Human Health and Ecological Risk Assessment
for the Use of Wildlife Damage Management Methods
by USDA-APHIS-Wildlife Services

Chapter VII

THE USE OF SODIUM CYANIDE IN WILDLIFE DAMAGE MANAGEMENT

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EXECUTIVE SUMMARY

USDA-APHIS Wildlife Services (WS) uses sodium cyanide (NaCN) to manage coyotes, red foxes, gray foxes, arctic foxes, and wild dogs that prey upon livestock, poultry, and federally designated threatened and endangered species or animals that are vectors of disease. This human health and ecological risk assessment is an evaluation of the risks to human health, nontarget animals, and the environment from NaCN use by WS.

WS uses the M-44, the name for the ejector device that delivers a single dose NaCN from a capsule, to target canids. The M-44 is spring-activated and is actuated when an animal pulls up on the capsule holder; a plunger propelled by the spring breaks through a capsule with dry NaCN to deliver the contents into the mouth of an animal. The WS applicator baits the M-44 capsule holder sides to attract target canids. Sodium cyanide reacts rapidly with moisture in the mouth or mucus membranes of the nose and eyes to form hydrogen cyanide (HCN), a toxicant. One NaCN capsule contains enough cyanide to be lethal to animals through oral contact, inhalation contact, and moist dermal pathway contact.

WS annually averaged the known take of 13,959 target canids and 362 nontarget species with NaCN between FY11 and FY15, recording 1,548,000 Method Nights with M-44s in 17 States. Additionally, 9,757 M-44s were fired with no known take. M-44s fired with no known take can occur from accidental discharge, not delivering a lethal dose, or a WS specialist not being able to find the animal. Target take was 97.5% of the known pulls. The high percentage of target take represents a highly effective tool in wildlife damage management with 15.6 pulls per 1000 method nights. Take with M-44s included 26 species, 4 target and 25 nontarget (three species had both target and nontarget take associated with them). Target species take included 95.2% coyotes, 3.1% common gray fox, 1.5% red fox, and 0.2% feral dogs. About 98% of the 362 nontarget species taken included raccoon (31.5%), gray fox (20.8%), red fox (12.8%), Virginia opossum (9.3%), feral or free-roaming dog (8.3%), striped skunk (5.7%), swift fox (5.4%), unlisted subspecies of kit fox (2.9%), and feral swine (1.1 %). The percentage of known take of nontarget species by the M-44 is low (2.5%) relative to target species.

In the environment, NaCN reacts rapidly with moisture to form HCN, which can complex with trace metals, adsorb to organic carbon compounds, volatilize, undergo microbial uptake, metabolism, or degradation; or break down to less toxic compounds. Hydrogen cyanide does not tend to bioaccumulate in aquatic or terrestrial organisms. The risk to aquatic fauna and flora is negligible because the product label restricts the use of the product within 200 feet of a water source. Offsite run-off or migration of cyanide to water bodies is unlikely due to the application method. The WS use pattern and label restrictions minimize acute and chronic exposure to most nontarget terrestrial vertebrate species. In cases where exposure does occur the acute risk to nontarget terrestrial vertebrates is high due to the high toxicity of NaCN. The potential for acute exposure is low for many nontarget terrestrial vertebrates because of the WS use pattern for M-44 devices, such as the use of specific bait, setting the trigger to a certain pull strength, and the size and position of the devices.

WS use of NaCN capsules minimizes the likelihood of human exposure to M-44s. M-44s are only commercially available to certified M-44 applicators. WS applicators certified to use the device follow product labeling language designed to promote public and applicator safety. Dietary exposure is unlikely because labeling does not permit usage in areas near water or planted crops. The risk to WS applicators is mitigated

by requiring training of applicators in the use M-44s, following label instructions, wearing protective clothing, including long-sleeved shirt, pants, waterproof gloves and a full face shield.

Sodium cyanide is the only product WS uses in wildlife damage management that contains cyanide. Several State agency programs also use M-44s in their state-run Predator Damage Management Programs. The labels restrict the number of M-44 devices on one acre, regardless of whether WS, a state agency, or private applicator sets the device. Other sources of cyanide in the environment come from natural or manmade sources. The WS program contributes a negligible amount of cyanide to the environment in comparison to industry, making cumulative effects unlikely.

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1 INTRODUCTION

The first registration of sodium cyanide (NaCN) as a pesticide was in 1947 to control ants on uncultivated and non-agricultural areas (USEPA 1994). Sodium cyanide products have changed since then with more emphasis focused on reducing harm to nontarget organisms and increasing safety to applicators (Blom and Connolly 2003). In 1987, the Environmental Protection Agency (USEPA) cancelled non-predacidal uses of NaCN including its use to control pests in homes, railway cars, and food distribution facilities (USEPA 1994). APHIS Wildlife Services (WS) uses NaCN to manage coyotes[1], red foxes, gray foxes, arctic foxes, and wild or feral dogs that prey on livestock, poultry, and threatened and endangered (T&E) species, or animals that are vectors of disease (Table 1).

Sodium cyanide comes in capsules (Figure 1) for a single dose delivery from an M-44 device (Figure 2) with each capsule containing about 0.88 g of NaCN active ingredient (ai). The device is spring-activated and ejects dry cyanide from a capsule into the mouth of the target animal. Sodium cyanide quickly transforms to hydrogen cyanide, a toxic fume, in the presence of moisture, which in turn causes death through asphyxiation.

Figure 1. Sodium cyanide capsule.

This human health and ecological risk assessment is a qualitative evaluation of the risks and hazards to human health, pets, and the environment including potential to take nontarget fish and wildlife from the use of NaCN by WS. The methods used to assess human health effects follow regulatory guidance and methods (NRC 1983, USEPA 2016a), and conform to other Federal agencies, such as the U.S. Environmental Protection Agency (USEPA), Office of Pesticide Programs. The methods used to assess the ecological risk to nontarget species generally follow USEPA ecological risk assessment methods.

This assessment starts with identifying the hazard (problem formulation) and then evaluates toxicity (the dose-response assessment) and exposure (identifying exposed populations and exposure pathways for these populations). Last, combining toxicity and exposure information provides a determination of adverse human health or ecological risks (risk characterization).

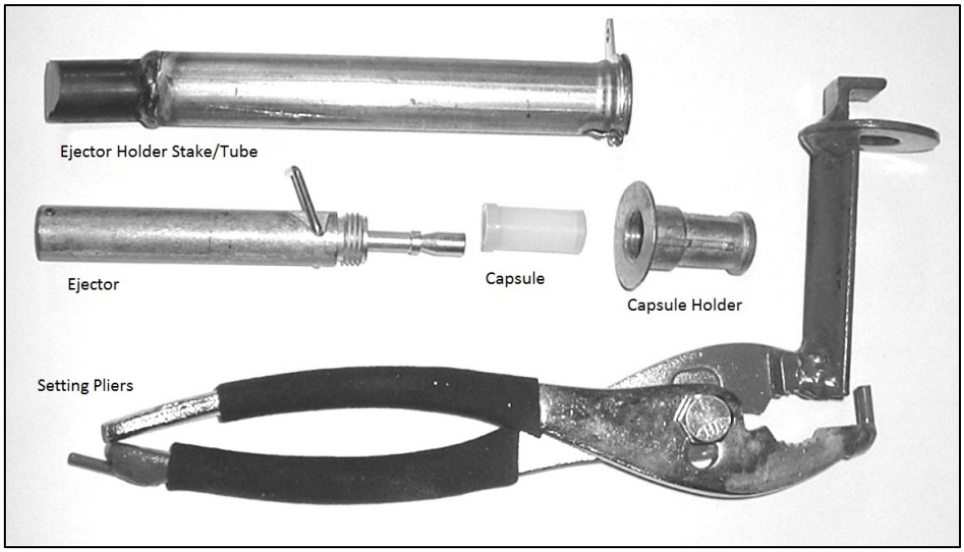

Figure 2. Parts, capsule, and setting pliers for the M-44.

