Title of Proposal: Property-Based Management and Optimization of Water Usage and Discharge in Industrial Facilities.

Statement of Critical Regional Water Problems:

The processing industries (e.g., petroleum, petrochemical, chemical) are major economic contributors to Texas and Gulf-Coast states. In addition to providing tremendous economic impact on the region, they also result in a major ecological impact because of their high levels of fresh water usage and wastewater discharge into our rivers and aquatic resources. In light of the escalating stringency in environmental regulations on the discharge of wastewater from processing facilities and the consistent calls for "zero discharge" targets, the fiber and polymer industries are facing a significant challenge of maintaining economic competitiveness while becoming more environmentally benign. Therefore, it is acknowledged that a critical need for the industry is to have design and operational strategies that can address economic and environmental issues simultaneously.

Nature, Scope, and Objectives of the Research:

The processing industries provide a significant economic impact on Texas and the Gulf Coast region. Because of the tremendous amount of fresh water and discharge of these processing facilities, they also have a significant ecological impact on the aquatic resources. The major challenge is that wastewater effluent from manufacturing facilities is composed of a multiplicity of contaminants including ions, salts, coloring/bleaching agents, and organics. At present, these plants face significant challenges in meeting EPA regulations. As the environmental regulations get more stringent, it is expected that a major portion of these critical processing facilities will be forced to close or move to other countries.

The objective of this research is to develop comprehensive, cost-effective design and operating schemes that target the optimization of water usage, recycling and discharge in the process industries. Process integration methodology will be employed as a systematic framework for identifying optimal solutions to the above-mentioned targets. This integrated approach will not only help the process industries meet environmental regulations for water usage and discharge but will also create an excellent potential for economic gain for the processing facilities in the region. These economic benefits will accrue as a result of optimizing the usage of water resources, minimizing wastewater treatment costs, maximizing the recovery of valuable materials and debottlenecking the process.

In order to determine optimal strategies for water usage and discharge in the process industries, it is crucial to develop a comprehensive, generic approach to water management and pollution prevention which would incorporate economics, reliability and product quality along with maximizing the use of already available process internal resources. Over the past decade, a new methodology has been developed which is capable of systematically minimizing waste and improving overall process efficiency. This approach, known as *process integration*, has been pioneered by Dr. El-Halwagi and his coworkers (e.g. Gabriel and El-Halwagi, 2005, Dunn and El-Halwagi, 2003; El-Halwagi, 1997). It is a holistic approach to the optimal allocation, generation, and separation of streams and species within a process. Mass integration involves the optimal allocation of species (e.g. water, process compounds, non-process elements) throughout the process and provides an excellent framework for developing cost-effective pollution-prevention strategies. The essence of mass integration is to understand the global flow of mass within a process and develop optimal strategies for the various species and streams within the process. Recent research has established that design of water usage systems can be optimized by using a property-based framework referred to as property integration which tracks and allocates water streams based on their functionalities in the process (Kazantzi and El-Halwagi, 2005; El-Halwagi et al, 2004).The aforementioned research activities will interact as illustrated by Fig. 1. Feed-forward and feedback mechanisms will be employed for coordination and task identification.

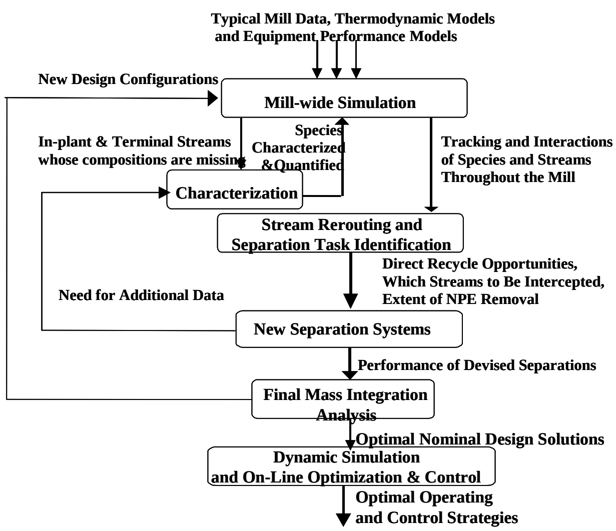

Fig. 1. Integration of Research Activities

In specific, the proposed research will be carried out via seven main tasks:

1. Develop process models including water usage and discharge.
2. Gather plant data on aqueous streams and chemical species to be included in the mass analysis. In case of missing data, sample, characterize, and analyze. Use these data to verify/refine the simulation models.
3. Identify direct recycle opportunities, water targets, and separation tasks.
4. Identify candidate separation technologies (conventional and novel) and analyze data.
5. Incorporate results of experimental separation in mass integration analysis. Develop necessary theoretical formulations and identify optimal solution strategies.
6. Develop dynamic simulation and optimum operating and control strategies.

Results Expected from this Project:

Because of the comprehensive nature of this approach, it is anticipated that the results will be generally applicable to a wide variety of industrial plants. Short-term impact will be in the form of cost-effective implementable solutions to the water problems of the industry. Long-term impact will include the identification of technology changes and best technology-based management practices for the Twenty First Century. The research will also identify priority research needs that should be carried out by research organizations as well as the industry.

References

Dunn, R. F. and M. M. El-Halwagi, “Process Integration Technology Review: Background and Applications in the Chemical Process Industry”, J. Chem. Tech. And Biotech, 78(1011-1021), (2003)

Gabriel, F. and M. M. El-Halwagi, “Simultaneous Synthesis of Waste Interception and Material Reuse Networks: Problem Reformulation for Global Optimization,” Environ. Prog. 24(2), July 2005, 171-180

El-Halwagi, M. M., I. M. Glasgow, M. R. Eden, and X. Qin, “Property Integration: Componentless Design Techniques and Visualization Tools”, AIChE J., 50(8), 1854-1869 (2004)

El-Halwagi, M.M., “Pollution Prevention through Process Integration Systematic Design Tools”, Academic Press, San Diego, CA (1997), pp. 1-190, 217-247.

Kazantzi, V. and M. M. El-Halwagi, “Targeting Material Reuse via Property Integration”, Chem. Eng. Prog., 101(8) 28-37(2005).