PREPARED FOR: Western Wake Partners

FROM: CDM/Hazen and Sawyer

PREPARED BY: Richard Tsang, Katya Bilyk

DATE: July 22, 2005

SUBJECT: Western Wake Regional Wastewater Management Facilities
Western Wake Water Reclamation Facility
PER Technical Memorandum No. 16 – Waste Activated Sludge Pumping/Thickening Facilities

INTRODUCTION

This technical memorandum (TM) is one in a series of TMs being prepared for the Preliminary Engineering Report for the Western Wake Regional Wastewater Management Facilities project. The purpose of this TM is to present the preliminary engineering information and data for the waste activated sludge (WAS) pumping and thickening facilities.

Sludge wasting from the secondary clarifiers and thickening are part of the solids processing strategy developed for the Western Wake Water Reclamation Facility. A summary of the strategy, shown on Figure 16-1, is as follows:

1. Collect settled solids from the secondary clarifiers at the WAS/RAS pump station
2. Pump WAS to the Thickening/Dewatering Building,
3. Thicken WAS with gravity belt thickeners (GBTs),
4. After thickening, hold solids under aerobic conditions,
5. Dewater the solids with centrifuges, and
6. Transport dewatered solids to private composting facility, Cary dryer, or landfill.

PROCESS REQUIREMENTS

The basis of design for the WAS pumping and thickening facilities are the projected maximum month and annual average day flows and loads determined by solids mass balance. The quantities in the mass balance were derived from a wastewater treatment plant model. The model is given influent wastewater quality parameters such as biochemical oxygen demand (BOD), total suspended solids, nitrogen, and phosphorus, as well as required effluent standards. The purpose of the model is to simulate various treatment processes to identify the preferred method of treatment and size the associated basins to meet the effluent limits. The model will also predict the amount of solids generated at the plant based on assumptions regarding BOD removed, reaction kinetics, and yield. The mass balance is shown in Table 16-1, and Figure 16-2 illustrates the critical points along the process flow diagram that correspond to where these quantities are generated.

TABLE 16-1
SOLIDS MASS BALANCE

		Maximum Month Condition		Average Day Condition		
Description	**Percent Solids**	**lb/d**	**gal/d**	**lb/d**	**gal/d**	**Process Step on Figure 16-1**
WAS	0.8	37,500	562,000	31,600	474,000	1
TWAS (GBT discharge)	3.0	35,600	142,000	30,020	120,000	3
Aerated Solids Effluent	2.3	27,600	144,000	23,300	121,000	
Cake (centrifuge discharge)	20.0	26,200	-	22,100	-	6
Filtrate from GBTs	-	1,900	420,000	1,600	354,000	2
Centrate from Centrifuges	-	1,400	127,000	1,200	107,000	5

Assumptions:
95% solids capture on GBT
95% solids recovery in centrifuge
VSS/TSS ratio is 0.75
40% VSS destruction in aeration holding tanks

The processes discussed in this memorandum are as follows:

1. WAS pumping (Process Step 1),
2. Filtrate from the GBTs, (Process Step 2),
3. Centrate from the centrifuges (Process Step 5), and
4. Thickened waste activated sludge (TWAS) going into the aerobic holding tank (Process Step 3).

The aerated holding tanks, Process Step 4, are discussed in TM 17, and centrifuge dewatering, Process Step 6, is discussed in TM 18.

Equipment was sized to efficiently process both the maximum month and average day sludge quantities.

OPERATING STRATEGY

The recommended operating strategy is to thicken and dewater one day's worth of sludge expected at maximum month flow conditions while operating the equipment up to sixteen hours a day seven days a week. Two 3-meter (m) GBTs are required to process all of the WAS generated in one day during one 16-hour shift. If one unit is out of service the functioning unit will operate longer than sixteen hours to thicken all of the WAS. Space has been reserved in the building floor plan to add a third 3-m GBT in the future.

