tree plantation but projections for the McNulty property need to be developed with consideration of 2009/2010 cropping plans.
- Develop a detailed operational schedule for biosolids handling activities in 2009 considering times to fill and drain day tank, movement of dredge around FSL, movement of hose-reel system in the field, time to load, transfer, and apply drying bed solids to the field, and considering WWTP staff availability and operational schedules, and necessary coordination with contract dredge/haul operators.
- Direct all solids in 2009 to the North FSL and begin drawing down the South FSL in 2009 to begin reclaiming the 3-foot design water cap depth.
- Schedule a meeting with DEQ to review the proposed biosolids management strategy and determine whether an expedited letter approval could be obtained for revising the PAN calculation procedures used within the currently approved BMP, prior to developing and approving a completely new BMP.

8. References

CH2M HILL. 1998. Poplar Tree Effluent and Biosolids Reuse System Preliminary Design Report. City of Woodburn, OR.

CH2M HILL. 2000. Biosolids Reuse Management Plan for the Woodburn WWTP Poplar Plantation. City of Woodburn, OR.

Cogger, C.G. and D.M. Sullivan. 1999. Worksheet for Calculating Biosolids Application Rates in Agriculture, PNW 511 (WSU, OSU, and Univ. of Idaho extension agencies, and USDA).

DEQ. 2005. Implementing Oregon's Biosolids Program. Internal Management Directive, December 2005. Oregon Department of Environmental Quality.

WDE, 1999. Managing Nitrogen from Biosolids. Washington State Department of Ecology Publication 99-508.

Table A-1: Liquid and Solids Volume and Mass Per Foot of Lagoon Depth

Checked by: Greg Brubaker/JAX; 3/30/09

Incremental volume per foot of depth					Cumulative volume per foot of depth			Incremental and cumulative solids per foot of depth						
EL (ft)	Depth (ft)	Incremental volume (cu-ft)	Incremental volume in one lagoon (gal)	Incremental volume in two lagoons (gal)	Cumulative volume from bottom - 1 lagoon (gal)	Cumulative volume from top - 1 lagoon (gal)	Cumulative volume in two lagoons (gal)	Incremental solids per ft - 1 lagoon (lbs)	Cumulative solids per foot from bottom - 1 lagoon (lbs)	Cumulative solids per foot from top - 1 lagoon (lbs)	Incremental solids per ft - 2 lagoons (lbs)	Cumulative solids per foot from bottom - 2 lagoons (lbs)	Cumulative solids per foot from top - 2 lagoons (lbs)	
168	0													
169	1	67,078	501,743	1,003,487	501,743	6,594,480	1,003,487	301,482	301,482	3,962,417	602,964	602,964	7,924,835	
170	2	69,692	521,296	1,042,592	1,023,040	6,092,737	2,046,079	313,231	614,713	3,660,935	626,461	1,229,425	7,321,871	
171	3	72,306	540,849	1,081,698	1,563,888	5,571,441	3,127,777	324,979	939,692	3,347,705	649,958	1,879,384	6,695,410	
172	4	74,919	560,394	1,120,788	2,124,283	5,030,592	4,248,565	336,723	1,276,415	3,022,726	673,447	2,552,830	6,045,451	
173	5	77,533	579,947	1,159,894	2,704,229	4,470,198	5,408,459	348,472	1,624,887	2,686,002	696,944	3,249,774	5,372,005	
174	6	80,147	599,500	1,198,999	3,303,729	3,890,251	6,607,458	360,221	1,985,108	2,337,530	720,441	3,970,215	4,675,061	
175	7	82,761	619,052	1,238,105	3,922,781	3,290,751	7,845,563	371,969	2,357,077	1,977,310	743,938	4,714,154	3,954,619	
176	8	85,374	638,598	1,277,195	4,561,379	2,671,699	9,122,758	383,713	2,740,790	1,605,341	767,427	5,481,580	3,210,681	
177	9	87,988	658,150	1,316,300	5,219,529	2,033,101	10,439,058	395,462	3,136,252	1,221,627	790,924	6,272,504	2,443,254	
178	10	90,602	677,703	1,355,406	5,897,232	1,374,951	11,794,464	407,211	3,543,463	826,165	814,421	7,086,925	1,652,331	
179	11	93,215	697,248	1,394,496	6,594,480	697,248	13,188,960	418,955	3,962,417	418,955	837,909	7,924,835	837,909	
180	12	95,829	716,801	1,433,602	7,311,281		14,622,562	430,703	4,393,121		861,407	8,786,241		water cap
181	13	98,443	736,354	1,472,707	8,047,635		16,095,270	442,452	4,835,573		884,904	9,671,145		water cap
182	14	101,056	755,899	1,511,798	8,803,534		17,607,067	454,196	5,289,769		908,392	10,579,537		water cap

