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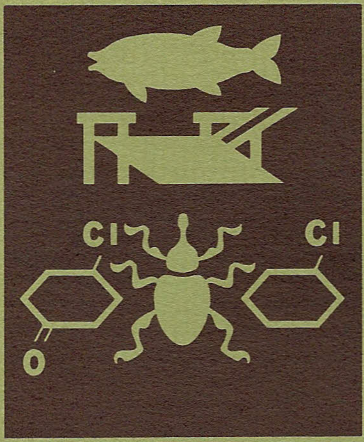

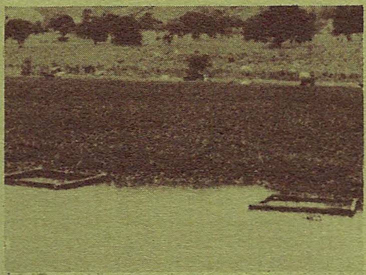

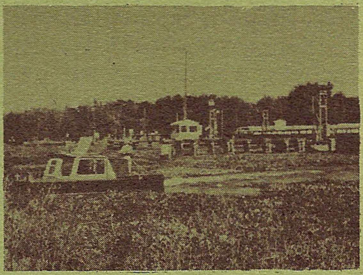

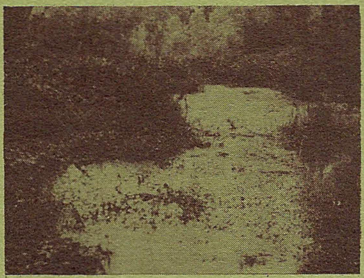

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AQUATIC PLANT CONTROL RESEARCH PROGRAM

Information Exchange Bulletin

IMPROVED AQUATIC PLANT MATERIAL DISPOSAL TECHNIQUES FOR MECHANICAL CONTROL OPERATIONS

BY BRUCE M. SABOL

INTRODUCTION

Mechanical methods were among the first techniques used to control nuisance aquatic plant infestations in many areas of the country. The first mechanical harvesting systems were designed to cut or chop the aquatic plants without removal from the waterbody. These types of machines were used 40 to 60 years ago to clear waterways in Louisiana clogged with waterhyacinth and alligatorweed, and water chestnut infestations in and around Chesapeake Bay.

In mechanical systems that provide for plant removal from the waterbody, the on-land disposal operation accounts for a large percentage of the total operational cost. If the mechanical system does not have several transport units, harvesting operations must be temporarily halted until already harvested plants can be transported to shore. Frequently, the land disposal site is not in the immediate vicinity of the harvesting site, which results in extra operational time and cost due solely to the long transport distances. Also, since the harvested plant material rarely contains more than 10 percent solids, removal and on-land disposal mean that the control operation handles 9 tons of water for each ton of actual plant material harvested. This results in a very expensive overall control operation, particularly when overland transport (e.g., trucking) is required to carry the harvested plant material to a remote site for disposal.

The U. S. Army Engineer Waterways Experiment Station (WES) has been conducting research for the Office, Chief of Engineers, and the Jacksonville District (SAJ) on mechanical means of controlling problem aquatic plant growth. A portion of the WES research has resulted in the design, construction, demonstration, and delivery of the Limnos Mechanical Control System to SAJ in 1979 (Figure 1). This system is a submerged aquatic plant harvesting system, unique in that it contains an onboard processor that grinds the harvested plants to achieve a substantial reduction in harvested plant volume. The system has four equipment components: an independent cutter (maximum cutter width of 18 ft, maximum cutting depth of 8 ft); a harvester with onboard processor; and two transport barges (maximum capacity of 17 tons and 480 ft^3 each). During a control operation, the cutter cuts the plants within a selected

Figure 1. Limnos system operating in a hydrilla-infested river.

swath width and water depth, and the detached plants float up to the surface due to their natural buoyancy. The harvester follows close behind the cutter, allowing enough time for the plants to reach the surface. Rotating circular rakes on the harvester's bow gather the floating plants in the water. The plants are then moved up an inclined conveyor to the processor (hammermill). In the processor, the plants are chopped into small fragments, then dropped into the attached hopper transport barge (Figure 2). When full, the barge is uncoupled; another empty barge is coupled to the harvester; and harvesting continues. The full barge is navigated to a shore take-out point, and the load is pumped onto land or into a truck for transport to a remote disposal site.