WAS PUMPS

The WAS pumps will serve as GBT feed pumps. A total of six WAS pumps (3 duty, 3 standby) are recommended with one dedicated duty and standby pump per clarifier. The pumps will be located in the return activated sludge (RAS)/WAS pump station structure, which was described in TM 12 Secondary Clarifiers/RAS Pumping Facilities.

The WAS influent to the GBTs is assumed to contain 0.8 percent solids. Based on the maximum month flow of 18 million gallons per day (mgd), approximately 562,000 gallons per day (gpd) of WAS can be expected. WAS pumps will feed the GBTs directly, as no intermediate wet well storage of WAS is planned.

The WAS pumps should be centrifugal, non-clogging, submersible solids handling pumps. The WAS pumps should have a variable frequency drive to allow for variable operation of the GBTs.

Each pump should be sized to load each GBT at a rate between 300 and 800 gallons per minute (gpm) with a design point of 500 gpm at 100 feet of total dynamic head (TDH). The TDH condition will be confirmed during detailed design.

GBTs

GBTs convey sludge on a porous horizontal belt that allows excess water to separate itself from the sludge by dropping into a catch basin below the belt. Sludge is typically mixed with polymer just before the belt and retained in a flocculation tank for 20 to 40 seconds under design conditions. The flocculated sludge is then discharged uniformly onto the belt (covering the entire surface) and advanced to the end of the belt using a system of rollers to guide the belt. Most of the water that will be removed drains away from the sludge as soon as the sludge drops onto the belt. To encourage additional drainage most GBTs are equipped with artificial flow impediments (like stationary rakes above the newly formed mat of sludge) that require sludge to flow around them in order to get from one side of the belt to the other. These impediments create lanes or channels in the sludge mat and offer an additional method of water release. At the discharge side of the belt the sludge drops into a hopper to be conveyed to the aerobic holding tanks. A belt wash system is also included to clean the belt as it returns to the influent side of the equipment via the roller/conveyer.

Gravity belt thickening is recommended because it is a low-energy process that reduces the volume of sludge at the facility. Three- to five-fold reductions in volume are common as long as polymer is used and the thickening equipment is operating within its design parameters.

Two 3-m GBTs are recommended in order to thicken all of the WAS daily in one 16-hour shift operating seven days a week. This sizing assumes the WAS influent to the GBTs contains 0.8 percent solids and that each GBT is loaded at 500 gpm, which results in a loading rate of 167 gpm per meter of press (gpm/m). Typically loading rates of less than or equal to 200 gpm/m are recommended. Note that although WAS pumps that can pump up to 800 gpm each (267 gpm/m) to match the hydraulic capacity of the belts are specified, operating the GBTs at that loading rate is not recommended.

Assuming the WAS is thickened to 3 percent solids, the filtrate volume will be approximately 420,000 gpd at maximum month conditions. Similarly, the volume of TWAS produced would be approximately 140,000 gpd at maximum month conditions.

TWAS PUMPS

Once the WAS is thickened it will drop into a tapered-bottom hopper on the discharge side of each GBT. Both of the hoppers will be sized to hold approximately 1,100-gallons (10 ft x 5 ft x 6 ft, length, width, and height, respectively). Each hopper will be mounted directly on top of an open throat progressive cavity pump. The discharge hopper arrangement will be similar to the arrangement at South Cary, shown on Figure 16-3. There will be three pumps total including one spare pump that will be provided but not installed. Each pump will be sized to convey TWAS at a pumping rate between 30 and 125 gpm. Therefore, the minimum hydraulic retention time in the hoppers is
expected to be nine minutes. The pumps will convey the TWAS to the aerobic holding tanks.

POLYMER SYSTEM

A polymer system is also recommended to aid in the coagulation of solids on the GBTs. It is recommended that a three-tank system – one liquid bulk tank and two makeup tanks be installed to store, prepare, age, and deliver polymer to the GBTs. Totes (286 gallon) of emulsion polymer were considered for this application to be consistent with practices at the North and South Cary Water Reclamation Facilities. However, one tote was estimated to last only 4 days at the maximum month capacity of 18 mgd assuming a conservative dose of 15 pounds of polymer per dry ton of solids. A bulk tank is recommended to reduce the amount of operator attention that the tote polymer system would require.

