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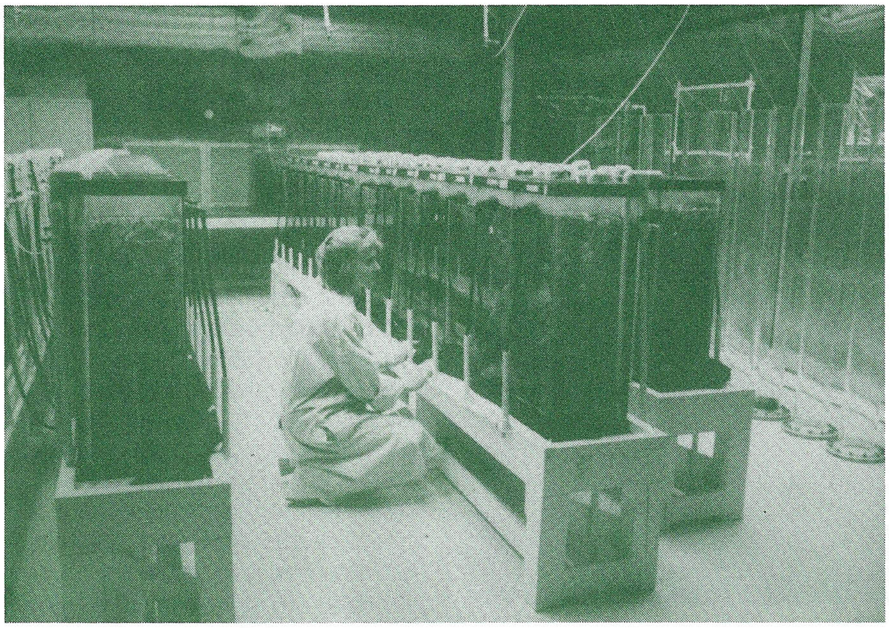
Chemical control technology

by
Kurt D. Getsinger and J. Lewis Decell

The objective of the Aquatic Plant Control Research Program's (APCRP) Chemical Control Technology Area is to develop technology that will improve the management of nuisance aquatic plants using herbicides and plant growth regulators (PGRs) in an environmentally compatible manner. The Chemical Control Technology Area includes seven work units: Herbicide Concentration/Exposure Time Studies, Herbicide Application Technique Development for Flowing Water, Herbicide Delivery Systems, Field Evaluation of Selected Herbicides for New Aquatic Uses, Plant Growth Regulators for Aquatic Plant Management, Species-Selective Use of Aquatic Herbicides and Plant Growth Regulators, and Coordination of Control Tactics with the Phenology of Aquatic Plants. Some shortened work unit titles will be used in the remainder of this article.



Herbicide CET study in WES controlled-environment chamber

Although the work units can function as independent research efforts, they have been carefully designed to operate interactively. This interactive approach allows results obtained from one or more work units to complement results from another, or to be used as "building-blocks" for more complex work units. As structured, these work units collectively encourage the development and evaluation of safe and effective chemical formulations and application techniques for the aquatic environment. Consequently, aquatic plant managers are provided with operational tools that minimize chemical dose, while maximizing the control of target plants, reducing the amount of chemicals placed in the environment and the effort and costs associated with aquatic applications.

An important function of the Chemical Control Technology Team (CCTT) is to develop working relationships with the chemical industry (primary developers and manufacturers of herbicides and PGRs) and the U.S. Environmental Protection Agency's (EPA) Pesticide Registration Branch. This cooperation enables CCTT researchers to stay informed of the latest developments in aquatic pesticides and regulations. In addition, interaction with U.S. Army Corps of Engineers

Districts and other Federal agencies responsible for aquatic plant management, such as the Tennessee Valley Authority, the U.S. Bureau of Reclamation, and the U.S. Department of Agriculture, is necessary to coordinate and focus resources on regional and national problems. Finally, cooperation with state and local aquatic plant management programs and institutional research facilities is maintained to augment the CCTT's laboratory and field research capabilities.