Problem

Land disposal of mechanically harvested aquatic plants may constitute 50 percent or more of the operational effort and expense involved in mechanically harvesting aquatic plants. The rationale in early efforts had been that land disposal was necessary to remove nutrients from aquatic-plant-infested waterbodies. However, subsequent studies have shown that such disposal practice does not significantly reduce available nutrients in many waterbodies. In spite of this, in-water disposal of aquatic plants has not been considered a viable option. No systematic studies have been conducted to determine the environmental impacts of aquatic disposal of harvested aquatic plants or to define environmental conditions for operational application.

Objectives

The objectives of this 4-year study are (1) systematic investigation of environmental impacts associated with in-water disposal of mechanically harvested and processed aquatic plants and (2) determination of operational and environmental conditions under which this disposal practice could be performed without harm to the aquatic environment.

Approach

A comprehensive literature review is being conducted to assess the technical state-of-the-art knowledge of mechanical devices capable of processing harvested aquatic plants and to quantify the natural processes involved in the decomposition of aquatic plants through natural senescence and through mechanical disruption.

A computer model will be designed that will predict environmental and water quality impacts of in-water disposal of harvested aquatic plants for various harvester designs and operational and

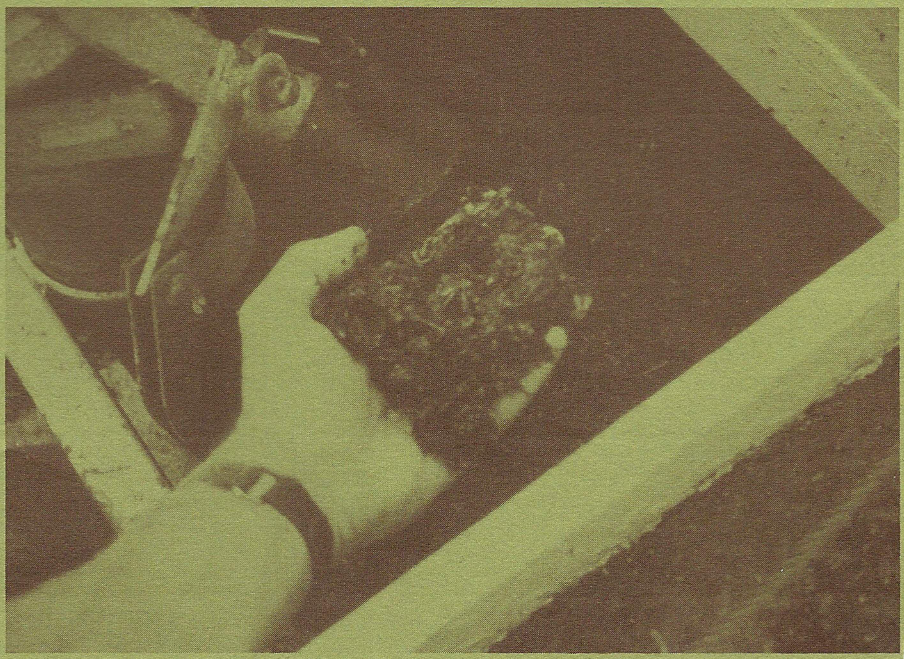

Figure 2. Close-up of chopped hydrilla in transport barge.

environmental conditions. This model will function as the principal research tool used for systematic examination of how design and operational and environmental factors affect the environmental impacts of disposal. The model will be calibrated using limited-scale field and laboratory tests as necessary. Field verification studies will be conducted at several different study sites. The model will be used to identify specific designs and operational and environmental conditions under which in-water disposal would result in minimal environmental impacts.

FIRST YEAR STUDY

The first year's research by WES focused on three potential environmental problems:

- Impact of decomposition of chopped plant material on oxygen concentrations in the aquatic disposal site.
- Nutrient release from the chopped plant material and subsequent algal response.
- Repropagation of chopped plant fragments.

