U.S. FISH & WILDLIFE SERVICE

Proposal for the Eradication of Aquatic Nuisance Species at Bradford 1 Spring

Ash Meadows National Wildlife Refuge

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Created for: Ash Meadows National Wildlife Refuge
8/20/2010

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1. Purpose of Document

1.1 Current Situation

The U.S. Fish and Wildlife Service (USFWS) is currently involved in wide-spread, in-depth ecosystem restoration efforts at Ash Meadows National Wildlife Refuge (AMNWR), for the purpose of improving and maintaining native and endemic flora and fauna communities with an emphasis on the recovery of threatened and endangered species. Twenty-six species are endemic to AMNWR, including four endangered fish species.

At least one or more aquatic nuisance species (ANS) is found in almost every spring on AMNWR (Appendix 1). These include the red swamp crayfish (*Procambarus clarkii*; crayfish), the western mosquitofish (*Gambusia affinis*), sailfin molly (*Poecilia latipinna*), largemouth bass (*Micropterus salmoides*), and red-rimmed melania (*Melanoides tuberculatus*), among others. Invasive species threaten the survival of endemic and endangered fish such as the Ash Meadows Amargosa pupfish (*Cyprinodon nevadensis mionectes*), Warm Springs pupfish (*Cyprinodon nevadensis pectoralis*), and the Ash Meadows speckled dace (*Rhinichthys osculus nevadensis*; dace).

ANS currently found at Bradford 1 Spring include crayfish and mosquitofish, which may be contributing to the decline of the endangered dace population. Historically, dace were found in many of the same springs as the Ash Meadows Amargosa pupfish, but have suffered extirpation or drastically decreasing populations due to invasive species introductions (AMNWR Recovery Plan 1990). Presently, viable dace populations are found in only two springs in AMNWR, Jackrabbit and Bradford 1 Springs, although they have been translocated to several others (Forest, Tubbs, and Point of Rocks Springs). Based on mark-recapture estimates, dace are currently suffering low and declining populations; therefore, it is imperative that restoration efforts focus on the habitat of this species. The Ash Meadows Geomorphic and Biological Assessment Final Report (2006) states, "speckled dace appear to be highly imperiled at Ash Meadows, and this species requires prompt habitat and population restoration, and well-designed translocation efforts." Restoration of Bradford 1 Spring should consist of ANS eradication if there is hope for dace preservation and spring reintroductions. Task 232 of the 1990 AMNWR Recovery Plan states, "the removal of these species is necessary to reestablish native species within their historic sites at historic population levels."

This document presents primary literature research, information, and recommendation on the potential eradication efforts of crayfish and mosquitofish from Bradford 1 Spring. In order to successfully reintroduce dace to historically occupied springs, source populations must be healthy and stable. Restoring the habitat to conditions prior to ANS introduction will likely favor and promote the native fish species.

2. Background

Bradford Springs were some of the first springs to be modified by humans, at least as early as the 1940's (AMNWR Geomorphic & Biological Assessment 2006). Three springs once occurred, now there are two. Along with much of AMNWR, ANS were introduced to the springs prior to the USFWS purchase of the land in 1984. Staff has since then worked towards restoring native species habitat to a semblance of the condition that existed before extensive anthropogenic alterations.

2.1 Characteristics of Bradford 1 Spring

The surface area of Bradford 1 Spring is approximately 61 square meters, and a volume of 52 cubic meters. It maintains cool water temperatures, fluctuating between 10.5°C to 28°C throughout the year, depending upon ambient air temperature and solar radiation. The spring previously flowed into an irrigation ditch running parallel to the road, connecting to Bradford Spring 2 (Appendix 2, taken from AMNWR Geomorphic & Biological Assessment 2006). Presently, the spring has no outflow as the rate of discharge almost equals that of evaporation, with the exception of a small overflow during winter months (unconnected to any neighboring spring). The spring benthic habitat consists mainly of silt and detritus, and the edges are surrounded by cattails (*Typha*) and rush (*Schoenoplectus*). There is a large Goodding's willow (*Salix gooddingii*) with thick grape vines adjacent to the spring, which provides shade on the pool (Appendix 3, Figures 1 & 2). Currently, the spring contains a declining population of dace (Appendix 3, Figure 3), and thriving populations of mosquitofish (Appendix 3, Figure 4) and crayfish (Appendix 3, Figure 5). There are no native or exotic snails present, or any other species of concern.

2.2 Ash Meadows Speckled Dace (*Rhinichthys osculus nevadensis)*

The Ash Meadows speckled dace is a cool-water fish, found to reproduce at temperatures ranging from 17.5°C to 24.0°C (Scoppettone et al. 2005). It is a water column and benthic omnivorous consumer, feeding on algae and invertebrates (Kennedy et al. 2005, Scoppettone et al. 2005, Williams & Sada 1985). Dace are prone to predation by crayfish as bottom dwellers. In 1983 the fish was federally listed as an endangered species (USFWS), and currently only found at significant numbers in two springs in AMNWR. Estimates of dace populations at Jackrabbit and Bradford 1 Springs in October 2009 declined from the previous year, and further still in April 2010 (AMNWR Native Fish Surveys, AMRIT meeting notes 13 April 2010). In order for this species to be reintroduced to its native range of springs and habitats throughout AMNWR, source populations at Jackrabbit and Bradford 1 Springs need to be at adequate levels, stable, and sustainable.

2.3 Aquatic Nuisance Species

2.3.1 Red swamp crayfish (*Procambarus clarkii*)

Due to its habitat and consumer generalist qualities, rapid growth, and high fecundity rate, the red swamp crayfish is one of the world's "most invasive species" (Barbaresi et al. 2003, Holdich 1999, Huner 1988). Crayfish prefer pond-like environments, but can persist in a range of habitats (ISSG 2006). They have high recruitment because of high productivity and reduced intraspecific competition for shelter preferences between adults and juvenile crayfish (Anotonelli, et al. 1999). Interspecifically, crayfish utilize many of same the resources as native species, such as algae, invertebrates, and detritus (Nystrom 1999, Rogowski & Stockwell 2006). As opportunistic feeders, crayfish consume native fish and amphibians, as well as fish and toad eggs (Holdich 1999, Kennedy et al. 2005, Nystrom 1999). Habitat degradation by burrows and water turbidity also are common problems associated with crayfish (Freeman et al. 2009, Holdich 1999, Rogowski & Stockwell 2006). The ability of the crayfish to burrow enables them to persist for months in dry surface conditions. Because of this species' generality, persistence, and burrowing capabilities, it is extremely difficult to eradicate.

2.3.2 Western mosquitofish (*Gambusia affinis*)

The mosquitofish is a surface-dwelling poeciliid species that is currently nonindigenous in 38 states (Nico et al. 2010). It prefers calm, open water, but can thrive in a number of habitats (Deacon et al. 1964, Haynes & Cashner 1995). Mosquitofish are live-bearing fish that feed on zooplankton, invertebrates, fish and amphibian eggs, as well as larval fish (Baber et al. 2008, Masterson 2008, Nico et al. 2010). Female mosquitofish have the ability to store sperm over the winter season contributes to its high rate of fecundity (Haynes 1993, Haynes & Cashner 1995, Milton & Arthington 1983, Nico et al. 2010). A study by Haynes (1993) revealed a population suffering 99% mortality can return to thousands of individuals by summer due to the survival of one female with overwinter sperm storage, making this species particularly difficult to extirpate.

2.4 Ash Meadows NWR Monitoring Reports

Ash Meadows NWR staff and volunteers work tirelessly to restore aquatic and terrestrial habitats to their pre-ANS, pre-anthropogenic states for the enhancement of fish, wildlife and plants on the refuge. Constant monitoring of native and non-native species populations and habitats is conducted by staff and scientists so that positive and knowledgeable decisions can be made in restoration efforts.

2.4.1 Eutrophication Report

The Eutrophication Report, written in 1998, detailed water quality conditions of Bradford 1 Spring and two neighboring springs, Davis and Bradford 2, which formerly contained dace populations. The purpose of the

report was to verify water chemistry between sites to increase success of future fish reintroduction and translocation, and is a valuable reference for examples of some water quality parameters that should be measured prior to dace translocation.

2.4.2 Ash Meadows Geomorphic and Biological Assessment Final Report

The Ash Meadows Geomorphic and Biological Assessment Final Report by Otis Bay, Inc. and Stevens Ecological Consulting, LLC (2006) describes the biology, hydrology, geology, and restoration recommendations for AMNWR. Included in this report is the urgency and recommended plan for focus on dace population and habitat restoration (p.108; Figure 4.4).

2.5 Current Control Efforts and Cost

For successful dace reintroduction to springs across the refuge, source populations at Bradford 1 and Jackrabbit springs must be strong and stable enough to withstand a loss of 20-30% to translocation (AMRIT 3 Sept 2010). In order to increase the dace population at Bradford 1 Spring, regular crayfish and mosquitofish trapping was implemented beginning September 2009 (AMRIT 3 Sept 2010).

If Bradford 1 Spring is trapped on a weekly basis by two Biological Technicians, approximately 47 weeks per year, the cost would accrue to almost $5,000 (excluding bait and travel expenses; Appendix 4). A mark-recapture population estimate at Bradford 1 in October 2008 and 2009 revealed estimates of ~175 and ~110 fish, respectively. An estimate in April 2010 calculated the dace population to be only ~67 adult individuals, even with weekly crayfish/mosquitofish trapping events from September 2009 (AMRIT 13 April 2010). Desirable dace numbers were not achieved for species translocation, and in fact decreased by 62% over the last 2.5 years. Weekly trapping at Bradford 1 Spring does not negatively impact the ANS enough to positively influence the dace population (Appendix 4, Figure 6). In order for crayfish and mosquitofish trapping to have an effect, trapping efforts must be increased significantly, which also substantially raises the cost. Even with a plan to consistently trap ANS, the resources for this work are indefinite; the refuge does not always have funding to employ biological technicians, and trapping is often intermittent. At such costs, trapping is neither an efficient, nor effective means of ANS control.

3. Literature Review

The following is a summary of control and potential eradication methods. Peay (2001) described most of the following techniques in case studies throughout England. Her report included method descriptions, rationales, effectiveness, limitations, environmental impacts, and scope for development. Gherardi and Holdich (1999)

also summarize studies and efforts utilizing many of the following methods and both of these sources of information are valuable references, should future control or eradication efforts be implemented.