Figure 16-3 Discharge hopper arrangement on discharge side of GBTs.

Bulk tanks are typically sized to hold 30 days worth of polymer. Based on the maximum month flow, the estimated required size of the bulk tank is 2,000 gallons. Truckload deliveries of polymer are available in volumes 1,500 gallon and greater. The tank would be located near an external wall such that deliveries can be made by having a truck pull up close to the Thickening/Dewatering Building and fill the tank using an external hard-piped connection to the tank. A 5,000-gallon bulk tank is recommended to allow a large factor of safety when scheduling deliveries of polymer and also remain above the 1,500-gallon minimum truckload delivery size.

Makeup tanks are also recommended. These tanks will cycle back and forth, each preparing one batch of polymer for the GBTs while the other is used as the feed source to the GBTs. A progressive cavity polymer transfer pump is recommended to transfer bulk polymer from the bulk tank to the makeup tanks. A rotameter will tie-into the bulk polymer piping to simultaneously mix the polymer with water from the potable water system, dilute the polymer, and fill the makeup tank. The makeup tank will dilute the emulsion polymer to a concentration of approximately 0.5 to 1 percent polymer by volume.

After a batch of polymer is prepared in the makeup tank, the effluent from the tank is further diluted with water to the appropriate concentration (typically 0.1 to 0.6 percent polymer by volume). Diluting the polymer to this range of concentrations will allow the polymer to properly unwind and function as designed. The dilution process is a two-step process in order to minimize the tank volume needed for the makeup tanks.

The recommended mix tank size, 1,500 gal. prepares enough polymer for one hour of belt run time at the maximum belt speed of 800 gpm per GBT. Having two tanks allows for 24-hour operation as there is no waiting for polymer to batch and/or disruption of the belts. The GBTs were sized for the maximum monthly flow. Therefore, if the plant were to expand in the future the polymer makeup and delivery system may need to be expanded, or the GBTs could be run more than 16 hours a day instead. The need to expand the polymer system will also depend on the optimal polymer dose, i.e. the lower the dosage the more likely it is that the existing polymer system can provide enough sludge for another 3-m GBT, which will be determined when the plant is operational.

Figure 16-4 Gravity discharge of GBT filtrate.

Three progressive cavity pumps with variable speed output are recommended to pump the polymer to the GBTs. Each GBT will have a dedicated pump and the third pump will be manifolded to the others as a backup unit. The output speeds of the pumps are estimated to be between 3 and 8 gpm. One progressive cavity pump is also needed to transfer polymer from the bulk tank to the makeup tanks. Space has been provided for a future fourth polymer feed pump.

FILTRATE AND CENTRATE HANDLING

Filtrate and centrate from the GBTs and centrifuges, respectively, will drain by gravity to a filtrate/centrate storage tank, which will be used to equalize the return of this sidestream into the aeration basins over 24 hours. Sidestream treatment is not necessary to meet the anticipated permit limits of 6 mg/L total nitrogen and 2 mg/L of total phosphorus and can be deferred until effluent limits are reduced to 3.5 mg/L of total nitrogen and 0.5 mg/L of total phosphorus. An illustration of the discharge line from the GBTs at the South Cary facility is shown on Figure 16-4. The equalization tank will be at a lower elevation than the first floor of the Thickening/Dewatering Building to facilitate gravity flow. The nutrient content of this sidestream is described in TM 20. A pair (one duty, one standby) of submersible pumps will transfer the liquid to the aeration basins.