Research tests were conducted during the summer of 1981 in Orange Lake, Florida. This north-central Florida lake is a large, shallow, eutrophic lake (maximum depth of 12.7 ft, mean depth of 9.4 ft, area of 13,000 acres) encircled by emergent aquatic plants and virtually completely infested with hydrilla. Three nonadjoining plots (approximately 200 ft between plots) were established in a hydrilla-infested area of uniform depth (7.5 ft) and plant density (20 tons/acre).

One plot was designated as a reference area; i.e., no harvesting was performed. Another plot (harvest) was used for normal harvesting with land disposal. The third plot (disposal) was used for harvesting and in-water disposal (Figure 3). Plants in the 0- to 5-ft layer were harvested from the harvest and disposal plots. Environmental data on water temperature, dissolved oxygen, and photosynthetic pigments were collected for 11 days before and 24 days after harvesting operations. By comparing the environmental conditions in the three plots, it was possible to detect effects attributable solely to harvesting and to in-water disposal, and to factor out the effects of external environmental conditions such as weather.

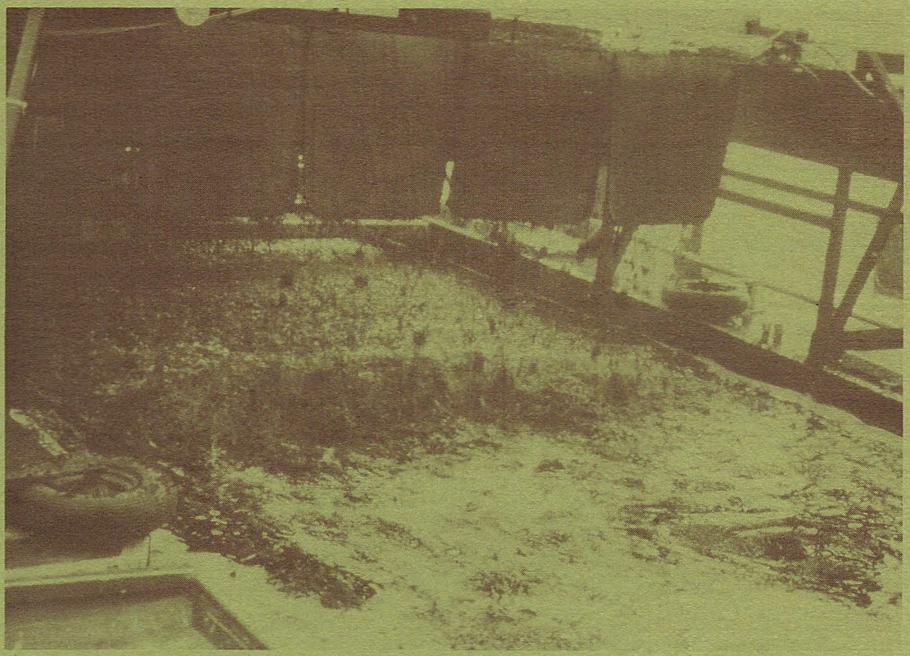

Figure 3. Chopped hydrilla falling back into the water after passage through the Limnos hammermill.

Results

As a result of this first-year study, the following was found:

a. A very short-term, less than 24 hr, decrease was detected in dissolved oxygen in the harvest and in the disposal plots. The light anaerobic hydrosoil that occurred at a bottom depth of 5 ft was assumed to have caused the decrease in dissolved oxygen since the hydrosoil was stirred up by the harvester's paddle wheels.

b. The daily minimum oxygen content in the water column was not affected by in-water disposal.

c. The accrual of dissolved oxygen in the water column between morning and afternoon readings may be used as an indicator of aquatic net primary production. Removal of aquatic plants greatly reduced this oxygen accrual through the day; in-water disposal did not function to further reduce this daily accrual.

d. Phytoplankton density, as indicated by chlorophyll *a* concentrations, increased as a result of in-water disposal but also increased to a lesser degree by direct plant removal.

e. Plant removal decreased thermal stratification, indicating improved vertical mixing in the water column.

f. Aquatic disposal resulted in a small but significant amount (0.6 percent) of hydrilla stem fragments that were viable in that they did repropagate. (Repropagation potential increases with stem fragment length and the number of nodes on the stem fragment.)

g. Most stem fragments sank to the bottom within 1 to 2 hr after disposal; the longest fragments, those with the greatest regrowth potential, remained floating on the water surface for 3 days or more.