Assumptions:

1. The analysis of volume per foot was performed for the square lagoon (1.51 ac bottom area and 2:1 sideslopes). Calculations were performed using the PondPack software (Bentley Systems) and utilize the Conic Method for Reservoir Volumes. Calculations for total FSL volume assumes the triangular lagoon has equivalent changes in volume with depth.
2. Biosolids within the solids accumulation depths averages 7.2% per Feb 2009 FSL sampling

Table A-2: FSL Characteristics and Design Solids Volumes

Purpose:					Reviewed by: Greg Brubaker/JAX; 3/30/09
Determine safe FSL operating level and volume/mass of sludge to be dredged in 2009					
Assumptions:					
Several Assumptions Based on Design Criteria from B&C Drawings					
Top of lagoon, EL	184	ft	(B&C)		
Max water surface level, EL (i.e. 2 ft of free board)	182	ft			
Design water cap depth	3	ft	(B&C)		
Design max solids blanket level, EL	179	ft			
Bottom elevation of the lagoon, EL	168	ft	(B&C)		
Design max sludge depth	11	ft			
*assume the solids blanket is uniformly distributed					
Solids Concentration in Lagoons					
Settled lagoon solids concentration	**7.2%**		<-Feb 2009 samples collected from mid sludge accumulation depth		
	0.6009	lbs dry solids/gal			
Dredged lagoon solids concentration	**3.4%**		<-Feb 2009 samples collected from dredge set at mid sludge accumulation depth		
	0.2837	lbs dry solids/gal			
Solids Buffer Capacity to Maintain in FSLs Below Design Water Cap					
Annual mass of solids to lagoon including VSR	**1,096,193**	lbs/yr	<-2010 design condition		
Years of buffer capacity to maintain in lagoons	**3.6**	yr	<-optimized to provide 2,000 dT buffer capacity, allowing alternating filling/draining of FSLs		
Mass buffer capacity to maintain in lagoons	4,000,000	lbs	2,000	dT	
	6,657,027	gal	<-Based on settled lagoon solids concentration		
Contract Dredge, Haul, and Land Apply Cost					
Parker Ag services quote for sludge removal, dewatering, hauling and land applications	**$0.10**	per gallon			
March 2009 Sludge Blanket Elevations					
South Lagoon					
Water cap depth	1	ft	<-Feb 2009 depth survey		
Sludge blanket elevation	181	ft			
North Lagoon					
Water cap depth	5	ft	<-Feb 2009 depth survey		
Sludge blanket elevation	177	ft			
Calculations:					
Cumulative solids at design max solids blanket level - 2 FSLs	7,971,020	lbs	3,986	dT	<-Accumulated solids in one FSL in pounds = 383,675 (El in feet) - 64,692,315
Cumulative solids at target max solids blanket level - 2 FSLs	3,971,020	lbs	1,986	dT	
South Lagoon sludge in storage	4,752,860	lbs	2,376	dT	<-Accumulated solids in one FSL in pounds = 383,675 (El in feet) - 64,692,315
North Lagoon sludge in storage	3,218,160	lbs	1,609	dT	<-Accumulated solids in one FSL in pounds = 383,675 (El in feet) - 64,692,315
Total sludge in storage	7,971,020	lbs	3,986	dT	
Mass of sludge to remove to meet target max solids level	4,000,000	lbs	2,000	dT	
	2,000	dT			
Volume of sludge to remove to meet target max solids level	**14,097,234**	gal	<-Based on dredged lagoon solids concentration		
Cost for removal	**$ 1,409,723**				
Target max solids blanket level, EL	**173.8**	ft	<- El in feet = (Accumulated solids in one FSL in pounds + 129,384,630) / 767,350		

