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Use of herbicides in areas of high water exchange: Practical considerations

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INTRODUCTION

There are a number of fundamental elements that must be considered when conducting a herbicide application to control submersed plants in large lakes, reservoirs, streams, and rivers. These fundamentals include general weed control principles such as proper identification of the target plant, selection of an herbicide that is effective against that target plant, and water quality. Other principles are crucial to applications that treat only a portion of a water body—rather than the entire water body—especially where water movement or flow might occur in the treatment area. In these cases, the aqueous herbicide concentration and exposure time (CET) relationships required for desired control of the target plant, size, and location of the treated site and, most importantly, site-specific bulk water exchange processes are essential components for treatment success. In this paper, we will review and discuss how the principles of CET relationships and water exchange processes are linked to the success, or failure, of submersed applications in the field, whether for research and demonstration purposes, or for operational activities. Although the principles of CET relationships and water exchange exist in water conveyance systems, such as irrigation and drainage canals, we will limit our discussion to partial treatments in surface water bodies for controlling submersed plants.

When the appropriate herbicide and rate are applied to the leaves of emergent or floating vegetation, and the appropriate degree of rainfastness is maintained on those treated leaves, the level of desired efficacy is usually achieved. Likewise, if an entire water body (usually consisting of a pond or small lake) is treated to control submersed plants, and water outflow is limited, the level of desired efficacy is usually achieved because maximum CET relationships are maintained. However, to achieve desired efficacy of submersed plants in partial water body treatments—particularly in large reservoir and riverine systems where complex hydraulic events occur—aqueous herbicide CET relationships and water exchange processes must be considered and evaluated. To put it simply, a good understanding of site-specific water exchange processes determines and greatly improves the level of treatment success in flowing water environments, and will enhance the cost effectiveness of potential herbicide applications.

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CONCEPT OF AQUEOUS HERBICIDE CET RELATIONSHIPS AND IMPACTS OF BULK WATER EXCHANGE PROCESSES

The success or failure of a herbicide treatment designed to control submersed plants will primarily depend upon two factors: 1) the concentration of the herbicide in water that surrounds the target plant, and 2) the length of time a target plant is exposed to dissipating concentrations of that herbicide. This dose/response phenomenon is herbicide and target plant-specific, and has been defined as a CET relationship.

Hydrodynamic processes driven by gravity flow (rivers, streams, canals), tides (lunar), wind (lake seiches), and thermal circulation patterns (lakes and reservoirs) impact bulk water exchange in submersed plant stands, alter herbicide CET relationships, and thus can play a major role in determining success or failure of a treatment. For instance, chemical applications to entire water bodies (i.e., whole-lake treatments) routinely provide adequate plant control because target plants are exposed to lethal concentrations of herbicides for sufficient time periods. In other words, a lethal CET threshold level has been achieved and plants are controlled. However, reduced efficacy can occur in systems where only portions of the water body are treated (e.g., partial-lake treatments, spot-treatments), and where water exchange processes in and around those treatment zones impact herbicide contact time in the vicinity of target plants. In other words, the lethal CET threshold level is never met, and plants are not adequately controlled.

In submersed plant stands, water exchange processes are complex, subtle, and difficult to predict and characterize. In these situations, the application of the inert fluorescent water-tracing (WT) dye, rhodamine (RWT), can provide an estimate of bulk water exchange and can be used to predict real-time posttreatment dispersion/dissipation of liquid and granular aquatic herbicides. When coupled with herbicide CET relationships, developed in laboratory or mesocosm trials, results from this tracer dye technique can be used to develop prescription treatment strategies where the appropriate herbicide, formulation (liquid or granular), and dose are used to overcome impacts of water exchange, and to provide desired and selective control of target plants.

In most cases, submersed plant control in public waters selectively targets an invasive plant such as Eurasian watermilfoil or hydrilla. The goal of species-selective control is to remove the unwanted invasive plant, while minimizing injury to the native plant community. Aqueous herbicide CET relationships can also be used to predict efficacy/injury to valuable native plants that might be

Table 1. Sites where water-exchange information, coupled with herbicide concentration and exposure time relationships and innovative application techniques, have been employed to manage the invasive submersed species, Eurasian watermilfoil and/or hydrilla, in large water bodies and rivers (1990–2016).