[1] Scientific names for species are listed in the text only for species not given in the Wildlife Damage Management Methods Risk Assessment Introduction.

1.1 Use Pattern

APHIS is the registrant for two sodium cyanide products it uses in its Predator Damage Management Program. Both products have the same formulation (Table 1) and use the same placement method. The first APHIS registration, #56228-15, is for coyotes, gray and red foxes, and feral dogs; this is currently registered in 16 states (AZ, CO, ID, MT, ND, NE, NM, NV, OK, OR, TX, UT, VA, WA, WV, and WY) and previously registered in three states (CA, MS, and SD). While APHIS holds the principal registration, five State Departments of Agriculture have state-limited, FIFRA §3 registrations (Montana - #35975-2, New Mexico – #39508-1, South Dakota - #13808-8, Texas - #33858-2 and Wyoming - #35978-1). The second APHIS registration, #56228-32, is for arctic fox, but it is currently not registered in Alaska and has not been used in the last ten years, from FY06 to FY15.

Table 1. Sodium cyanide product registrations held by APHIS, as amended January and July, 2018.

Product	Active Ingredients	Inert Ingredients	Directions for Use	Registration Target Species
M-44 Cyanide Capsules (EPA. Reg. No. 56228-15)[1] (Approved 13 Jan 1987)	91.06% NaCN (0.97 grams (970 mg) plus or minus 3% or about 883 mg of NaCN (970 mg capsule contents x 91.06 % NaCN))[3]	8.94%. Silica desiccant, fluorescent particle marker, petroleum hydrocarbon wax capsule (Scheel SC-100) [3]	No more than 10 units per 100 acres of pastureland or 12 units per square mile of open rangeland. Not for use in food crops.	Coyotes, red fox, gray fox, and wild dogs
M-44 Cyanide Capsules Arctic Fox (EPA Reg. No. 56228-32)[2] (Approved 22 Feb 1995)			For use only in the Aleutian Islands, AK. Not for use in areas within 200 feet of the median high tide	Arctic fox

[1] Accessed @ https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:102:::NO::P102_REG_NUM:56228-15. *Last visited 9/27/19*
[2] Accessed @ https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:102:::NO::P102_REG_NUM:56228-32. *Last visited 9/27/19*
[3] Blom and Connolly 2003

Between Fiscal Year 2011 (FY11 = Oct. 1, 2010 – Sept. 30, 2011) and FY15, WS set M-44 devices with NaCN capsules under the "M-44 Cyanide Capsules for Coyotes, Fox, Wild Dogs" (EPA. Reg. No. 56228-15) label in 17 states (Table 2) for a total 1,547,616 nights or 1,548 1000 method nights[2]; the Artic Fox label was not used. During this time, NaCN killed an annual average of 13,959 target (9.0 animals per 1000 method nights or 97.5% of the known animal take) and 362 nontarget animals (0.2 animals per 1000 method nights or 2.5% of the known animal take) (Table 3). Additionally, 9,757 M-44s were discharged with no known take (6.3 animals per 1000 method nights). Not all animals are found because: 1) the discharge is not sprayed into the animal's mouth due to the animal grasping it from the side and not the top, and, therefore, the animal does not get a lethal dose; 2) an animal brushes up against the device, snags or drags the ejector, and discharges it; 3) the treated animal moves into dense cover and cannot be found; or 4) the animal is removed by another animal or person. The animals not found is expected to be a percentage of the take, but unknown (Table 3 assumes 50% to be conservative with a similar percentage of take as the known take). Thus, the overall use of the NaCN as a WDM method represents a highly effective tool with 15.5 discharges per 1000 method nights.

Species take from FY11 to FY15 for NaCN included 26 species with 4 target species and 25 nontarget species (3 species were both target and nontarget species and were only counted once). From FY11 to FY15, the annual average of known take was 97.5% target species, including 13,285 coyotes, 435 gray fox, 210 red fox, and 29 feral dogs (Table 3). During this time, WS annually averaged the take of 362 nontarget animals (2.5% of the total known take) (Table 3). Of the nontarget species, 42% were species on the label (feral/free-roaming dogs, and gray and red fox). The most common nontarget species taken were raccoons (31.5% of the nontarget take), common gray fox (21.0%), red fox (12.7%), Virginia opossum (9.4%), feral or free-roaming

[2] Method Nights is a standard unit of measure for methods left in the field to take wildlife and is the equivalent of 1000 nights for any number of a device to be set in the field.

dogs (8.3%), striped skunks (5.8%), swift fox (5.2%), and feral swine (1.1%). These species accounted for 97.8% of the nontarget take and were all predators with the exception of feral swine.

Table 2. The annual average number of sodium cyanide capsules that took target, nontarget and unknown animals those capsules tested, damaged, or tested, and method nights for WS in WDM from FY11 to FY15 throughout the United States.

ANNUAL AVERAGE SODIUM CYANIDE USE BY WS FOR FY11 TO FY15						
STATE	**Target Take**	**Nontarget Take**	**Unknown Take**	**Capsules Destroyed**	**Total Capsules Used**	**% of Total Use**
Arizona	16	0	6	0	22	**0.1%**
California	8	0	8	3	19	**0.1%**
Colorado	17	0.4	3	3	23	**0.1%**
Idaho	103	0	31	27	161	**0.6%**
Montana	612	1	128	319	1,060	**3.8%**
Nebraska	976	0.2	181	461	1,618	**5.9%**
Nevada	196	0.4	22	1	219	**0.8%**
New Mexico	989	40	225	23	1,277	**4.6%**
North Dakota	690	10	167	281	1,148	**4.2%**
Oklahoma	3,170	41	1,094	817	5,122	**18.5%**
Oregon	227	0	27	3	257	**0.9%**
South Dakota	4	0.2	0.4	0.2	5	**0.02%**
Texas	5,566	123	6,709	0.4	12,398	**44.9%**
Utah	115	0	12	89	216	**0.8%**
Virginia	267	49	400	387	1,103	**4.0%**
West Virginia	801	89	605	816	2,311	**8.4%**
Wyoming	202	8	139	321	670	**2.4%**
Total	**13,959**	**362**	**9,757**	**3,552**	**27,629**	
% of Capsules	**50.5%**	**1.3%**	**35.3%**	**12.9%**		
% of take	**58.0%**	**1.5%**	**40.5%**	**N/A**		

Of the average annual nontarget known take from FY11 through FY15, none were T&E species (Table 3). However, 0.6 gray wolves, 0.2 bald eagles, and 0.4 golden eagles were taken annually over the 5-year period (1.2 sensitive species per year). Additionally, of the annual average of 30 feral or free-roaming dogs taken as nontarget species, six were or possibly were pet dogs with their owners (typically trespassing) or running at large[3] while the others were feral dogs or unidentifiable dogs without a collar. Of annual average of six pet dogs, two were the landowners' dogs, two were neighbors' dog as far as 7 miles from the incident, and two unknown (had a collar or collar marks, but no identification and the landowner or neighbors did not whose dog it was). The landowners and most neighbors were aware that the devices had been placed and thought that their dogs did not run as far as the devices were placed and allowed them to run free. It should be noted that 98.7% of all M-44s discharged with known take were by canids. Other carnivores (including opossum) accounted for 1.2% of the take and non-carnivore take accounted for less than 0.1% of the take. Thus, nontarget risks for this WDM method appear relatively low and M-44s are highly selective for canids.