Table A-3: 2008-2030 Solids Production (Allocated Industrial Flow Scenario)

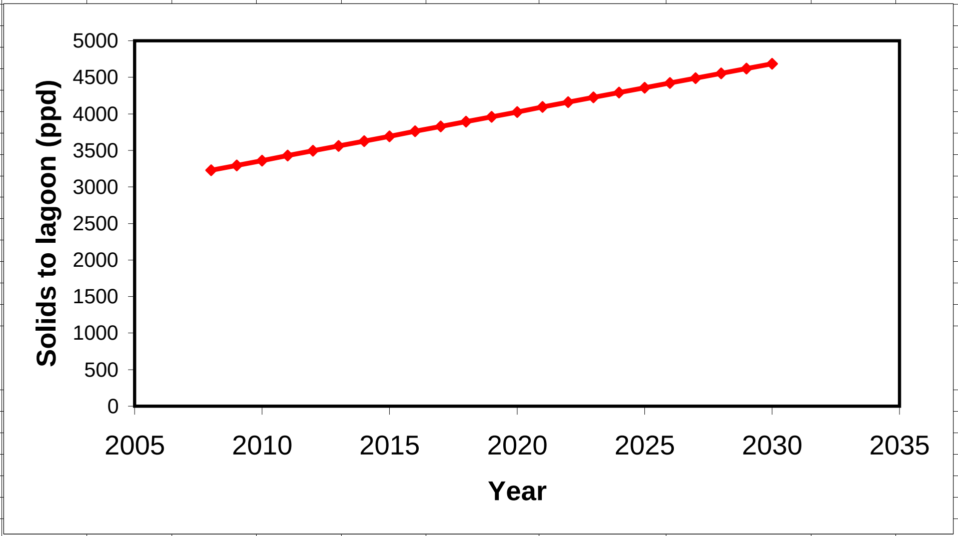
Checked by: Greg Brubaker/JAX; 3/30/09

assuming this number is in pounds of total solids per day	
Pro2D predicts the average volatile solids content to be	71%
assume all the solids stay in the lagoon (i.e. the TSS conc. of the SN is zero)	
The volatile solids reduction in the lagoon is assumed to be	15%

Per the Woodburn CIP Implementation plan_Table 022409 SENT TO CLIENT
Land application of industrial waste starts in 2023

Input solids timeline

Year	Solids to lagoon (lbs/dy TSS)	Solids to lagoon (lbs/yr TSS)	VSS (lbs/yr VSS)	FSS (lbs/yr FSS)	TSS after 1 yr (lbs/yr)	TSS after 1 yr (dT/yr)
2008	3228	1,178,308	836,599	341,709	1,052,818	526
2009	3295	1,202,581	853,832	348,748	1,074,506	537
2010	3361	1,226,853	871,066	355,787	1,096,193	548
2011	3428	1,251,126	888,299	362,826	1,117,881	559
2012	3494	1,275,398	905,533	369,865	1,139,568	570
2013	3561	1,299,671	922,766	376,904	1,161,256	581
2014	3627	1,323,943	940,000	383,943	1,182,943	591
2015	3694	1,348,216	957,233	390,982	1,204,631	602
2016	3760	1,372,488	974,466	398,022	1,226,318	613
2017	3827	1,396,761	991,700	405,061	1,248,006	624
2018	3893	1,421,033	1,008,933	412,100	1,269,693	635
2019	3960	1,445,306	1,026,167	419,139	1,291,380	646
2020	4026	1,469,578	1,043,400	426,178	1,313,068	657
2021	4093	1,493,851	1,060,634	433217	1,334,755	667
2022	4159	1,518,123	1,077,867	440256	1,356,443	678
2023	4226	1,542,396	1,095,101	447295	1,378,130	689
2024	4291	1,566,312	1,112,082	454231	1,399,500	700
2025	4357	1,590,229	1,129,062	461166	1,420,869	710
2026	4422	1,614,145	1,146,043	468102	1,442,239	721
2027	4488	1,638,062	1,163,024	475038	1,463,608	732
2028	4553	1,661,979	1,180,005	481974	1,484,978	742
2029	4619	1,685,895	1,196,986	488910	1,506,348	753
2030	4684	1,709,812	1,213,967	495845	1,527,717	764