Discussion

The lack of significant adverse effects of aquatic disposal on the oxygen regime was documented. This differed from the reduced oxygen levels commonly reported during natural plant die-backs and after herbicide treatment in lake environments. The lack of reduced oxygen level is believed to have been caused by the fact that decomposition occurs on the bottom of the lake. In the case of natural die-back and herbicide treatment, plants decompose and release nutrients in the water column until the plant mat has decayed sufficiently to sink. In the harvesting and in-water disposal tests conducted by WES, the water column was immediately cleared of plants, resulting in immediately improved vertical and horizontal mixing. The particulate fraction of the processed plant material (which contains the bulk of organics and nutrients) quickly sank to the bottom of the lake. As a result, most of the decomposition and nutrient release occurred near the lake bottom, probably resulting in a lesser effect on the dissolved oxygen throughout the water column.

Plant Fragment Viability

Even though the number of fragments that remained viable after passing through the Limnos hammermill was extremely low (0.6 percent), floating fragments had the potential for establishment in other parts of the water body as a result of transport by water and wind action. In water bodies already completely infested with plants, fragment repropagation should be of minimal concern. However, in water bodies that are partially infested, additional measures should be taken to minimize fragment spreading to uninfested areas. One possible method that could be used to minimize fragment dispersion in lake environments would be harvesting and in-water disposal operations performed in an infested area surrounded by a buffer zone of dense surface-matted submerged aquatic plants. These uncut plants would act as a barrier to dispersion of floating fragments.

EVALUATION OF PREVENTION METHODOLOGY AS AN AQUATIC MANAGEMENT CONCEPT

BY K. JACK KILLGORE

BACKGROUND

The WES in cooperation with the Seattle District (NPS) initiated a Large-Scale Operations Management Test (LSOMT) in 1979 to evaluate the concept of prevention as an operational method for managing problem aquatic macrophytes in waters of the Seattle District. The primary objective was to develop operational methods to retard dispersal of Eurasian watermilfoil (*Myriophyllum spicatum* L.) from Lake Osoyoos downstream via the Okanogan River and subsequent establishment in the Columbia River drainage system (Figure 1).

Eurasian watermilfoil, a submersed aquatic member of the plant family Haloragaceae (Figure 2), was apparently introduced into North America from Europe in the 19th century. The plants can disperse rapidly by vegetative fragmentation. Profuse growth of