State	Water body	Herbicide(s)
Alabama	Guntersville Reservoir	2,4-D, endothall, diquat
Florida	Crystal River	endothall, copper
	Loochloosa Lake	endothall, fluridone
	Lake Kissimmee	fluridone, endothall
	Lake Toho	fluridone, endothall
	St. Johns River	fluridone
	Lake Seminole–Spring Creek	fluridone, endothall
	Withlacoochee River	fluridone
	Wakulla Springs	endothall
Idaho	Lake Pend Oreille	triclopyr, 2,4-D, endothall, diquat
Minnesota	Lake Minnetonka	endothall, 2,4-D, triclopyr
Montana	Noxon Rapids Reservoir	endothall, triclopy, diquat
North Carolina	Lake Gaston	fluridone, diquat, copper, endothall
Virginia	Potomac River	various products
Washington	Pend Oreille River	triclopyr

present in treatment zones. Information on CETs for some of the most common invasive plants and many key native plants, has been documented in reports, technical communications, and the peer-reviewed literature (see Bibliography).

Over the past 25 yr, operational-scale treatments around the United States have verified that the linkage of water exchange information, herbicide CET relationships, and innovative application techniques greatly improve management of Eurasian watermilfoil and hydrilla in large lakes, reservoirs. and rivers (Table 1). In addition, new treatment standards have been developed for the environmentally sound management of submersed weeds in high water-exchange situations, previously proclaimed "unmanageable" just a few years ago.

SELECTION OF TREATMENT PLOTS AND APPLICATION TECHNIQUES TO MAXIMIZE CET RELATIONSHIPS

Selection of treatment plots

Herbicide treatment research plots should be selected based upon situations that maximize herbicide CET relationships. From an operational standpoint, if CET relationships are maximized, less herbicide can be applied to achieve desired control of target plants in the plot/site—this of course reduces environmental loading of pesticides, increases longevity of control, and lessens overall costs associated with treatments. Ideally, treatment plots should be situated where bulk water exchange processes are limited, such as areas of a water body that are sheltered from factors that can influence water exchange or movement. For instance, CET relationships will be improved in plots located in a "dead-end" cove, rather than along a shoreline which is more likely exposed to wind-generated water currents. Conversely, a cove located at the mouth of a tributary stream might be greatly impacted by water exchange processes, depending upon the discharge volume of the incoming stream. Treatment plots (especially small ones) that are bounded by steep drop-offs in depth can lead to rapid mixing of treated and untreated water, resulting in diminished herbicide CET relationships.

Documenting water exchange processes in plots is recommended in order to link CET relationships with efficacy results. In other words, pretreatment knowledge of water exchange can greatly aid in predicting and "explaining" herbicide effectiveness against treated vegetation. It can also aid in documenting dilution of the treated water by mixing of untreated water in the plot, and by characterizing aqueous dissipation of herbicide concentrations beyond the boundaries of the treated plot. Movement of herbicide concentration outside plot boundaries can be critical with respect to location of water intake systems and potential injury to nontarget plants in the area. In many cases, knowledge of the direction of herbicide dispersion can be used to optimize treatments because invasive plants outside the physically treated area will receive an adequate CET. As noted above, RWT dye is an accepted, and often optimal, method for determining bulk water exchange processes in potential treatment plots, and can be valuable as a pretreatment simulation of herbicide applications when ambient conditions in the plot are similar during the dye treatment and the herbicide treatment. The RWT dye can be measured real time with a fluorometer. It is also used to explain treatment failures, because on-site monitoring of the dye allows for in-field tracking, and increasing the number of samples does not greatly increase project costs. Posttreatment sampling of herbicide concentrations within and outside of the treated area can also provide information that allows managers to predict and explain efficacy (or lack thereof) of the current treatment, as well as information that can be used to plan for future treatments in these areas. Although there have been many attempts to use flow meters to assist in predicting aquatic herbicide behavior, the complex hydrodynamics in even a small treatment area can result in production of data that is confusing at best to a biologist or natural resource manager. Flow meters perform much better in linear-flow systems.