There is uncertainty with the level of nontarget take from the use of M-44s due to the discharge of devices without any carcass being located. WS M-44 applicators write down the suspected reason that the M-44 was fired in their diaries, but do not record it in the Management Information System (MIS[4]). But an estimate was

[3] These incidents are kept on Adverse Effects Incident Information Reports – FIFRA 6(a)(2)s. Owners are contacted as soon as possible.

[4] MIS - Computer-based Management Information System used for tracking WDM activities and damage. Throughout the text, data for a year (i.e. FY11 to FY15) will be given and is from the MIS. MIS reports are not be referenced in the text or Literature Cited Section because MIS reports

added to take, though we believe this is an overestimate of take (Table 3). Assumptions for the additional estimate included 1) It is believed that 50% of the NaCN capsules fired without an animal found (4,879) possibly involved take or the animal being taken away by people or a scavenger, 2) that the animals taken are similar percentages to WS take (this is typical of diary recordings), among the 26 species taken (Table 3) 3) that 45% of the capsules discharged did not supply a lethal dose to the animal, and 4) 5% were accidentally discharged by animals or winds blowing debris. Thus, 4,757 target species would be added and 123 nontarget species (Table 3). Numbers for this estimation procedure are given, but it is just an estimation to show possible total take. Even with the additional take, no species take would be high enough to have a significant impact on their population.

Table 3. The annual average number of target and nontarget animals killed with sodium cyanide from M-44s by WS in WDM activities from FY11 to FY15 throughout the United States.

ANNUAL AVERAGE SPECIES TAKEN WITH SODIUM CYANIDE-M-44s BETWEEN FY11 AND FY15							
SPECIES	**TARGET**			**NONTARGET**			**M-44s FIRED**
M-44s Discarded/Damaged							3,550
M-44s Discharged-Unknown							9,759[1]
SPECIES	**Known**	**Unknown**	**Est.**	**Known**	**Unknown**	**Est.**	
Coyote**	13,285	4,527	17,812	0	0	0	13,285
Feral/Free-Roaming Dog*	29	10	39	30	10	40	59
Common Gray Fox	435	148	583	76	26	102	511
Red Fox**	210	72	282	46	16	62	256
Gray Wolf^				0.6	0	0.6	0.6
Swift Fox				19	6	19	19
Kit Fox^				10	3	13	10
Bobcat				0.2	0	0.2	0.2
Feral/Free-roaming Cat*				0.4	0	0.4	0.4
Black Bear^				2	1	3	1.6
Raccoon				114	39	153	114
Ringtail				0.2	0	0.2	0.2
Hog-nosed Skunk				0.4	0	0.4	0.4
Hooded Skunk				0.2	0	0.2	0.2
Striped Skunk				21	7	28	20.6
Fisher				0.2	0	0.2	0.2
Virginia Opossum**				34	12	46	33.6
Woodchuck				0.4	0	0.4	0.4
White-toothed Woodrat				0.2	0	0.2	0.2
Feral Swine*				4	1	5	4
Collared Peccary				0.8	0	0.8	0.8
Black Vulture				0.2	0	0.2	0.2
Bald Eagle				0.2	0	0.2	0.2
Golden Eagle				0.4	0	0.4	0.4
Common Raven				2	1	3	2
American Crow				0.2	0	0.2	0.2
ANIMALS Taken (4T, 25NT – 26 spp.)[3]	**13,959**	**4,757**	**18,71**	**362**	**123**	**485**	**24,079[2]**
% TARGET/NONTARGET	**97.5%**			**2.5%**			**N/A**

* Introduced Species ** - Some populations were introduced ^ Unlisted subspecies or DPSs Est. = Estimate

[1] Assuming that 50% of the M-44s with unknown discharge reason had no take (4,879) from a nonlethal dose or accidental discharge and the other 50% (4,880) were involved take, but not found and had similar percentages of take as species in table; an estimate of take can be made for these (this would be an estimate of additional take, but expected to be fairly conservative).

[2] Does not include test fired/damage sodium cyanide capsules.

[3] Three species were target and nontarget species.

are not kept on file. A database is kept that allows queries to be made to retrieve the information needed. Many WS applicators use the MIS to record GPS coordinates of M-44s set.

2 PROBLEM FORMULATION

2.1 Chemical Description and Product Use

WS uses the M-44 device to deliver sodium cyanide. To set the M-44, the applicator places the NaCN capsule into the capsule holder (Figure 2) and threads the holder onto the ejector unit (Figures 3 and 4) called the M-44. Next, the applicator places the ejector unit into a tube, placing the trigger in a notch and then rotates the locking ring over the trigger arm (Figure 5).

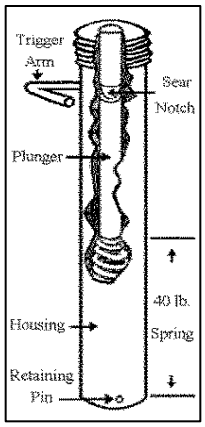

Figure 3. Ejector unit for an M-44.

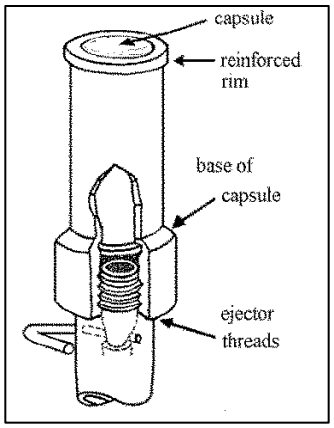

Figure 4. Capsule holder for an M-44.

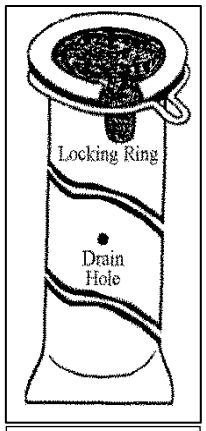

Figure 5. M-44 stake.

When an animal pulls on the capsule holder, the trigger is depressed which activates the plunger. When the plunger is activated, the spring is released which pushes the plunger through the capsule which is held in place by the capsule holder. The plunger breaks through the bottom and top of the capsule ejecting the contents of the capsule into the mouth of an animal that pulls on it from above. The capsule holder is wrapped with a soft material such as yarn, gauze, wool, rabbit fur, adhesive tape or any other material that is somewhat soft to allow wrapping, thick enough to prevent the coyote or other target animal from biting into the metal, and absorbent to soak in the bait scent (Figure 6). The wrap and bait do not extend over the top of the holder as this could prevent ejection of the cyanide. When an M-44 is set, it is very small (Figures 7, and 9), just larger than a quarter from the side (Figure 6) and the size of a quarter from above (Figure 7).