Example Calc, conceptually following example 8-15 in Metcalf and Eddy to determine TSS remaining
If the lagoon achieves 35% reduction of volatile solids (per the B&C design data sheet), determine the resulting TSS conc. in the lagoon after a year. Per M&E, the volatile solids destruction will occur within 1 year

The fixed solids (FSS) remain after the year so FSS remaining = FSS (lbs/yr)
The volatile solids remaining = (1-0.15)* VSS (lbs/yr)
The total solids in the lagoon after 1 year = FSS + (1-0.15)*VSS

Table A-4: 2008-2030 Solids Production (Actual Industrial Flow Scenario)

Checked by: Greg Brubaker/JAX; 3/30/09

assuming this number is in pounds of total solids per day

Pro2D predicts the average volatile solids content to be **71%**

assume all the solids stay in the lagoon (i.e. the TSS conc. of the SN is zero)

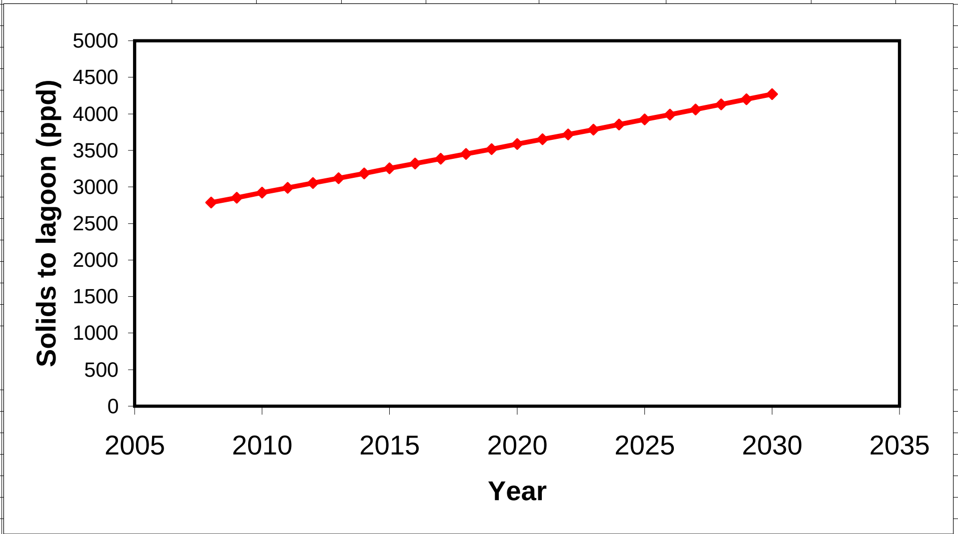
The volatile solids reduction in the lagoon is assumed to be **15%**

Per the Woodburn CIP Implementation plan_Table 022409 SENT TO CLIENT

Land application of industrial waste starts in 2023

Input solids timeline

Year	Solids to lagoon (lbs/dy TSS)	Solids to lagoon (lbs/yr TSS)	VSS (lbs/yr VSS)	FSS (lbs/yr FSS)	TSS after 1 yr (lbs/yr)	TSS after 1 yr (dT/yr)
2008	2787	1,017,412	722,363	295,049	909,058	455
2009	2854	1,041,685	739,596	302,089	930,745	465
2010	2920	1,065,957	756,829	309,128	952,433	476
2011	2987	1,090,230	774,063	316,167	974,120	487
2012	3053	1,114,502	791,296	323,206	995,808	498
2013	3120	1,138,775	808,530	330,245	1,017,495	509
2014	3186	1,163,047	825,763	337,284	1,039,182	520
2015	3253	1,187,320	842,997	344,323	1,060,870	530
2016	3319	1,211,592	860,230	351,362	1,082,557	541
2017	3386	1,235,865	877,464	358,401	1,104,245	552
2018	3452	1,260,137	894,697	365,440	1,125,932	563
2019	3519	1,284,410	911,931	372,479	1,147,620	574
2020	3585	1,308,682	929,164	379,518	1,169,307	585
2021	3652	1,332,955	946,398	386557	1,190,995	595
2022	3718	1,357,227	963,631	393596	1,212,682	606
2023	3785	1,381,500	980,865	400635	1,234,370	617
2024	3854	1,406,654	998,724	407930	1,256,845	628
2025	3923	1,431,809	1,016,584	415224	1,279,321	640
2026	3992	1,456,963	1,034,444	422519	1,301,796	651
2027	4061	1,482,118	1,052,303	429814	1,324,272	662
2028	4130	1,507,272	1,070,163	437109	1,346,748	673
2029	4198	1,532,427	1,088,023	444404	1,369,223	685
2030	4267	1,557,581	1,105,883	451698	1,391,699	696



