UPGRADING A CONTACT STABILIZATION TREATMENT PLANT TO A NITRIFYING ACTIVATED SLUDGE PROCESS BY USING INTEGRATED FIXED-FILM ACTIVATED SLUDGE (IFFAS) MEDIA

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The City of Green Cove Springs is a small community located in Clay County. The City operates two wastewater treatment plants to provide service to the City's approximately 6,500 sewer customers. This paper describes recent improvements to the northernmost Harbor Road Wastewater Treatment Plant (WWTP). The Harbor Road plant was constructed in 1983, and is currently permitted as a 0.75 mgd contact stabilization process with a discharge to the St. Johns River. In addition to the operational plant, the site also includes an abandoned 0.5 mgd contact stabilization plant that consists of four concrete tanks. The plant is currently under a consent order from the Florida Department of Environmental Protection (FDEP) to meet a maximum unionized ammonia limit of 0.2 mg/L on the discharge to the St. John River.

The plant could not be modified to completely nitrify the influent ammonia due the limitations of the contact stabilization process and the available aeration tank volume. Nitrification could be accomplished by converting the process to a complete mix flow pattern and by increasing the amount of biomass under aeration. The increased biomass could result from increasing the aeration tank volume at the same mixed liquor concentration or by increasing the concentration of the mixed liquor using the same tank volume. The two alternatives were constrained by two issues: a restricted amount of funding to build new tanks and the limitation of the existing clarifier to handle a higher mixed liquor concentration.

A compromise solution was reached by combining both approaches. The existing digester was converted to additional process tankage. However, this volume increase alone was still not enough to meet the SRT needed to provide nitrification. An Integrated Fixed-film Activated Sludge (IFFAS) process was selected to provide the additional biomass needed without increasing the solids loading on the clarifier.

The IFFAS system selected consists of sheets of rope-like media woven into a web pattern. This woven media is hung on steel frames. These frames are installed in the aeration basin and secured to the existing concrete walls. Biomass growth occurs on the

media. This biomass is “fixed” and remains under aeration without being passed onto the clarifier. This paper will document the design and construction and performance of the new facility utilizing the IFFAS media. Construction was completed on the facility upgrades in December 2002.

Background

The Harbor Road Wastewater Treatment Plant (WWTP) is located north of Governor’s Creek and west of U.S. 17 in Green Cove Springs, Florida. Prior to modifications, the facility was divided into two plants; a 0.5 mgd contact stabilization (Plant 1) and a 0.75 mgd field erected contact stabilization (Plant 2). Together both plants had a rated design capacity of 1.25 mgd. However, the combined Harbor Road WWTP was restricted to a permitted discharge capacity of 0.95 mgd in order to reduce operator staffing requirements. The 0.5 mgd plant was placed into service in 1973, but had not been in operation since April 1995. The 0.75 mgd plant, placed into service in 1986, provided a chlorinated-dechlorinated effluent that was discharged to the St. Johns River. The plant had an influent bar screen, aeration, secondary clarification, chlorination and aerobic holding of residuals. Processed sludge was sent to onsite-drying beds adjacent to the WWTP. The solids fraction from the adjacent sludge beds was hauled to the Clay County Landfill for disposal. The aerobic holding tank was decanted, and the supernatant and sludge bed drainage returned to the headworks for treatment at the Harbor Road WWTP.

The WWTP’s contact-stabilization process was designed to effectively remove influent carbonaceous biological oxygen demand (CBOD). Prior to the modifications, the plant was performing as designed with respect to CBOD. However the plant had violated its unionized ammonia limit. These violations were the result of a combination of the increased flows at the plant and the limitations inherent in the contact-stabilization process with respect to nitrification of influent ammonia. In the year 2002, as part of an effort to reduce the amount of effluent discharged to the St. Johns River, the City of Green Cove Springs was able to secure funding to complete a full-scale reuse system at the Harbor Road facility. As part of the reclaimed water system, modifications needed to occur to reduce the effluent unionized ammonia discharged to the river when the golf course cannot accept effluent. As a result of the proposed modifications, disinfected reclaimed wastewater from the plant will be sent to the proposed City reuse system. The scope of the reuse system is currently limited to the Magnolia Point golf course. Water that does not meet reclaimed water standards will be automatically dechlorinated and diverted to the existing St. Johns River outfall.