3.1 Mechanical

Mechanical methods of crayfish and mosquitofish control include hand netting, seine netting, trapping, and electrofishing (Holdich et al. 1999, Gherardi & Holdich 1999, Peay 2001).

3.1.1 *Netting.* Netting crayfish involves manually searching the body of water and removing all crayfish by hand or kick-netting. This is a labor-intensive technique which success depends largely on habitat, bed substrate, and removal of every crayfish (Peay 2001). Thick vegetation and soft substrate make it difficult to locate all crayfish, especially burrowing individuals. Since Bradford 1 Spring is very silty, murky, and deep in some areas, hand-netting crayfish is not practical; this method is best utilized in streams with running water to decrease turbidity. While it might be possible to hand-net a small number of mosquitofish, it would not result in long-term control or eradication.

3.1.2 *Trapping.* Trapping success varies with bait, trap design, and duration. Currently at AMNWR, Gee crayfish traps with extensions are baited with dry cat food. These traps only catch larger crayfish due to the larger mesh size and entrance holes. Studies have showed crayfish to prefer baits with specialized attractants, fish oil/scraps, manufactured pelleted baits, or meat scraps, although some of these are expensive (Gherardi & Holdich 1999, Rach & Bills 1987, Ribbens & Graham 2004). Many crayfish trappers strongly recommend fresh or frozen [unspoiled] fish scraps in bait boxes, advising against chicken or dog/cat food (Bullard 2009, Crayfish Facts 2007, Romaire 2006). The water temperature also can determine bait effectiveness, with studies showing that for cooler temperature waters, fresh fish scraps are preferred over commercially-produced baits (Beecher & Romaire 2010, FAO 2010, Romaire 2006). While studies have allowed traps to sit overnight, it is unadvisable to do so where endemic/endangered species may be caught and predated inside traps. Small-mesh minnow traps are floated to concentrate on trapping *Gambusia* on the surface, but in Bradford 1, it often captures crayfish and dace, as well. To control or eradicate the ANS population, trapping would have to focus on removing the viably reproducing individuals, which is impossible to target using this method (Peay 2001).

3.1.3 *Electrofishing.* Some studies have shown electrofishing to be an effective method for capturing crayfish, although results vary with habitat (Alonso 2001, Gherardi & Holdich 1999). Alonso (2001) calculated by depletion estimates to have captured up to 93% of the crayfish population in creeks where this method was

utilized. This method may be used for some crayfish control, but unlikely for crayfish or mosquitofish eradication (Holdich 1999).

3.1.4 Summary of mechanical methods

Intensive efforts of mechanical removal of crayfish and mosquitofish are needed to have a significant decrease in ANS populations, and population suppression usually does not persist (Holdich et al. 1999, Peay 2001). The use of mechanical methods also may have negative effects on non-target species that are unintentionally shocked or caught in the nets and traps, causing trap stress and sometimes predation. Many intensive trapping efforts entail extended periods of trap-sitting (Bills & Marking 1988), which is not advisable at Bradford 1 Spring. In order to reduce trap stress and predation on dace, trapping duration of two to three hours is the maximum amount of time traps can be set. This simultaneously reduces trap stress on native species, but also reduces trap success. Even with frequent, concentrated netting, trapping, and electrofishing, mechanical removal of ANS is an impractical method for long-term control due to high manual labor costs, low efficiency, and low success rates. ANS populations may return to high numbers in a few breeding seasons even if a significant decline occurs. If continuing to utilize trapping as a control method, other bait types should be tested and considered to increase catch per unit effort (CPUE).

3.2 Physical

Physical methods of removing ANS include desiccation, isolation by water diversion, and habitat destruction or modification (Gherardi & Holdich 1999, Kennedy et al. 2005, Peay 2001).

3.2.1 *Desiccation.* While some studies have attempted crayfish eradication by desiccation, typical success is very difficult due to the crayfish's ability to burrow for extended periods of time to escape dry conditions. More importantly, complete desiccation or water flow diversion is risky at Bradford 1 because the pool contains the springhead source.

3.2.2 *Habitat destruction.* Habitat destruction would involve draining the site, excavating crayfish burrows, and removing soil away from the location to prevent crayfish re-colonization. Peay (2001) reports this method to be "sound, but difficult to put into practice." If any crayfish burrows or eggs are missed or left behind, re-colonization is probable, making success very difficult to accomplish. Destroying crayfish habitat would likewise destroy dace habitat, which would be counterproductive. Furthermore, since this method requires draining water from the site, this technique is not feasible for Bradford 1 Spring.

3.2.3 *Habitat modification.* A study by Kennedy et al. (2005) at the AMNWR Jackrabbit Spring restoration site following removal of tamarisk along the spring outflow revealed ANS population numbers to decline, and native species to increase. During autumn at Bradford 1, the leaves of the Goodding's willow and grape vines accumulate in the spring, replenishing detritus each season (Figure 2). Reducing the amount of dead leaf litter/detritus may decrease crayfish numbers by removing a valuable food resource for the population, as well as cover for juveniles. Crayfish juveniles as small as 6 mm have appeared numerous in scoops of dead leaf litter on the bottom of Bradford 1 (E. & A. Bradshaw, pers. comm.). Seasonal trimming of the Goodding's willow and removal of the grape vines should be implemented, with crayfish trapping/monitoring for documentation of affects.

3.2.4 Summary of physical methods

Desiccation and habitat destruction are not possible due to the physical characteristics of Bradford 1 Spring. However, some control of crayfish may be achieved by minimizing the surrounding vegetation of the spring on a seasonal basis. Care should be taken to determine a balance between vegetation removal and appropriate shading of the pool to minimize solar radiation and subsequent temperature rises of the dace habitat.

3.3 Biological

Biological control techniques consist of predator introduction, diseases, and viral infections (Gherardi & Holdich 1999).

3.3.1 *Introduced predators.* A significant reason why non-native crayfish and mosquitofish thrive so well throughout AMNWR is because springs contain few natural predators of the ANS. Introduction of a predatory fish to a nonindigenous crayfish population, while shown to be effective by Englund (1999), would mean an additional non-native species on the Refuge. Most importantly, this would risk an introduction elsewhere, either unintentionally or maliciously. This method would not eradicate the crayfish or mosquitofish, and an additional ANS would only add to the list of species to eliminate. Removal of the predator would be imperative before dace could be returned to the spring. Predatory species introduction should not be considered when endangered and endemic species survival is of concern.

3.3.2 *Crayfish plague.* Crayfish plague is a fungal disease which has been shown to be 100% lethal to susceptible species (Gherardi & Holdich 1999). Unfortunately, while the European species of crayfish suffer high mortality due to the plague, it only causes death in North American species when the crayfish are put under environmental stress (Davidson et al. 2010, Dieguez-Uribeondo and Soderhall 2008). Until scientists

genetically modify the plague to target North American species (costly and time-consuming), it is not suitable to eradication crayfish at Bradford 1.

3.3.3 *White Spot Syndrome Virus.* The White Spot Syndrome Virus (WSSV) is a pathogen that can cause up to 100% mortality in aquatic crustaceans, although mortality rate does depend on species (Davidson et al. 2010, Edgerton et al. 2002, Maeda et al. 2000, Shi et al. 2005, Zhan et al. 2008). It can be spread by inoculating dead crayfish with the virus, taking advantage of *P. clarkii*'s cannibalistic behavior (Davidson et al. 2010, Edgerton et al. 2002). After a period of some days the virus breaks down in sunlight, thus requiring re-inoculation though reducing the concern of introducing another foreign species (Edgerton et al. 2002). Shi et al. (2005) showed *P. clarkii* cells to be susceptible to WSSV invasion and replication, and recent appearance of the virus in Louisiana confirms this species of crayfish to be susceptible. The virus is not known to affect fish or other invertebrates aside from shrimp (Davidson et al. 2010). Further study on the virus will reveal specific mortality rates and effects on *P. clarkii*, but in the meantime it may be considered a control (if not, eradication) option. If the use of WSSV is contemplated, care is required to prevent the virus from spreading to adjacent states where crayfish are native.

3.3.4 Summary of biological methods

Non-native predator introductions cannot be considered as a viable option for biological control of ANS species at Bradford 1 Spring. As crayfish plague is not lethal to North American species of crayfish, it is also not a useful technique for crayfish control or eradication. The White Spot Syndrome Virus may be a reasonable approach to the crayfish problem, particularly since Bradford 1 Spring does not contain any native species of crayfish or shrimp. However, the virus would not affect mosquitofish, and if eradication efforts or made, both species should be targeted.

3.4 Chemical

Biocides have not been widely used for attempts at crayfish eradication, probably due to their environmental impact. Chemical toxicity will affect fish, invertebrates, and sometimes vegetation. If chemicals were to be used as a method for crayfish and mosquitofish eradication at Bradford 1 Spring, native dace would require trapping and relocation for the duration of the treatment. Following chemical application, sufficient time will need to be allotted for toxin breakdown and invertebrate re-colonization before dace reintroduction.

3.4.1 *Organophosphates.* Organophosphates (active ingredient fenthion) are an extremely toxic insecticide to crayfish (Carlson & Fuller 1976). The chemical does not appear harmful to mammals, fish, or frogs, although

heavy use of insecticides in Spain resulted in high bird mortality (Gherardi & Holdich 1999). Studies have also shown the pesticide to bioaccumulate in crayfish tissues, and persist in the environment for longer periods of time (Gherardi & Holdich 1999, Peay et al. 2006). Since this toxin bioaccumulates and does not target mosquitofish, further options should be explored.

3.4.2 *Sodium hypochlorite.* Sodium hypochlorite (bleach) is highly toxic to fish and invertebrates. Bleach is readily broken down by organic matter and sunlight, therefore concern of toxic persistence is negligible though effectiveness is significantly decreased (Peay 2001, WDATCP 2009).

3.4.3 *Sodium hydroxide.* Using sodium hydroxide (lye) to raise water pH will cause crayfish mortality within 1 hour of exposure (Peay 2001, Ribbens & Graham 2004). For highest mortality rates, deoxygenation by sodium sulphite prior to lye application would produce higher crayfish mortality rates. Lye is a simple method and easily neutralized using mineral acid (Peay 2001, Ribbens & Graham 2004).

