Fluridone: herbicide treatment FAQ

What is Fluridone?

Fluridone is a slow-acting systemic herbicide used to control hydrilla, Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Like other systemic herbicides, it moves from submersed foliage to roots or immersed foliage (Marquis et al. 1981, Westerdahl and Getsinger 1988). A plant's susceptibility to fluridone is associated with its uptake rate and rate of translocation. Fluridone is absorbed from water by plant shoots and from the hydrosoil by the roots of aquatic vascular plants.

Fluridone interferes with the synthesis of RNA, proteins, and carotenoid pigments and thereby affects photosynthesis of the targeted plants (Bartels et al. 1978, Berard et al. 1978, NYSDEC, 1994). Specifically, fluridone inhibits the formation of carotene, a plant pigment, causing the rapid degradation of chlorophyll by sunlight, preventing the formation of carbohydrates necessary to sustain the plant. Fluridone (1-methyl-2-phenyl-5-[3-(trifluoromethyl)phenyl]-4[1H]-pyridinone) was registered with USEPA in 1986 and the NYSDEC in 1993 after undergoing required testing and evaluation as mandated by federal and state law (NYSDEC, 1994). Trade names for fluridone products include Sonar® and Whitecap®. Fluridone has been used in New York State in a large number of lakes since 1996 to control Eurasian watermilfoil and other invasive plants. Fluridone has also been used to successfully eradicate hydrilla in California.

It can be applied in a number of formulations: an aqueous suspension known as Sonar A.S. (USEPA Registration Number 67690-4) and three pellet forms known as Sonar SRP (USEPA Registration Number 67690-3), Sonar PR Precision Release (USEPA Registration Number 67690-12), and Sonar Q Quick Release (USEPA Registration Number 67690-3). The liquid formulations are generally applied via broadcast surface spraying or through the use of underwater application equipment. The pellet forms are usually applied via broadcast spreading. Fluridone can show effective control of submersed plants where there is little water movement and an extended time for the treatment. Granular formulations of fluridone are more likely to be effective when treating areas of higher water exchange or when applicators maintain low levels over long time periods (WSDOE, 2000).

For all formulations, aquatic plant control is obtained by maintaining an adequate concentration of the product in the treated area for a sufficient time period. Damage in susceptible plants usually appears in 7-10 days after water treatment (WSDOH, 2000). However, the desired level of plant control is usually achieved 30-90 days after the application of the herbicide. Concentrations up to 50 parts per billion are allowed in New York State, although the concentration of the applied chemical is often substantially lower to best match the susceptibility of target plants relative to native plants not targeted for control. The Tompkins County Soil and Water Conservation District is proposing the use of both liquid and pellet formulations to maintain a season-long dosage rate of 3-5 parts per billion (ppb), based on the site-specific evaluation of the Cayuga Inlet and recommendations from independent academic evaluators. It would be applied by the licensed and certified pesticide applicator, Allied Biological, a New Jersey-based company with an office in Maryland, NY.

Is Fluridone Toxic to Animals or Humans?

The use of any aquatic herbicide poses risks to non-target plants and aquatic organisms. However, federal and state pesticide regulations and strict application guidelines are in place to minimize exposure of non-target organisms. As a manufactured chemical that is released into the environment, fluridone has been extensively evaluated for non-target impacts in aquatic ecosystems, through the federal and state registration process and through product development. Aquatic organisms will have only limited exposure to fluridone in the water as a result of dispersion, dilution and microbial degradation of the chemical into carbon, hydrogen, oxygen and organic acids, even during an extended application period. No adverse impacts have been identified which are expected to result from the presence of fluridone at or below the NYS acceptable residual level of 50 ppb and the EPA acceptable residual level of 150 ppb for potable water (NYSDEC, 1994).

Fluridone applied at the approved concentration rate has not been found to be toxic to waterfowl and wildlife. Laboratory animals (mice, rats, dogs) fed with fluridone in their diets showed little signs of toxicity even when fed levels which far exceed potential human exposure from use of Sonar. Fluridone is not considered to be a carcinogen or mutagen and is not associated with reproductive or developmental effects in test animals (WADOH, 2000).