Service Area Description

The Harbor Road WWTP services the north central portion of the City of Green Cove Springs, the Magnolia Point area, as well as outlying areas to the north of City limits. The service area and location of the Harbor Road WWTP are shown on **Figure No. 1**.

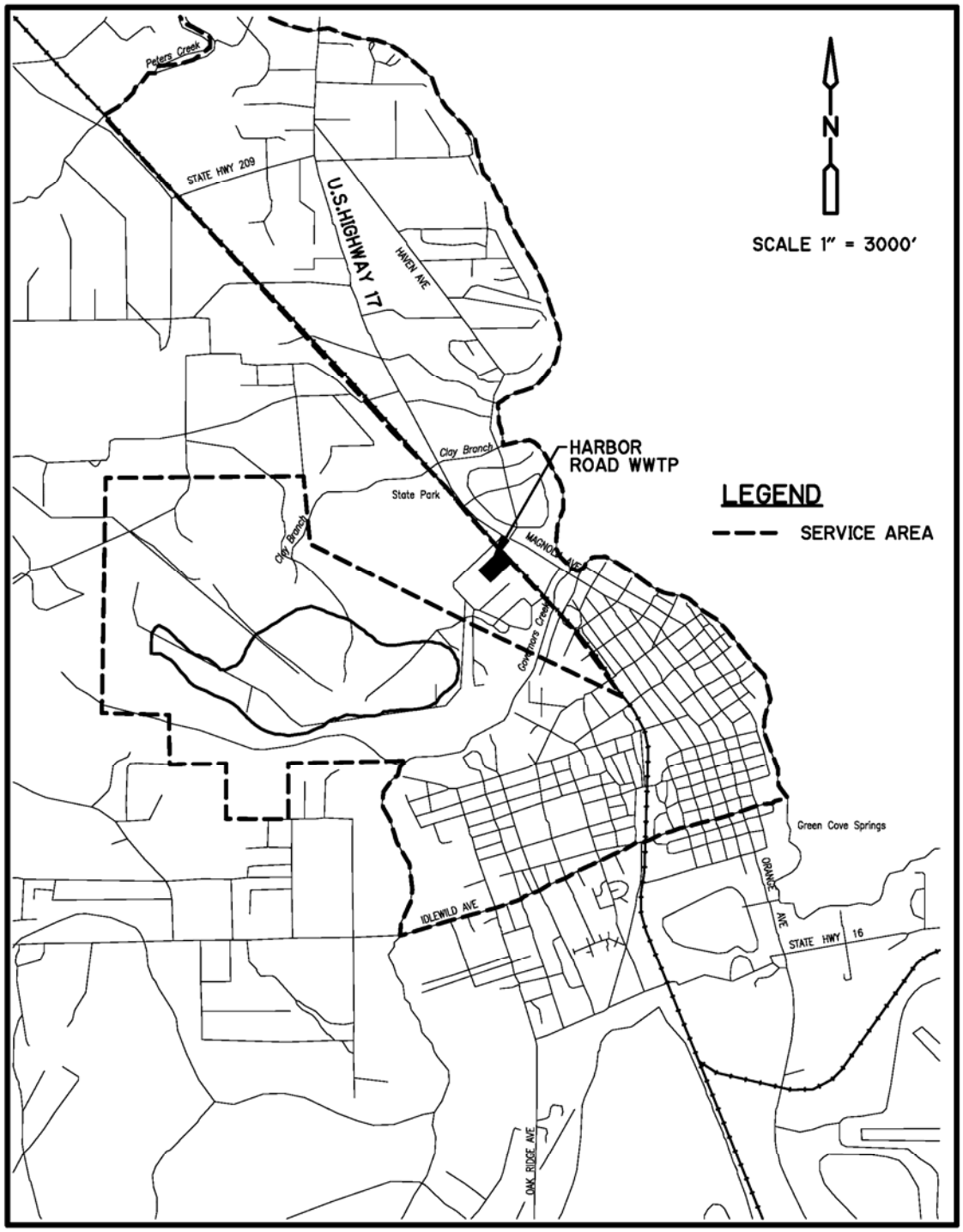

Figure No. 1
Harbor Road WWTP Preliminary Design Report
Service Area

CDM Camp Dresser & McKee

No residential package plants are located in the service area. Residential and commercial land use categories are the predominant land uses within the service area. Industrial wastewater flow to the plant is negligible.

Flow and Wastewater Characteristics

Wastewater Flow

The flow data for the period January 1998 through September 2000 was obtained from operations staff. The average annual daily flow (AADF), the maximum daily flow (MDF), and 3 month rolling average AADF for the period is presented in **Table 1**.

Table 1 Flow Summary[a]

Year	AADF (mgd)	Maximum Daily Flow (mgd)	3-MADF (mgd)
1998	0.460	1.402	0.590
1999	0.478	0.708	0.474
2000[a]	0.476	0.863	0.463

[a] Through September 30, 2000

Wastewater flow at the existing facility is characterized by seasonal fluctuations. Peak flows occur during the summer with lower than average daily flows during the winter.

Physical, Chemical, and Biological Characteristics

Physical, chemical, and biological characteristics of the raw wastewater flow to the Harbor Road WWTP are based on records of past flow to the existing plant. Influent characteristics are summarized in **Table 2**.

Table 2 Pollutant Loading Summary

Parameter	Maximum Month		Maximum Week		Maximum Day		Annual Average
	Value	Peak Factor	Value	Peak Factor	Value	Peak Factor	
Flow (mgd)	0.608	1.29	0.743	1.58	1.40	2.98	0.471
$CBOD_5$ (mg/l)	254	1.54	390	2.36	---	---	165
BOD Loading (lbs/day)	1152	1.76	1623	2.48	---	---	654
Total Suspended Solids (mg/l)	253	1.58	426	2.66	---	---	160

Domestic, Industrial, and Infiltration/Inflow Contributions

