



San Francisco Public Utilities Commission

San Francisco, CA

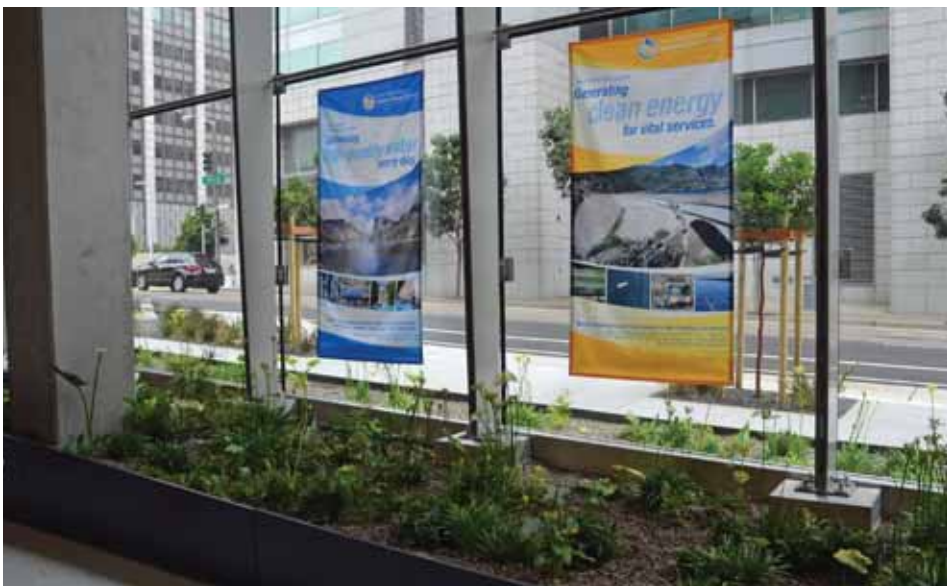
COMPLETION DATE **2012**
APPLICATION **municipal**
SYSTEM CAPACITY **5,000 gpd**
REUSE **flush toilets + irrigate nearby park**

CASE STUDY

LIVING MACHINE SYSTEMS, L3C

Living Machine® Systems, L3C (LMS) - based in Charlottesville, Virginia - is a social benefit corporation, focused on ensuring lasting water resources for communities across the globe. Our proven ecological wastewater treatment and reuse system is compact, efficient, and cost effective. From Ghana to San Francisco and from schools and office towers to resorts, the Living Machine® system has been installed in dozens of locations around the world.

LMS and its predecessor, Living Technologies, Inc., have designed and refined ecological wastewater treatment systems since 1995. While constructed wetlands and other natural treatment technologies have been successfully utilized for decades, today's Living Machine technology allows a radically smaller footprint and higher treatment performance relative to other natural treatment systems. In comparison to conventional wastewater treatment technologies the Living Machine system offers reduced energy use and significant savings in both capital and life cycle costs while achieving the highest treatment and reuse water quality standards. LMS designs beautiful, energy-efficient, high-performance wastewater treatment systems that foster water reuse in rural, suburban, and urban areas.



Interior Vertical Flow Wetland Cell



Design by KMD/Stevens Architects

SYSTEM BENEFITS

- The building will reduce water use by over 70% and save approximately 750,000 gallons of water per year while providing an additional 900,000 gallons per year for nonpotable uses off-site.
- The system will provide attractive exterior and interior foliage and a pleasant public space.
- Will treat all wastewater generated by the building's employees and produce high quality water to flush toilets and for future off-site irrigation.

Design Basis + Architectural Integration

PROJECT OVERVIEW

When planning its 277,500 square foot Administration Building in downtown San Francisco, the Public Utilities Commission - the area's provider of power, drinking water and wastewater services - was strongly committed to being a national leader in sustainable design. The challenge was to identify and use green technologies that could work within the constraints of the building's urban environment, as well as fulfill long-term cost-saving measures.

WHY A LIVING MACHINE?

The SFPUC opted for integrated solar panels and wind turbines to generate energy and a Living Machine® system to treat and reuse its wastewater. As the only ecological system capable of treating blackwater with a small physical footprint, appropriate to an urban setting, the Living Machine was the obvious choice. Beyond size and integration issues, energy efficiency, low maintenance costs, water quality results and aesthetics were key elements for the SFPUC.