Methods to mitigate water exchange processes

In some situations, manipulation of treatment plots can reduce water exchange processes on a temporary basis and greatly increase CET relationships. Barrier curtains that extend from the water's surface to the bottom can be secured around the treatment area to suppress water exchange within the plot. Once the required CET relationships have been achieved, the curtains are removed. Barriers can allow for the use of herbicides that have extended (days to weeks) CET requirements, where they would be ineffective if the normal water exchange processes in those plots occurred. These curtains were originally developed to contain oil spills or other accidental releases of hazardous materials into water bodies. Barrier curtains are most effectively used to isolate a small cove, or stretched across a narrow neck of water to isolate a larger section of a water body. There are limitations involved when considering the use of barrier curtains including: a) initial purchase expense; b) deployment, proper cleaning/storage are labor intensive; c) possible navigation hazards; d) they are subject to disruption in rough water conditions; and d) they cannot be effectively used in high water-flow conditions.

Water exchange processes can also be impacted by the areal size and shapes of plots. For example, a 0.4 ha (1 ac) treatment plot surrounded by untreated water on all boundaries will experience a more rapid exchange of water, diluting herbicide concentrations more quickly, than will occur in a 12 ha (25 ac)treatment plot in a similar location. This is due to a plot edge effect that results in 254 m (832 ft) of edge for one acre square plot and only 1274 m (4,180 ft) of edge for a square plot that is 25 times larger. Likewise, the shape of a plot can have a large impact. Herbicide concentrations applied to a long, narrow plot will decline more quickly than when herbicides are applied to a "bulkier" plot such as a broad square or rectangle. Again, in terms of edge per plot, a 0.4 ha (1 ac) shoreline plot that is 12 m (30 ft) wide and 443 m (1,452 ft) long will have 903 m (2,964 ft) of edge (452 m [1,482 ft] if placed directly along the shoreline) versus a 0.4 ha (1 ac) square plot that would have 254 m (832 ft) of edge. Optimizing the location, size, and shape of plots will determine if field study results validate findings from greenhouse/growth chamber studies, and if this information will be of use to aquatic plant managers in a real-world operational situation.

One obvious and well-established strategy for mitigating impacts of water exchange processes centers on the temporal aspects of herbicide applications. For instance, treatments can be planned and timed to take advantage of historical "reduced-flow" events, especially in rivers, streams, and reservoirs. Snow-melt and/or spring rains frequently produce freshets that greatly increase water volumes and flows in large systems, particularly those with extensive watersheds. However, in most years, water levels in these systems subside over documented time periods, which become more favorable for adequate herbicide contact times in many selected treatment areas. Although target plants might be at a more mature growth stage in late summer—when water flows have calmed and when herbicide uptake and activity is reduced compared to early and tender spring growth stages—control might be adequate with adjustments in herbicide application rates, because increased rates and length of contact time can supersede disadvantages of treating older plants.

Another approach to extend herbicide CET relationships is through sequential applications on the same plot, sometimes referred to as "bump" or "back-to-back" treatments. Properly timed sequential treatments can overcome herbicide dilution and dissipation rates in the treated plots, extending contact time and providing acceptable efficacy against target plants. In practice, sequential applications should only be conducted if water exchange processes are understood in the treatment plot, so the precise timing of the "bump" application is achieved. This approach remains an area of active research, but these principles are being used operationally at several sites where single treatments were not providing adequate control. An awareness that some herbicide labels restrict the total amount of a product applied to a given location during a growing season, and that this total concentration level cannot be exceeded, must be acknowledged.

Also, reductions in water movement, due to limited discharges and flows during maintenance/repair or power generation events on reservoir dams, can provide a window of reduced water exchange periods more conducive to herbicide applications. Scheduling of such major infrastructure activities is typically planned several years in advance, which can provide adequate preparation time for potential herbicide treatments. Furthermore, there might be reservoir systems that have diurnal water discharge schedules (e.g., pumped-storage facilities), where periods of low water exchange are consistently forecast and herbicide treatments can be planned accordingly.

Clearly, along with confirmation of the target plant to be controlled, water exchange processes drive the final selection of herbicides that match product specific CET relationships. The greater the water exchange, the shorter the aqueous contact time, and by default, quick-acting herbicides become the products of choice. Lastly, there are some field situations where water flow regimes simply cannot be overcome, and herbicides are not an option for those situations. Applying herbicides in plots where contact times are inadequate must be avoided. Aquatic herbicide treatments are costly, and poor performance due to water exchange processes not only diminishes confidence in chemical approaches, but also contributes to chemical loading into aquatic environments with no actual benefits.