The worst-case sidestream flow from the GBTs is approximately 1,500 gpm, assuming 0.8 percent solids are thickened to 6 percent solids. However the average design flow is approximately 800 gpm, assuming 0.8 percent solids are thickened to 4 percent solids. Similarly, the worst-case flow from the centrifuge is 135 gpm, assuming an influent of 2.0 percent solids is dewatered to 20 percent cake and the solids loading rate is 150 gpm. However the average design flow from the centrifuge is approximately 100 gpm, assuming an influent of 3.1 percent solids is dewatered to 20 percent solids and the solids loading rate is 120 gpm. Thus, the total centrate and filtrate flows anticipated are 1,020 gpm, but provisions for flows as high as 1,640 gpm should be made. Table 16-2 summarizes these conditions. In addition, estimated belt washwater and flushing water quantities for the GBTs and centrifuges, respectively, have been included. Other flows that might be routed to this pump station such as drainage for the perimeter of the building have also been considered.

TABLE 16-2
FLOWS TO FILTRATE AND CENTRATE WASTEWATER PUMP STATION

	Condition	
	Maximum Month[1]	**Worst-Case[2]**
Constant Flows during Thickening/Dewatering		
Filtrate Flow (gpm)	800	1,385
Centrate Flow (gpm)	100	135
Belt Washwater (gpm)	120	120
Subtotal (gpm)	**1,020**	**1,640**
Intermittent Flows		
Flushing Water (gpm)[3]	300	300
Drainage (gpm)[4]	200	200
Total (gpm)	**1,520**	**2,140**

1 GBTs and centrifuges operating at 500 gpm/GBT and 120 gpm/centrifuge.
2 GBTs and centrifuges operating at 800 gpm/GBT and 150 gpm/centrifuge.
3 Estimated to be 300 gpm for 30 minutes a day to clean centrifuges.
4 Assumed to occur for 30 minutes a day as a result of hose washdown of the solids processing area below GBTs.

The recommended centrate/filtrate storage tank size is approximately 650,000 gallons. This volume will be sufficient to handle the worst-case sidestream quantities described in Table 16-2 assuming that the storage tank discharge rate to the aeration basins is constant over 24 hours. Not discharging sidestreams into the aeration basins for an extended period of time will require a larger storage tank. The estimates of sidestream flows to the aeration basins and the required storage volume under worst-case and maximum month conditions are shown in Table 16-3.

TABLE 16-3
SIDESTREAM FLOW TO AERATION BASINS

Flow to Filtrate and Centrate Storage Tank (gpm)	Intermittent Flows (gal)	Daily Volume Generated (gal)	Equalized Discharge Rate to Aeration Basins (gpm)*	Required Storage Volume (gal)
1,020	15,000	996,000	690	333,000
1,640	15,000	1,589,000	1,100	533,000

*Daily volume generated divided by 24 hours per day and 60 minutes per hour.

Ancillary Equipment

There are several additional items that will be housed in the Thickening/Dewatering Building that relate to the GBTs. These items include but are not limited to the following:

1. Booster pump for water pressure
2. Monorail in GBT processing area
3. Odor control provisions for GBT processing area and Polymer Room

Summary

Table 16-4 provides a summary of all the equipment recommended for solids thickening.

ALTERNATIVES EVALUATION

A modifications that may be considered to increase flexibility for maintenance purposes is adding intermediate storage between the WAS pump station and the GBTs and feeding the GBTs from this tank.