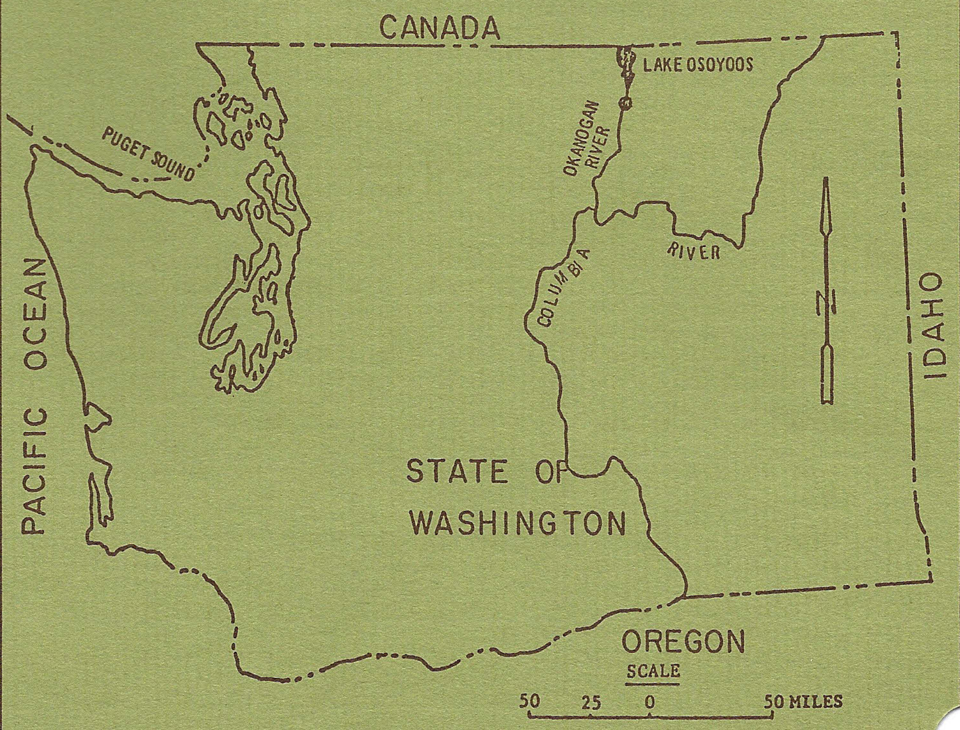

Figure 1. General location of the LSOMT watermilfoil prevention program

Figure 2. Morphology of Eurasian watermilfoil

newly established populations in a waterbody competes with existing populations of native aquatic plant species and interferes with the economic, recreational, and irrigational aspects of waterbodies. Although current prevention research is directed towards Eurasian watermilfoil, specialized prevention programs could be planned and implemented for managing other rapdily spreading problem aquatic plants.

ELEMENTS OF A PREVENTION PROGRAM

The success of any aquatic plant management program will depend on the effective implementation of five basic elements: training, monitoring, reporting, public awareness, and treatment. These five elements of a plant management program for a prevention strategy are each discussed in the following paragraphs.

Training

Personnel must be trained to implement a prevention plan. Manuals, office and field workshops, seminars, and other procedures can be used to instruct personnel in aquatic plant identification and population dynamics, aquatic plant management concepts, monitoring methods, and treatment methods.

Monitoring

Monitoring can be used to detect established population levels, to detect new colonies of problem aquatic species, and to assess the effectiveness of treatment measures. Monitoring large areas generally involves collecting and analyzing an appropriate combination of ground truth and aerial survey data.

Intensive ground surveys are usually adequate for maintenance- and control-level monitoring because the plant communities are generally dominated by a single target species. More extensive ground surveys are necessary in a prevention program.

In a prevention program, aerial photographs are obtained to construct a base map of all detected aquatic plant colonies of potential concern to ground surveys crews (Figure 3). Then ground surveys of these colonies can detect the presence or absence of target species among the aerially detectable plants. Early ground surveys are essential since the target species should be detected prior to becoming a dominant member of the flora.

Color aerial imagery at a scale of 1:5000 is almost certain to provide adequate resolution to detect submerged aquatic plants in applicable habitats. However, when funding constraints do not provide for large-scale aerial photography or when the objective of the monitoring is to determine the general location of aquatic plant populations for subsequent ground survey, less regard for areal extent, and therefore smaller scale (i.e., 1:10,000) photography will suffice.

The monitored area should include not only the areas known to be colonized by the target species, but also areas of potential infestation. Most problem aquatic plants can disperse and become established far from the parent population. Frequent and accurate monitoring efforts are important in a prevention program. Without sufficient ground and aerial monitoring, the other elements of a prevention program may be misdirected.

Reporting

Reporting procedures should be devised that provide systematic transmission of monitoring or treatment data on problem aquatic plants to management. Weekly or monthly reports are necessary for a successful prevention program. A cooperative effort by Federal, State, and local agencies reporting the status of the target species augments the monitoring element and is helpful for planning annual treatment strategies.

Public Awareness

Use of all available means of informing Federal, State, and local officials and the general public of the hazards of permitting the unchecked distribution and growth of the target aquatic plant species should be considered. Motivation of informed citizens to participate in the overall prevention effort can be helpful. Public meetings, brochures, newspaper articles, television, radio, magazines, special notices, and legislative efforts all can be used to minimize the problem of convincing the public that a potential problem exists when it is not yet evident.

Treatment

Treatment programs are used to achieve the desired level of control of aquatic plant populations in a specified local environmental, social, or ecomonic situation. Before any treatment program is selected, potential users should examine not only effectiveness of a proposed treatment but also consider any local constraints. Type and effort of treatment will vary between a prevention program and maintenance or control programs.