3.4.4 *Rotenone.* Rotenone is a common piscicide which was previously used on AMNWR for convict cichlid *(Archocentrus (Cichlasoma) nigrofasciatus)* and black bullhead (*Ameiurus melas*) eradication. If used thoroughly and completely, this may result in mosquitofish eradication. Unfortunately, crayfish have been reported to withstand 500 times the concentration of that used for fish (Holdich et al. 1999, Peay 2001). The persistence of the toxin in the environment is low, as re-stocking of water bodies with fish has been known to begin a week following the piscicide application (Marking 1992).

3.4.5 *Synthetic pyrethroids.* Synthetic pyrethroids (aka permethrin insecticides; agriculture pesticides with active ingredient cyfluthrin) also show promising preliminary results for use against crayfish (Bills & Marking 1988, Marking 1992, Morolli et al. 2006, Peay 2001, Sandodden & Johnsen 2009). Pyrethroids have high toxicity to crayfish, but are not as effective against fish. Positively, they have low toxicity to mammals and birds, low accumulation in the environment, and biodegradeability (Morolli et al. 2006, Peay 2001).

3.4.6 *Natural pyrethrums.* Natural pyrethrums (active component pyrethrin) in combination with the deoxygenator, sodium sulphite, show promising results as a potential ANS biocide agent (Peay & Hiley 2006, Peay et al. 2006). Pyrethrum is produced from the flowers of a particular species of the *Chrysanthemum* plant and is commonly used as organic insecticides on crops. It has a low toxicity to mammals, birds, and vegetation, but is extremely toxic to fish and crustaceans and will affect amphibians (Peay et al. 2006, Young 2010). Prior application of a deoxygenator causes emergence of crayfish from their burrows. Following this with pyrethrum

results in extensive crayfish mortality, however insecticide toxicity is reduced when combined with the deoxygenator and in the presence of high amounts of clay and organic matter. Similar to sodium hypochlorite, natural pyrethrums also rapidly breaks down in sunlight (Peay et al. 2006).

3.4.7 Summary of chemical methods

Potential still remains for ANS eradication by chemical agent, and is encouraged by Peay (2001). Organophosphate insecticides should not be used because of their higher environmental impact, persistence, and bioaccumulation, as well as their ineffectiveness against non-native fish. Bleach should also not be used due to the high amount of organic matter in Bradford 1, greatly reducing its effectiveness. Lye, in conjunction with a deoxygenator, is easy to neutralize and very effective at treating crayfish, although mosquitofish can survive in a large range of pH (4.7 - 10.2, UCA 2010) and probably would not be impacted severely. Rotenone is effective for mosquitofish eradication if applied very thoroughly (as previously stated, even one gravid female can maintain the population), but is not highly effective against crayfish. A synthetic pyrethroid could be considered for use against crayfish, but it does not have high effectiveness against fish. Natural pyrethrum may be an option for crayfish and mosquitofish eradication, given their high toxicity to target species, low toxicity to non-target species, low persistence in the environment, and the natural containment of Bradford 1 (no outflow). Any use of biocides must be laboratory tested prior to field application to understand its toxicity and effectiveness with Bradford 1 Spring's specific water parameters, and native dace should be relocated. Use of a deoxygenator would require re-oxygenation of the spring prior to dace reintroduction. Close monitoring of the spring should be performed following the treatment.

3.5 Examples of Failed and Successful Eradication Attempts

3.5.1 Mechanical methods

Although Gherardi and Holdich (1999) note studies that show crayfish populations to reduce via intense trapping, these studies also admit that the ANS populations are not under control or eliminated, and are likely to return to elevated levels within a few breeding seasons. Bills and Marking (1998) also utilized trapping as a method to control ANS populations, and continuously trapped crayfish for six weeks. While the population was reduced, they state that the possibility of elimination is impractical because the traps do not capture small-sized crayfish, and "it is doubtful that trapping could be a successful control measure." Peay et al. (2006) explains that mechanical methods (manual, trapping, and electrofishing) were utilized unsuccessfully before turning to biocide treatments.

3.5.2 Physical methods

Successful attempts at crayfish eradication by desiccation are few and far between. Peay (2001) reported physical attempts at crayfish removal difficult to complete, and re-colonization was confirmed two years following the effort. However, AMNWR achieved crayfish and mosquitofish elimination from School Springs by this method (Weissenfluh 2008). With careful, meticulous, and aggressive action, crayfish can be extirpated by physical means. Unfortunately, as Bradford 1 pool is the actual springhead, this method is not feasible.

3.5.3 Biological control methods

As stated previously, biological control methods such as introduced predators or the crayfish plague are not supported by management. As the White Spot Syndrome Virus remains an interesting option, there are no records of using the virus as a control agent against crayfish, although much research has been conducted on its effects and potential means of prevention in aquaculture (Lu et al. 2009).

3.5.4 Chemical methods

AMNWR has utilized Rotenone a number of times to eradicate ANS, including mosquitofish (Weissenfluh 2008). In January of 2008, three treatments of rotenone were applied to the Fairbanks Spring system to eradicate convict cichlids and coincidentally, mosquitofish. No cichlids or mosquitofish have been observed or captured in the springhead or outflow since the treatment. In July 2008, rotenone was again used for invasive fish eradication. At the time, Davis Spring contained black bullhead and mosquitofish. No captures of either species occurred following treatment. Although it may be early to determine success, results of rotenone use in 2008 appear positive for eradicating aquatic nuisance fish.

Peay (2001) described chemical methods for crayfish eradication. Although field trials were unsuccessful due to chemical dispersion to unaffected/unapplied areas and the outflow, Peay stated that biocides are the only viable option for crayfish eradication.

Peay et al. (2006) notes that natural pyrethrum is a common organic insecticide, first used against crustaceans (water hoglouse) in 1947 in public water mains, although this was the first instance of its use against crayfish in small ponds in Scotland. Initial observations are positive for eradication of crayfish, but further monitoring for confirmation is required.

Sandodden & Johnsen (2009) were tentatively able to eradicate crayfish from a system of ponds and creeks in Norway by the use of a synthetic pyrethroid (BetamaxVet) and desiccation. Again, further monitoring is required for a positive eradication, but results are promising.

4. Proposal for eradication of ANS at Bradford 1

Several researchers studying crayfish control and eradication techniques have expressed the opinion that, for the best chance of successful ANS elimination, a combination of methods should be used. Bills & Marking (1988) stated, "resolving crayfish problems will require the use of multiple approaches developed for each specific situation." Likewise, Freeman et al. (2009) reports, "no single strategy or universal solution is likely to be attainable," and Barbaresi and Gherardi (2000) conclude, "it is unlikely that trapping would eradicate a crayfish population unless coupled with other methods, either biological or chemical, whose impact on the aquatic environment must be carefully evaluated before their usage."

4.1 Recommended Options

The following consists of a list of options for eradicating ANS from Bradford 1 Spring. Davis Spring is ¾ mile East of Bradford 1, and similar to it physically (Appendix 3, Figure 7). It has no outflow and the rate of discharge appears similar to Bradford 1. ANS, black bullhead and mosquitofish, were previously eradicated from this site in 2008, but crayfish persist. Since this site is so similar to Bradford 1, it may present an ideal location to investigate the effectiveness of these chemical methods, without the worry of endangering native species.

4.1.1 Option 1

A method that has potential to eradicate both, crayfish and mosquitofish, at the same time.

Natural pyrethrum + sodium sulphite [for deoxygenation]

- Advantages
  - Targets crayfish and mosquitofish, and can effect bullfrogs
  - Breaks down rapidly in sunlight (low persistence)
  - Low toxicity to mammals and birds
- Disadvantages
  - Fatal to any remaining dace not removed from the spring
  - May effect native amphibians
  - Will kill invertebrates (dace food source)
  - May need re-application due to rapid environmental breakdown
  - Costly (compared to synthetic pyrethroids, which do not target fish)
- Sequence
  - Laboratory test chemical effectiveness with Bradford 1 water chemistry
  - Trim surrounding rush, grapevines, and willow
  - Trap to remove dace (see Dace salvage options)
  - Trap intensely (can leave traps overnight after dace are removed) & electroshock for ANS

    - Capture and relocate native toads
    - Install crayfish fence to prevent migration
    - Drain down to minimize chemical use
    - Apply sodium sulphite to induce crayfish emergence from burrows
    - Treat with natural pyrethrum thoroughly
    - Remove crayfish attempting migration from spring
    - Monitor daily for appearances of exotics and determine if re-application is necessary
    - Test water quality using trapped mosquitofish and crayfish
    - Allow time for invertebrate re-colonization before dace reintroduction
    - Reintroduce dace
    - Weekly monitoring for ANS (ideally), monthly at a minimum
    - Monthly dace population estimates
- Necessary equipment for option implementation
    - Appropriate chemicals and applicators
    - Personal Protective Equipment (PPE)
    - Water testing kits
    - Hedge clippers for vegetation removal
    - Crayfish fence materials
    - Pump for draining
    - Traps and bait for pre-application trapping
    - Buckets and nets for trapping and migrating crayfish removal

4.1.2 Option 2

Two-phase procedure. First phase to target mosquitofish, second phase to target crayfish.