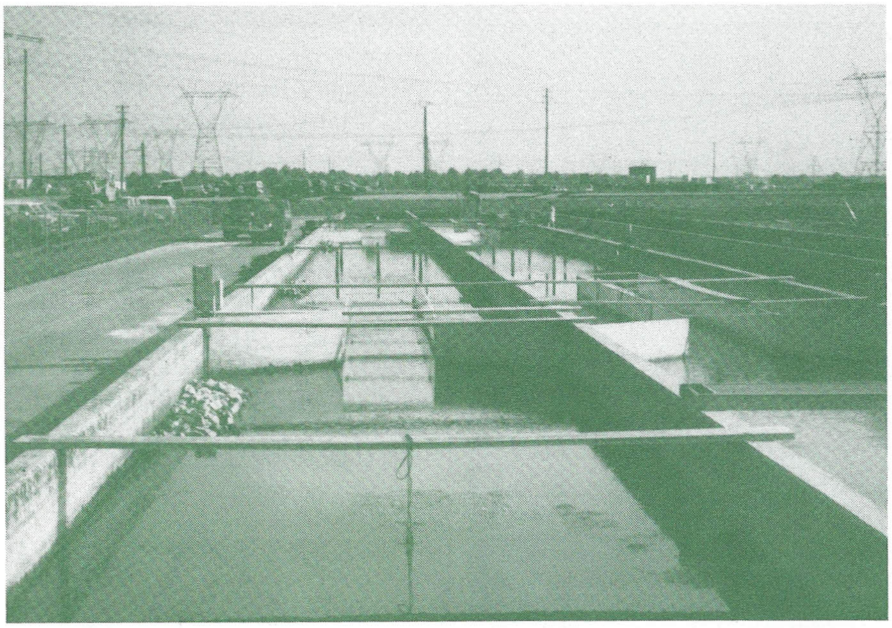
This article summarizes the specific objectives of the Chemical Control Technology Area work units and highlights the interactive nature of chemical control studies within the APCRP.

Work unit summaries

Herbicide concentration/ exposure time (CET) studies

Research in this work unit is designed to evaluate EPA-registered, as well as experimental use permit (EUP), herbicides and PGRs for aquatic uses. These studies are conducted at the U.S. Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi, under controlled-environment conditions. Major nuisance species, such as Eurasian watermilfoil and hydrilla, are treated with various herbicides (for example, 2,4-D, copper, diquat, endothall, fluridone, and triclopyr) over a range of selected doses and contact times. The unique properties of each chemical (for example, rate of application, mode of action, environmental half-life, and species selectivity), require that CET relationships be developed for each target plant. For example, use rates and exposure time requirements for contact herbicides (milligrams per liter per hour) differ dramatically from use rates and exposure times for some systemic herbicides (micrograms per liter per week).

Results from these studies are used to establish effective CET relationships for each herbicide and target plant. This information is then employed in the Herbicide Application Technique Development for Flowing Water and the Herbicide Delivery Systems work units to develop innovative application techniques, some of which are currently being used operationally to improve the control of Eurasian watermilfoil and hydrilla. In addition, data obtained from this work unit will be used in the herbicide fate model being developed in the APCRP Simulation Technology Area.



Hydraulic channels (flumes) used for aquatic herbicide research located at the TVA Aquatic Research Laboratory, Browns Ferry, Alabama

Herbicide application technique development for flowing water

In this work unit herbicide application techniques are developed to minimize the amount of active ingredient used and the frequency of treatments, while maximizing efficacy against target plants in high water-exchange environments such as rivers, canals, tidal areas, and large lakes/reservoirs. Results from the CET work unit provide the pertinent dose/response information required to develop improved and innovative application techniques.

Water movement can dramatically influence the off-target dispersion of herbicides in treated plots. In addition, thermal stratification of the water column (which readily occurs in submersed plant stands) can isolate layers of water and reduce vertical mixing of herbicides. Both of these situations can result in the inconsistent control of submersed plants. For this reason, application techniques are evaluated in large, outdoor flumes or in field situations.