Wastewater discharged into the wastewater collection system is from predominantly residential sources. Currently, there are no major industrial users discharging into the system. Additionally, contributions from industrial sources are not anticipated to increase in the foreseeable future.

Process Design

Due to the limitations of the contact stabilization process, a method was needed to achieve nitrification to reduce the effluent unionized ammonia to within permit levels. This would allow the City to keep its existing outfall to the St. Johns River as a back up to the proposed reuse system. The first step was to analyze the capacities of the existing unit processes.

Limitations

Due to the tankage existing but not in use at Plant No.1, the initial plan was to use the existing digester in Plant No. 2 as additional process tankage to increase the SRT and achieve nitrification. The Plant No. 1 digester and chlorine contact chamber would be utilized and tied into the new improvements. After evaluating the unit processes of the existing plant, the limiting process for a conversion to a traditional nitrifying activated sludge process was the secondary clarifier. The clarifier could not effectively handle the increased mixed liquor concentration loading that would result from the increasing the SRT to achieve nitrification.

Preliminary Options (Traditional)

To increase the operational SRT, the total mass of solids under aeration would need to be increased. A number of modifications using traditional treatment methods were evaluated that would allow the existing facilities to provide full nitrification.

Utilize the Plant No. 1 Secondary Clarifier – This option included utilizing the Plant No. 2 digester as additional process tankage, and rehabilitating the Plant No. 1 clarifier to increase the clarifier area available to process the additional solids. An analysis on this option revealed that the additional clarifier area was not sufficient to treat the full plant capacity (0.75 mgd) and would result in a reduction in treatment capacity.