Phase 1: Rotenone

- Advantages
    - Targets mosquitofish
    - Has been used on the refuge previously
    - Low persistence in the environment
    - Inexpensive
- Disadvantages
    - Fatal to any remaining dace not removed from the spring
    - Effects any gill-breathing organisms – may include Odonates, a food resource of dace
    - Does not target crayfish
- Sequence
    - Trap and relocate dace
    - Trim surrounding vegetation
    - Trap intensely/electroshock
    - Drain down to minimize chemical use
    - Apply Rotenone treatment
    - Closely monitor for mosquitofish and reapply as necessary
- Necessary equipment for option implementation
    - Appropriate chemicals and applicators
    - Personal Protective Equipment (PPE)
    - Water testing kits
    - Hedge clippers for vegetation removal
    - Pump for draining
    - Crayfish fence materials

- Traps and bait for pre-application trapping
- Buckets and nets for trapping and migrating crayfish removal

Phase 2: Sodium hydroxide [w/sodium sulphite + mineral acid for neutralization]

- Advantages
  - Targets crayfish, may affect any surviving mosquitofish
  - Relatively inexpensive
  - Easy to neutralize
- Disadvantages
  - Fatal to dace not removed from the spring
  - Not favored by public
- Sequence
  - Trim surrounding vegetation if necessary
  - Trap intensely/electroshock
  - Install crayfish fence to prevent migration
  - Drain down to minimize chemical use
  - Apply sodium hydroxide to raise pH
  - Remove crayfish attempting migration from spring
  - Monitor daily for appearances of exotics and determine if re-application is necessary
  - Test water quality, neutralize with mineral acid and continue testing water chemistry
  - Allow time for invertebrate re-colonization before dace reintroduction
  - Reintroduce dace
  - Weekly monitoring for ANS (ideally), monthly at a minimum
  - Monthly dace population estimates
- Necessary equipment for option implementation
  - Appropriate chemicals and applicators
  - Personal Protective Equipment (PPE)
  - Water testing kits
  - Hedge clippers for vegetation removal
  - Crayfish fence materials
  - Pump for draining
  - Traps and bait for pre-application trapping
  - Buckets and nets for trapping and migrating crayfish removal

4.2 Dace Salvage Options

A disadvantage of using chemical methods as a means for ANS control or eradication is the necessity to temporarily relocate native species from the spring requiring treatment. As little is known about dace sensitivity and the population is very low, holding dace in a large tank is risky and time-consuming. Translocating the dace to another spring is also precarious since the population survival is uncertain. Releasing them into Jackrabbit Spring and combining populations is not advisable due to the chance of a stochastic event that could lead to the extinction of the entire population.

4.2.1 Davis Spring

If a crayfish eradication method is determined, field tested, and successful at Davis Spring, this would be an ideal location for holding dace while treatments for Bradford 1 Spring commence. Since Davis has been proposed as a location for dace reintroduction and is so similar to Bradford 1, it would be reasonable to suspect dace may do very well in this environment (AMRIT 12 Dec 2008).

4.2.2 Horseshoe Reservoir

A possible approach to holding dace away from Bradford 1 Spring is to use a submerged tank in Horseshoe Reservoir (HR). A 500-gallon tub, designed with water flow-through screens and a screened top, would allow dace to feed on growing algae and simultaneously be protected from predators. Constant flow through the tank would ensure fresh water and oxygen supply. The water temperature of HR is similar to Bradford 1, but water quality parameters should be taken to gain an understanding of water chemistry similarities (Eutrophication Report 1998). This design would require minimal maintenance (weekly checks) and upkeep. If dace were to escape from the holding tank into HR, it would be within historical distribution on AMNWR.

4.2.3 Mini Fish Farm

A second option is to hold the dace population in the 400-gallon Mini Fish Farm at Refuge Headquarters. There are few instances where holding dace in tanks has been attempted, and success has varied due to fish jumping out of the tanks, disease, and stress (Kaya 1991, Ketschmann 2005, Weedman et al. 2005).

Utilizing HR or the Mini Fish Farm for dace salvage would offer an opportunity to learn important information about this species and its ability to withstand the stress of translocation and holding.

4.3 Risk of Reinvasion

The risk of re-invasion by ANS is important to consider when contemplating an ANS eradication attempt. Bradford 2 and Tubbs Springs are the closest water bodies to Bradford 1 containing ANS, about 1/8 of a mile and a ¼ mile, respectively. Currently, all three springs are connected by a ditch that remains dry between Bradford 1 and Bradford 2, however Tubbs contributes water flow running East-West, connecting to the North-South outflow of Bradford 2 (Appendix 1). Since there is no water connecting Bradford 1 Spring with either Bradford 2 or Tubbs Springs, the greatest concern would be the overland migration of crayfish, however it is unlikely crayfish would have reason to venture far from Bradford 2 without prompting due to draining or chemicals. Since Bradford 1 Spring does not experience high visitation, the concern of new ANS introduction is minimal. Furthermore, future geomorphic and hydrologic restoration plans for Bradford 1, Bradford 2, and Tubbs Springs do not propose connecting any of these springs together (Appendix 1).

4.4 Monitoring Required

Close monitoring of Bradford 1 Spring immediately following ANS treatment will be vital to ensure eradication success. Daily ANS trapping should be performed, with chemical re-application if necessary. After one month of close monitoring, weekly or bimonthly trapping should be performed, leading to a monthly trapping and dace population estimate. Monthly monitoring for ANS should continue for 1-2 years following treatment.

4.5 Recommended Actions

Measures that should be taken if eradication attempts are not made.

4.5.1 Trimming surrounding vegetation

- Removing some of the surrounding vegetation that can contribute to detritus build up in the spring may help reduce the crayfish population.

4.5.2 Increase trapping effort

- If eradication of ANS is not attempted, trapping effort must increase substantially in order to improve the dace population. Consistent methods and data recording should be performed so that future analysis of trapping effort versus effect can be made.

4.5.3 Experimenting with various crayfish baits

- Trying different crayfish baits, that are feasible, can increase crayfish trapping success.
    - Manufactured crayfish baits (ex. Purina Cajun World™ or Purina Southern Pride™ Crawfish Baits) – check prices, might be possible to order online or from Las Vegas.
    - May be able to get fish scraps (preferably from oily fish) from the grocery store seafood section for little or no cost – just be sure to freeze ASAP to maintain freshness. If not, trap for bass or goldfish on AMNWR.

4.5.4 Consistent population monitoring

- Currently at AMNWR, Native Fish Surveys are conducted at each spring every-other year. An estimate taken once every two years is not sufficient to monitor the dace population at Bradford 1. Since the dace population is so low, close monitoring should take place with population estimates biannually at a minimum at Bradford 1 and also at Jackrabbit Spring.

4.5.5 Research

- Although some information can be inferred from *Rhinichthys osculus*, very little is known about the subspecies of dace found on AMNWR. Details on Ash Meadows speckled dace habitat preference would be enormously helpful in habitat planning and management for this endangered species.

4.6 Conclusion

The particular characteristics of Bradford 1 Spring – its small size and natural containment – make it an ideal location for ANS eradication. It is tremendously difficult for speckled dace to improve their population at Bradford 1 Spring with such heavy competition and predation due to ANS. Spatially, mosquitofish predate and compete for resources on the surface of the spring pool, while crayfish predate and compete for resources on the spring bottom. These circumstances leave the dace population under stress for recruitment and resources, potentially leading to another local extinction of the species and limiting the species distribution to only one spring system. It is vital that attention and focus be given to this spring and dace population if there is hope to prevent a reduction of dace to only one spring system on the AMNWR.

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Appendix 1

Ash Meadows National Wildlife Refuge Aquatic Exotic Species Inventory

As Of FY 2010												
	Exotic Species											
Water Body	Gambusia	Sailfin Molly	Largemouth Bass	Spotted Bass	Green Sunfish	Koi	Convict Cichlid	Bullfrog	Crayfish	Melania Snail	Black Bullhead	
Fairbanks Sp	0						0	1	1	1		
Soda Sp	0							1	1	1		
Purgatory Sp												
Rogers Sp	1							1	1	1		
Cold Sp	1								1			
Longstreet Sp	1	1	?					1	1	1		
Five Sp	1							1	1			
Shaft Sp												
Chalk Sp												
Peterson Res	1							1	1			
Mary Scott Sp												
N Scruggs Sp	1											
S Scruggs Sp	1								1	1		
Marsh Sp								1				
N Indian Sp	0								1	1		
S Indian Sp	0								0	1		
School Sp	0								0	1		
Collins Ranch Sp												
Crystal Sp	1	1	0	0	0			1	1	1		
Crystal Res			1	1	1							
Horseshoe Marsh												
L Crystal Marsh												
Bradford Sp #1	1							1	1			
Bradford Sp #2	1							1	1	?		
Tubbs Sp												
Forest Sp		1								1		
Kings Pool												
POR Sp	1	1						1	1	1		
Davis Sp	0							1	1		0	
Jackrabbit Sp	1	1						1	1	1		
Big Sp	1	1	1					1	1	1		
Brahma Sp												
Bole Sp	1											
Last Chance Sp												
TOTAL	14	6	2	1	1	0	0	14	16	13	0	67

=Eradicated Populations in 2008
=Eradicated Populations in 2009
Eradicated Population in 2010.
=Counted As One Population

68 =Populations at the beginning of FY 2010
1 =Eradicated Populations (aiming to eradicate 2 populations of crayfish from N/S Indian Springs (1 each)
67 =Current Populations at the end of FY 2010

Notes: 2 Gambusia populations were eradicated by desiccation from the N/S Indian Springs in FY 2009
Notes: A single common goldfish was captured in the CR siphon barrier in FY2009 but this does not constitute a population
Notes: A single Koi was removed from King's Pool in FY2007

