Conceptual Design of Total-flow Automatic Sampler for Pumping Station S-5A

Presented to:
South Florida Water Management District

Presented by:
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June 18, 2001

Outline

- Florida International University's
  - Hemispheric Center for Environmental Technology
- S-5A Sampler project introduction
- Limitations of the current auto-sampler
- Conceptual design of proposed auto-sampler
- Comparison with current auto-sampler (simulation)
- Implementation of proposed auto-sampler
  - Operation
  - Error analysis
- Path forward

FIU's Recent Achievements

What milestones did FIU achieve in 2000?

- ☐ a. Established a College of Law
- ☐ b. Achieved the top Carnegie research university ranking
- ☐ c. Became Florida's only public urban university with a chapter of Phi Beta Kappa
- ☐ d. Launched an intercollegiate football program
- ☑ e. All of the above

It was a *very* good year.

Diversity




52% Hispanic
14% African American
3% Asian
9% International

FIU
Florida International University

is a designated
HBCU/MI (Minority Institution)

FIU's Non Profit Entity

FIU Research Corporation

501(c)3

HCET

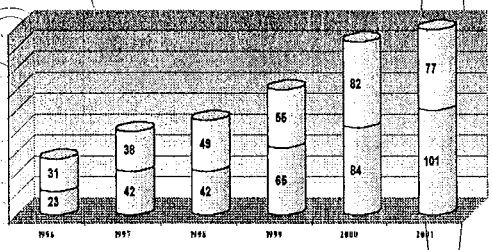
HCET's Core Capabilities


Energy

Information Technology

Environmental

HCET Personnel



☐ Full-Time and Staff ☐ Grad and Undergrad Students

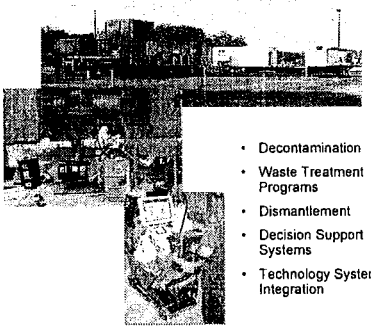
Growth of HCET's Facilities

1995
7000 square feet

2001
250,000 square feet on 38 acres

Research & Development

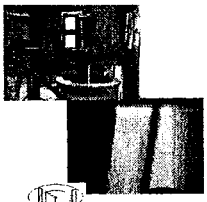
- Environmental & Engineering Services
- Information Technology and Training
- International Programs
- Business and Program Development
- Science Research & Development



- Decontamination
- Waste Treatment Programs
- Dismantlement
- Decision Support Systems
- Technology Systems Integration

Research & Development

- Environmental & Engineering Services
- Information Technology and Training
- International Programs
- Business and Program Development
- Science Research & Development



- Computer-based modeling, simulation, and visualization
- Slurry transport
- Soil & GW
- Fuel cells
- Waste treatment technology
- Sensors
- Robotics & Automated
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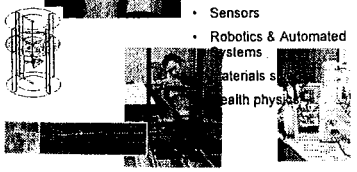

Personnel Experience

Over 300 Years of Demonstrated Field Experience

- Environmental Remediation
- Field Assessment and Inspection
- Construction
- Site Operations
- Engineering - Title I/II/III
- Environmental Health & Safety
- Environmental Engineering
- Facility Deactivation & Decommissioning
- Project Management
- Project Controls
- Waste Management
- Plant Maintenance
- QA/QC
- Information Technology

HCET Capabilities

- Environmental Management
- Regulatory Compliance
- Analytical Chemistry
- Remediation Needs Assessment
- Quality Assurance
- Mechanical, Electrical, Civil and Chemical Engineering
- Business Management and Administration
- Waste Characterization and Sensor Technology
- Health Physics/ Radiological Analysis
- Information Technology

Site Offices

Client Experience

- Department of Energy
- Department of Defense
- United States Air Force
- Environmental Protection Agency
- National Aeronautics and Space Administration
- National Institute of Safety and Health
- Florida Department of Transportation
- Bureau of Land Management

Industry Experience

- Bechtel-National
- Bechtel-Jacobs, LLC
- EG&G
- Georgia Power
- Illinois Power
- Martin Marietta
- Rust Remediation
- Texas Utilities
- Waste Management, Inc.
- Westinghouse
- UNC, Inc.
- Babcock & Wilcox
- Burroughs/Unisys
- Commonwealth Edison
- Fluor Daniel
- ICF Kaiser
- Management Analysis Company
- Shell Oil
- US Aluminum Corporation