Figure 6. Wrapped M-44 capsule holder in ejector tube.

Figure 7. Wrapped capsule holder with capsule inside.

Figure 8. M-44 capsule and label.

Figure 9. A set M-44 without bait added (black pointed out by arrow) and an elevated sign.

The NaCN capsule (Figure 8) is made of transparent plastic to allow a visual check of the cyanide and seal. The cap, the top of the capsule, provides a moisture-tight seal. M-44 capsule sealant is Scheel SC-100 Petroleum Hydrocarbon Wax. M-44 capsules are waxed on the bottom to prevent moisture from entering, but excess wax is removed by the applicator to ensure proper functioning of the M-44. The capsule is effective as long as the seal is intact and the cyanide is loose. When cyanide is "clumped" or "caked," the capsule has been exposed to moisture. The capsule is then disposed, typically by incineration. New capsules and capsules in storage are inspected before use. The capsules are susceptible to a variety of damage such as hot temperatures from transporting and gnawing from rodents. Each M-44 capsule contains a mixture of NaCN and inert ingredients (Figure 8). The amount of NaCN mixture in each capsule is approximately 0.97 gram (0.03 ounce). This includes 0.88 gram of NaCN, the active ingredient, and 0.09 gram of inert ingredients. One of the inert ingredients is a marker that is detectable in or around the mouth of animals taken by the M-44. If it were necessary to ensure a particular animal was killed with NaCN or not, a shortwave, ultraviolet light (366nm) can be used in a dark place to make the markers visible, even if the markers were not visible in daylight (this can occur even with the colored markers). The color marker for WS cyanide capsules is blaze orange. Capsules made for state and other certified applicators are yellow.

Each box of NaCN capsules has a label with a quality control card inside which has the manufactured date and each box is date stamped, i.e. "08 15" which means August of 2015. This allows older capsules to be used first, but it is suggested that capsules be used within 6 months of the date of manufacture; older capsules are more likely to show the effects of temperature. Each capsule in a box has its own label (Figure 8) which stays on the capsule, even when in use in the capsule holder.

M-44 ejectors are the functioning part of the M-44. Routine maintenance checks involve test-firing ejectors monthly to ensure that the plunger has enough force to drive through a capsule. During the checks, the ejectors are inspected for corrosion, which is removed with a wire brush as necessary. The ejector is also oiled. After placement in the field, applicators check M-44s at least weekly, per label requirements, unless the applicator is "weathered-out," unable to travel to the location due to weather conditions.

WS personnel may only use the M-44 device according to the appropriate label. Full documentation of livestock depredation, including evidence that wild canids were responsible for predation is required before applications of the M- 44. In the case of federally listed T&E species and in areas where wild canids may be vectors of a communicable disease, M-44s can be used to reduce the population of wild canids in that area.

Each M-44 Cyanide Capsule label and the M-44 Capsule Arctic Fox label, (last revised in January and July 2018, respectively) includes an additional 26 use restrictions (given in bold below) contained in an included Use Restriction Bulletin. These 26 use restrictions provide additional safety precautions to the applicator, public, pets, nontarget wildlife, and the environment. The following are the 26 use restrictions with supporting comments or explanations (not bolded), which are not part of the label. In addition to the below use restrictions APHIS has developed guidelines for the use of M-44's that are not part of the label, but intended to provide additional protection measures to human health and the environment (Appendix 1).

1. Use of the M-44 device shall conform to all applicable Federal, State, and local laws and regulations. This use restriction is self-explanatory. For example, some states have banned the use of M-44s and WS personnel do not use these in those states.

2. Applicators shall be subject to such other regulations and restrictions as may be prescribed from time-to-time by the U.S. Environmental Protection Agency (USEPA). WS field personnel receive additional restrictions or changes issued by the USEPA from their supervisors to ensure that they comply with this use restriction.

3. Each applicator of the M-44 device shall be trained in: (1) safe handling of the capsules and device, (2) proper placement of the device, and (3) necessary record keeping. WS supervisors are responsible for insuring that thorough training in the prescribed areas is provided to all M-44 applicators. New applicators are given intensive training in the use of M-44s with periodic refresher training, usually as prescribed by the state pesticide registration unit. It should be noted that antidote kits are no longer available or in use and were part of this use restriction.

4. M-44 devices and sodium cyanide capsules shall not be sold or transferred to, or entrusted to the care of any person not supervised or monitored, by the Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) or any agency not working under a WS cooperative agreement. The USDA registration for the M-44 NaCN capsule prohibits the distribution of the device except in programs that are clearly USDA-APHIS-WS functions. WS Policy states that M-44 devices will be used under the USDA registration only in operational programs with designated supervisors who have responsibility over trained applicators. Cooperator under WS supervision can check M-44s to see if they have been discharged, but are not be allowed to work directly with the M-44s unless they are considered an WS employee. States can have their own registration for the M-44 and are required to follow these use restrictions and other labeling as well.

5. The M-44 device shall only be used to take wild canids: (1) suspected of preying on livestock or poultry; (2) suspected of preying on federally designated threatened or endangered species; or (3) that are vectors of a communicable disease. This use restriction provides specific language for the damage situations when the M-44 can be used. T&E species being protected with M-44s must be federally listed, and not just listed by a State.

6. The M-44 device shall not be used solely to take animals for the value of their fur. Furs can be salvaged if the animal was taken for legitimate predator damage management activities as prescribed in Use Restriction #5.

7. The M-44 device shall only be used on or within 7 miles of a ranch unit or allotment where losses due to predation by wild canids are occurring or where losses can be reasonably expected to occur based upon recurrent prior experience of predation on the ranch unit or allotment. Full documentation of livestock depredation, including evidence that such losses were caused by wild canids, will be required before applications of the M-44 are undertaken. This use restriction is not applicable when wild canids are controlled to protect Federally designated threatened or endangered species or are vectors of a communicable disease. Livestock depredation must be verified and documented by WS personnel before M-44s can be used. Reported losses from livestock owners do not allow use of M-44s unless these were verified. Historical recurrent losses are more than one verified loss incident within the last three years, or several times in the past 10 years. These losses are recorded in the WS MIS. Control can be conducted within 7 miles of documented losses on properties without losses, but it must be documented that it is for the property with verified losses.

8. The M-44 device shall not be used: (1) in areas within national forests or other federal lands set aside for recreational use, (2) in areas where exposure to the public and family and pets is probable, (3) in prairie dog towns, or, (4) except for the protection of federally designated threatened or endangered species, in National and State Parks; National or State Monuments; federally designated wilderness areas; and wildlife refuge areas. To determine whether the applicable land management agency has set aside any area on federal Lands for recreational use either on a permanent or temporary basis, the APHIS State Director or his/her designated representative who are considering authorizing or are responsible for ongoing use of M-44 capsules on public lands, must contact each applicable land management agency quarterly to determine whether any portions of the projected or current M-44 use areas are, or are to be, set aside for recreational use. Within 30-days of that contact, the APHIS State Director, or his/her designated representative, must provide the applicable land management agency with written documentation specifying the applicable land management agency's determinations of what projected or current M-44 use areas are to be set aside for recreational use. For purposes of this Use Restriction, areas set aside for recreational use include areas where and when there are scheduled recreational events, areas identified on maps with "recreation" in the title, areas where developed or known camping occurs, areas near designated or known recreational trail heads and designated or known vehicle access sites. This restriction is strictly interpreted with regards to items 1, 3, and 4. Item 2 requires

common sense judgment and input from local sources regarding uses and seasonal changes in public use. In addition, the WS State Director is responsible to ensure that public recreation areas are avoided by further consultations with land management agencies. This use restriction minimizes the possibility of exposure to the public and pets. WS Policy requires M-44 not to be set within 0.5 miles of a residence without an approved variance (WS Form 205).