Delivery of herbicides to plant stands and the role of formulations

There is much debate on which type of formulation—liquid versus granular—can provide the optimum delivery of herbicides to submersed plant stands. Regardless of the delivery system, once the chemical is released into the water column it is subject to all of the water-exchange processes described above. There is some preliminary evidence, using water tracing dyes, that indicate the placement of a herbicide in the lower portion of the water column (within the plant stand)—with liquid drop hoses beneath the surface or granular carriers that sink towards the bottom—might provide somewhat longer contact times around target plants. However, active water exchange events can often override this advantage. Over the years, work has been conducted to develop "slow-release" carriers that extend herbicide CET relationships in plant stands, but none of these devices have provided significant results in the field. Although in theory, slow-release technology should be a solution to extended CET relationships, it has yet to be demonstrated in a practical and cost-effective manner. Furthermore, this type of technology presents unique regulatory hurdles that can be difficult to overcome. Clearly, improving herbicide delivery techniques is an area that needs more investigation, and should also be linked with application timing and the life cycle events of target and nontarget plants. The "bump" treatments discussed above are essentially a manual method that simulates some properties of a slow-release carrier.

DATA COLLECTION AND SAMPLING

The axiom that "no two lakes are alike" can be modified to assert that "no two treatment plots are alike" within a water body. The unique and variable morphometry, shoreline structure, water exchange processes (which can vary on a diurnal, weekly, and seasonal basis), and other issues make it very difficult to establish true replicate plots for evaluations conducted in large water systems. It is always best to "replicate" plots whenever possible (more is better), but intensive sampling within each plot can help overcome some of the field sampling variability across plots. When sampling for aqueous herbicide concentrations and water quality parameters, even distribution of sampling sites in the plot, sampling throughout the water column at each site, and appropriate timing of sampling events can provide a reasonable characterization of what is occurring in the plot. Because water exchange processes influence events within plots, establishment of sampling sites outside of the plot boundaries can be very useful, particularly in characterizing herbicide CET relationships, off-target movement of chemical residues, and impacts on vegetation (target and nontarget) outside of plots. The water tracing dyes can be used as an indicator of where outside-of-plot sampling sites should be located, relative to the plot. Also, plots must be placed far enough apart to prevent aqueous herbicide cross contamination. Distance between plots should be determined by the projected aqueous dissipation of the herbicide being evaluated, ambient processes that might impact water exchange such as flow, wind direction, tides, etc. In rivers, streams, and reservoirs, untreated control plots should be established well upstream from any treated plots.

There are also some well-accepted quantitative methods for assessing changes in submersed vegetation within plots. Statistical comparison of these changes, between plots and over time (pretreatment through posttreatment), greatly enhances the value of the study, and provides a scientifically-sound basis for developing operational management guidance. Most importantly, design of field sampling protocols should be mindful per the scale and scope of the evaluations, including availability of sampling personnel and other pertinent resources. Limited resources will usually determine sampling protocols, so a thorough understanding of the "questions" to be answered by the study can help prioritize location, size, and number of plots required to conduct a valid field evaluation.

REGULATORY ISSUES

Regulatory issues must be addressed when treating plots in public waters, particularly in water bodies prone to dynamic bulk water exchange processes, such as large lakes, reservoirs, and rivers. Each herbicide registration (label) has been granted with varying degrees of use restrictions that must be followed during an application. One major regulatory concern is off-target movement of aqueous herbicide residues from treated plots into surrounding untreated waters. Off-target movement of these residues can be influenced by gravity flow, wind energy, and thermal circulation patterns—i.e., water exchange processes. Because a key use restriction can be the level of herbicide concentrations occurring at functioning irrigation or potable water intakes, it is crucial to establish plots in locations that will minimize or eliminate this condition. In other words, treatment plots should not be established too close to, and particularly upstream of, a water intake.

Another regulatory concern deals with repeated applications during a growing season. If making sequential applications to extend herbicide contact times (CET relationships), make sure to follow label guidance per the number of applications allowed on a given surface acre, and/or the maximum herbicide loading that is allowed on a seasonal or yearly basis on a given acre for a given product. If these conditions are exceeded, the applicator is in violation of the label.