Partnerships

- 3M
- Bechtel-Jacobs, LLC
- LTC Americas
- ICF Kaiser
- Science Applications International Corporation
- Practical Machine engineering
- Raytheon E-Systems
- LAW Engineering
- US Army Corps of Engineers
- Battelle Memorial Institute
- Pacific Northwest National Laboratory
- Pratt & Whitney Corporation
- Burns and Roe
- CH2M Hill
- Montgomery Watson
- First Choice Technologies
- Ogden Engineering
- IT/OHM Corporation
- Duke Power
- Precision Labs
- Colorado Center for Environmental Management
- MSC Technology Applications
- British Nuclear Fuels Ltd.
- AEA Technology
- EarthTec
- E2M
- RSIS
- Hydrogeologic
- MITKEM
- NRCE
- Wendy Lopez, Inc.

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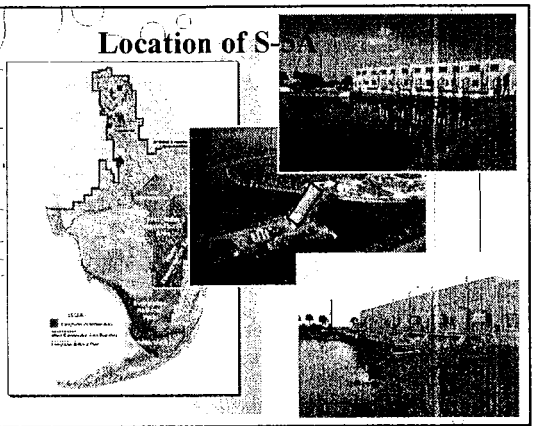
Design of Total-flow Automatic Sampler for Pumping Station S-5A

Introduction

- S-5A is a large pumping station in the Palm Beach County
- Consists of six axial flow pumps, each 116 in. in diameter and rated at 800 cfs
- Objective is to pump surplus water from agricultural area, L-10, L-12 basin into Water Conservation Area 1 (WCA1)

Location of S-5A



Background

- Location
  - Structure 5A is located at the northern tip of the Water Conservation Area 1 (WCA1).
  - Entry point for water into the Everglades Protection Area
- Water quality
  - Proximity to the Everglades Agricultural Area (EAA) makes it a receiving point for run-off water from sugar and other farms
  - Runoff is rich in nutrients – especially **phosphorus**
    - Adverse effect of **phosphorus** on the ecology of Everglades

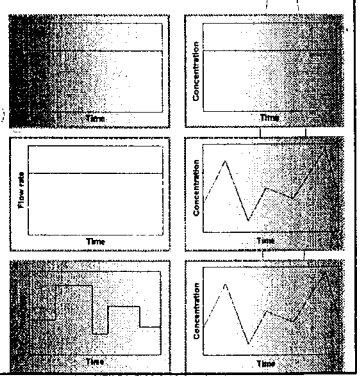
Why is S-5A important?

- Discharge is used for estimating the water quality
  - Determining the **phosphorus loading** due to agricultural run-off from the farms
    - Quantifying eutrophication (excessive plant growth) for water draining into the Everglades
  - Everglades Forever Act (EFA)
    - Reduction in phosphorus levels

Sampling and Load Determination

Sampling Situations:

- Constant flow and constant concentration- infrequent
- Constant flow but varying concentration- frequent
- Varying flow and varying concentration- flow proportional



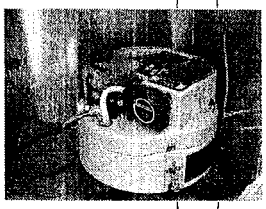
Sampling at S-5A

- EAA-EFA Mandates
  - require flow-proportional sampling
  - stipulates water quality monitoring system such that total loading of phosphorus can be accurately determined
- This rule when applied to the sampling system at S-5A

samples must be collected so that they are representative of the overall discharge from the station

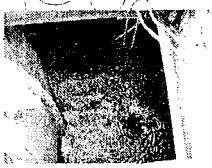
Current Sampling at S-5A

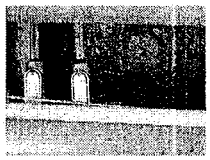
- An auto-sampler that takes samples in conjunction with pump operation from a fixed location
  - Totalizer triggers sample collection
  - Frequency- once every 8 min
- Grab samples are also taken, about 15 ft. upstream of the pumping station
  - Frequency - weekly



Limitations of the current configuration of auto-sampler

- Location – The sampler is designed to collect the sample aliquot only from the inlet bay at Pump 4.