Example Calc, conceptually following example 8-15 in Metcalf and Eddy to determine TSS remaining
If the lagoon achieves 35% reduction of volatile solids (per the B&C design data sheet), determine the resulting TSS conc. in the lagoon after a year. Per M&E, the volatile solids destruction will occur within 1 year

The fixed solids (FSS) remain after the year so FSS remaining = FSS (lbs/yr)
The volatile solids remaining = (1-0.15)* VSS (lbs/yr)
The total solids in the lagoon after 1 year = FSS + (1-0.15)*VSS

Table A-5: Biosolids PAN Based on Long Term Annual Average Basis

Checked by Greg Brubaker/JAX, 3/30/09

PAN Calculated per DEQ IMD Recommended Procedures

Biosolids Treatment/ Application Method	Parameter	Nutrient Content mg/kg	%	lb/DT Biosolids	ON-PAN Yr 1	ON-PAN Yr 2	ON-PAN Yr 3	ON-PAN Yr 4	ON-PAN Yr 5	Long Term lb/ton PAN	Decay series for organic N (As % of ON ORIGINALLY applied) Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Comment
	TKN	49,228	4.9	98.456												
Lagoon stored - Liquid applied at 3.4% TS	ON	33,583	3.4	67.166	13.4	5.4	2.0	0.7	0.7	22.2	20	8	3	1	1	Worksheet for Calculating Biosolids Application Rates in Agric. (PNW0511e). Assume 2 years storage.
	NH3-N	15,645	1.6	31.29						29.7						Assume 5% volatilization loss for liquid applied solids (WDE, 1999). Low levels suggested for closed forest stands.
	NOx-N	58	0.0058	0.116						0.1						Assume 100% available. PNW0551e
			Total N	**99**					**Total lb PAN/dT**	**52**						
			TS (%)	**3.4**					**% of TN**	**53**						
	TKN	35,245	3.5	70.5												TKN estimated by adjusting for the reduction in NH3-N during dewatering.
Drying bed - surface applied at 32% TS	ON	33,583	3.4	67.166	23.5	5.4	2.0	0.7	0.7	32.2	35	8	3	1	1	Worksheet for Calculating Biosolids Application Rates in Agric. (PNW0511e)
	NH3-N	1,662	0.17	3.3						1.7						NH3-N estimated using the liquid loss fraction in dewatering solids from 3.4 to 32% TS. Assume 15% volatilization loss for dewatered solids (WDE, 1999). Low levels suggested for closed forest stands.
	NOx-N	6	0.00062	0.012						0.0						Assume 100% available. PNW0551e
			Total N	**71**					**Total lb PAN/dT**	**34**						
			TS (%)	**32**					**% of TN**	**48**						

PAN Calculated per Current Approved Biosolids Management Plan

Biosolids Treatment/ Application Method	Parameter	Nutrient Content mg/kg	%	lb/DT Biosolids	ON-PAN Yr 1	ON-PAN Yr 2	ON-PAN Yr 3	ON-PAN Yr 4	ON-PAN Yr 5	Long Term lb/ton PAN	Decay series for organic N (As % of ON ORIGINALLY applied) Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Comment
	TKN	49,228	4.9228	98.456												
Lagoon stored - Liquid applied at 3.4% TS	ON	33,583	3.4	67.166	67.2	0.0	0.0	0.0	0.0	67.2	100	0	0	0	0	100% ON available in first year.
	NH3-N	15,645	1.6	31.29						15.6						Assume 50% volatilization loss.
	NOx-N	58	0.0058	0.116						0.1						Assume 100% available.
			Total N	**99**					**Total lb PAN/dT**	**83**						
			TS (%)	**3.4**					**% of TN**	**84**						