Reducing or maintaining the size of established populations of

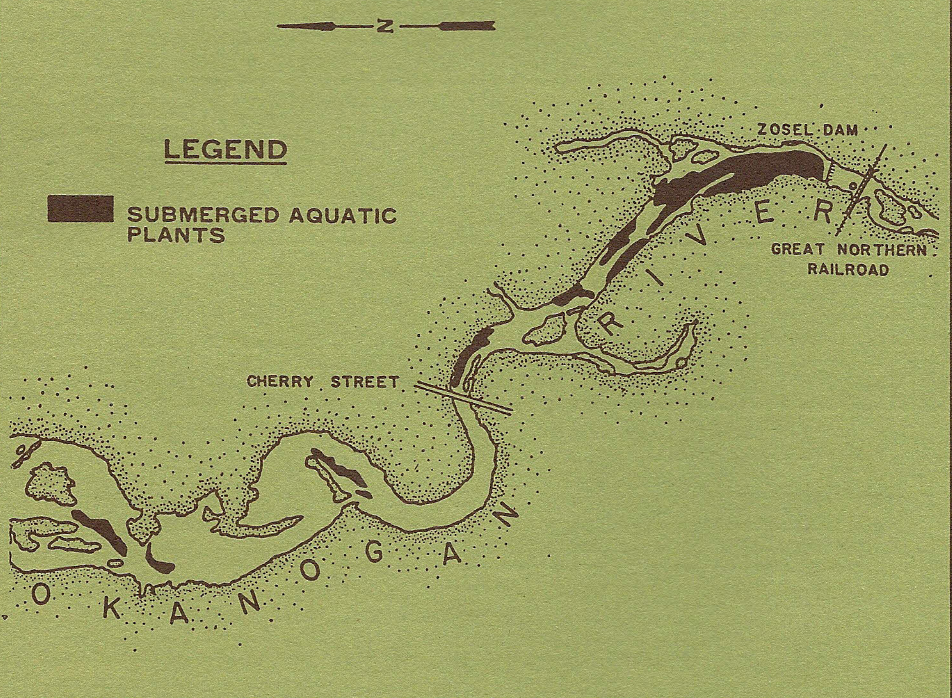

Figure 3. Base map showing locations of submerged aquatic plant in the Okanogan River, Okanogan County, Washington, as interpreted from aerial photography

a target species requires continued costly treatments. On a per-unit-area-treated basis, treatment costs of a prevention program can be even higher. These high costs are due to the extremely effective but costly methods that may be required to keep newly establishing populations of a target species below zero problem levels. However, one goal of a prevention program is to avoid maintenance and control treatments that would become required for a rapidly increasing acreage of the problem species. While the per-unit-area cost of prevention treatments can be high, the avoidance of accumulating maintenance and control treatments may make prevention treatment cost-effective. Further inspection of these trade-offs is needed.

Many different treatment methods have been used for maintenance or control efforts, including various conventional, mechanical, chemical, and biological methods. These treatments may augment a prevention program by reducing the ability of source populations of a problem species to disperse to adjacent areas. Relatively less conventional treatment methods were used as part of the NPS prevention research where the objective was to keep new populations of Eurasian watermilfoil below the zero problem level. These methods included a fragment barrier, hand-pulling, and use of a diver-operated dredge.

Fragment barrier. A barrier system is intended to prevent or retard the downstream dispersal of a target aquatic plant (primarily fragments) from established colonies. A certain percent of aquatic plants always escape downstream (37.8 percent in the NPS LSOMT), but the barrier provides a means of retarding downstream dispersal.

Hand-pulling. When problem aquatic plants are growing over a small area, hand-pulling of plants is feasible. Hand-pulling is limited by bottom sediment type, water depth (ideally, waist deep or less), size of the area treated, water temperature, underwater visibility, and time and fiscal constraints. This treatment method should be attempted only in small high-use areas (e.g., boat-launch areas) where the presence of the target species will impact on user interests and where the implementation of other treatment methods is not feasible. Hand-pulling can be species specific and thus of utility in prevention programs.