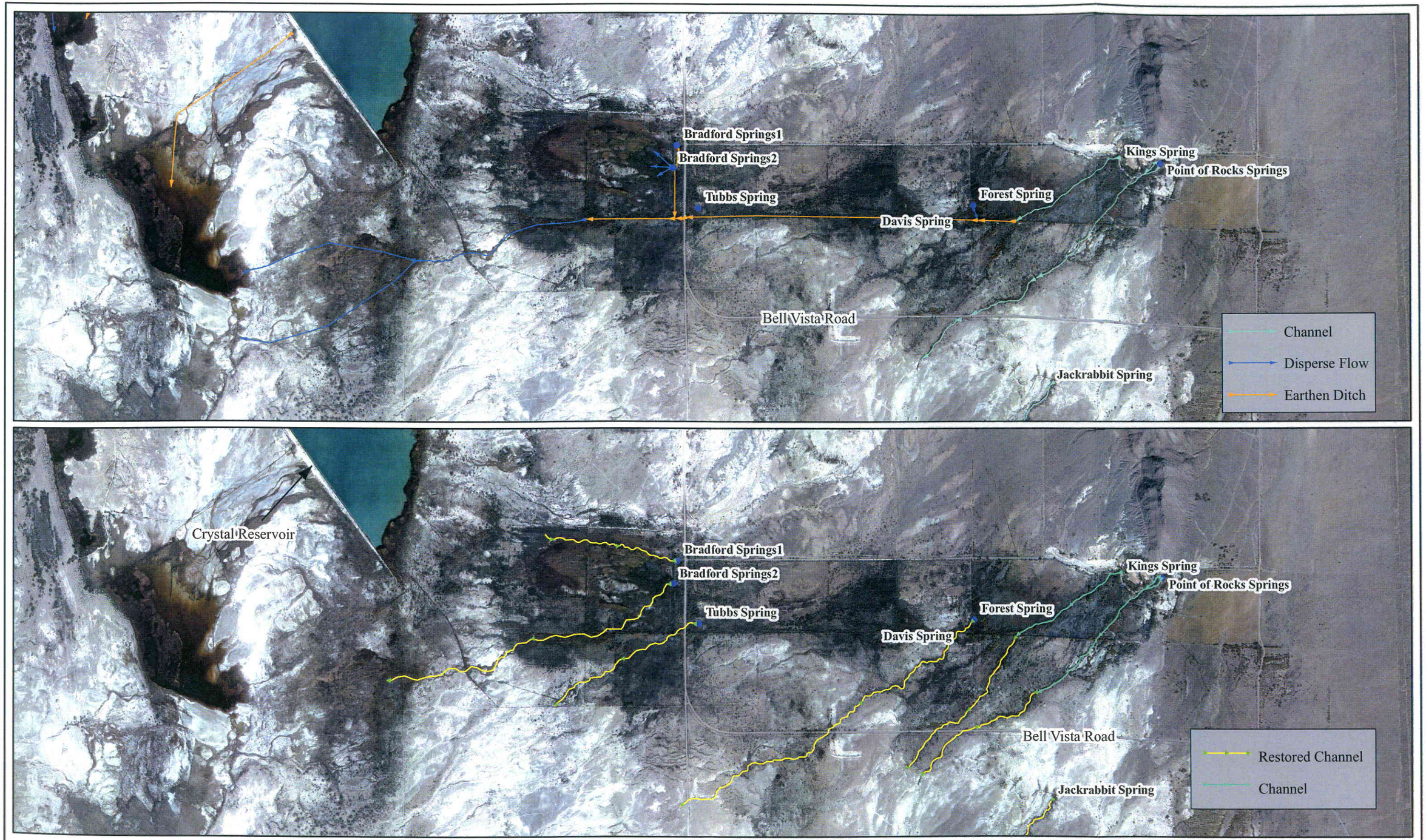


Figure 4.4. Existing water distribution (top) and proposed restored conditions (bottom) from Point of Rocks Spring to Bradford Spring.

Quickbird Sattelite Image acquired August 2004 reprojected to WGS 84 UTM Zone 11N. Color assignment 123 (Blue, Green, Red)

Appendix 3

Figure 1. Bradford 1 Spring, summer

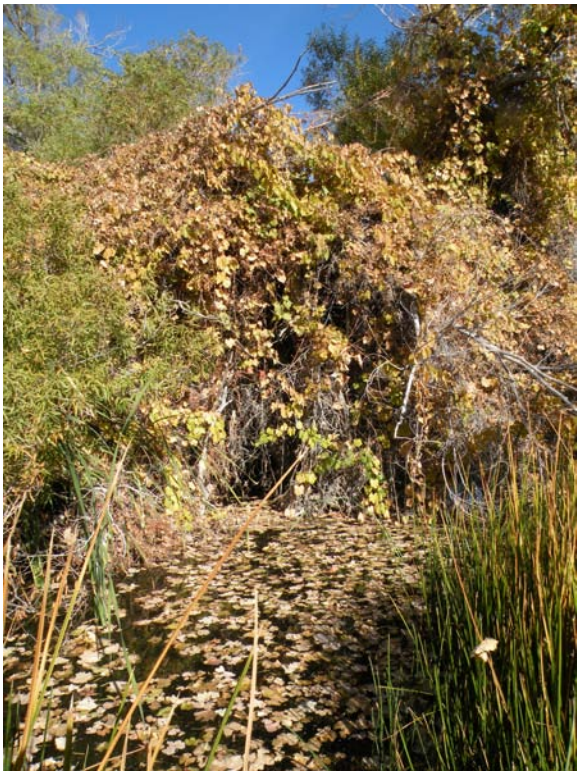


Figure 1. Bradford 1 Spring, autumn

Figure 3. Ash Meadows Speckled Dace, *Rhinichthys osculus nevadensis*

Figure 4. Exotic Western Mosquitofish, *Gambusia affinis*

Figure 5. Red swamp crayfish, *Procambarus clarkii*

Appendix 4

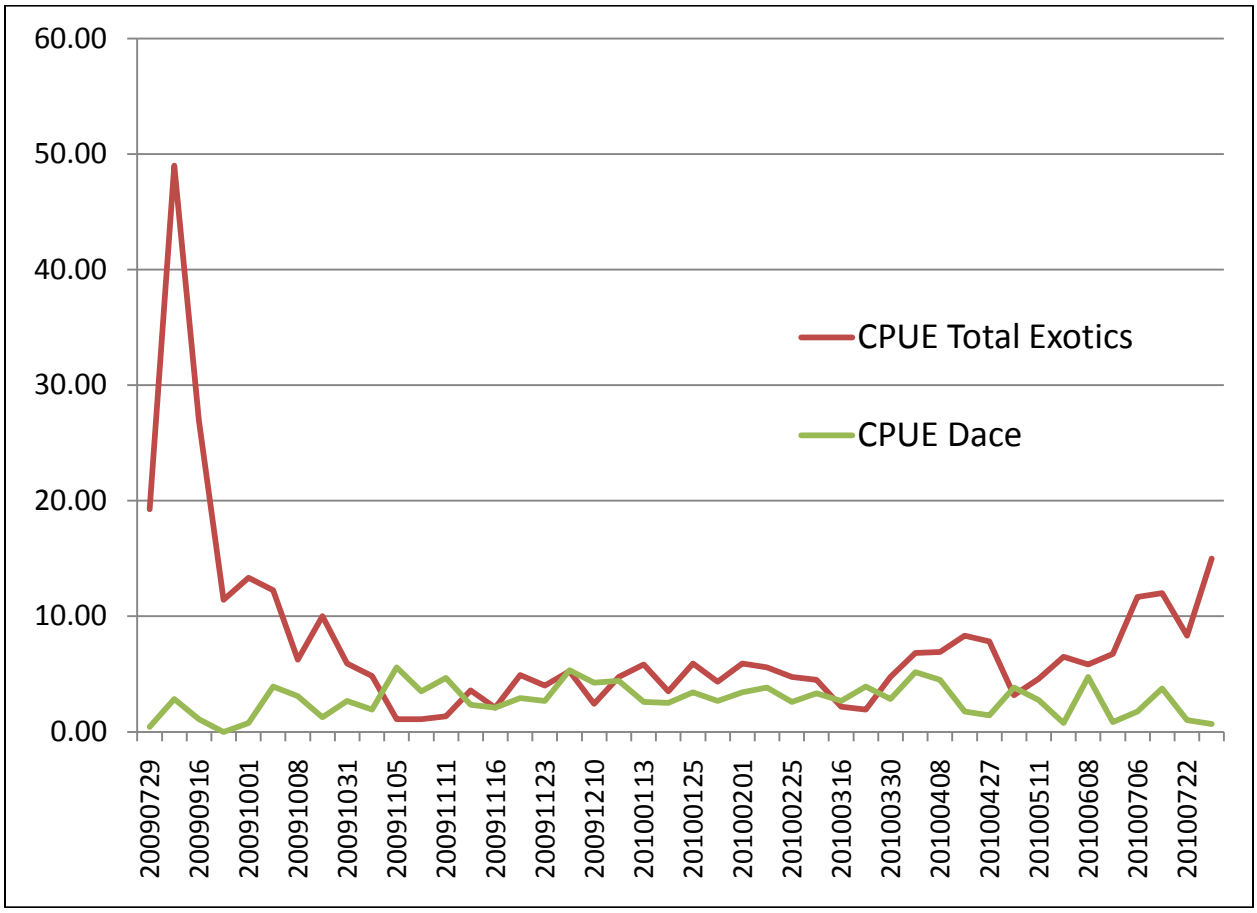
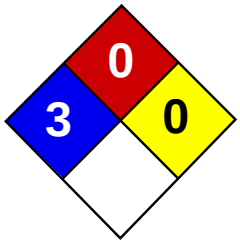


Figure 6. Catch per unit effort of trapping at Bradford 1 Spring, July 2009 – July 2010

Estimated trapping cost per year

(47 trapping events/year) x (2.5 hour trap duration) x (2 individuals) x ($21/hour labor) = $4,935/year



Material Safety Data Sheet
Hydrochloric acid, 20%(v/v) MSDS

Section 1: Chemical Product and Company Identification

Product Name: Hydrochloric acid, 20%(v/v)

Catalog Codes: SLH2932

CAS#: Mixture.

RTECS: Not applicable.

TSCA: TSCA 8(b) inventory: Hydrochloric acid; Water

CI#: Not applicable.

Synonym:

Chemical Name: Not applicable.

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Hydrogen chloride	7647-01-0	4.8-9.12
Water	7732-18-5	90.9-95.2

Toxicological Data on Ingredients: Hydrogen chloride: GAS (LC50): Acute: 4701 ppm 0.5 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, . Hazardous in case of skin contact (corrosive), of eye contact (corrosive). Slightly hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrogen chloride]. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, , teeth. Repeated or prolonged exposure to the substance can produce target organs damage.

Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances: Non-explosive in presence of open flames and sparks, of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep container dry. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as alkalis, moisture. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
Hydrogen chloride STEL: 7.5 (mg/m3) from ACGIH (TLV) [United States] STEL: 5 (ppm) from ACGIH (TLV) [United States] CEIL: 5 (ppm) from NIOSH CEIL: 7.5 (mg/m3) from NIOSH CEIL: 5 (ppm) from OSHA (PEL) [United States] CEIL: 7 (mg/m3) from OSHA (PEL) [United States]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Disagreeable and choking. (Strong.)

Taste: Acid. (Strong.)

Molecular Weight: Not applicable.