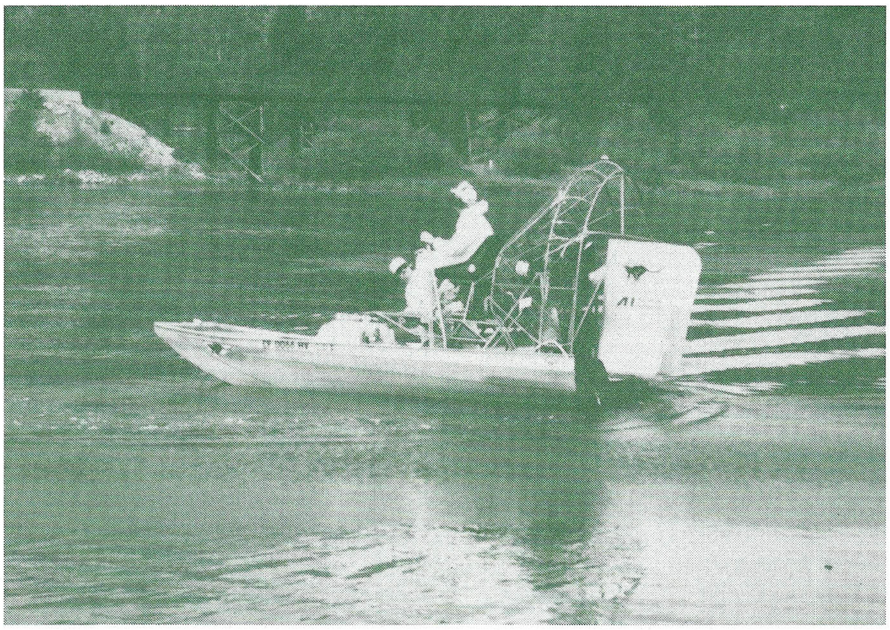
Research in this work unit has focused on describing water movement and stratification in hydrilla and Eurasian watermilfoil stands and on the potential impact of these conditions on herbicide contact time and efficacy. Studies have been conducted within submersed plant stands using flowmeters and tracer dyes to characterize water exchange. Results from this work are being implemented by operational personnel to select both type and timing of submersed application techniques that will minimize the impacts of water movement in high water-exchange environments.

Herbicide delivery systems

This work unit makes use of relationships developed in the CET work unit to improve herbicide delivery to submersed plants by dispensing low doses of active ingredient over long periods of time. Studies are designed to develop environmentally compatible, controlled-release (CR) carrier systems, such as polymers, elastomers, gypsum, and proteins. These CR systems are evaluated for herbicide release rates and plant tissue burden levels, as well as efficacy, in small-scale facilities at WES. Large-scale verification studies are being conducted in outdoor flumes and selected field sites. Results from this work will be used to improve efficacy of treatments in flowing water systems. This work unit also provides data for herbicide fate and effects models being developed in the APCRP Simulation Technology Area.

Field evaluation of aquatic herbicides

The most effective application techniques and chemical formulations developed in the work efforts described above are evaluated for efficacy under large-scale field conditions in this work unit. These cooperative studies involve the efforts of chemical companies; Corps Districts; Federal, state, and local agencies; universities; contractors; and WES. In addition, environmental fate and dissipation data collected in these studies are used to prepare field manuals/reports on the use of aquatic herbicides. These data are also available for chemical companies to use in fulfilling EPA requirements for registration or reregistration of specific herbicide formulations. Results from these field evaluations can aid in changing the registration status, site use, or amendments of residue tolerances for aquatic herbicides.



Airboat application of an aquatic herbicide

Aquatic plant growth regulators

Traditional efforts to control submersed aquatic plants usually destroy the standing crop, often resulting in widespread plant decomposition and disruption of overall community structure. In addition, total removal of plant biomass may result in fluctuations of nutrient levels, turbidity, and dissolved oxygen, and the concomitant loss of habitat may dramatically impact food-web relationships. Some PGRs offer the potential of slowing vertical growth rate of nuisance submersed plants, reducing the negative impacts that topped-out plants can impose on a waterbody. Thus, the beneficial qualities provided by underwater vegetation (for example, invertebrate and fish habitat, waterfowl food, oxygen production, nutrient sinks, and sediment stabilization) can be retained.

Studies designed to evaluate the effectiveness of PGRs on aquatic plants are being conducted in controlled-environment systems at WES. Herbicides that demonstrate PGR potential in the CET work unit are also be evaluated in this work unit. Since PGR efficacy may be quite sensitive to life-cycle events of specific target plants, information obtained from the Phenology of Aquatic Plants work unit will be useful in evaluating growth-regulating effects. The most promising plant growth-regulating compounds will receive additional evaluations in mesocosm, pond, and field situations.