No adverse effects were observed on crayfish, bass, bluegill, catfish, long-neck soft-shell turtles, frogs, water snakes, and waterfowl from the use of 0.1 to 1.0 ppm of fluridone during field experiments (Arnold 1979, McCowen et al, 1979). Zooplankton were reduced slightly when 1.0 ppm was applied, a substantially higher dosage than will be used in the Cayuga Inlet treatment, but populations quickly recovered. Total numbers of benthic organisms did not change significantly at 0.3 ppm (Parka et al. 1978).

Parka et al. (1978) and Arnold (1979) reported that fluridone did not accumulate in fish. It was observed in bodies of bluegills 15 days after treatment, but the amount in the head or body did not exceed the concentration in the water. Grant et al. (1979) showed that channel catfish contained a low fluridone residue (0.015 ppm) 120 days after treatment of ponds, but no fluridone residue was detected in largemouth bass or bluegill fish. Fluridone did not bioconcentrate in any of the fish species. In laboratory tests using mosquito fish (*Gambusia affinis*), McCowen et al. (1979) observed that they survived and produced young at all rates of fluridone treatment. Hamelink et al. (1986) concluded that fluridone is not expected to have adverse effects on the assortment of fish and invertebrates utilized in their study or on similar non-target aquatic organisms. He reported that fathead minnows were not affected by continuous exposure to fluridone of 0.48 mg/l or less over their life cycle. The researchers did not observe any effects when daphnids, amphipods, or midge larvae were continuously exposed to concentrations of fluridone (0.2 mg/l or less for 32 days, 0.6 mg/l or less for 60 days, or 0.6 mg/l or less for 30 days, respectively). They determined that the acute median lethal concentrations of fluridone were 4.3 mg/l for invertebrates and 10.4 mg/l for fish. In the same study, growth and survival of channel catfish were not negatively affected by continuous exposure to fluridone concentrations of 0.5 mg/l or less for 60 days after hatching.

Similar observations have been made with fluridone use in other parts of the world. Investigators of Gatun Lake, Panama, concluded that total numbers and community structure of zooplankton, phytoplankton, and benthic organisms did not vary significantly during field tests of fluridone (Theriot *et al*. 1979). Kamarianos et al. (1989) concluded that no detrimental effects occurred in fish productive aquatic ecosystems (Greek ponds) treated with fluridone.

No adverse human health effects are anticipated due to exposure to fluridone under the expected conditions of use. Drinking water must not exceed 0.05 parts per million to meet New York state's drinking water tolerance (NYSDEC, 1994), and the label recommends waiting from 7 to 30 days before using fluridone treated water for irrigation- **this will restrict some uses of water drawn within the**

proposed treatment area. The state and federal label do not restrict use of fluridone-treated water for swimming or domestic purposes, but do contain a restriction against use of fluridone within 1/4 mile of any potable water intake. However, when treating hydrilla at rates of 20 ppb or less, as proposed for the Cayuga Inlet application, this restriction does not apply.

Significant routes by which the general public can be exposed to aquatic herbicides are:

1. Using the waterbody as a drinking water source (ingestion),
2. Swimming (incidental ingestion and dermal exposure),
3. Eating aquatic organisms (ingestion).

The acceptable dose (dose at which no adverse effects are expected to occur) for fluridone was calculated based on available toxicology data and on EPA regulations. This concentration, which was determined for each route of exposure, would be expected to cause no adverse effects to human health. The calculation of an acceptable dose assumes that the herbicide is not carcinogenic, and fluridone has been determined by the EPA to not cause cancer.

For water ingestion, two intake rate scenarios were used; a worst-case analysis assuming the treated water was used as the drinking water supply, and a more likely exposure scenario assuming incidental water ingestion while swimming. The incidental ingestion scenario is still conservative because it was assumed that people were exposed daily for a prolonged period of time (chronic exposure) to initial herbicide concentrations.