Diver-operated dredge. A diver-operated dredge can be a feasible method for removal of entire plants growing in various substrates (Figure 4). The method is relatively time consuming and is not as cost-effective compared to other mechanical treatments or to herbicide treatments. The dredge should be considered only in situations where there is sparse occurrences of the target species (as in a prevention program) and when the main objective is to eradicate the problem species or to follow up a herbicide treatment. Time required for removal of problem submerged aquatic

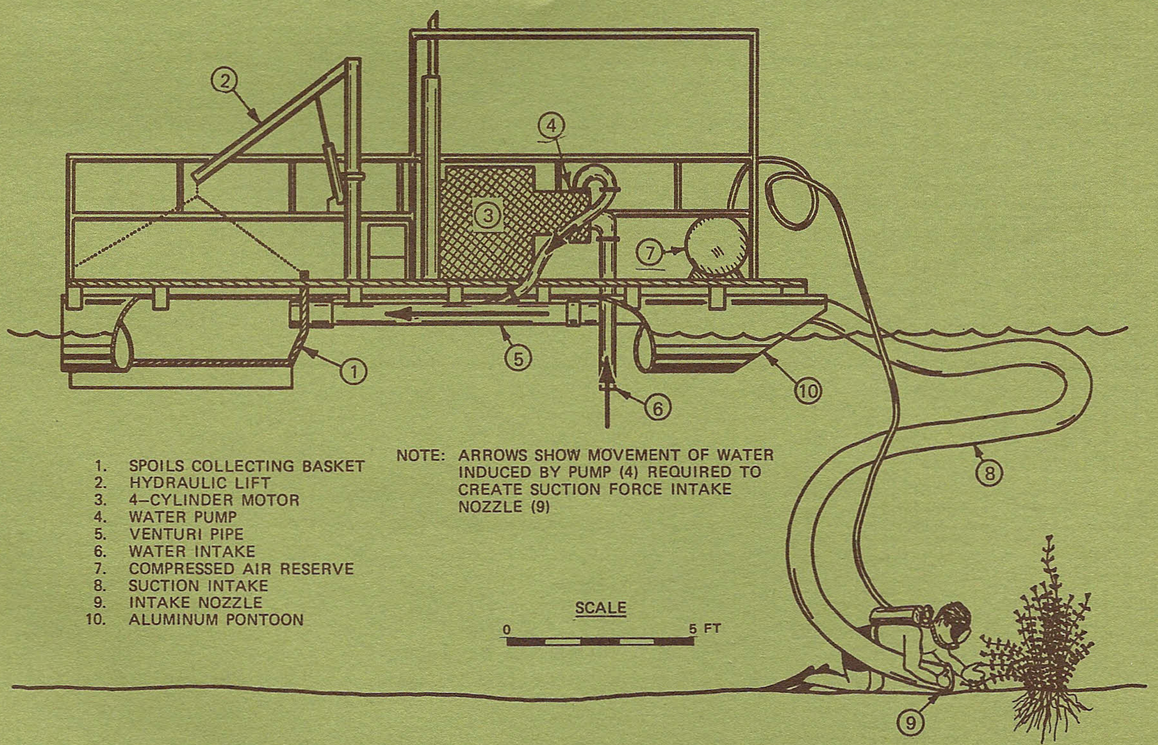

Figure 4. Diver dredge schematic side view (from Studies on Aquatic Macrophytes, Part XIV, Ministry of Environment, British Columbia)

plants by dredging can range from 16 to 136 hours/acre and depends on the plant density and substrate type. Like hand-pulling, a diver-operated dredge can remove target species with minimal disturbance of nontarget species.

DISCUSSION

Management of problem populations of aquatic plants in the Nation's waterways has been a growing concern of the Corps of Engineers. Management aimed at preventing relatively uninfested waters from becoming sites of problem aquatic plant growth, while requiring farsighted planning and commitment of funds to pending problems, represents the best approach to minimizing problem aquatic plant growth in many CE Districts. A prevention program must simultaneously acknowledge the improbability of completely stopping the problem species from reaching a previously uncolonized waterbody and the probability that early detection and subsequent treatment can prevent the population from attaining problem levels. The monitoring element, while important in any aquatic plant management effort, is critical in a prevention program. Many treatment methodologies have been developed to manage problem aquatic plants, and many of these are suitable for prevention-oriented management.

This bulletin is published in accordance with Army Regulation 310-2. It has been prepared and distributed 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 as well as other Federal agencies, State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited and will be considered for publication so long as they are relevant to the management of aquatic plants as set forth in the objectives of the APCRP, which are, in general, to provide 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. 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, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Miss. 39180, or call 601-634-3494.

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