Species-selective use of aquatic herbicides and plant growth regulators

This new work unit will develop and evaluate species-selective aquatic plant management practices using herbicides and PGRs. While weedy species can be removed using traditional chemical control tactics, these treatments usually impact native species as well. Using herbicides/PGRs in a species-selective manner can result in the control of target vegetation, while enhancing the growth of desirable or beneficial plants. Allowing these species to grow and flourish can slow the reinvasion of weedy species and provide improved fish and wildlife habitat. In this way, bodies of water plagued with monoculture infestations of exotic plants can be restored to a healthy, diversified and balanced aquatic community.

Studies at WES will focus on species-selective responses to applications (rate and timing) of selected herbicides/PGRs. Once responses of weedy (for example, hydrilla and Eurasian watermilfoil) and various nonweedy species (for example, pondweeds and wild celery) have been determined, desirable, herbicide-resistant plants can be selected for further evaluation. The most promising chemicals will be applied to mixed plant communities in a mesocosm system at WES' Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, Texas. Results from this work will be used to develop guidance for managing aquatic vegetation using a species-selective approach.

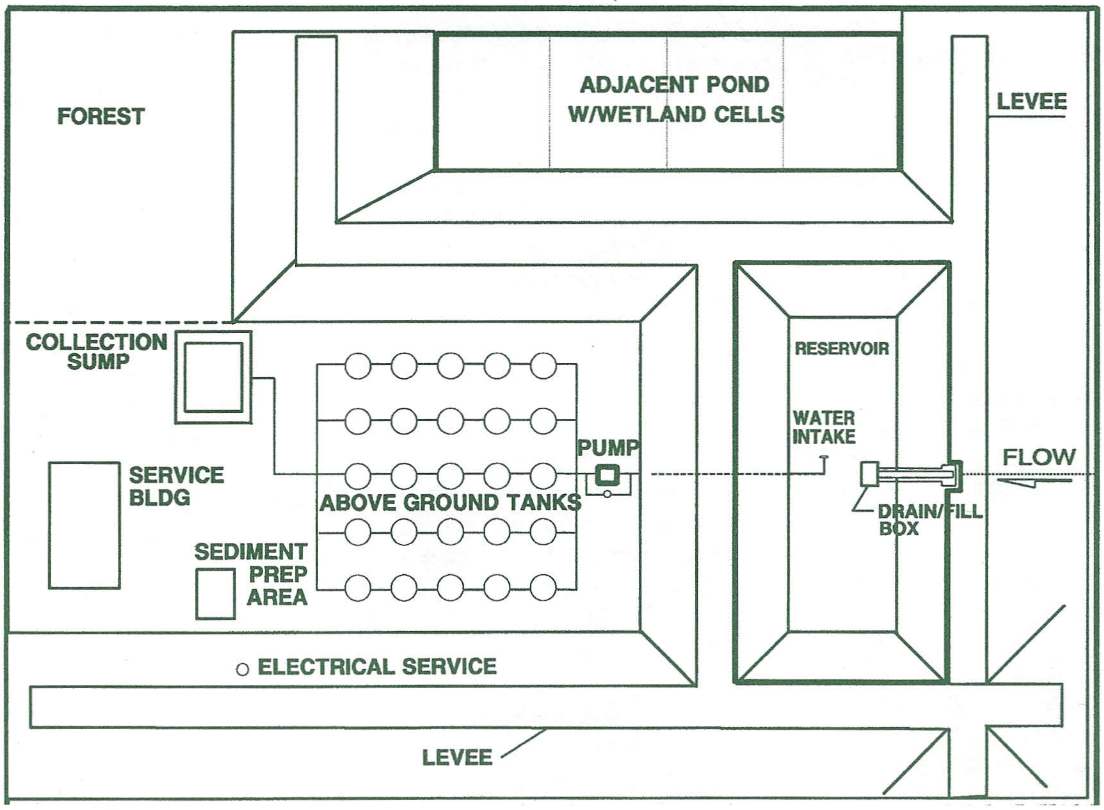
Phenology of aquatic plants

Certain factors associated with the survival strategy of plants (for example, rapid growth, photosynthetic efficiency, effective dispersal, and energy reserves) can enhance a species' ability to attain nuisance population levels. A thorough understanding of a species' survival strategy can be used to identify weak points in its growth cycle which can then be exploited to improve the control of that plant. Once identified, these susceptible periods can be predicted on the basis of growth-cycle events, morphological characteristics, and environmental cues. An easily recognized characteristic or cue will enable field personnel to determine the optimum time for applying appropriate control techniques (chemical, biological, physical, or integrated) by taking advantage of the weak link in the plant's growth cycle to maximize efficacy.