Color: Clear Colorless.

pH (1% soln/water): Acidic.

Boiling Point: The lowest known value is 100°C (212°F) (Water).

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: Weighted average: 1.01 (Water = 1)

Vapor Pressure: The highest known value is 2.3 kPa (@ 20°C) (Water).

Vapor Density: The highest known value is 0.62 (Air = 1) (Water).

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether.

Solubility:
Easily soluble in cold water, hot water. Soluble in diethyl ether.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials

Incompatibility with various substances:
Reactive with alkalis. Slightly reactive to reactive with oxidizing agents, organic materials.

Corrosivity:
Extremely corrosive in presence of aluminum. Highly corrosive in presence of zinc. Corrosive in presence of steel, of copper. Slightly corrosive in presence of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts violently (moderate reaction with heat of evolution) with water especially when water is added to the product. Isolate hydrogen chloride from heat, direct, alkalies (reacts vigorously), organic materials, and oxidizers (especially nitric acid and chlorates), amines, copper and alloys (e.g. brass), hydroxides, zinc (galvanized materials), lithium silicide (incandescence), sulfuric acid(increase in temperature and pressure) Hydrogen chloride causes aldehydes and epoxides to violently polymerize. It reacts with oxidizers releasing chlorine gas. Hydrogen chloride gas is emitted when this product is in contact with sulfuric acid. Adsorption of Hydrochloric Acid onto silicon dioxide results in exothmeric reaction. Hydrogen chloride causes aldehydes and epoxides to violently polymerize. Hydrogen chloride or Hydrochloric Acid in contact with the folloiwng can cause explosion or ignition on contact or other violent/vigorous reaction: Acetic anhydride, Alcohols + hydrogen cyanide, Aluminum, Aluminum phosphide, Aluminum-titanium alloys (with HCl vapor), 2-Amino ethanol, Ammonium, Ammonium hydroxide, 1,4-Benzoquinone diimine, Calcium acetylide (incandescence upon warming), Calcium carbide, Calcium phosphide, Carbon tetrachloride + silver perchlorate (produce trichlormethyl perchlorate), Cesium acetylene carbide, Cesium carbide, Cesium telluroacylates, Chlorine + dinitroanilines (evolves gas), Chloroacetaldehyde oxime, Chlorosulfonic acid, Cyanogen chloride (when catalyzed by HCl), 1,1-Difluoroethylene, Dinitroanilines, Ethylene, Ethylene diamine, Ethyl 2-formylpropionate oxime (when generated by using HCl as a catalyst), Ethylene imine, Fluorine, HClO4, Hexalithium disilicide, Hydrogen peroxide, Lithium silicide, Metal acetylides, carbides, Magnesium boride, Methyl vinyl ether, Mercuric sulfate, Nitric acid + glycerol, Oleum, Perchloric acid, Potassium, Potassium permanganate, beta-Propiolactone, Propylene oxide, Rubidium acetylide, Rubidium carbide, Rubidium acetylene carbide, Silicon dioxide, Silver chlorite, Sodium (with aqueous HCl), Sodium 2-allyloxy-6-nitrophenylpyruvate oxime, Sodium hydroxide, Sodium tetraselenium, Sulfonic acid, Sulfuric acid, Tetraselenium tetranitride, 2,4,6-Tri(2-acetylhydrazino)-1,3,5-trinitrobenzene, Uranium phosphide, Vinyl acetate. Hydrogen chloride gas can react with formaldehyde to form bis(chloromethyl)ether, a human carcinogen. Most metals, as well as certain coatings, plastics, and rubbers, are attacked by hydrogen chloride. Addition of hydrochloric acid to the following results in an exothermic reaction: Cesium cyanotridecahydrodecarborate(2-), Potassium ferricyanide, Vinylidene fluoride. Addition of hydrochloric acid to potassium ferrocyanide or ammonium hexacyanoferrate(II) results in an endothermic reaction. Hydrochloric acid in the presence of alcohol and glycols results in dehydration reactions. (Hydrogen chloride)

Special Remarks on Corrosivity:
This compound is highly corrosive when in solution (especially to most metals except: gold, mercury, platinum, silver, and tantalum). The anhydrous gas is not corrosive . (Hydrogen chloride) Will not occur.

Polymerization:

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
Acute oral toxicity (LD50): 900 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 1108 ppm, 1 hours [Mouse]. Acute toxicity of the vapor (LC50): 3124 ppm, 1 hours [Rat]. (Hydrochloric Acid)

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrogen chloride]. Contains material which may cause damage to the following organs: kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, , teeth.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (irritant), of ingestion, . Hazardous in case of skin contact (corrosive), of eye contact (corrosive). Slightly hazardous in case of inhalation (lung sensitizer, lung corrosive).

Special Remarks on Toxicity to Animals:
Lowest Published Lethal Doses (LDL/LCL) LDL [Man] -Route: Oral; 2857 ug/kg LCL [Human] - Route: Inhalation; Dose: 1300 ppm/30M LCL [Rabbit] - Route: Inhalation; Dose: 4413 ppm/30M (Hydrochloric Acid)

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (fetoxicity). May affect genetic material. (Hydrochloric Acid)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Corrosive. Causes severe skin irritation and burns. Eyes: Corrosive. Causes severe eye irritation and burns. May cause permanent damage to the eyes. Inhalation: Inhalation of vapor or mist may be destructive to tissue of the mucous membranes and upper respiratory tract. It may affect the lungs/respiration. Inhalation of mist or vapor may produce nose, throat, and laryngeal burning, and irritation, pain and inflammation, coughing, sneezing, choking sensation, hoarseness, laryngeal spasms, upper respiratory tract edema, chest pains, as well has headache, and palpitations. Inhalation of high concentrations may also cause chemical burns of the upper respiratory tract, constriction of the larynx and bronchi, nasospetal perforation, glottal closure, dyspnea, bronchitis. Chemical pneumonitis and pulmonary edema can also occur, particularly if exposure is prolonged. It may affect the liver Ingestion: Causes irritation and burns of the mouth, throat, esophagous (gastrointestinal tract) with nausea, vomitting abdominal cramps, diarrhea. It can also cause thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (esophogeal, gastric, pyloric). May affect behavior (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system (kidneys - renal failure, nephritis). Chronic Potential Health Effects: Prolonged or repeated inhalation or ingestion may affect liver, respiration(changes in pulmonary function, chronic bronchitis), teeth (yellowing of teethand erosion of tooth enamel), kidneys, and behavior. Prolonged or repeated skin contact may cause dermatitis. Prolonged or repeated eye contact with vapor/mist may cause conjunctivitis

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Hydrochloric acid, solution UNNA: 1789 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Hydrochloric acid Illinois toxic substances disclosure to employee act: Hydrochloric acid Illinois chemical safety act: Hydrochloric acid New York release reporting list: Hydrochloric acid Rhode Island RTK hazardous substances: Hydrochloric acid Pennsylvania RTK: Hydrochloric acid Minnesota: Hydrochloric acid Massachusetts RTK: Hydrochloric acid Massachusetts spill list: Hydrochloric acid New Jersey: Hydrochloric acid New Jersey spill list: Hydrochloric acid Louisiana RTK reporting list: Hydrochloric acid Louisiana spill reporting: Hydrochloric acid TSCA 8(b) inventory: Hydrochloric acid; Water TSCA 4(a) proposed test rules: Hydrochloric acid SARA 302/304/311/312 extremely hazardous substances: Hydrochloric acid SARA 313 toxic chemical notification and release reporting: Hydrochloric acid 24% CERCLA: Hazardous substances.: Hydrochloric acid: 5000 lbs. (2268 kg);

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada):
CLASS D-1A: Material causing immediate and serious toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):
R34- Causes burns. S24/25- Avoid contact with skin and eyes. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S28- After contact with skin, wash immediately with plenty of water. S36/37/39- Wear suitable protective clothing, gloves and eye/face protection. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 0

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 10:32 AM

Last Updated: 11/06/2008 12:00 PM

NATURAL PYRETHRIN CONCENTRATE

MATERIAL SAFETY DATA SHEET

Manufacturer's Name & Address
Southern Agricultural Insecticides, Inc. Phone: 1-941-722-3285
PO Box 218, Palmetto, Fla. 34220 Chemtrec: 1-800-424-9300

I NOMENCLATURE

Product Name: NATURAL PYRETHRIN CONCENTRATE EPA Reg. No. 655-587-829
Chemical Name: Pyrethrum

II INGREDIENTS

Pyrethrum	CAS No. 8003-34-7 (< >)	0.96%	OSHA (TWA) 5 mg/m^3
Piperonyl Butoxide Tech.	CAS No. 51-03-6	9.60%	(TWA) (N/D)
Petroleum Solvent	CAS No. 64742-47-8	81.44%	(TWA) 300 ppm (supplier recommendation)
Emulsifier	CAS No. (supplier claims as confidential)	8.0 %	(TWA) (N/D)

This product contains a toxic chemical or chemicals (< >) subject to the reporting requirements of Section 313 of Title III and of 40 CFR 372. Any copies or redistribution of this MSDS must include this notice.

III PHYSICAL PROPERTIES

Boiling Point: N/D Specific Gravity (H_2O=1): 0.8250 Melting Point: N/D
Vapor Pressure: (mmHg) N/D Evaporation Rate: (Butyl Acetate = 1): N/D
Vapor Density: (air=1) N/D Solubility In Water: Emulsifies
Appearance/Odor: Yellow to amber liquid, pleasant woody odor.

IV FIRE AND EXPLOSION DATA

Flash Point (method used): 152°F (closed cup) Flammable Limits: Lel 0.6 Uel 7.0 (solvent)
NFPA Hazard Ratings: Health: 1 Flammability: 2 Reactivity: 0
Extinguishing Media: Foam, CO_2, Dry Chemical, or Sand.
Special Fire Fighting Procedures: Do not inhale vapor. Use self contained breathing apparatus and protective clothing. This product is toxic to fish, birds and other wildlife, prevent spread of contaminated runoff.
Unusual Fire & Explosion Hazards: Combustible liquid. Keep containers cool to avoid explosive ignition.