- If pump(s) other than Pump 4 are running, sampling may be from a stagnant zone.

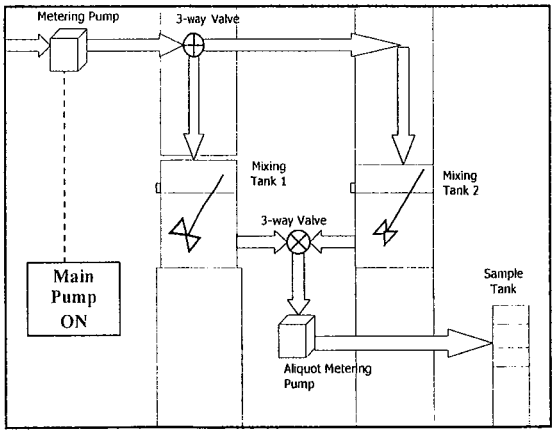
Limitations of the current auto-sampler ...contd.

- Variations in phosphorus concentration with time – might not be adequately captured in the aliquots i.e. the samples collected are not representative of flow.
- Total Phosphorus Loading based on such a **sample concentration** will not be accurate.

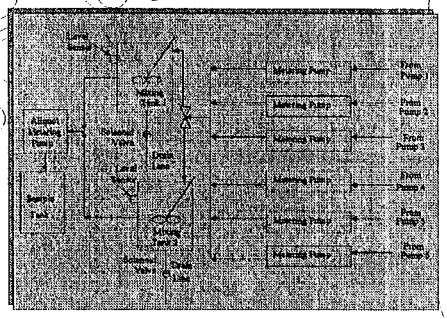
Conceptual Design of the Proposed Auto-sampler

Conceptual Basis of the Proposed Auto-sampler

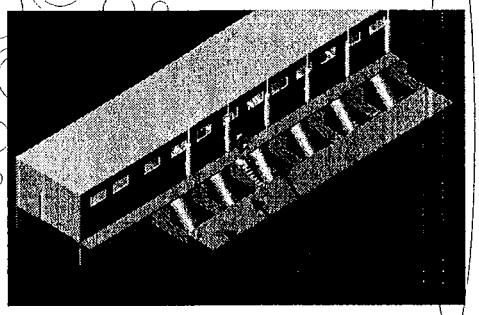
- Continuous sampling of the discharge
- Representative sampling i.e. sampling from each individual pump that is running
- Flow-proportional sampling
- **Total flow auto-sampler**



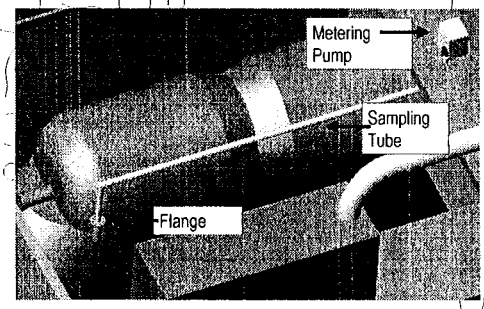
Schematic drawing of the proposed total flow auto-sampler



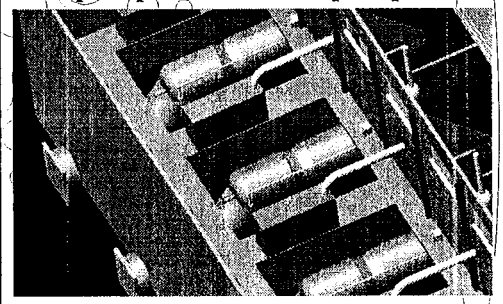
Overview of the pumping station



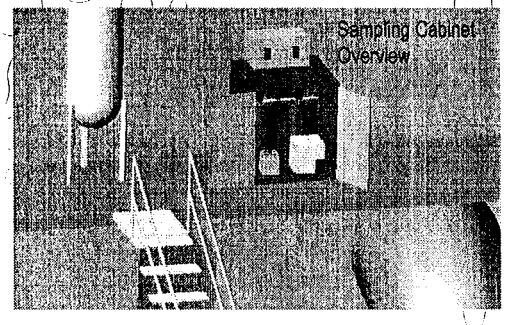
Tubing for sampling and location of metering pump