Phenological studies are being conducted on the major aquatic weed species (waterhyacinth, milfoil, hydrilla, and alligatorweed) at the LAERF. Results from these studies will be used in the Flowing Water and PGR work units and will be related to the timing of application techniques based on phenological events associated with the target weed. In addition, phenology information will enhance the use of nonchemical control technologies, as well as contribute to the plant growth modeling effort in the APCRP Simulation Technology Area.

Work unit interactions

Interactions among the Chemical Control Technology Area work units are summarized in Figure 1. Selected chemical compounds (unregistered, EUP, and registered) are studied via a series of



Schematic of Chemical Control Mesocosm System at the LAERF

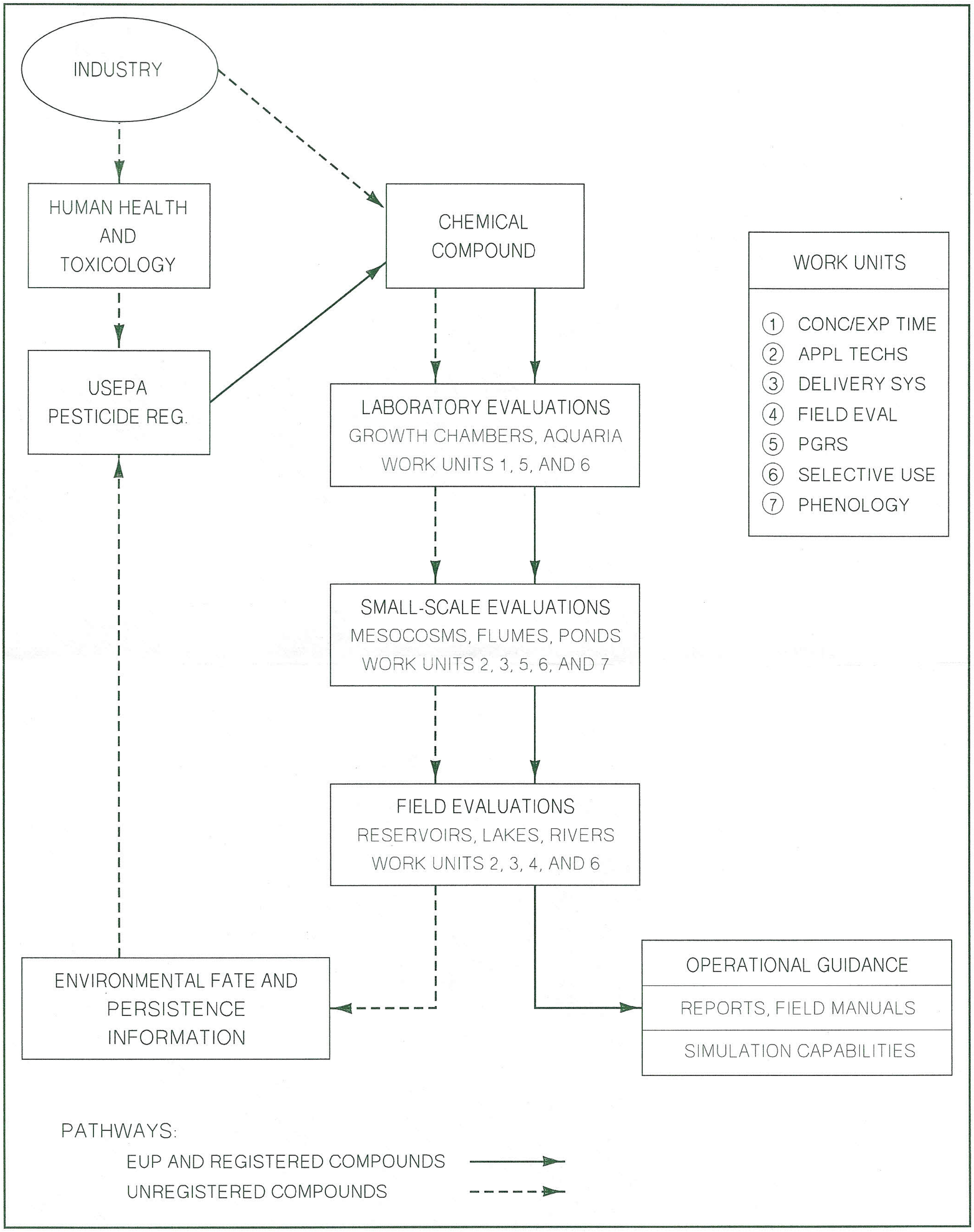


Figure 1. Flowchart of Chemical Control Technology Area work unit interactions

laboratory, small-scale, and field evaluations. Once these evaluations have been completed, guidance for the use of the EUP and registered compounds is provided to operational personnel in the form of technical reports and field manuals. In addition, data from these evaluations are used to enhance and develop simulation capabilities. Environmental fate and persistence information obtained on unregistered compounds is eventually provided to the EPA (in combination with the human health and toxicology data submitted by industry) for use in the aquatic labelling and registration process. A bibliography of recent CCTT publications is given at the end of this article.