V Reactivity Data

Stability: Stable. Conditions to avoid for stability: None.
Incompatibility: Strong acids and alkalis. Hazardous Decomposition or Byproducts: None.
Hazardous Polymerization: Will not occur. Conditions to avoid for Hazardous Polymerization: None.

VI Health Hazard Data

Routes of Exposure: Inhalation: Yes. Skin: Yes. Ingestion: Yes.
Health Hazards (Acute and Chronic): Acute exposure may lead to irritation of eyes and mucosa and nervous system symptoms.
Chronic effects: At high oral doses, the type of solvent in this product has caused irreversible damage to the liver and kidney (male only) in rats. These effects are not relevant to humans at occupational levels of exposure.
Carcinogenicity: NTP: No. IARC Monographs: No. OSHA Regulated: No.
Signs and Symptoms of Overexposure: Irritation of eyes and mucosa, hyperexcitability, uncoordination, diarrhea, chronic convulsions. If symptoms occur, see a physician.
Medical Conditions Generally Aggravated by Exposure: None known.
Emergency and First Aid Procedures: If swallowed, Call a physician or Poison Control Center immediately. Do not induce vomiting. Vomiting may cause aspiration pneumonia. If inhaled, remove victim to fresh air. If on skin, remove contaminated clothing and wash affected areas with soap and water. If in eyes, flush eyes with plenty of water. Call a physician immediately if irritation persists.

NATURAL PYRETHRIN CONCENTRATE
MATERIAL SAFETY DATA SHEET

VII Precautions for Safe Handling and Use

Steps to be taken in case material is released or spilled: Take care to avoid contact with pesticide and wear protective equipment to prevent contact with the product or its vapors. Cover the spilled area with generous amounts of absorbent material, such as clay, diatomaceous earth, sand or sawdust. Sweep the contaminated absorbent onto a shovel and put the sweepings into a salvage drum. Dispose of wastes as below.

Waste disposal method: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. This product is toxic to fish, birds and other wildlife. Do not contaminate the environment through improper disposal.

Precautions for handling and storage: Do not use or store near heat or open flame. Exposure to temperatures above 130° F. may cause bursting. Keep out of reach of children, domestic animals and pets. Do not contaminate water, food or feed by storage or disposal.

Other precautions: Periodically inspect stored materials.

VIII Control Measures

Respiratory protection: Not usually required. Avoid inhalation of vapors.

Ventilation: Local Exhaust: As required to meet exposure guidelines. Special: Not applicable.
Mechanical: As required to meet exposure guidelines. Other: Not applicable.

Protective Gloves: Chemical resistant.

Eye Protection: Face shield, safety glasses or goggles.

Other protective clothing or equipment: Wear long pants, long sleeved shirt or other body covering clothes. Avoid skin or eye contact.

Work/Hygienic practices: Wash thoroughly after handling and before eating. Do not wear contaminated clothing.

The information given in this safety sheet refers only to this product and is not applicable to combinations with other chemicals.

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

Revision date 5/97

Material Safety Data Sheet

SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT/CHEMICAL NAME: CFT Legumine™

Emergency Contact: 1-800-858-7378 (National Pesticide Information Center)

Transportation Emergency Contact: 1-800-858-7378 (National Pesticide Information Center

Manufactured for: CWE Properties Ltd., LLC
P.O. Box 336277
Greeley, CO 80633

SECTION 2: HAZARDS IDENTIFICATION SUMMARY

KEEP OUT OF REACH OF CHILDREN –WARNING – May be fatal if inhaled. May be fatal if swallowed. Causes substantial, but temporary, eye injury. Causes skin irritation. Do not breathe spray mist. Do not get in eyes, on skin, or on clothing. Wear goggles or safety glasses. This product is an orange, viscous liquid with slight petroleum odor.

SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Ingredients:	Percentage By Weight	CAS No.	TLV (Units)
Rotenone	5.00	83-79-4	5 mg/m$_3$
Other Associated Resins	5.00		
Inert Ingredients, Including N-Methylpyrrolidone	90.00	872-50-4	not listed

SECTION 4: FIRST AID MEASURES

IF SWALLOWED: Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-900-858-7378 immediately for treatment advice. Do not induce vomiting unless told to do so by the Poison Control Center or physician. Do not give any liquid to the person. Do not give anything by mouth to an unconscious or convulsing person.

IF INHALED: Remove victim to fresh air. If not breathing, give artificial respiration, preferably by mouth-to-mouth. Call a physician, Poison Control Center, or the National Pesticide Information

Center at 1-800-858-7378 immediately for treatment advice.

IF IN EYES: Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin with plenty of water for 15-20 minutes. Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.

Note: Have the product container or label with you when obtaining treatment advice.

SECTION 5: FIRE FIGHTING MEASURES

Flash Point (Method Used): 192°F (89°C) (Closed Cup)

Flammable Limits: LFL: Not established
UFL: Not established

Extinguishing Media: CO_2, foam, dry chemical water spray.

Special Fire Fighting Procedures: Use self-contained breathing apparatus and full protective equipment. Fight fire from upwind from a safe distance and keep non-essential personnel out of area.

SECTION 6: ACCIDENTAL RELEASE MEASURES

SPILL/LEAK PROCEDURES: Wear protective clothing as described in Section 8 (Exposure Controls / Personal Protection) of this MSDS. Absorb liquid with material such as clay, sand, sawdust, or dirt. Sweep up and place in a suitable container for disposal and label the contents. Area can be washed down with a suitable solution of bleach or soda ash and an appropriate alcohol (methanol, ethanol, or isopropanol). Follow this by washing with a strong soap and water solution. Absorb any excess liquid as indicated above, and add to the disposal container. This product is extremely toxic to fish. Fish kills are expected at recommended use rates. Keep spills and cleaning runoff out of municipal sewers and open bodies of water.

SECTION 7: HANDLING AND STORAGE

HANDLING: Avoid inhalation of vapors. Harmful if swallowed, inhaled or absorbed through skin. Avoid contact with skin. Wear clean protective clothing. Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

STORAGE: Store in original containers only. Store in a dry place away from children and domestic animals. Do not store at temperatures below 40 F/4.4^{O}C. This product is stable for a minimum of 1 year when stored in sealed drums at 70^{O}F/21.1 $_{o}$C. Do not contaminate water, food or feed by storage or disposal.

SECTION 8: EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHS PELs (see section 3).
RESPIRATORY PROTECTION: When working with an undiluted product in a confined space, use a non-powered air purifying respirator equipped with an N–, R-, or P-series filter. For emergency or non-routine operations (cleaning reactor vessels or storage tanks), wear an SCBA"

Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **PROTECTIVE CLOTHING/EQUIPMENT:** Wear chemical-resistant gloves, boots, and aprons to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Viscous liquid
Appearance and Odor: Orange liquid with slight solvent odor.
Specific Gravity: 1.019 g/ml
Bulk Density: 8.506 lbs./gal.

Emergency Telephone Number: 1-800-858-7378

Revision Date: July 12, 2007

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable at room temperature in closed containers under normal storage and handling conditions.
Conditions to Avoid: None known.
Incompatibility: Strong acids and strong oxidizers,
Hazardous Decomposition Products: Oxides of carbon.
Hazardous Polymerization: Will not occur.

SECTION 11: TOXICOLOGICAL INFORMATION

Acute Oral LD_{50} (rat): 55.3 – 264 mg/kg
Acute Dermal LD_{50} (rabbit): >2020 mg/kg
Inhalation LC_{50} (rat): 0.048 mg/L (4 HR)
Eye Irritation (rabbit): Moderately irritating
Skin Irritation (rabbit): Moderately irritating
Skin Sensitization (guinea pig): Not a sensitizer
Carcinogenic Potential: Not listed by IARC, NTP, or OSHA. ACGIH lists Rotenone as TLV A4: Not classifiable as to human carcinogenicity.

SECTION 12: ECOLOGICAL INFORMATION

This product is extremely toxic to fish. Fish kills are expected at recommended usage rates. Consult local Fish and Game agencies before applying this product to public waters to determine if a permit is needed for such an application.

SECTION 13: DISPOSAL CONSIDERATIONS

Do not reuse empty containers. **Plastic:** Triple rinse (or equivalent), then offer for recycling, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke. **Metal:** Triple rinse (or equivalent), then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill or by other procedures approved by state and local authorities. Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal law and may contaminate groundwater. Do not contaminate water, food or feed by storage or disposal.

SECTION 14: TRANSPORT INFORMATION

U.S DOT Shipping Description: Pesticide, Liquid, Toxic, N.O.S. (Rotenone), 6.1, UN2902, III, Marine Pollutant, ERG Guide 151Emergency Telephone Number: 1-800-858-7378

SECTION 15: REGULATORY INFORMATION

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) HAZARD RATINGS:

Category	Rating
Health	4
Flammability	2
Instability	0

0: Least
1: Slight
2: Moderate
3: High
4: Severe

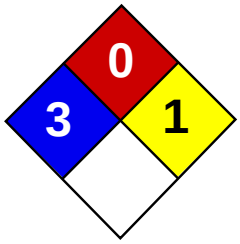
SARA Hazard Notification/Reporting:

SARA Title III Hazard Category:
Immediate: Yes – Fire: No – Delayed: No – Reactive: No
Reportable Quantity (RQ) U.S. CERCLA: Not listed
SARA Title III, Section 313: N-methylpyrrolidone (CAS: 872-50-4) 10.0%
RCRA Waste Code: Not listed
California Proposition 65: WARNING: This product contains chemicals known to the State of California to cause cancer or birth defects or other reproductive harm.

SECTION 16: OTHER INFORMATION

Prepared by: ERR
Issue Date: July 12, 2007
Revision Notes: July 12, 2007
NOTE: *CFT Legumine is a Restricted Use Pesticide due to Aquatic Toxicity*

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state, and local laws and regulations.



Material Safety Data Sheet
Sodium Hydroxide, 50% MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium Hydroxide, 50%

Catalog Codes: SLS3127, SLS4549

CAS#: Mixture.

RTECS: Not applicable.

TSCA: TSCA 8(b) inventory: Sodium hydroxide; Water

CI#: Not applicable.

Synonym: Sodium Hydroxide, 50% Solution

Chemical Name: Not applicable.