WETLAND SIZE PARAMETERS

TIDAL WETLAND CELLS

Parameters	Values	Units
COD Loading	190	$\text{g m}^{-3} \text{d}^{-1}$
TKN Loading	45	$\text{g m}^{-3} \text{d}^{-1}$
Cycle Frequency	12	per day
Oxygen Requirement	174	$\text{g m}^{-3} \text{d}^{-1}$
Oxygen Supplied	106	$\text{g m}^{-3} \text{cycle}$
Oxygen Supplied	1278	$\text{g m}^{-3} \text{d}^{-1}$

VERTICAL WETLAND CELLS

Parameters	Values	Units
COD Loading	60	$\text{g m}^{-3} \text{d}^{-1}$
TKN Loading	15	$\text{g m}^{-3} \text{d}^{-1}$
Cycle Frequency	-	per day
Oxygen Requirement	49	$\text{g m}^{-3} \text{d}^{-1}$



Exterior of 525 Golden Gate Avenue with Vertical Flow Wetland Cell

ARCHITECTURAL INTEGRATION

- One of the wetland treatment cells is incorporated into the lower lobby of the building.
- The remaining wetland cells are incorporated into the city sidewalk on Polk and Golden Gate Streets.
- Materials and plantings for both interior and exterior wetland cells were coordinated with project architect and landscape architects to integrate with site and building aesthetics

PROJECT PARTNERS

CLIENTS: San Francisco Public Utilities Commission

Project Manager: San Francisco Department of Public Works

ARCHITECT: KMD/Stevens Architects

LANDSCAPE ARCHITECT: Antonia Bava Landscape Architecture

GENERAL CONTRACTOR: Webcor Builders

ENGINEERING PARTNERS: Aqua Nova Engineers, SJ Engineers

Site Plan



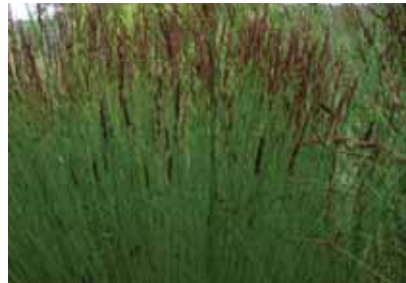
Plant Community

EXTERIOR PLANTS

- Plants are native or naturalized species.
- Plants suited to very low light conditions and require low maintenance
- Capable of withstanding strong seasonal winds and demanding urban environment



Acanthus mollis, Bear's Breach



Chorodropetalum tectorum, Cape Rush



Juncus effusus, Quartz Creek Rush



Acorus gramineus, Japanese Sweet Flag



Cyperus alternifolius gracilis, Umbrella Plant

INTERIOR PLANTS

- Plants specifically chosen for low light conditions within the lobby.
- Striking foliage and flowers for aesthetic qualities.
- Three distinct canopy heights:
Low= Rumorha Med= Zantedeschia + Agapanthus High= Acorus



Rumohra adiantiformis, Leather Leaf Fern



Agapanthus Praecox, Lily of the Nile



Zantedeschia aethiopica, Giant Calla Lily



Cyperus alternifolius gracilis,
Umbrella Plant

Engineering Details

TREATMENT SYSTEM DESIGN

- The Living Machine system consists of two tidal-flow Stage 1 treatment cells and three vertical-flow Stage 2 treatment cells, filled with a Lightweight Expanded Shale Aggregate (LESA) media. A diversity of microbial organisms comprise a fixed film (biofilm) that grows on and adheres to the exterior surface and within the pore space of the LEESA media.
- In Stage 1, the biofilm is exposed to the atmosphere several times daily through LMS's patented fill and drain cycling. Recurrent exposure to aerobic and anoxic environments helps to eliminate odors and enhances nitrification, denitrification and removal of BOD, TSS and an array of organic and man-made compounds. After Stage 1, water moves on to Stage 2.
- Stage 2 consists of three vertical flow wetland cells. The first two cells are internally recycled and the final cells provides a single pass. Stage 2 removes remaining BOD, TSS, and completes nitrification. The water leaving this stage is very clean but requires final filtration and disinfection for re-use.
- Wastewater from the Living Machine is pumped through a two stage filtration system, followed by two stage ultraviolet (UV) and chlorine disinfection. The first filter is an automatic self-cleaning filter, which removes any coarser particles, followed by a cartridge filter designed to catch any remaining small particles. Filtering of the effluent is necessary to remove fine particles that will inhibit UV disinfection. Online turbidity, UV transmissivity, and chlorine sensors assure that reuse water quality standards are continuously being achieved.