9. The M-44 device shall not be used in areas where federally listed threatened or endangered animal species might be adversely affected. Each applicator shall be issued a map, prepared by or in consultation with the U.S. Fish and Wildlife Service, which clearly indicates such areas. (1) Except as provided in paragraph (2) below, the M-44 device shall not be used in areas occupied by any federally listed threatened or endangered species or any federally listed experimental populations as set forth in the most current versions of maps that have been prepared or approved by the U.S. Fish and Wildlife Service (FWS). At the time of application, the applicator must be in possession of the most current map, if such map exists, that covers the application site. If maps covering the application site do not exist, then the M-44 applicator must, prior to application, consult with FWS to determine whether the application site is in an area occupied by listed animal species. Any use of the M-44 thereafter shall be consistent with any conditions or limitations provided by FWS through such consultation. (2) Notwithstanding paragraph (1), the M-44 device may be used in areas occupied by endangered, threatened, or experimental populations if use in such areas a) has been addressed by FWS in special regulations pursuant to section 4(d) of the ESA, in requirements imposed through incidental take statements or incidental take permits, or in other applicable agreements with the FWS, and b) the applicator's use of the M-44 is consistent with any conditions or limitations provided by FWS for such use. This use restriction ensures that impacts to T&E species from use of the M-44 are minimized. This restriction applies to species such as the San Joaquin kit fox (*Vulpes macrotis mutica*), ocelot (*Leopardus pardalis*), jaguar (*Panthera onca*), grizzly bear (*Ursus arctos horribilis* - conterminous US Distinct Population Segment (DPS)), and gray wolf (listed subspecies and DPSs, e.g., *Canis lupus nubilus, C, l. baileyi*)).

10. One person other than the individual applicator shall have knowledge of the exact placement location of all M-44 devices in the field. This restriction is meant to ensure that someone is capable of retrieving the M-44 devices from the field in the event the original applicator is incapacitated. Locations recorded on a map in sufficient detail so that a supervisor or other designated person can find the M-44s is considered adequate. GPS unit coordinates are also adequate in retrieving the M-44s. Two people are not required to be present during initial placement.

11. In areas where more than one governmental agency is authorized to place M-44 devices, the agencies shall exchange placement information and other relevant facts to ensure that the maximum number of M-44's allowed is not exceeded. WS policy is not to use M-44s where others are using them. However, if another agency in a state can use M-44s, WS does work with them to ensure that the maximum number of M-44s used in a given area does not exceed the number allowed (Use Restriction #15).

12. The M-44 device shall not be placed within 200 feet of any lake, stream, or other body of water, provided that natural depression areas which catch and hold rainfall only for short periods of time shall not be considered "bodies of water" for purposes of this restriction. The primary intent of this restriction is to protect nontarget animals that may be more common around bodies of water and to prevent exposure to humans and dogs that concentrate around certain bodies of water. During certain times of the year, it may be necessary to be further than 200 feet because of increased activity levels. Thus, WS personnel use close observation and good judgment to ensure that the public and pets have a minimal opportunity to be exposed to an M-44.

13. The M-44 device shall not be placed in areas where food crops are planted. The M-44 may be placed in adjacent fields to food crops or in fields after harvest, but not in fields with food crops (crops intended for human consumption). A crop is considered a "food crop" when, for wheat or corn, it is jointed or booted (the head is developing). Crops, such as alfalfa, intended solely for livestock grazing, is not considered a "food-crop." If a farmer decides that a crop will not be harvested because of poor quality or yields, the crop is not considered a "food crop."

14. The M-44 device shall be placed at least a 50-foot distance or at such a greater distance from any public road or pathway as may be necessary to remove it from the sight of persons and domestic animals using any such public road or pathway. M-44s are kept away from the public and normal public access thoroughfares and trails. This Use Restriction minimizes the chance that the public and pets encounter an M-44.

15. The maximum density of M-44's placed in any 100 acre pasture land areas shall not exceed 10; and the density in any 1 square mile of open range shall not exceed 12. This restriction means that in any 100 acres of pasture or any square mile, a maximum number of M-44s can be set. Applicators monitor the location of their sets in relation to each other because this restriction does not recognize artificial boundaries such as roads and fences. The established density levels are not based on technical findings, but encourage the use of a minimum number of M-44s to resolve a problem.

16. No M-44 device shall be placed within 30 feet of a livestock carcass used as a draw station. No more than four M-44 devices shall be placed per draw station and no more than five draw stations shall be operated per square mile. Similar to Use Restriction #15, the established density levels are not based on technical findings, but M-44 applicators must remain within these limits. Additionally, this Use Restriction minimizes the potential for nontargets to be taken.

17. Supervisors of applicators shall check the records, warning signs, and M-44 devices of each applicator at least once a year to verify that all applicable laws, regulations, and restrictions are being strictly followed. WS personnel are held accountable for their use of the M-44 and supervisors are there to make sure all applicable laws and record keeping requirements are being followed.

18. Each M-44 device shall be inspected at least once every week, weather permitting access, to check for interference or unusual conditions and shall be serviced as required. Logical reasons prohibiting a weekly visit are recognized such as "weathered out." However, it should be clear that a weekly inspection by the applicator is the intent of this use restriction. If an inspection cannot be made due to illness or otherwise, it should be documented along with the reason why and relayed to the supervisor; another certified person should check the equipment, if available, if not, a cooperator can visually inspect them to determine if any require immediate service.

19. Damaged or nonfunctional M-44 devices shall be removed from the field. Damaged units pose a health hazard to the user and minimize the efficacy of the use of sodium cyanide in predator damage management. These devices are removed from the field.

20. An M-44 device shall be removed from an area if, after 30 days, there is no sign that a target predator has visited the site. This Use Restriction is meant to minimize the number of M-44s in the field. However, WS personnel typically move M-44s if a site they had selected is not being visited by the target animal and they have failed to stop losses. However, it should be noted that this Use Restriction is not intended to conflict with Restriction 7.

21. All persons authorized to possess and use sodium cyanide capsules and M-44 devices shall store such capsules and devices under lock and key. This restriction requires that both the devices and capsules be stored under lock and key in storage sheds or vehicles at all times when unattended, including while in transit. This minimizes the potential for sodium cyanide capsules being stolen.

22. Used sodium cyanide capsules shall be disposed of by deep burial or at a proper landfill site. Incineration may be used instead of burial for disposal. Place the capsules in an incinerator or refuse hole and burn until the capsules are completely consumed. Capsules may be incinerated using either wood or diesel fuel. Spent M-44 capsules are not discarded on the ground surface. Capsules are disposed of in the field only on private lands by burying them a minimum of 6" underground or, when conditions prohibit, the capsules may be stored in an empty, labeled carton and returned to the supervisor. Supervisors typically incinerate used and unused capsules. This minimizes potential for the public to come into contact with an M-44 capsule.