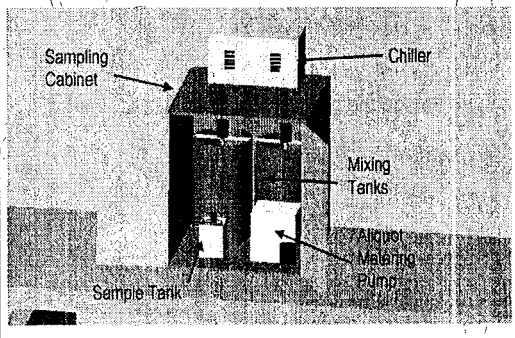
Panoramic view of the metering pumps for all main pumps



Overview and location of the sampling cabinet



Contents of the sampling cabinet



Design Parameters

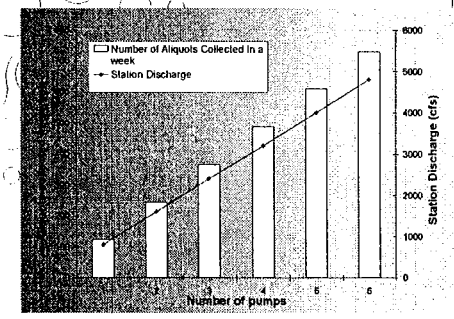
- Flowrate in sampling tube - 6 ft/s (max)
- Diameter of sampling tube - 3/8 in
- Length of sampling tube - 120 ft (max)
- Volume of Mixing tank(s) - 55 gal (208 L)
- Volume of Sample Tank - 10 gal (38 L)
- Volume of each aliquot sample - 50 mL
- Frequency of aliquot sampling - Once every 5 minutes (at maximum discharge)

Different sampling scenarios (based on number of pumps running)

Number of Pumps Running	6	5	4	3	2	1
Station Discharge cfs (MgalImin)	4800 (2.16)	4000 (1.8)	3200 (1.44)	2400 (1.08)	1600 (0.72)	800 (0.36)
Total Flowrate of Sampling Stream(s) from Pump Bay Gal/min	12	10	8	6	4	2
Residence time in Mixing Tank (min)	4.6	5.5	6.9	9.2	13.75	27.5
Time between Aliquot Sampling (min)	4.6	5.5	6.9	9.2	13.75	27.5
Number of Aliquots Collected in a week (Basis: 8 hrs of operation every day)	730	610	487	365	243	122
Volume of Aliquots Collected in a week Gal (L)	9.6 (36.5)	8 (30.5)	6.42 (24.3)	4.84 (18.3)	3.22 (12.2)	1.6 (6.1)

* A flow rate of 2 gpm for the metering pump corresponds to a discharge rate of 800 cfs through the main pump

Station Discharge Scenarios

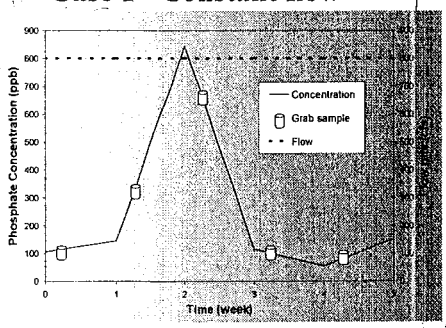


Comparison of current and proposed auto-samplers

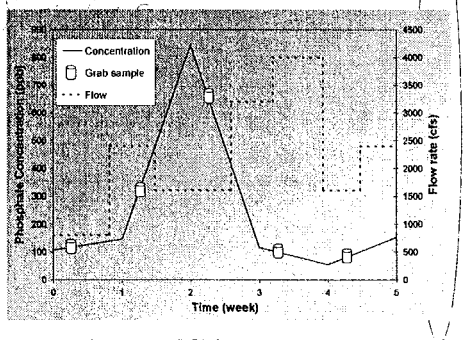
Comparison using simulation study

- Error associated with the sampling technique - assuming that there are no measurement or instrument errors
- Variations in concentration with time
- For two cases of discharge:
  - constant discharge
  - varying discharge
- **It is assumed that the current auto-sampler collects samples that are representative of the discharge.**

Case 1 - Constant flow



Case 2 – Varying flow



Results from simulation study

Aliquots collected	Case 1	Case 2
S-5A Grab	5	5
S-5A Auto-sampler	1120	3090
Proposed Total flow Auto-sampler	1832	4784

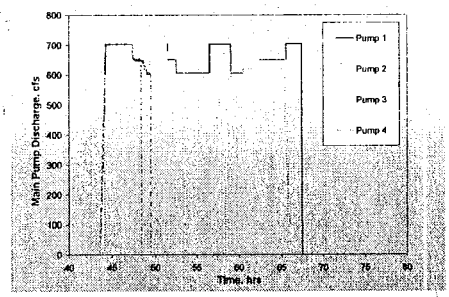
	CASE 1		CASE 2	
	Loading (Ton)	% Error	Loading (Ton)	% Error
True	176.2		431	
S-5A Grab	175	0.9	481	12
S-5A Auto-sampler	176.1	0.06 *	433	0.6 *
Proposed Total flow auto-sampler	176.2	0	431	0