TABLE 16-4
THICKENING EQUIPMENT LIST

WAS Pumps	
Number	6 (3 standby)
Type	centrifugal, solids handling
Capacity per Unit (gpm)	300 - 800
hp	30
Sludge Thickening	
Type:	Gravity Belt Thickener
Belt Width, (meters)	3
Quantity	2
Design Hydraulic Loading Rate (gpm)	500
Feed Sludge Concent. (mg/l)	8000
Operating Schedule (hr/day)	8
Processing Rate (dry lb/day)	37,500
Thickened Sludge Conc. (%)	3
Thickened Waste Sludge/Digester Feed Pumping	
Number	3 (1 uninstalled spare)
Type	Progressive Cavity/VFD
Capacity per Unit (gpm)	30 - 125
hp	10
Centrate/Filtrate Transfer Pumping	
Number	2 (1 standby)
Type	Vert. Non-Clog/VFD
Capacity per Unit (gpm)	400-1200
hp	60
Thickening Polymer System	
Type	Liquid emulsion
Quantity of Bulk Tanks	1
Quantity of Mixing Tanks	2
Days of storage in bulk tank	30
Hydraulic residence time, mixing tanks (hr)	1
Volume of bulk tank, gal	5000
Volume of mixing tank, gal	1500
Activity	40%
Specific gravity of polymer	1.3
Dosing range (lb polymer/dT solids)	6 - 15
Polymer concentration Leaving Mixing Tank (v/v, %)	0.69%

Thickening Polymer Feed Pumps

Type	Progressive cavity
Quantity	3 (1 standby)
Capacity, gpm	3 to 8
Horsepower	2

Thickening Post-Dilution Stand

Dilution rate, gpm	3 to 13
Polymer concentration to GBTs (v/v, %)	0.50%

PROPOSED FACILITIES

Overview

The proposed layout for the Thickening/Dewatering Building is shown on Figure 16-5. The Thickening/Dewatering Building will contain the following key functions:

1. Solids thickening area
2. Centrifuge dewatering area
3. Polymer preparation and storage area
4. Control room
5. Electrical room
6. Blower room
7. Monorail for thickening area
8. Bridge crane for dewatering area

The building will be two-storied with most of the equipment located on the first floor. The second floor will house the centrifuges, centrifuge polymer feed facilities, and a control room. The centrifuge area will be structurally supported with columns but will not have an enclosed first floor below it. Instead, there will be drive-through access for a truck below the centrifuges so cake from the centrifuges can be loaded and hauled away for disposal.

The Electrical Room will provide power to all of the solids processing equipment from one central location. The electrical design criteria are discussed further in the Electrical Requirements section. The blower room will contain four aeration blowers for the aerobic holding tanks, three of which are operational and one will be a standby unit for redundancy.

Features

The following design features are incorporated to facilitate productive operation and easy maintenance.

1. Seven removable wall/floor panels, also known as knockout walls or Kal Walls, will be provided to accommodate the removal of a centrifuge scroll, or polymer bulk or makeup tank.
2. One twenty-foot rollup door will be provided to accommodate the removal of a GBT component.
3. The second story control room with windows juts out into the thickening area such that an operator can simultaneously observe centrifuge operation and GBT operation from the second floor.
4. Centrifuge scrolls can be hoisted from the second floor to ground level floor using a removable panel in the floor of the dewatering area and a bridge crane.
5. A monorail will be included in the thickening processing area to lift and move GBT components.
6. The polymer processing areas will be separated from the rest of the building by walls to allow for better climate control. Humid conditions are to be avoided with polymer to prevent hydrolization.

A cost estimate for this building is included at the end of this section.

INSTRUMENTATIONS AND CONTROLS

Controls for the GBTs and WAS pumps will be by a programmable logic controller (PLC) in the Thickening/Dewatering Building in the solids thickening area. A touch screen monitor will be the user interface. The second story control room will also have the ability to operate the GBTs and WAS pumps. In order to transfer control from one location to another, the operator will need to enter a password. The default operations center for thickening will be in the solids thickening area.