23. Bilingual warning signs in English and Spanish shall be used in all areas containing M-44 devices. All such signs shall be removed when M-44 devices are removed. (a) Main entrances or commonly used access points to areas in which M-44 devices are set shall be posted with warning signs to alert the public to the toxic nature of the cyanide and to the danger to pets. Signs shall be inspected weekly to ensure their continued presence and ensure that they are conspicuous and legible. (b) An elevated sign shall be placed within 25 feet of each individual M-44 device warning persons not to handle the device. Signs are placed at obvious access points (Figure 10) into an area and within 25 feet of each M-44 device (Figure 9) placed in the field. This restriction alerts the public of the presence of these devices so they do not venture on such properties, especially with a pet. Landowners normally warn people when they enter their property that the devices are in the field and to be alerted to the potential hazards.

Figure 10. Sign posted at the entrance to an area where M-44s are being used.

24. Each authorized or licensed applicator shall carry on his person instructions for obtaining medical assistance in the event of accidental exposure to sodium cyanide. This restriction minimizes harm to applicators in the event of an accidental exposure to NaCN. Following the label directions for personal protection equipment, long sleeve shirt and pants, shoes plus socks, waterproof gloves, and a full face shield (Figure 11), the applicator can avoid NaCN poisoning. It should be noted that the amyl nitrate antidote kits are no longer registered for use and this Use Restriction was changed to reflect that change.

Figure 11. Servicing an M-44 with the appropriate personal protection equipment including pants, long-sleeve shirt, waterproof gloves, and a full face shield.

25. In all areas where the use of the M-44 device is anticipated, local medical people shall be notified of the intended use. This notification may be through a poison control center, local medical society, the Public Health Service, or directly to a doctor or hospital. They shall be advised of the antidotal and first aid measures required for treatment of cyanide poisoning. It shall be the responsibility of the supervisor to perform this function. WS supervisors inform the hospitals and other medical

staff that will handle an exposure in a given area. This reduces time that it would take to determine what medical attention is required by the victim.

26. Each authorized M-44 applicator shall keep records dealing with the placement of the device and the results of each placement. Such records shall include, but need not be limited to: (a) the number of devices placed; (b) the location of each device placed; (c) the date of each placement, as well as the date of each inspection; (d) the number and location of devices which have been discharged and the apparent reason for each discharge; (e) the species of animals taken; and (f) all accidents or injuries to humans or domestic animals. WS personnel keep a diary and enter records into the MIS. WS wildlife damage management (WDM) activities including the placement, checking, and pulling of M-44s, the dates of placement and inspections, the number discharged, and the species taken. GPS coordinates or a map are typically kept for locations in diaries along with the apparent reason for M-44s pulled with no recoveries, but these can be added to the remarks section in the MIS. Accidents and injuries to people or pets require a 6A2 form be reported. It is the responsibility of the applicator to make sure that these records are kept and forwarded to their supervisor who forwards to the appropriate WS personnel (these are kept by the WS Operational Support Staff).

2.2 Physical and Chemical Properties

Sodium cyanide (NaCN, CAS No. 143-33-9) is an inorganic white salt with an almond-like odor. It has a boiling point of 1,496°C and a melting point of 563°C (National Institutes of Health (NIH) 2016). It is highly soluble with a solubility in water of 48 g/100 ml at 10°C and 82 g/100 ml at 34.7°C (Agency for Toxic Substances and Disease Registry (ATSDR) 2006). It is non-volatile, with a low vapor pressure of 1 mm Hg at 817°C (0 mm Hg at 68°F (20°C) (Homan 1987, CDC 2015). It is stable under ordinary conditions of use and storage, and readily hydrolyzes to hydrogen cyanide.

Hydrogen cyanide (HCN, CAS No. 74-90-8) is a colorless, flammable liquid or gas with a boiling point of 25.7°C (Towill et al. 1978). It has a bitter, almond odor (Towill et al. 1978, NIH 2016). The dissociation constant (pK_a) for hydrogen cyanide is 9.31 (a weak acid) which means cyanide will mostly be in the undissociated form (Kjeldsen 1998, NIH 2016). It has a density of 1.61 gm/cm^3. Its vapor pressure at 25°C is 742 mm Hg indicating that it is volatile (Kjeldsen 1998, NIH 2016). It has a Henry's Law constant of 180-300 suggesting that it volatilizes readily from water (Simeonova and Fishbein 2004).

The M-44 Cyanide Capsules Coyotes, Fox, Wild Dogs (EPA. Reg. No. 56228-15) registration label allows use on pastures, rangeland, and forestland but does not allow use in areas planted to food crops. The label limits application rates to no more than 10 units per 100 acres of pastureland or 12 units per square mile of open rangeland. For use in forest lands, the rangeland rate applies, unless the forest is within a fenced-in area and serves as a pasture (USEPA 1994) (Table 1). Applicators must use the product within seven miles of the location where livestock and poultry losses are occurring (USEPA 1994). However, this limit does not apply to those areas where there is a need to protect federally designated threatened or endangered species or when the target animals are vectors of disease (USEPA 1994).

The M-44 Cyanide Capsules Arctic Fox (EPA Reg. No. 56228-32) registration label is for the control of arctic fox in the Aleutian Islands of Alaska (Table 1) where they were introduced and considered an invasive species. WS has not used this label for a number of years. Part of the problem was minimal efforts conducted for arctic fox during this time; most arctic fox take is associated with protecting nesting migratory birds on islands where they were introduced and considered invasive.

Delivery of NaCN capsules is with the spring-activated M-44 device. The M-44 device is selective for canids because of the baits used and canid feeding behavior. An animal attracted to the bait will try to pick up or pull

the baited capsule holder. When the animal pulls on the M-44 device, it triggers the spring which launches the NaCN into the animal's mouth or face (Blom and Connolly 2003). About four pounds pressure is needed to activate the device, which helps to exclude small nontarget animals.

On contact with eye, nose, and mouth mucus or saliva, NaCN immediately converts to hydrogen cyanide, which is absorbed through the permeable membranes of the nose, mouth, lungs, and stomach. Hydrogen cyanide interferes with several biochemical processes, including the oxidative enzyme systems essential to cellular respiration, leading to central nervous system depression, cardiac arrest, and gross respiratory failure (Way 1984, Weimeyer et al. 1986, Ballantyne 1988). Lethal doses of cyanide can cause rapid death, usually within minutes of exposure (Connolly et al. 1986). Many animal species can detoxify cyanide to the less toxic thiocyanate compound, which the animal excretes in urine (Way 1984).

Applicators use capsules within 6 months of manufacture as capsules lose potency over time (Blom and Connolly 2003). WS recommends applicators only take the number of capsules needed for the day's work to avoid exposure of capsules to environmental conditions (temperature, moisture, etc.) that may contribute to their degradation (Blom and Connolly 2003).

2.3 Environmental Fate

The environmental fate describes the process by which NaCN moves and transforms in the environment. The environmental fate processes include: 1) mobility, persistence, and degradation in soil, 2) movement to the air, and 3) migration potential to groundwater and surface water.