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium hydroxide	1310-73-2	50
Water	7732-18-5	50

Toxicological Data on Ingredients: Sodium hydroxide LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, . Slightly hazardous in case of inhalation (lung sensitizer). Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation

leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention immediately. Finish by rinsing thoroughly with running water to avoid a possible infection.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances: Non-explosive in presence of open flames and sparks, of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards:
Sodium hydroxide reacts to form explosive products with ammonia + silver nitrate. Benzene extract of allyl benzenesulfonate prepared from allyl alcohol, and benzene sulfonyl chloride in presence of aquesous sodium hydroxide, under vacuum distillation, residue darkened and exploded. Sodium Hydroxde + impure tetrahydrofuran, which can contain peroxides, can cause serious explosions. Dry mixtures of sodium hydroxide and sodium tetrahydroborate liberate hydrogen explosively at 230-270 deg. C. Sodium Hydroxide reacts with sodium salt of trichlorophenol + methyl alcohol + trichlorobenzene + heat to cause an explosion. (Sodium hydroxide)

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of acetic acid.

Large Spill:
Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of acetic acid. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, reducing agents, metals, acids, alkalis, moisture.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
Sodium hydroxide STEL: 2 (mg/m3) from ACGIH (TLV) [United States] TWA: 2 CEIL: 2 (mg/m3) from OSHA (PEL) [United States] CEIL: 2 (mg/m3) from NIOSHConsult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Odorless.

Taste: Alkaline. Bitter. (Strong.)

Molecular Weight: Not applicable.

Color: Clear Colorless.

pH (1% soln/water): Basic.

Boiling Point: 140°C (284°F)

Melting Point: 12°C (53.6°F)

Critical Temperature: Not available.

Specific Gravity: 1.53 (Water = 1)

Vapor Pressure: The highest known value is 2.3 kPa (@ 20°C) (Water).

Vapor Density: The highest known value is 0.62 (Air = 1) (Water).

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, incompatible materials, water/moisture

Incompatibility with various substances:
Reactive with oxidizing agents, reducing agents, metals, acids, alkalis. Slightly reactive with water

Corrosivity:
Extremely corrosive in presence of aluminum, brass. Corrosive in presence of copper, of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Hygroscopic. Much heat is evolved when solid material is dissolved in water. Therefore cold water and caution must be used for this process. Generates considerable heat when a sodium hydroxide solution is mixed with an acid Sodium hydroxide solution and octanol + diborane during a work-up of a reaction mixture of oxime and diborane in tetrahyrofuran is very exothermic, a mild explosion being noted on one occassion. Reactive with water, acids (mineral, non-oxidizing, e.g. hydrochloric, hydrofluoric acid, muriatic acid, phosphoric), acids (mineral, oxidizing e.g. chromic acid, hypochlorous acid, nitric acid, sulfuric acid), acids (organic e.g. acetic acid, benzoic acid, formic acid, methanoic acid, oxalic acid), aldehydes (e.g. acetaldehyde, acrolein, chloral hydrate, foraldehyde), carbamates (e.g. carbanolate, carbofuran), esters (e.g. butyl acetate, ethyl acetate, propyl formate), halogenated organics (dibromoethane, hexachlorobenzene, methyl chloride, trichloroethylene), isocyanates (e.g. methyl isocyanate), ketones (acetone, acetophenone, MEK, MIBK), acid chlorides, strong bases, strong oxidizing agents, strong reducing agents, flammable liquids, powdered metals and metals (i.e aluminum, tin, zinc, hafnium, raney nickel), metals (alkali and alkaline e.g. cesium, potassium, sodium), metal compounds (toxic e.g. berylium, lead acetate, nickel carbonyl, tetraethyl lead), mitrides (e.g. potassium nitride, sodium nitride), nitriles (e.g. acetonitrile, methyl cyanide), nitro compounds (organic e.g. nitrobenzene, nitromethane), acetic anhydride, hydroquinone, chlorohydrin, chlorosulfonic acid, ethylene cyanohydrin, glyoxal, hydrosulfuric acid, oleum, propiolactone, acylonitrile, phorosous pentoxide, chloroethanol, chloroform-methanol, tetrahydroborate, cyanogen azide, 1,2,4,5 tetrachlorobenzene, cinnamaldehyde. Reacts with formaldehyde hydroxide to yield formic acid, and hydrogen. (Sodium hydroxide)

Special Remarks on Corrosivity: Very caustic to aluminum and other metals in presence of moisture.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Extremely hazardous in case of inhalation (lung corrosive). Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (corrosive), of ingestion, .

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Investigation as a mutagen (cytogenetic analysis), but no data available. (Sodium hydroxide)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May be harmful if absorbed through skin. Causes severe skin irritation and burns. May cause deep penetrating ulcers of the skin. Eyes: Causes severe eye irritation and burns. May cause chemical conjunctivitis and corneal damage. Inhalation: Harmful if inhaled. Causes severe irritation of the respiratory tract and mucous membranes with coughing, burns, breathing difficulty, and possible coma. Irritation may lead the chemical pneumonitis and pulmonary edema. Causes chemical burns to the respiratory tract and mucous membranes. Ingestion: May be fatal if swallowed. May cause severe and permanent damage to the digestive tract. Causes

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Sodium hydroxide, solution (Sodium hydroxide) UNNA: UN1824 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Illinois toxic substances disclosure to employee act: Sodium hydroxide Illinois chemical safety act: Sodium hydroxide New York release reporting list: Sodium hydroxide Rhode Island RTK hazardous substances: Sodium hydroxide Pennsylvania RTK: Sodium hydroxide Minnesota: Sodium hydroxide Massachusetts RTK: Sodium hydroxide New Jersey: Sodium hydroxide Louisiana spill reporting: Sodium hydroxide TSCA 8(b) inventory: Sodium hydroxide; Water CERCLA: Hazardous substances.: Sodium hydroxide: 1000 lbs. (453.6 kg);

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada):

CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 1

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 1

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 06:32 PM

Last Updated: 11/06/2008 12:00 PM

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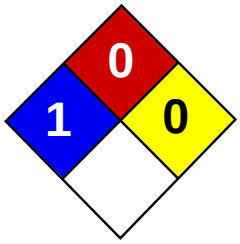

Material Safety Data Sheet
Sodium sulfite MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium sulfite

Catalog Codes: SLS2383

CAS#: 7757-83-7

RTECS: WE2150000

TSCA: TSCA 8(b) inventory: Sodium sulfite

CI#: Not available.

Synonym: Sulfurous Acid, Disodium salt

Chemical Name: Sulfurous acid, disodium salt

Chemical Formula: Na2SO3

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium sulfite	7757-83-7	100

Toxicological Data on Ingredients: Sodium sulfite: ORAL (LD50): Acute: 820 mg/kg [Mouse.]. 3650 mg/kg [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of ingestion, of inhalation (lung irritant). Slightly hazardous in case of skin contact (irritant), of eye contact (irritant).

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: 3 (Not classifiable for human.) by IARC. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to peripheral nervous system, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. Wear suitable protective clothing. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, combustible materials, organic materials, acids.

Storage:
Air sensitive. Moisture sensitive. Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance:
Solid. (Solid crystalline powder. Powdered solid. Crystals solid.)

Odor: Sulfurous. Odorless.

Taste: Sulfurous. Saline.

Molecular Weight: 126.04 g/mole

Color: White or Tan to slightly pink

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposition temperature: >500°C (932°F)

Critical Temperature: Not available.

Specific Gravity: 2.63 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in cold water, hot water. Soluble in glycerol. Almost insoluble in alcohol.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materitals, air, moisture, dust generation

Incompatibility with various substances: Reactive with oxidizing agents, combustible materials, organic materials, acids.

Corrosivity:
Corrosive in presence of aluminum, of zinc, of copper. Slightly corrosive in presence of steel.

Special Remarks on Reactivity:
Air sensitive. Moisture sensitive. Keep container tightly closed. When heated to decompostion, it emits toxic fumes of Na2O and SOx

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 820 mg/kg [Mouse.].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: 3 (Not classifiable for human.) by IARC. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. May cause damage to the following organs: peripheral nervous system, central nervous system (CNS).

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation (lung irritant). Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals:
Lowest Published Dose: LDL [Rabbit] - Route: Oral; Dose 2825 mg/kg

Special Remarks on Chronic Effects on Humans: May affect genetic material(mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Acute Potential Health Effects: Skin: Causes skin irritation. Eyes: Causes eye irritation and may cause chemical conjunctivitis. Conjunctivitis may be more noted in sensitive individuals. Inhalation: Causes upper respiratory tract and mucous membrane irritation. May cause hypersensitivity reaction with swelling of the tongue, bronchospasm, bronchoconstriction diaphoreisis, flushing, urticaria, hypotension, tachycardia, and anaphylaxis particularly in asthmatic people who are sulfite sensitive. Ingestion: May cause gastrointestinal tract irritation with abdominal pain, nausea, vomiting and diarrhea. May affect behavior/central nervous system (CNS depression with convulsions, somnolence), respiration (respiration depression), and cardiovascular system (circulatory disturbancs, hypotension). It may liberate sulfurous acid which may result in caustic injury. Hypersensitivity reaction with swelling of the tongue bronchospasm, bronchoconstriction diaphoreisis, flushing, urticaria, hypotension, tachycardia, and anaphylaxis may occur more frequently with people who are asthmatic. Chronic Potential Health Effects: Skin: Prolonged or repeated skin contact may cause dermal sensitization (contact dermatitis), but this is rare. Inhalation: Prolonged or repeated inhalation may cause chronic irritation, inflammation, delayed pulmonary edema, and alteration of sense of smell and taste. Ingestion: Prolonged or repeated ingestion may affect the bone marrow (bone marrow atrophy), and behavior/central/peripheral nervous systems (CNS depression and paralysis).

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium sulfite

Other Regulations: Not available.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R22- Harmful if swallowed. R36/37/38- Irritating to eyes, respiratory system and skin. S22- Do not breathe dust. S24/25- Avoid contact with skin and eyes. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S36- Wear suitable protective clothing.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References:
-The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. RTECS (Registry of Toxic Effects of Chemicals). Hazardous Substance Data Bank (HDSB)

Other Special Considerations: Not available.

Created: 10/09/2005 06:36 PM

Last Updated: 11/06/2008 12:00 PM