Table A-6: 2009-2030 Annual Solids Mass Balance (Allocated Industrial Flow Scenario)																							
									Checked by: Greg Brubaker/JAX; 3/30/09														
Annual Solids Balance																							
	Units	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Inflows																							
Solids Inflow to FSLs	[dT/yr]	537	548	559	570	581	591	602	613	624	635	646	657	667	678	689	700	710	721	732	742	753	764
Outflows																							
Existing Poplar Tree Plantation	[dT/yr]	212	195	85	134	220	251	269	269	269	269	269	269	269	195	85	134	220	251	269	269	269	269
McNulty Poplar Tree Expansion	[dT/yr]	31	28	40	80	109	123	128	128	128	128	68	40	80	109	123	128	128	128	128	68	40	80
Additional Poplar Tree Expansion	[dT/yr]	0	0	0	0	26	26	65	75	112	112	152	162	180	180	192	138	141	179	189	139	139	179
Contract Dredge/Haul	[dT/yr]	355	1,018	1,018	1,018	226	191	140	142	115	126	157	185	138	194	289	300	222	163	146	267	305	236
Storage																							
Beginning Solids Storage	[dT]	3,986	3,925	3,232	2,648	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986
Ending Solids Storage	[dT]	3,925	3,232	2,648	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986
Design Max Solids Storage	[dT]	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986
Target Max Solids Storage	[dT]	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986
Years of Accumulation in Storage	[yr]	7	6	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Contract Dredge/Haul Volume	[MG/yr]	2.5	7.2	7.2	7.2	1.6	1.3	1.0	1.0	0.8	0.9	1.1	1.3	1.0	1.4	2.0	2.1	1.6	1.1	1.0	1.9	2.2	1.7
Contract Dredge/Haul Cost	[$/yr]	$250,000	$718,000	$718,000	$718,000	$159,000	$135,000	$99,000	$100,000	$81,000	$89,000	$111,000	$131,000	$97,000	$137,000	$204,000	$212,000	$156,000	$115,000	$103,000	$188,000	$215,000	$166,000
Poplar Tree Land Application Management																							
	Units	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Existing Poplar Tree Plantation	*[ac]*	*67.5*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*
1 yr old trees	[ac]		32	48											32	48							
2 yr old trees	[ac]			32	48											32	48						
3 yr old trees	[ac]	20.0			32	48											32	48					
4 yr old trees	[ac]					32	48											32	48				
5-12 yr old trees	[ac]	47.5	48				32	80	80	80	80	80	80	80	48				32	80	80	80	80
Biosolids Loading Capacity	**[dT/yr]**	**212**	**195**	**85**	**134**	**220**	**251**	**269**	**269**	**269**	**269**	**269**	**269**	**269**	**195**	**85**	**134**	**220**	**251**	**269**	**269**	**269**	**269**
McNulty Poplar Tree Expansion	*[ac]*	*12*	*26*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*
1 yr old trees	[ac]		26	12								26	12								26	12	
2 yr old trees	[ac]			26	12								26	12								26	12
3 yr old trees	[ac]	12			26	12								26	12								26
4 yr old trees	[ac]					26	12								26	12							
5-12 yr old trees	[ac]						26	38	38	38	38	12	0	0	0	26	38	38	38	38	12	0	0
Biosolids Loading Capacity	**[dT/yr]**	**31**	**28**	**40**	**80**	**109**	**123**	**128**	**128**	**128**	**128**	**68**	**40**	**80**	**109**	**123**	**128**	**128**	**128**	**128**	**68**	**40**	**80**
Additional Poplar Tree Expansion	*[ac]*	*0*	*0*	*0*	*0*	*25*	*25*	*25*	*25*	*51*	*51*	*51*	*51*	*59*	*59*	*59*	*59*	*59*	*59*	*59*	*59*	*59*	*59*
1 yr old trees	[ac]					25				26				8			25				26		
2 yr old trees	[ac]						25				26				8			25				26	
3 yr old trees	[ac]							25				26				8			25				26
4 yr old trees	[ac]								25				26				8			25			
5-12 yr old trees	[ac]									25	25	25	25	51	51	51	26	34	34	34	33	33	33
Biosolids Loading Capacity	**[dT/yr]**	**0**	**0**	**0**	**0**	**26**	**26**	**65**	**75**	**112**	**112**	**152**	**162**	**180**	**180**	**192**	**138**	**141**	**179**	**189**	**139**	**139**	**179**
		80	112	124	124	149	149	149	149	175	175	175	175	183	183	183	183	183	183	183	183	183	183
Loading Rate Assumptions																							
	Agronomic PAN Rate (lb/ac/yr)	Agronomic Biosolids Loading Rate (dT/ac/yr)																					
1 yr old trees	120	1.1																					
2 yr old trees	120	1.1																					
3 yr old trees	200	2.6																					
4 yr old trees	220	3.0																					
5-12 yr old trees	240	3.37																					
Average Biosolids PAN Content	[lbs/dT]	52																					
Effluent PAN Contribution	[lbs/ac/yr]	65																					