Sodium cyanide is soluble in soil moisture and dissociates to free cyanide (CN, HCN) (Eisler 1991, Dzombak et al., 2006). In soil, the dominant form of free cyanide is hydrogen cyanide given the pH range of 4 to 9 for most soils (Dzombak et al. 2006). Cyanide is mobile in soil (NIH 2016). Hydrogen cyanide and cyanide anions do not strongly adsorb to soil and movement into ground water can occur (Eisler 1991, Eisler and Wiemeyer 2004, Dzombak et al. 2006). Soil properties such as pH, clay content, and organic matter affect cyanide adsorption in soil and its movement through soil to groundwater (Ghosh et al. 2006b). Hydrogen cyanide seldom remains in soils because it complexes with trace metals, adsorbs to organic carbon content, or volatizes (Towill et al. 1978, Castric 1981, Kjeldsen 1998, Dzombak et al. 2006, NIH 2015). Hydrogen cyanide weakly adsorbs or does not adsorb to inorganic components (e.g., metals) but readily adsorbs to organic matter (Dzombak et al. 2006). In contrast cyanide anions can complex with oxide minerals in the soil (Dzombak et al. 2006, Ghosh et al. 2006a). Evidence suggests that soil microorganisms degrade hydrogen cyanide to products such as carbon dioxide and ammonium (Castric 1981, Kjeldsen 1998, Boening and Chew 1999, ATSDR 2006, Ghosh et al. 2006b). Researchers detected no cyanide 24 hours after adding 200-ppm NaCN to 100 g soil samples, suspecting decomposition by microorganisms (not specifically tested) but did not report the half-life (Aslander 1928 summarized in USFWS 1975). In another study, after 15 days, researchers detected no cyanide in soil amended with 15 g NaCN per square meter of soil at a depth of 7-10 cm (study summarized in USFWS 1975). Thus, these studies suggest that the half-life for NaCN is rather short, but it is unknown.

Sodium cyanide reacts with moisture in the atmosphere as well as atmospheric carbon dioxide to form hydrogen cyanide (USEPA 1994, Eisler 1991, Dzombak et al. 2006). Hydrogen cyanide volatizes from dry soil surfaces existing as a vapor or gas in the atmosphere (NIH 2016). Cyanide in the air is mostly in the form of hydrogen cyanide, although small amounts of cyanide in the form of metal-cyanide complexes may bound to particulate matter in the air (ATSDR 2006). The half-life for hydrogen cyanide in the atmosphere ranges from

one to three years, undergoing reaction with photochemically-generated hydroxyl radicals (ATSDR 2006, NIH 2016).

On contact with water, NaCN dissociates to free cyanide (CN, HCN), which, depending on pH, forms toxic hydrogen cyanide (Eisler 1991, Dzombak et al. 2006). Hydrogen cyanide is also soluble in water and volatizes from water surfaces based on its Henry's Law constant (Dzombak et al. 2006). Cyanide persistence in surface waters under normal conditions is low but persistence is longer when cyanide contaminates underground water (Way 1981). The half-life of hydrogen cyanide in water is unknown (ATSDR 2006). Hydrogen cyanide does not bioaccumulate in aquatic or terrestrial organisms (USEPA 1994).

2.4 Hazard Identification

Cyanide is a rapid-acting asphyxiator in humans and animals. At lethal doses, inhalation, dermal absorption, or swallowing of cyanide causes death within minutes. Through a series of metabolic reactions, it depresses the central nervous system resulting in respiratory arrest and death (Eisler 1991). Humans and animals can detoxify sublethal doses of cyanide, converting cyanide to thiocyanate, which the body excretes in urine (Eisler 1991 summarizes several studies).

2.4.1 Toxicokinetics

Hydrogen cyanide has high acute toxicity. Toxicity depends on the dose, exposure type, and exposure length. Entry of cyanide into the human body is through inhalation, ingestion, and dermal contact; once inside the body, the biochemical action of cyanide is the same. Distribution is rapid and moves throughout the body (Bhandari et al. 2014). After inhalation, cyanide was in the lungs, heart, blood, kidneys and brain (Gettler and Baine 1938, ATSDR 2006). After ingestion, cyanide occurred in these same tissues, as well as the stomach and spleen (Gettler and Baine 1938, Ansell and Lewis 1970, ATSDR 2006).

Hydrogen cyanide's chemical and physical nature enables its rapid adsorption through biological membranes (Ballantyne 1987). Inhalation toxicity tests are limited primarily as a result of the high toxicity of the compound. Cyanide toxicity from inhalation exposure is dependent on the cyanide concentration and the exposure time (Table 4) (Ballantyne and Marrs 1987). In inhalation studies, the LC_{50} value for the female rat is 1,129 mg/m^3 (1,004 ppm) for 1 minute, 493 mg/m^3 (438 ppm) for 5 minutes, and 173 mg/m^3 (153 ppm) in air for 30 minutes (Ballantyne 1987)[5]. Human exposure to hydrogen cyanide in air was immediately fatal at a concentration of 0.3 mg/L (270 ppm) to one known occurrence of exposure; however, the expected LC_{50} after 10 minutes is likely higher at 0.61 mg/L (546 ppm) (Kopras 2012). Ansell and Lewis (1970) cite one study that estimates 100 mg of hydrogen cyanide is lethal for a 150 pound man. Symptoms of inhalation toxicity can quickly disable a victim (e.g., muscle weakness and loss of consciousness), which could prevent escape from cyanide in the air (Ballantyne and Marrs 1987).

Sodium cyanide is corrosive to the skin and eyes (USEPA 1994, USEPA 2010b). Exposure of intact skin to NaCN and hydrogen cyanide is less hazardous than other exposure routes with abraded skin increasing cyanide absorption (Ballantyne and Marrs 1987) (Table 4). Hydrogen cyanide in air absorbs through the skin and can cause lethal toxicity (Ballantyne and Marrs 1987). Entry of hydrogen cyanide through the eyes can

[5] The conversion factor for hydrogen cyanide in air is 1 ppm = 1.12 mg/m^3 and 1 mg/m^3 = 0.890 ppm at 20 °C and 101.3 kPa (Simeonova and Fishbein 2004)

also lead to acute lethal toxicity (Ballantyne and Marrs 1987).The dermal LD_{50} for hydrogen cyanide in humans is about 100 mg/kg (Isom 1993).

2.4.2 General Poisoning Effects

Symptoms in the first stage of cyanide poisoning in humans may include headache, vertigo, nausea, vomiting, and changes in pulse rate. In the second stage, the person may experience convulsions, clammy skin, and further changes in pulse rate. Symptoms such as heart rate changes, body temperature decrease, blue colored lips and extremities, bloody saliva, and coma may precede the final stage of lethal poisoning (Way 1981, 1984, Eisler 1991, ATSDR 2006).

Table 4. Acute cyanide toxicity studies to avian (single-dose) and aquatic species.