ESTIMATED CAPITAL COSTS

The estimated capital costs for Thickening operations and the Thickening/Dewatering Building are shown in Table 16-5. These costs include the structural components for the Thickening/Dewatering

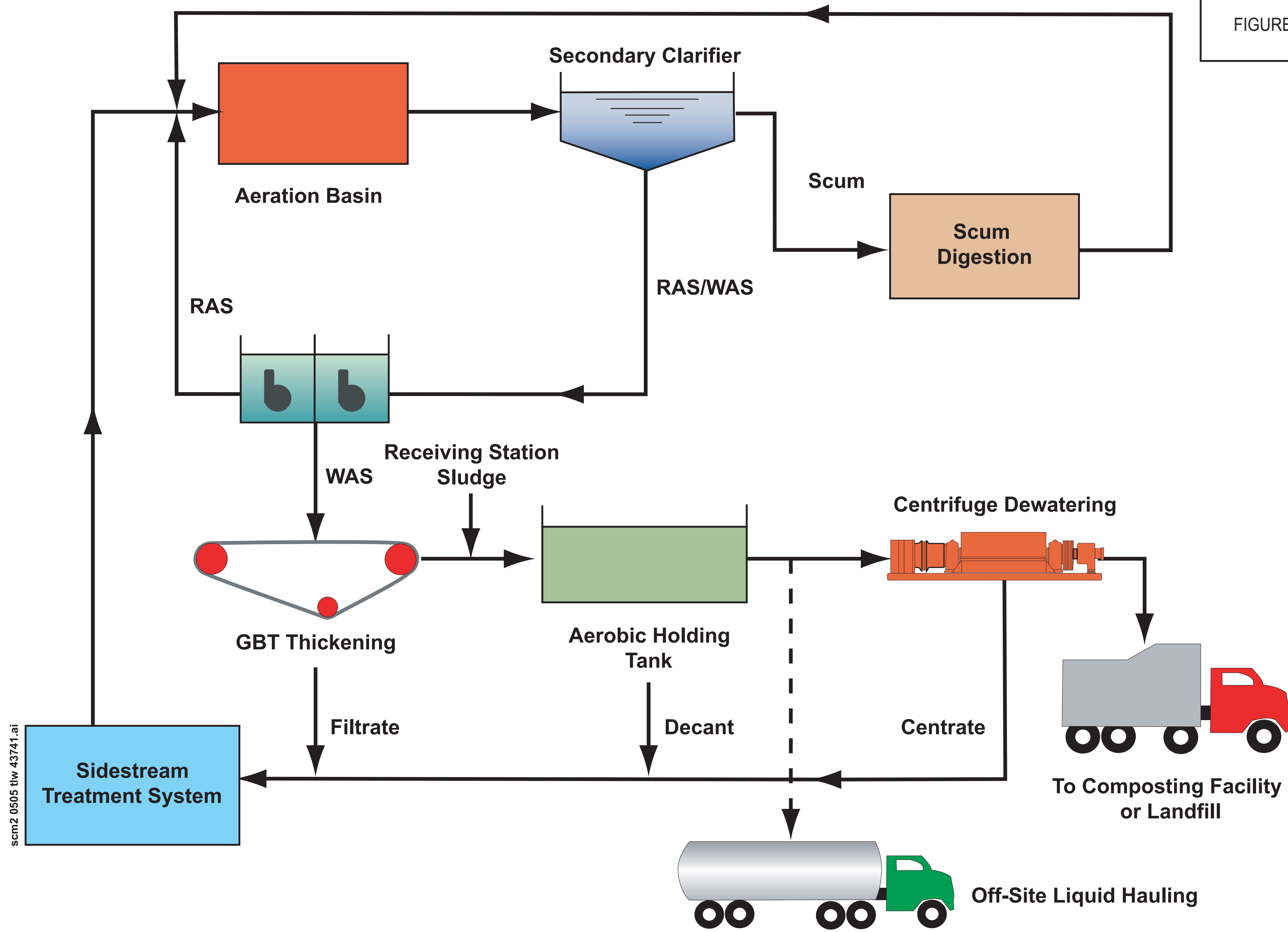
Building as well as the mechanical and instrumentation costs associated with Thickening. The mechanical and instrumentation costs associated with Dewatering are presented in TM 18. These costs are expressed without contingencies, engineering and construction administration, and legal and financial fees and are referred to as the base cost. Therefore, the base cost for Thickening operations is $3,622,300. An itemized list of these expenses is shown in Table 16-5.