The U.S. Environmental Protection Agency (EPA) will allow an unregistered product to be field tested in water for efficacy up to a maximum of 0.4 ha (1 ac) year^{-1} pest species^{-1}. This can be useful for treating emergent or floating-leaved plants, but plots $\leq$ 0.4 ha ($\leq$ 1 ac) in size do not work well for submersed plant evaluations in large systems, as noted in earlier. To evaluate aquatic plots $\geq$ 0.4 ha ($\geq$ 1 ac) requires some type of valid EPA and state label.

Finally, it is always wise to consult with the responsible state agencies during the planning stages of field study development. In addition to the agencies that label and permit the use of herbicides, coordination with Federal and state fish and wildlife agencies can be critical—especially if protected nontarget species utilize areas within or near the treatment sites. The ideal situation is to have local agencies act as co-operators on the project, supplying technical input and in-kind services if possible. The public can be particularly sensitive to pesticides applied to water (even if the application is a regarded as a research project), and securing state and/or local partners can provide vital guidance on selection of water bodies and treatment sites. In today's political climate, this coordination and partnership will ultimately determine the success or failure of a project.

BASIC FIELD SAFETY

Conducting field studies on the water can present many unique challenges from a human safety standpoint. Aquatic field studies are more complicated, and inherently more precarious, than typical terrestrial field trials because they require the use of boats, specialized sampling equipment, and other logistical factors. Investigators must adhere to all of the rules and requirements for operating boats (they can vary across water bodies and states): running lights, personal floatation devices, anchors, etc. In addition, environmental safety issues will be different from risks associated with terrestrial applications, such as potable water and irrigation intake set-back distances, and possibly swimming and fishing restrictions. All Federal use restrictions will be indicated on the herbicide label, but states have the authority to further limit and/or restrict aquatic use—and some do just that.

Weather conditions must be monitored closely because they can change rapidly, especially with approaching weather fronts. If conditions are questionable, postpone treatments and sampling events until weather is favorable for safe boating. High winds, heavy seas, and thunderstorms can pose serious safety concerns. It is wise to learn the overall study site: location of boat ramps, large open water fetches, depth profiles, areas of dangerous currents, navigation hazards, high boat traffic zones, etc. Develop and leave a "float plan" with a responsible person on shore, and notify them when investigators are off the water.

THE FUTURE OF HERBICIDE USE IN MOVING WATER

Unfortunately, invasive submersed plants will continue to spread and infest flowing water systems in North America. Although considerable progress has been made in effectively using herbicides in moving waters, the hydrodynamic complexity found in such systems still presents considerable application challenges. However, if invasive plant communities are not controlled in flowing systems, these areas will function as refugia for establishment of new infestations and reinfestations in many other water bodies. Prudent use of aquatic herbicides can play a key role in managing unwanted vegetation in moving water, but advances in technology and unique strategies will be needed to optimize control. Improved techniques for estimating water exchange processes in potential treatment sites—and more prescriptive linkage of that information to herbicide CET relationships—need to be developed and evaluated. Utilization of innovative application techniques and strategies must continue, and constantly be refined to improve species-selective plant control in moving water environments. Registration of systemic, quick acting herbicides will be another critical factor for successfully controlling target plants in high water exchange situations. To achieve this partial list of future challenges will take a dedicated, consistent, and collaborative effort among industry registrants, independent third-party research groups, and aquatic plant management practitioners. Without this future commitment, the degradation of arguably our most valuable resource, clean and abundant water, will accelerate.

BIBLIOGRAPHY

Fox AM, Haller WT, Getsinger KD. 1991. Factors that influence water exchange in spring-fed tidal canals. Estuaries 14(4):404–413.

Fox AM, Haller WT, Getsinger KD. 1992. Correlation of bensulfuron methyl and dye concentrations in water following concurrent application. J. Aquat. Plant Manage. 30:73–74.

Fox AM, Haller WT, Getsinger KD. 1993. Correlation of endothal and fluorescent dye concentrations following concurrent application to tidal canals. Pestic. Sci. 37:99–106.