PERFORMANCE SUMMARY

Units (mg/l)	Design Influent	Influent	Design Effluent	Effluent
BOD	260	228.5	<10	ND
TSS	70	69	<10	ND
TKN as N	140	135.5	<10	2.7
Turbidity	-	-	<2.0	-

* Below Detection Limits



Final Construction Phase - Interior Vertical Flow Wetland Cells



Exterior Tidal Flow Wetland Cells- Installation of Underdrain



Filtration Components



Final Construction Phase - Exterior Vertical Flow

Living Machine Process Diagram



PRIMARY



STAGE 1



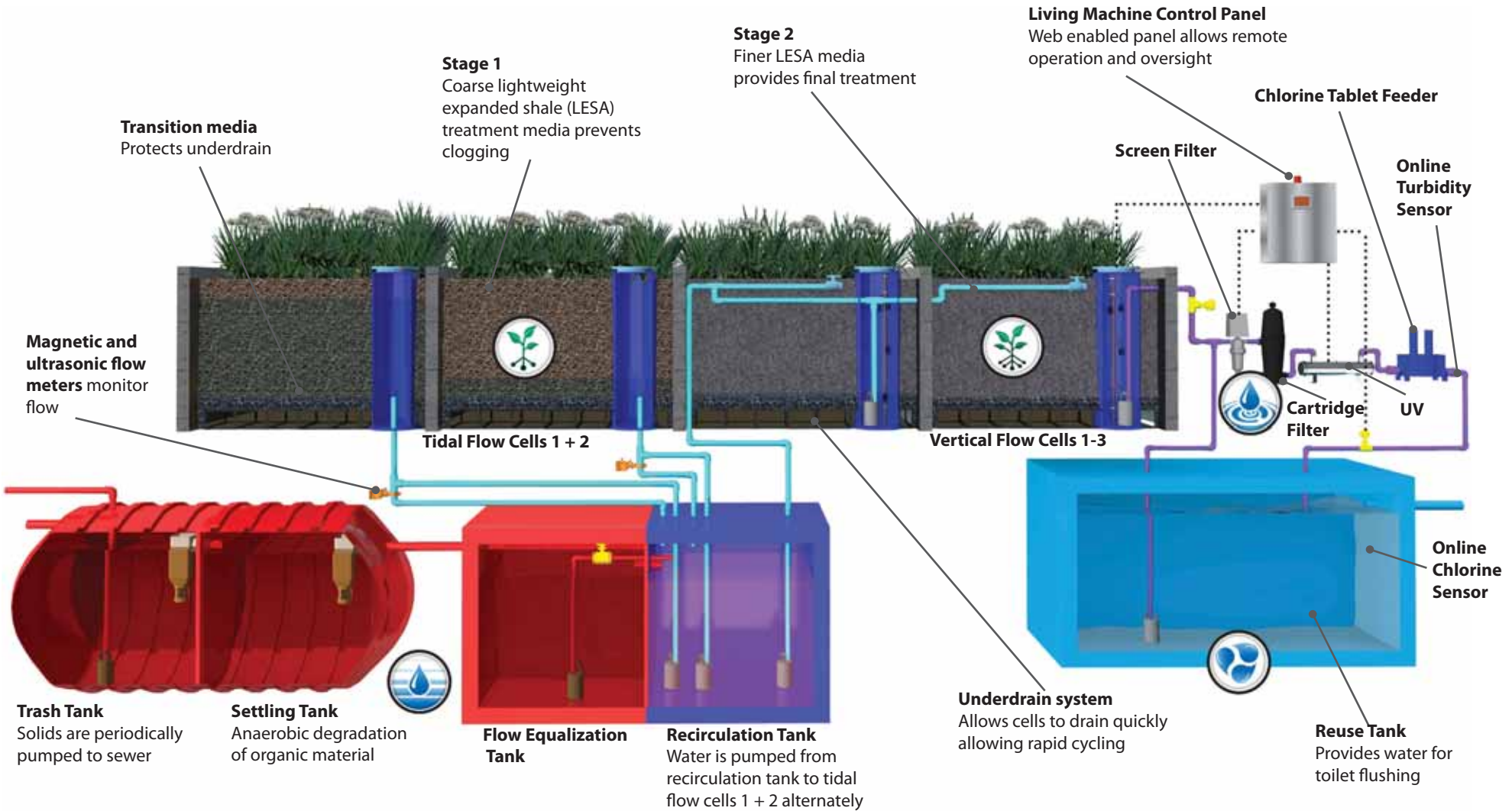
STAGE 2



POLISHING



REUSE



Control System

Aqua Nova Engineering, PLC

3452 Bleak House Rd., Earlysville, VA 22936 | Tel. 434-202-7052

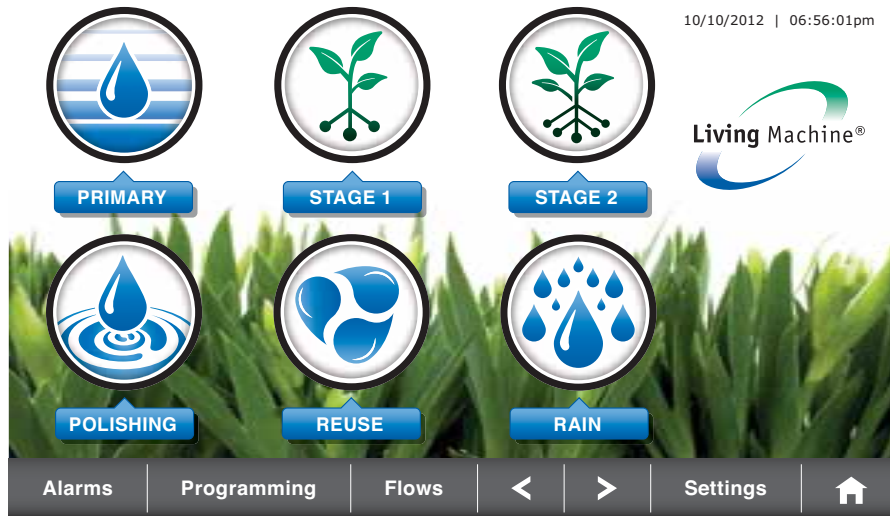
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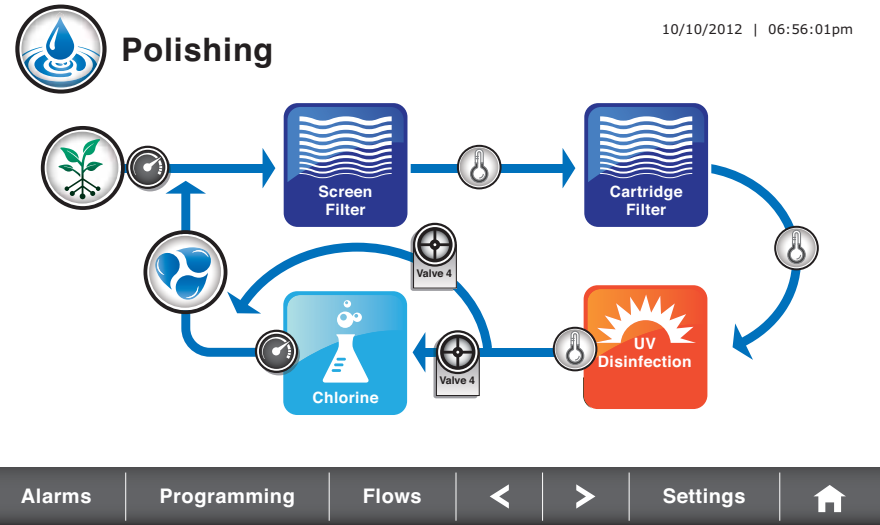
CONTROL SYSTEM DESIGN