Future work

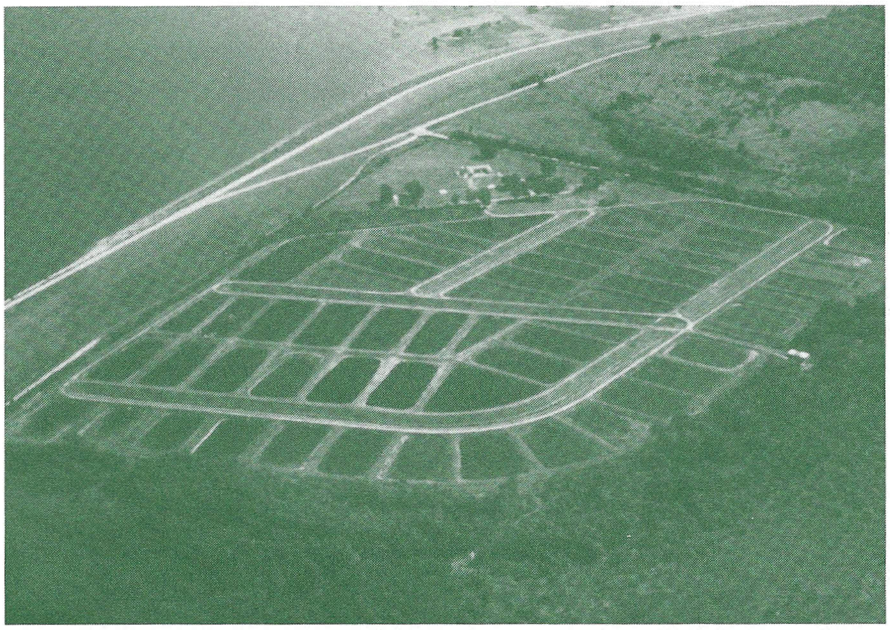
The future of managing aquatic vegetation with chemicals will depend upon the development and use of low-dose, nonpersistent, and species-selective products. Ongoing research efforts at WES will continue to focus on ways of improving the management of aquatic weeds using herbicides and PGRs, while reducing chemical application efforts. Through the implementation of CET relationships, innovative application techniques, and plant phenological data, researchers will be able to determine the least amount of chemical required (and the appropriate delivery systems needed) to optimize target plant control while minimizing damage to desirable nontarget vegetation. Management of this kind translates into spending less on chemicals and operational treatments. Perhaps more importantly, this strategy significantly reduces the amount of chemicals placed into the environment, allowing managers to lessen any adverse environmental impacts associated with chemical control. Moreover, this management approach can achieve and maintain a healthy, species-diverse aquatic plant community.

For further information on this subject, contact Dr. Kurt Getsinger at (601) 634-2498 or Lewis Decell at (601) 634-2683.

Bibliography of recent chemical control technology team publications

Fox, A. M., Haller, W. T., and Getsinger, K. D. 1991. "Factors That Influence Water Exchange

Mesocosm tanks used for chemical control research at the LAERF



Aerial view of the LAERF

in Spring-fed Tidal Canals," *Estuaries*, Vol 14, No. 4, pp 404-413.