Build an Additional Clarifier or Additional Aeration Tankage – This option would build additional clarifier capacity to effectively process the higher mixed liquor concentration. Or alternatively build additional tankage and aeration volume to reduce the mixed liquor concentration to a level that could be processed by the existing clarifier. This option would have been preferred, however, the additional tankage could not be fit into the funds available for the project.

Convert Plant No. 1 Clarifier to a Primary Clarifier – This option converted the existing Plant No. 1 secondary clarifier to a primary clarifier to reduce the loading to Plant No. 2 thereby reducing the MLSS required to achieve nitrification to a level

manageable by the existing clarifier. This alternative also proved to be cost prohibitive due to the need for all of the primary effluent to be re-pumped to Plant No. 2.

Preliminary Options (Non-Traditional)

Based on the analysis that indicated that traditional approaches to nitrification would not be feasible within the project budget, these additional options were considered:

IFFAS (rope type) – This option consisted of installing racks of woven media into the aeration basins. This media would allow the growth of additional biomass without passing this additional biomass to the secondary clarifier in the mixed liquor. Thereby allowing the liquid side of the process to operate at a mixed liquor concentration similar to what it had previously operated. This option was the least expensive and simplest of the three and was chosen for final design.

IFFAS (sponge type) – This option consisted of installing sponge type media into the mixed liquor under aeration. Biofilm will grow on the media, thus increasing the biomass under aeration. This option required special equipment to separate and return the media to prevent its being passed on to the secondary clarifier. This option was more expensive than the IFFAS rope media and required the addition of media periodically to maintain the biomass levels under aeration.

Membrane Bioreactor – This option consisted of installing membrane units and suction pumps in the aeration basin to take the place of the secondary clarifier. This option required additional equipment (pumps, cleaning tanks, hoisting cranes). This alternative would have merited additional consideration if the effluent were required to meet a reduced phosphorus limit. It was rejected due to its higher costs and the ability to meet the required limits with simpler technology.

Design

Design of the IFFAS rope media system was prepared using the guidelines presented in the Water Environment Research Foundation (WERF) document *Investigation of Hybrid Systems for Enhanced Nutrient Control* (WERF, 2000). The basic premise of the design was to determine the amount of treatment that could be achieved through the liquid side alone and then design the media to account for any additional treatment required for peaks. Design features extracted from the WERF document included: the ability to maintain the mixed liquor concentration above the nitrifier washout condition, reducing the amount of soluble BOD available to the biofilm on the media, and the ability to chlorinate the RAS line to control nematode growth. The modifications to the existing contact stabilization plant to a nitrifying activated sludge process are shown on **Figure No. 2.** These modifications include the creation of an aerobic selector to reduce the soluble BOD in the mixed liquor and the installation of four IFFAS frames in the new and existing aeration basins.