Operations and maintenance costs are presently being developed.

TABLE 16-5
PRELIMINARY COST ESTIMATE

Building	$	1,800,000
GBTs	$	320,000
TWAS Pumps	$	54,000
Piping	$	18,000
Hopper	$	15,000
Monorail	$	15,000
GBT Equipment Installation	$	250,000
Polymer System	$	131,000
Instrumentation	$	130,000
Electrical	$	889,300
Subtotal	***$***	***3,622,300***
Construction Contingencies	$	523,800
Engineering and Construction Services	$	401,600
Legal and Financial	$	220,900
Total Construction Cost	**$**	**4,638,600**

FIGURE 16-1



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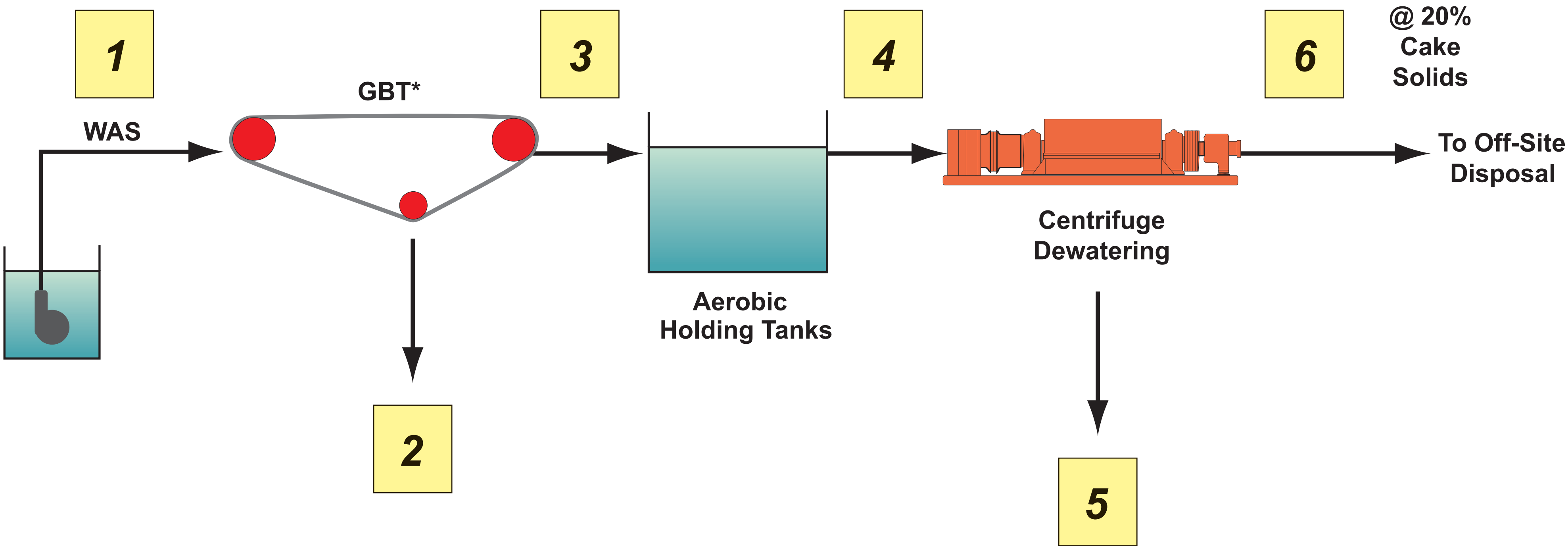
WESTERN WAKE REGIONAL WASTEWATER MANAGEMENT FACILITIES