Getsinger, K. D., Fox, A. M., and Haller, W. T. 1990. "Understanding Water Exchange Characteristics to Improve Control of Submersed Plants," *Aquatic Plant Control Research Program*, Vol A-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fox, A. M., Haller, W. T., Getsinger, K. D., and Green, W. T. 1991. "Characterization of Water Exchange in Hydrilla-infested Tidal Canals of the Crystal River, Florida," Miscellaneous Paper A-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Getsinger, K. D., Green, W. R., and Westerdahl, H. E. 1990. "Characterization of Water Movement in Submersed Plant Stands," Miscellaneous Paper A-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Getsinger, K. D., and Westerdahl, H. E. 1988. "Evaluation of Endothall/Adjuvant Mixtures in Flowing Water," Miscellaneous Paper A-88-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lembi, C. A., and Netherland, M. D. 1990. "Bioassay of Plant Growth Regulator Activity on Aquatic Plants," Technical Report A-90-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Luu, K. T., and Getsinger, K. D. 1990. "Seasonal Biomass and Carbohydrate Allocation in Waterhyacinth," *Journal of Aquatic Plant Management*, Vol 28, pp 3-10.

Luu, K. T., and Getsinger, K. D. 1990. "Seasonal Biomass and Carbohydrate Distribution in Waterhyacinth: Small-scale Evaluation," Technical Report A-90-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nelson, L. S., and Van, T. K. 1991. "Growth Regulation of Eurasian Watermilfoil Using Bensulfuron Methyl," *Aquatic Plant Control Research Program*, Vol A-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

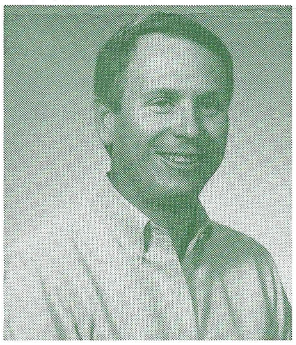
Netherland, M. D., Green, W. R., and Getsinger, K. D. 1991. "Endothall Concentration and Exposure Time Relationships for the Control of Eurasian Watermilfoil and Hydrilla," *Journal of Aquatic Plant Management*, Vol 29, pp 61-67.

Netherland, M. D., and Getsinger, K. D. 1992. "Efficacy of Triclopyr on Eurasian Watermilfoil: Concentration and Exposure Time Effects," *Journal of Aquatic Plant Management*, Vol 30, pp 1-5.

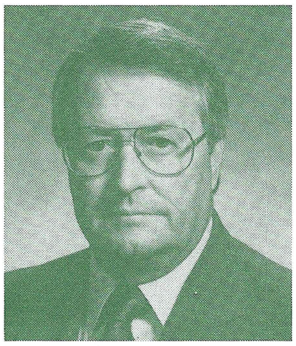
Westerdahl, H. E., and Getsinger, K. D., eds. 1988a. "Aquatic Plant Identification and Herbicide Use Guide; Vol I, Aquatic Herbicides and Application Equipment," Technical Report A-88-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Westerdahl, H. E., and Getsinger, K. D., eds. 1988b. "Aquatic Plant Identification and Herbicide Use Guide; Vol II, Aquatic Plants and Susceptibility to Herbicides," Technical Report A-88-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Dr. Kurt D. Getsinger is a research biologist in the Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station. He leads the Chemical Control Technology Team and his expertise includes management of nuisance aquatic vegetation using herbicides and plant growth regulators. Dr. Getsinger has a Bachelor of Science degree in biology from Campbell University, a Master of Science degree in biology from East Carolina University, and a Ph.D. in plant physiology from Clemson University.



Lewis Decell is Manager, Environmental Resources Research and Assistance Programs (ERRAP), in the Environmental Laboratory. His responsibilities include management of the Corps' Aquatic Plant Control Research Program (APCRP), the Water Quality Research Program (WQRP), the Natural Resources Research Program (NRRP), the Water Operations Technical Support (WOTS) Program, and the Natural Resources Technical Support (NRTS) Program. Lewis holds a Bachelor of Science Degree in civil engineering from Mississippi State University and Master of Science in environmental engineering sciences from the University of Florida.



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This issue reports on ongoing work in the seven work units of the Chemical Control Technology Area of the Aquatic Plant Control Research Program. Work unit interactions and future research are also discussed.

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This bulletin is published in accordance with AR 25-30 as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices and other Federal and State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited, but should be relevant to the management of aquatic plants, providing tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J.L. Decell, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call AC 601/634-3494.

ROBERT W. WHALIN, PhD, PE
Director

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3909 HALLS FERRY ROAD
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