Estimated initial water concentrations did not exceed either the water supply maximum allowable concentration (MAC) or the incidental ingestion MAC for adults or children. Also, estimated initial concentrations did not exceed calculated MACs for fluridone for the dermal exposure route and the ingestion of aquatic organisms. For dermal exposure, the model used to calculate a MAC was based on the assumption that contaminants are carried through the skin as a solute in water. Thus, the flux rate of water across the skin boundary was assumed to be the factor controlling contaminant absorption rate. For ingestion of aquatic organisms, the contaminant intake rate was calculated from a daily fish ingestion rate (6.5 grams/day) multiplied by a bioconcentration factor for accumulation of the contaminant in fish tissue.

In addition to potential risks from systemic absorption of the herbicides, there is a potential for effects from direct contact of herbicides with skin and eyes. Fluridone is not irritating to the skin, and only minor effects were noted after application of undiluted fluridone to the eyes of rabbits. Thus, no adverse effects are expected from contact with dilute solutions.

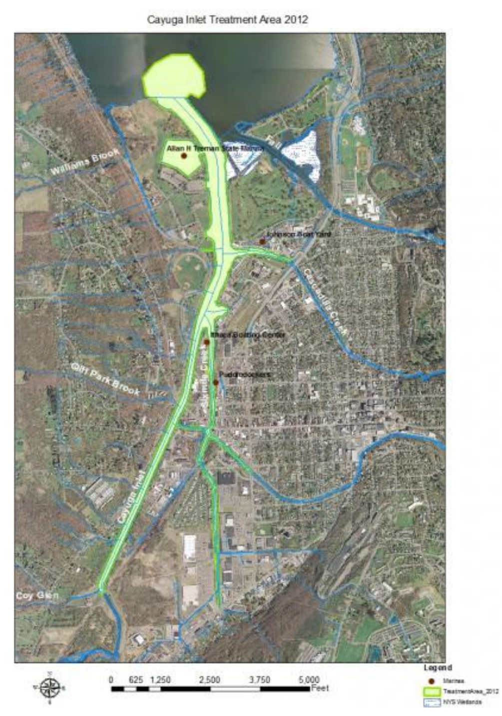
An issue associated with the use of fluridone concerns a potential photolytic breakdown product. N-methyl formamide (NMF) is a potential teratogen, fetotoxin, hepatotoxin, and cytotoxin. NMF was first observed in laboratory photolytic studies using distilled water and lake water (Saunders and Mosier 1983). However, NMF was not observed in field studies conducted outdoors in artificial ponds with radiolabelled fluridone (Berard and Rainey 1981 in Osborne et al. 1989) or in experimental ponds in Florida at a detection limit of 2 ppb (Osborne et al. 1989).

Although NMF has never been observed as a breakdown product under natural conditions, worst case calculations were performed on its potential to affect human health by the state of Washington (WSDOE, 2000). In summary, the safety factors for NMF exposure through drinking water and through skin absorption are very high, both under a worst case scenario (30,303 X and 1,111,111 X, respectively) and under more realistic conditions (>149,254 X and >5,555,555 X). Under worst case conditions, a person would need to drink 15,852 gallons of treated drinking water per day to reach the NOEL, or greater than 78,077 gallons per day under realistic case conditions. For incidental ingestion, a person would have to swim in fluridone treated water for 1,014 years under worst case conditions and for >5,070 years under realistic case conditions in order to be exposed to equal the no-effect level (NOAEL, No Observable Adverse Effect Level), or the concentration at which health effects were first observed.

Washington State concluded that the use of fluridone according to label instructions does not pose any effect to human health. These are large margins of safety, and the amount of water a person would need to drink or the time a person would need to swim to reach the NOAEL is very unrealistic (WSDOE, 2000).

Where, When and How Will Fluridone Be Applied?