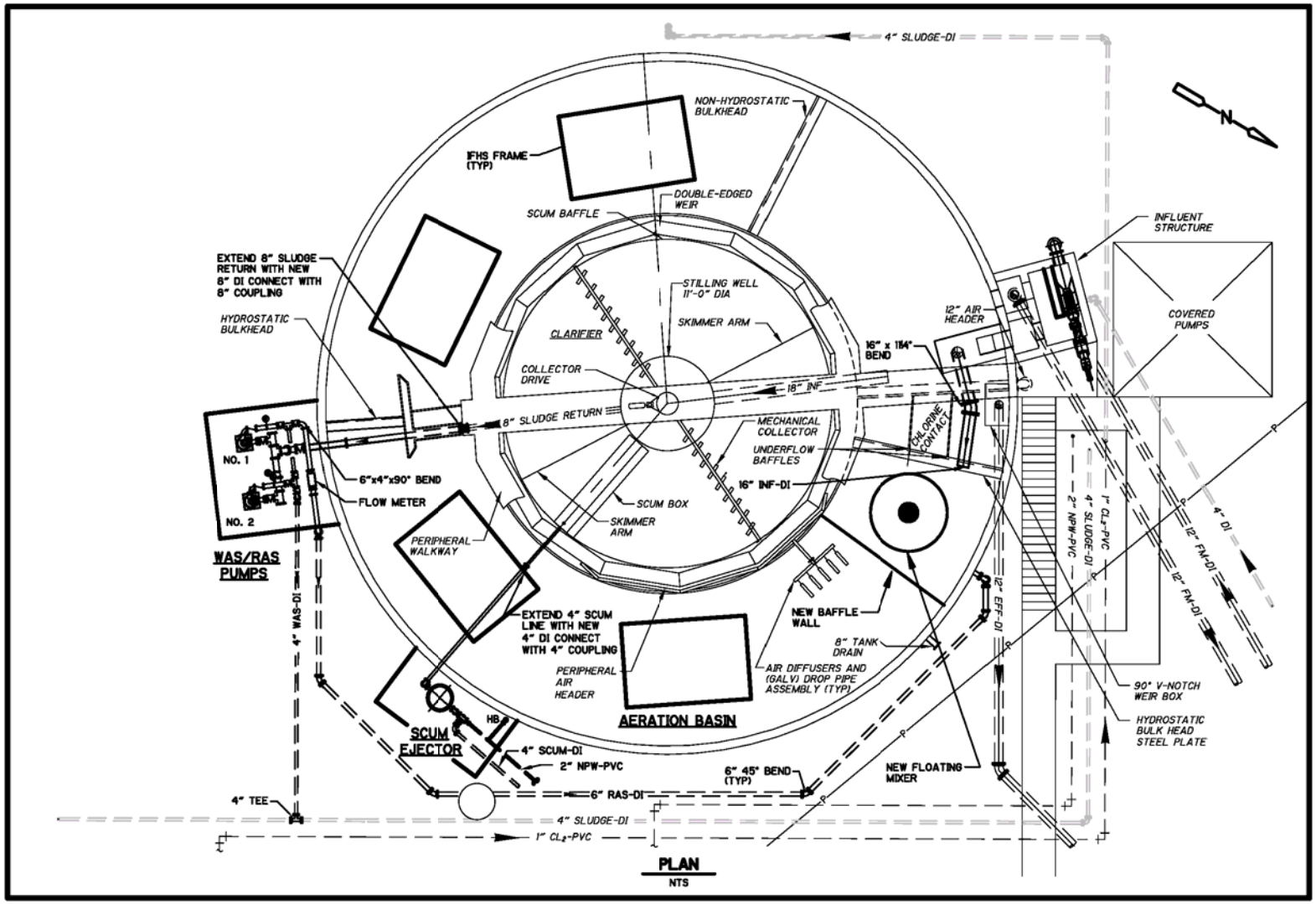

Figure No. 2
Harbor Road WWTP Preliminary Design Report
Existing Treatment Unit Modifications

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IFFAS Frames Stored at the Jobsite

Close-up of IFFAS Frame and Media

Aerobic Selector Zone and IFFAS Frame

IFFAS Frame Showing Aeration Headers

Performance

Start up of the plant was December 6, 2002. To date, the performance of the process modifications has been as expected. The plant began to nitrify within three days of the modifications. The City is currently performing performance testing on the plant to determine the extent that the IFFAS media assist in the nitrification process and if the media has had an effect on the settling characteristics of the sludge. Average values for the months of December, January and February are presented in **Table 3**. As shown in the table effluent nitrogen and sludge settling characteristics are showing improvement.

Table 3 Harbor Road Performance (December 2002 – February 2003)

Parameter (Average Daily)	December	January	February
Influent Ammonia (mg/L)	34.0	32.5	36.0
Effluent Ammonia (mg/L)	3.3	0.9	0.5
Sludge Characteristics (SDI)	1.5	1.0	1.2
(SVI)	71	99.8	89.5

Testing Program

The plant is currently undergoing a comprehensive testing program. The goal of this testing program is to determine the extent of the effectiveness of the media to aid in nitrification. This testing will include daily samples and calculations for temperature, nitrogen balance, SRT, soluble BOD, SVI and a weekly-calculated fix film growth rate for the media.

Special Recognition

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