Fox AM, Haller WT, Getsinger KD, Green WR. 1991. Characterization of water movement in hydrilla-infested, tidal canals of the Crystal River, Florida. MP A-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 26 pp.

Fox AM, Haller WT, Getsinger KD, Petty DG. 2002. Dissipation of triclopyr herbicide applied in Lake Minnetonka, MN concurrently with rhodamine WT dye. Pest Manage. Sci. 58:677–686.

Getsinger KD, Fox AM, Haller WT. 1996. Herbicide application technique development for flowing water: Summary of research accomplishments. MP A-96-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 16 pp.

Getsinger KD, Green WR, Westerdahl HE. 1990. Characterization of water movement in submersed plant stands. MP A-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 18 pp.

Getsinger KD, Madsen JD, Koschnick TJ, Netherland MD. 2002. Whole lake fluridone treatments for selective control of Eurasian watermilfoil: I. Application strategy and herbicide residues. J. Lake Reservoir Manage. 18(3):181–190.

Getsinger KD, Netherland MD. 1997. Herbicide concentration/exposure time requirements for controlling submersed aquatic plants: Summary of research accomplishments. MP A-97-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 18 pp.

Getsinger KG, Netherland MD, Grue C, Koschnick TJ. 2008. Improvements in the use of aquatic herbicides and future research directions. J. Aquat. Plant Manage. 46:32–41.

Getsinger KD, Sisnero, D, Turner EG. 1993. Use of water exchange information to improve chemical control of Eurasian watermilfoil in Pacific Northwest rivers. TR A-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 26 pp.

Getsinger KD, Sprecher SL, Langeland KA, Haller WT, Fox AM, Joyce JC. 1994. Dissipation of the herbicide bensulfuron methyl in Lake Seminole, Georgia. TR A-94-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 67 pp.

Getsinger KD, Stewart RM, Madsen JD, Way AS, Owens CS, Crosson H, Burns AJ. 2002. Use of whole-lake fluridone treatments to selectively control Eurasian watermilfoil in Burr Pond and Lake Hortonia, Vermont. ERDC/EL TR-02-39, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS. 79 pp.

Getsinger KD, Turner EG, Madsen JD, Netherland MD. 1997. Restoring native plant vegetation in a Eurasian watermilfoil-dominated plant community using the herbicide triclopyr. Regul. Rivers Res. Manage. 13:357–375.

Madsen JD, Getsinger KD, Stewart RM, Owens CS. 2002. Whole lake fluridone treatments for selective control of Eurasian watermilfoil: II. Impacts on submersed plant communities. J. Lake Reservoir Manage. 18(3):191–200.

Petty DG, Skogerboe JG, Getsinger KD, Foster DR, Houtman BA, Fairchild JF, Anderson LW. 2001. The aquatic fate of triclopyr in whole pond treatments. Pest Manage. Sci. 57:764–775.

Petty DG, Getsinger KD, Madsen JD, Skogerboe JG, Haller WT, Fox AM, Houtman BA. 1998. Dissipation of the herbicide triclopyr in Lake Minnetonka, Minnesota. TR A-98-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 96 pp.

Poovey AG, Getsinger KD, Skogerboe JG, Koschnick TJ, Madsen JD, Stewart RM. 2004. Small-plot, low-dose treatments of triclopyr for selective control of Eurasian watermilfoil. J. Lake Reservoir Manage. 20(4):322–332.

Skogerboe JG, Getsinger KD, Glomski LAM. 2006. Efficacy of diquat on submersed plants treated under simulated flowing water conditions. J. Aquat. Plant Manage. 44:122–125.

Turner EG, Netherland MD, Getsinger KD. 1991. Submersed plants and algae as factors in the loss of Rhodamine WT dye. J. Aquat. Plant Manage. 29:113–115.

Turner EG, Getsinger KD, Burns ER 1995. Chemical control field studies and demonstrations on Guntersville Reservoir. Joint Agency Project Guntersville Project, Aquatic Plant Management Report, Tennessee Valley Authority, Muscle Shoals, AL, and U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 78 pp.

Turner EG, Getsinger KD, Netherland MD. 1994. Correlation of triclopyr and rhodamine WT dye in the Pend Oreille River. J. Aquat. Plant Manage. 32:39–41.