Fluridone takes 30 to 90 days, under optimum conditions, to completely kill target plants such as hydrilla. For best results, fluridone should be applied just before or just after plants begin to grow. However, the persistence of the reproductive tubers (embedded in the bottom sediments) and turions (on the upper leaves of the plant) require an extended exposure to the herbicide. This will allow for control of plants growing from root crowns in the spring and tubers later in the summer, and will prevent the development of turions and tubers later in the summer and fall.



The permit for application of fluridone to appx.166 acres of the Cayuga Inlet is currently pending approval from the NYS Department of Conservation. Approval is expected in the spring of 2012. The application will consist of application of both liquid and pellet formulations. Liquid formulations will be applied directly by a licensed applicator (Allied Biological) and through the use of flow-adjusted meter injection systems at several locations throughout the treatment area to maintain a season-long, low dosage treatment to prevent hydrilla re-establishment from tuber germination and root crowns in the spring, tubers during the summer growing season, and tuber and turion generation in the fall. Liquid injections will be supplemented by Sonar pellet formulations directly on dense beds of plants. The expected meter dosage rate will be 2-10 ounces per day, with actual treatment adjusted by weekly fluridone residual monitoring in multiple locations to maintain a dosage of 3-5 ppb. The licensed pesticide applicator, Allied Biological, will evenly apply fluridone pellets below the water surface using air-boats outfitted with special booms. Areas that are inaccessible to air boats will be treated using a hand-sprayer.

The 166-acre Cayuga Inlet treatment area is bounded by the eastern jetty and lighthouse at the mouth of the Inlet to the north and the fish ladder to the south. The treatment area includes the Allan S. Treman State Marina, Johnson's Boatyard & Marina, the Linderman Inlet and paddle docks at Cass Park, the Ithaca Farmers Market dock and portions of Cascadilla Creek, the embayment near the Cornell crew team boathouse, and the west side of the Inlet Island.

The proposed treatment area is located away from major swimming areas and 3 miles from the municipal water intake at Bolton Point.

How long does fluridone last in the water after treatment?

Fluridone has a water solubility of 12 ppm; water solubility can strongly influence the environmental fate and persistence of an herbicide (Westerdahl and Getsinger 1988). The primary fate process affecting fluridone persistence in aquatic environments is photolysis (West et al. 1983). Fluridone is stable to oxidation and hydrolysis (McCowen et al. 1979), and volatilization is not expected to be significant. A photolysis half-life of 5.8 days for fluridone was observed in flasks containing pond water (Muir and Grift 1982).

Numerous investigators have measured the half-life of fluridone in surface water with a range of results. Hall et al. (1984) and Elanco Company stated that the apparent half-life of fluridone in water is 14 days or less. Fluridone aqueous half-lives ranged from 5 to 60 days in a study by West et al. (1983), from 4 to 7 days in a Canadian pond study (Muir et al. 1980), and from 2 to 3.5 days in another Canadian pond study (Muir and Grift 1982). Weed Science Society of America (1983) stated that fluridone has a half-life of 21 days in water when used for control of aquatic vegetation. The half-life of fluridone in Snyders Lake (NY) was calculated as 50-75 days (Kishbaugh, 2011).

In a further study, West and Parka (1981) observed in two ponds using two methods of detection that the rate of fluridone dissipation from water was similar in both ponds. The half-lives of fluridone were 21 and 26 days after surface application and application along the pond bottom. They concluded that the method of applying fluridone to the pond did not appear to affect herbicide dissipation from the aquatic environment.

Finally, Grant et al. (1979) observed that fluridone began to dissipate from the water in 3 to 14 days after treatment, while Kamarianos et al. (1989) observed that fluridone levels in a Greek pond populated with carp decreased to below detection limits after 60 days. In the Greek study, fluridone decreased in the water at a high rate during the first days after application, and no fluridone was detected after two months, results similar to Langeland and Warner (1986).

Fluridone can persist for months when applied in the fall. The decreased temperatures and low light levels slow its dissipation from water. This has resulted in using fluridone for fall applications in the Midwest where lakes freeze (WADOE, 2000). High lake turbidity also increased the half-life to more than 50 days in Waneta Lake in New York, and resulted in measurable fluridone concentrations several months after the initial treatment (Kishbaugh, 2011).