Table A-7: 2009-2030 Annual Solids Mass Balance (Actual Industrial Flow Scenario)

Checked by: Greg Brubaker/JAX; 3/30/09

Annual Solids Balance

	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Inflows																							
Solids Inflow to FSLs	[dT/yr]	465	476	487	498	509	520	530	541	552	563	574	585	595	606	617	628	640	651	662	673	685	696
Outflows																							
Existing Poplar Tree Plantation	[dT/yr]	212	195	85	134	220	251	269	269	269	269	269	269	269	195	85	134	220	251	269	269	269	269
McNulty Poplar Tree Expansion	[dT/yr]	31	28	40	80	109	123	128	128	128	128	68	40	80	109	123	128	128	128	128	68	40	80
Additional Poplar Tree Expansion	[dT/yr]	0	0	0	0	0	0	0	0	0	0	0	0	48	48	117	134	198	198	266	283	300	300
Contract Dredge/Haul	[dT/yr]	355	922	922	922	180	146	133	144	155	166	237	275	198	255	396	129	94	74	0	53	76	47
Storage																							
Beginning Solids Storage	[dT]	3,986	3,853	3,184	2,624	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,883	1,986	1,986	1,986	1,985	1,986	1,986
Ending Solids Storage	[dT]	3,853	3,184	2,624	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,883	1,986	1,986	1,986	1,985	1,986	1,986	1,986
Design Max Solids Storage	[dT]	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986	3,986
Target Max Solids Storage	[dT]	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986	1,986
Years of Accumulation in Storage	[yr]	8	7	5	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3
Contract Dredge/Haul Volume	[MG/yr]	2.5	6.5	6.5	6.5	1.3	1.0	0.9	1.0	1.1	1.2	1.7	1.9	1.4	1.8	2.8	0.9	0.7	0.5	0.0	0.4	0.5	0.3
Contract Dredge/Haul Cost	[$/yr]	$250,000	$650,000	$650,000	$650,000	$127,000	$103,000	$94,000	$102,000	$109,000	$117,000	$167,000	$194,000	$140,000	$180,000	$279,000	$91,000	$66,000	$52,000	$0	$37,000	$53,000	$33,000