* Errors are based on the assumption that the current auto-sampler takes representative samples

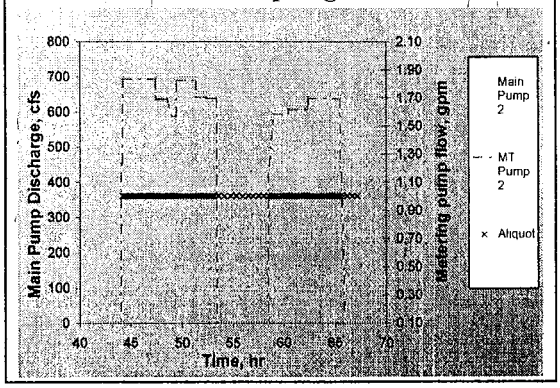
Implementation

- Automatic operation
- Flow rate of sampling streams controlled to be proportional to the discharge from the pump
- Pump discharge calculated from the pump RPM
- Accuracy - Error analysis

Actual pump discharge for the week of Jan 1- Jan 7, 1994



Flow of sampling streams



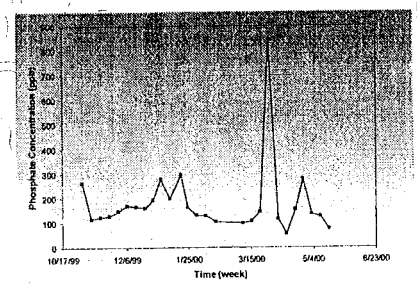
Maintenance

- Designed for ease of flushing to prevent fouling in the-
  - tanks -Mixing and Sample
  - tubing
- Valves and metering pumps easily available (off the shelf) and replaceable

Error Analysis

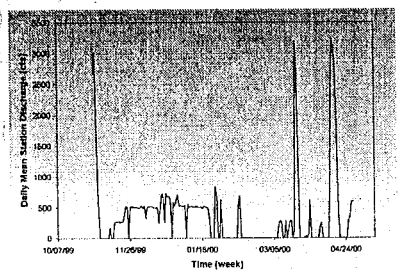
- Sources of error considered
  - Calculating discharge
  - Flow of sampling stream (metering pump)
  - Volume of Aliquot metered
- Actual concentration and flow data from November 1999 to May 2000

Concentration profile



The above figure shows the phosphate concentration based on actual grab samples taken at S-5A for a period of 26 weeks from November 1999 to May 2000. This profile was used for error analysis.

Discharge profile



The above figure shows the actual discharge from the S-5A station for a period of 26 weeks from November 1999 to May 2000 obtained from DBHYDRO. This profile was used for error analysis.

Results from error analysis

Source	Relative Error present	Relative Error caused (in determining phosphate loading)
Flow computation	± 10%	± 0.5 %
Sampling stream flow (metering pump)	± 2%	± 0.05%
Aliquot metering	± 0.5%	±0.005
All three combined		±1%

Proposed Sampler - summarized

- Proposed auto-sampler is a total flow sampler
- It takes the sample continuously at a rate proportional to the discharge flow
- The proposed sampling system is capable of sampling from all the pumps, thereby ensuring that representative samples are taken.
- Annual Phosphorus loading calculated on the basis of composite sample concentration will be accurate.

Proposed Design

- Strengths
  - Accurate Loadings - Total flow and Continuous sampling
- Ease of operation and Maintenance
  - Automatic Flushing
  - Valves and metering pumps are easily replaceable
- Level of Complexity
  - Medium
- Required level of operator skill
  - Familiarity with computers
- Approximate Cost
  - $30K

Experts Contacted

- Ronald Klauda at Maryland Department of Natural Resources
- Rob Waschbusch at USGS, Middleton, WI
- Richard Bell at USGS, Little Rock, AK
- Arthur Leitz at USGS, Miami, FL

Acknowledgements

- David Struve, Maxine Cheeseman, Bahram Charkhian
- Stuart Vanhorn & Cherry James
- Matahel Ansar
- John Moorman, Linda Crean

Path Forward

- Implementation of the proposed auto-sampler
  - Will not replace the grab sampling and the current auto sampler but simultaneous use of the 3 sampling methods
- Comparative sampling analysis of the 3 techniques will be carried out