SOLIDS PROCESS FLOW DIAGRAM

FIGURE 16-2



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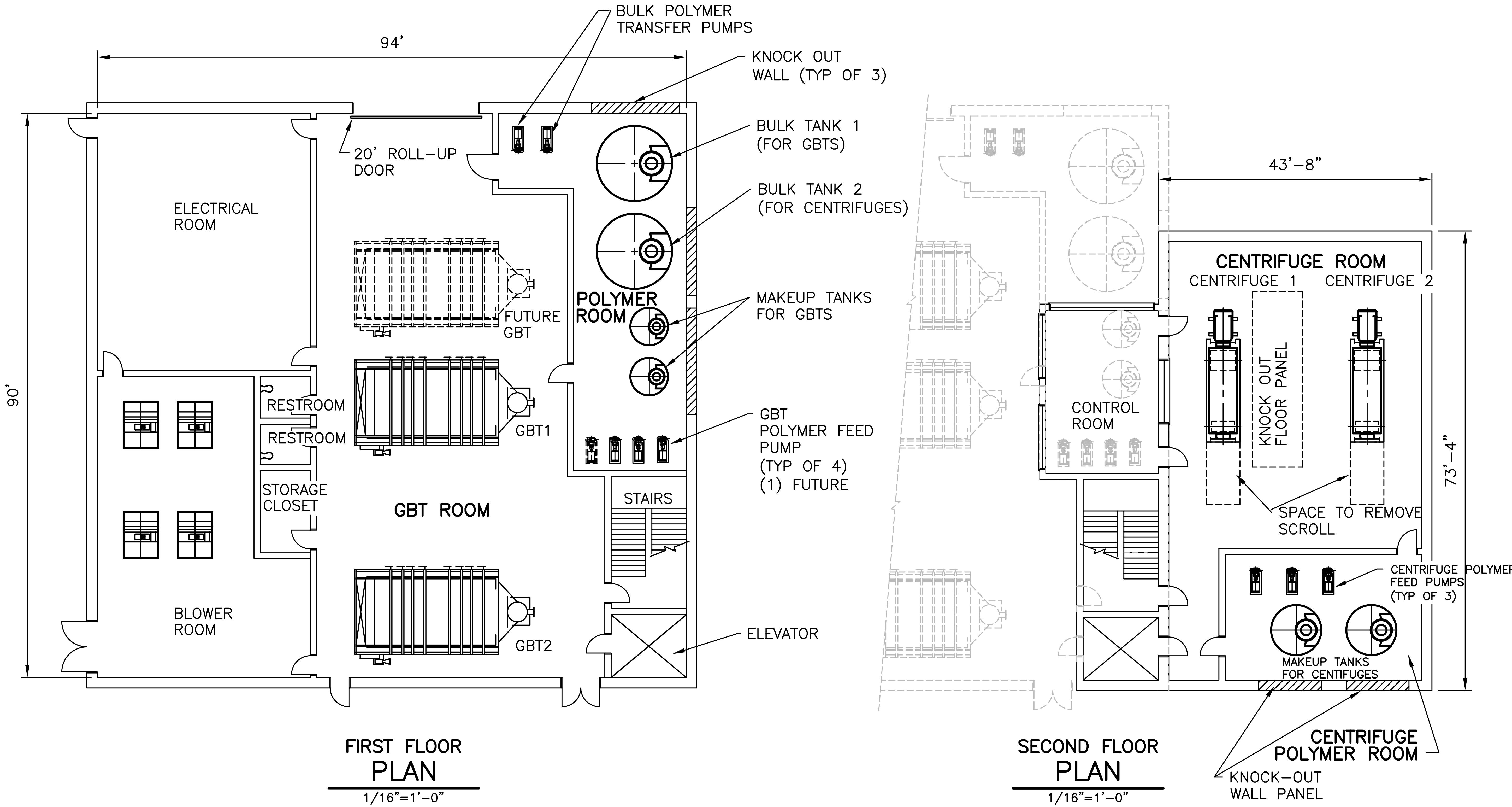
WESTERN WAKE REGIONAL WASTEWATER
MANAGEMENT FACILITIES

SOLIDS MASS BALANCE

FIGURE 16-5



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WASTEWATER MANAGEMENT FACILITIES

THICKENING
DEWATERING BUILDING

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