Drift of fluridone into non-treatment areas may also occur depending on the chemical formulation and suspending agent used, and on currents in the treatment area. This may reduce the fluridone concentrations in the treatment area beyond those dissipated by photolysis and plant update.

According to the New York State Environmental Impact Statement for fluridone, the expected average half-life for fluridone in the water column is 20 days. However, based on the turbidity of the Cayuga Inlet and the data from fluridone applications in high turbidity lakes in New York State, a more reasonable estimate for the half-life of fluridone would probably be closer to 50 days.

Is water safe to drink or swim in after fluridone treatment?

There are no label restrictions against drinking, swimming, or fishing in water treated with fluridone (EPA 1986). EPA has established a drinking water standard for fluridone of 0.15 ppm, and the EPA registration label recommends waiting 7 to 30 days before using treated water for irrigation.

The New York Sanitary Code for public water supplies regulates fluridone as an Unspecified Organic Contaminant (UOC), and has established the MCL for UOC at 0.05 ppm (or 50 ppb, parts per billion). This state rule takes precedence over the EPA limit of 150 ppb, and means that human consumption of water is prohibited when fluridone concentrations are greater than 0.05ppm. No restrictions are necessary in water bodies that serve as a source of potable water at the 50 ppb application rate (NYSDEC, 1994), although the target concentration for the Cayuga Inlet treatment is expected to be no more than $1/10^{th}$ of this allowable rate.

Fluridone levels will be monitored within the 166-acre Cayuga Inlet treatment area over time (before, during, after treatment) as required by the pending NYS DEC pesticide permit. In addition, the Tompkins County Department of Health, working in cooperation with the City of Ithaca, has developed a water quality monitoring program for three locations in the Cayuga Inlet and adjacent tributaries upstream of treatment area and five locations on the southern shelf of Cayuga Lake. Water samples will be collected in regular intervals to evaluate water quality and public health criteria and to determine future dosage rates.

The label for fluridone has no restrictions relative to the site of application if fluridone concentrations remain below 20 ppb. The Bolton Point water intake is located 3 miles from the Inlet at a depth of 75 feet and will not be affected. At the planned treatment rates, no setbacks are required for lakefront homeowners.

Will applications of herbicide harm native aquatic plants?

There are few native plants found in Cayuga Inlet, and thus the expected non-target plant loss within the Inlet is expected to be very small. Significant dilution of fluridone is anticipated by the time treated water leaves the Inlet and enters Cayuga Lake, and thus minimal impact is expected on the aquatic plants growing on the southern shelf of Cayuga Lake. There are also no threatened or endangered plant species within the Inlet or the southern end of the lake.

Hydrilla, the target of the fluridone application in the Cayuga Inlet, reproduces primarily by fragmentation and vegetative buds (tubers and turions). Native aquatic plants are largely seed producers, and seeds will not be affected by the fluridone treatment. The sensitivity of non-target native plants is a function of the application rate (dosage) and duration of exposure.

Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove hydrilla and other targeted exotic plants, such as Eurasian watermilfoil. Hydrilla is considered highly susceptible to the effects of fluridone. Some native aquatic plants, especially emergent plants, are minimally affected by low concentrations of fluridone (NYSFOLA 2009). The impact to floating leaf and emergent plants tend to be low and short-lived, particularly at the dosage rate planned for the Cayuga Inlet. At higher dosage rates in other New York State lakes, the pads of water lilies can exhibit chlorosis, resulting in a discoloration of the mid vein, although this effect is usually temporary. Floating leaf plants exhibiting chlorosis usually recover within the year of treatment or become re-established within the following year (Kenaga, 1992). This phenomenon was also observed in several New York state lakes (Kishbaugh, 2011).

Emergency rule enacted to combat invasive water plant

June 2012 -- The New York State DEC has issued an emergency regulation that allows the use of fluridone pellets for 90 days to kill hydrilla in waters less than two feet deep.

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