Poplar Tree Land Application Management

	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing Poplar Tree Plantation	*[ac]*	*67.5*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*	*80*
1 yr old trees	[ac]		32	48											32	48							
2 yr old trees	[ac]			32	48											32	48						
3 yr old trees	[ac]	20.0			32	48											32	48					
4 yr old trees	[ac]					32	48											32	48				
5-12 yr old trees	[ac]	47.5	48				32	80	80	80	80	80	80	80	48				32	80	80	80	80
Biosolids Loading Capacity	**[dT/yr]**	**212**	**195**	**85**	**134**	**220**	**251**	**269**	**269**	**269**	**269**	**269**	**269**	**269**	**195**	**85**	**134**	**220**	**251**	**269**	**269**	**269**	**269**
McNulty Poplar Tree Expansion	*[ac]*	*12*	*26*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*	*38*
1 yr old trees	[ac]		26	12								26	12								26	12	
2 yr old trees	[ac]			26	12								26	12								26	12
3 yr old trees	[ac]	12			26	12								26	12								26
4 yr old trees	[ac]					26	12								26	12							
5-12 yr old trees	[ac]						26	38	38	38	38	12	0	0	0	26	38	38	38	38	12	0	0
Biosolids Loading Capacity	**[dT/yr]**	**31**	**28**	**40**	**80**	**109**	**123**	**128**	**128**	**128**	**128**	**68**	**40**	**80**	**109**	**123**	**128**	**128**	**128**	**128**	**68**	**40**	**80**
Additional Poplar Tree Expansion	*[ac]*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*45*	*45*	*45*	*45*	*89*	*89*	*89*	*89*	*89*	*89*
1 yr old trees	[ac]													45				44					
2 yr old trees	[ac]														45				44				
3 yr old trees	[ac]															45				44			
4 yr old trees	[ac]																45				44		
5-12 yr old trees	[ac]																	45	45	45	45	89	89
Biosolids Loading Capacity	**[dT/yr]**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**48**	**48**	**117**	**134**	**198**	**198**	**266**	**283**	**300**	**300**

Loading Rate Assumptions

	Agronomic PAN Rate (lb/ac/yr)	Agronomic Biosolids Loading Rate (dT/ac/yr)
1 yr old trees	120	1.1
2 yr old trees	120	1.1
3 yr old trees	200	2.6
4 yr old trees	220	3.0
5-12 yr old trees	240	3.4
Average Biosolids PAN Content	[lbs/dT]	52
Effluent PAN Contribution	[lbs/ac/yr]	65

Table A-8: 2009-2030 Annual Solids Mass Balance (Allocated Industrial Flow Scenario)

checked by: Greg Brubaker/JAX, 3/30/09

Liquid Application

	MUs 1, 2, 4, 5, 8, 9, 10	MUs 3, 6, 7	Totals	
Allowable PAN Loading Rate	**240**	**200**		lbs PAN/ac
Effluent PAN Contribution	65	66		lbs PAN/ac
Allowable Biosolids PAN Loading	175	134		lbs PAN/ac
Biosolids PAN Content	**52**	**52**		lbs PAN/dT
Biosolids Mass Loading Rate	3.4	2.6		dT/ac
Percent Solids	**3.4**	**3.4**		%
Biosolids Volumetric Loading Rate	23,753	18,188		gal/ac
Equivalent Irrigation Depth	0.9	0.7		in
Available Land in 2009	**47.5**	**20.0**	**67.5**	**ac**
Total Mass Loading in 2008	160	52	**211**	**dT**
	319,673	103,064	**422,737**	**lbs**
Total Volumetric Loading in 2009	1.1	0.4	**1.5**	**MG**
Notes	Planted 1999 - 11th year trees	Harvested early 2007 - 3rd year coppice		

Drying Bed Solids Application

	Upper Terrace Fields	Totals	
Allowable PAN Loading Rate	**75**		lbs PAN/ac
Effluent PAN Contribution	**0**		lbs PAN/ac
Allowable Biosolids PAN Loading	75		lbs PAN/ac
Biosolids PAN Content	**34**		lbs PAN/dT
Biosolids Mass Loading Rate	2.2		dT/ac
Percent Solids	**3.4**		%
Biosolids Volumetric Loading Rate	15,610		gal/ac
Equivalent Irrigation Depth	0.6		in
Available Land in 2009	**20.0**	**20.0**	**ac**
Total Mass Loading in 2008	44	**44**	**dT**
	88,458	**88,458**	**lbs**
Total Volumetric Loading in 2009	0.312	**0.312**	**MG**
Notes	Allowable PAN reduced to 75 lb/ac/yr to spread the 42 dT of drying bed processed material available in 2009 over the 20 acres of terrace fields. Application will be subject to development of a cropping plan for 2009/2010.		