The Living Machine system operation is fully automated through the control panel which operates all mechanical components of the system based on operator settings and sensor signals. A touch-panel human-machine interface (HMI) display is integrated into the inner door of the control panel. This touch panel provides a graphical interface to monitor system performance and to change system parameters. Within the control panel is a programmable logic controller (PLC). This microcomputer interfaces with the HMI and electromechanical devices through motor starters and relays.

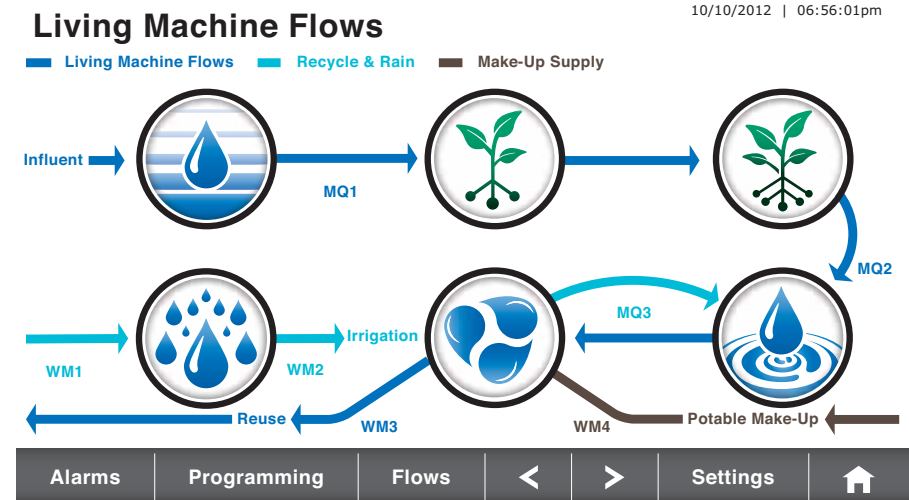
The control system acquires readings from field sensors and switches within the panel, as well as user entered parameters provided through the HMI to make operational decisions based on these inputs. Example screens from the HMI are provided below. The Control System for this project integrates operation of the rainwater collection and reuse system as well.



Dashboard Control Screen



Polishing Control Screen



Flows Control Screen