Test species	Test	Results	Reference
Birds			
Mallard	LD_{50}	2.7 mg/kg	Lanno and Menzie 2006
American Kestrel	LD_{50}	4.0 mg/kg	Weimeyer et al. 1986
Feral Rock Pigeon	LD_{50}	4.0 mg/kg	Weimeyer et al. 1986
Black Vulture	LD_{50}	4.8 mg/kg	Weimeyer et al. 1986
Eastern Screech-Owl	LD_{50}	8.6 mg/kg	Weimeyer et al. 1986
Japanese Quail	LD_{50}	8.5–10.3 mg/kg	Weimeyer et al. 1986
European Starling	LD_{50}	17 mg/kg	Weimeyer et al. 1986
Domestic Chicken	LD_{50}	21 mg/kg	Weimeyer et al. 1986
Fish			
Bluegill	48-hr LC_{50}	0.16 mg/kg	Ketcheson and Fingas 2000*
	96-hr LC_{50}	87 µg/ml (HCN)	Ballantyne and Marrs 1987*
Brook Trout	96-hr LC_{50}	94 µg/ml (HCN)	Ballantyne and Marrs 1987*
Carp	5-hr LD_{100}	1 ppm	Bridges 1958
Carp (fingerlings)	LC_{50} (NaCN 95% AI)	1 mg/L	Muniswamy et al. 2008
Goldfish	5-hr LD_{100}	1 ppm	Bridges 1958
Green sunfish	4-hr LD_{100}	0.5 ppm	Bridges 1958
Rainbow trout	LC_{50} (96.5% AI)	0.118 ppm (highly toxic)	USEPA 1994
	96-hr LC_{50}	0.05-0.09 mg/L	Ketcheson and Fingas 2000*
Invertebrates			
Daphnia spp.	96-hr LC_{50}	80 µg CN/L	Lanno and Menzie 2006
Water Flea	96-hr LC_{50}	0.09-0.3 mg/L	Ketcheson and Fingas 2000*
Mollusks			
Apple Snail	96-hr LC_{50}	1.6-2.9 mg/L	Ketcheson and Fingas 2000*
Pond Snail	24-hr LC_{50}	3.3 mg/L	Ketcheson and Fingas 2000*
River Snail	24-hr LC_{50}	940 mg/L	Ketcheson and Fingas 2000*
	48-hr LC_{50}	760 mg/L	
Freshwater Mussel (juvenile)	48-hr EC_{50}	4.81 mg/L	Pandolfo et al. 2012
	96-hr EC_{50}	1.10 mg/L	

AI = Active Ingredient

* Papers were compilation of studies to date

Signs of chronic, but nonlethal, exposure to cyanide may include lesions of the optic nerve, goiter, depressed thyroid function, and ataxia, among others (Solomonson 1981). An oral dose of 0.714 mg/kg cyanide caused muscle weakness and hallucinations in human males (Ketcheson and Fingas 2000). USEPA (2010b) summarized reports of four people exposed to oral doses of cyanide along with the post-exposure and post-medical treatment symptoms. One person ingested 5.6-7.6 mg/kg, another ingested 8.6 mg/kg, while the dose for the other two cases was unknown. All developed lesions on two regions of the brain and displayed symptoms of Parkinsonism, including tongue and eyelid tremors, general rigidity, and slow movement.

2.4.3 Acute Toxicity to Mammals

Sodium cyanide is toxic to humans and is in Toxicity Category I for oral, dermal and inhalation toxicity, the most toxic of the four categories (USEPA 1994). In humans, an LD_{50} estimate for NaCN is 2.86 mg/kg (Isom 1993). A minimum lethal dose of NaCN in humans is about 150 mg (Ansell and Lewis 1970). Another study calculates a person weighing 154 pounds would have to ingest 0.2 g (200 mg or 2.9 mg/kg) to receive a lethal dose of NaCN (Ketcheson and Fingas 2000). Reported low acutely toxic NaCN doses for humans by the oral route are 0.7 mg/kg, 6.6 mg/kg, and 2.9 mg/kg (Anonymous 2012).

Sodium cyanide is acutely toxic to mammals with oral LD_{50} levels generally below 10 mg/kg (Table 5). Cattle, sheep, and rabbits have LD_{50} values below the coyote, a target species which has an LD_{50} of 4.1 mg/kg (Sterner 1979) (Table 5).

Inhalation toxicity tests are limited mostly primarily because cyanide is highly toxic (Table 5). In inhalation studies, the LC_{50} value for the female rat is 1,129 mg/m^3 for 1 minute, 493 mg/m^3 for 5 minutes, and 173 mg/m^3 in air for 30 minutes (Ballantyne 1987).

Ballantyne (1988) calculated an ocular (eye) LD_{50} value of 4.5 mg/kg for NaCN for New Zealand white rabbits. Ballantyne (1988) noted the following signs of toxicity, in order of appearance: rapid breathing, weak movements, convulsions, coma, and irregular shallow breathing (Table 5). The time to death ranged from 2 to 12 minutes. The eyes developed inflammation, lachrymation (tear production), conjunctival hyperemia (reddening of the thin membrane lining the inner surface of the eyelid and the white part of the eyeball), and chemosis (swelling of the conjunctiva). Ballantyne (1988) exposed dry skin of rabbit to 200 mg NaCN with no signs of toxicity. The dermal LD_{50} for NaCN in rabbit is 11.8 mg/kg (time to death between 21 to 171 minutes) to intact wet skin and 7.7 mg/kg (time to death between 12 to 180 minutes) to abrade dry skin (Ballantyne 1988).

2.4.4 Sublethal and Chronic Toxicity to Mammals

Sublethal and chronic oral dose-response studies in humans are lacking (USEPA 2010b). People who eat cyanogenic plants can develop symptoms of chronic cyanide toxicity, although dietary deficiencies can confound symptoms. Symptoms include paralysis, tropic ataxic neuropathy (a neurological syndrome), and eye degeneration (USEPA 2010b). The half-life for the conversion of a nonlethal dose of cyanide to thiocyanate in humans is between 20 to 60 minutes (Ketcheson and Fingas 2000).

USEPA (2010b) summarized two cases of dermal absorption from hydrogen cyanide in the air that caused dizziness, weakness, difficulty breathing, and unconsciousness in humans. In both cases, workers wore respiration protection available at the time (years 1932 and 1950). In one case, hydrogen cyanide concentration was measured at 2% (20,000 ppm).

USEPA (2010b) summarized chronic effects of cyanide inhalation in humans, which include changes in thyroid function and neurological symptoms. Chronic cyanide exposure in mammals may cause lesions of the optic nerve, goiter, ataxia, and depression of the thyroid (USEPA 2010b). Exposure of factory workers to cyanide in the air caused tearing, photosensitivity, and conjunctival hyperaemia (redness of the eye particularly the sclera) (Simeonova and Fishbein 2004). At one factory location, cyanide concentration of 17 mg/m^3 came from a 24-hour measurement one day after factory closure. At two other facilities, about 13%

of the workers developed symptoms at cyanide concentrations measured 1.11 and 4.66 "cyanide-hours" ($mg/m^3 \times h$).

Table 5. Acute toxicity studies for sodium cyanide and hydrogen cyanide administered to mammals.

Test species	Test	Results	Reference
Sodium Cyanide (*Acute Oral Toxicity*)			
Cattle/Sheep	LD_{50}	2.0-3.0 mg/kg	Matheny 1979
Dog	LD_{50}	1.0-2.0 mg/kg	Matheny 1979
Coyote	LD_{50}	4.1 mg/kg	Sterner 1979
Sodium Cyanide (NaCN) and Hydrogen Cyanide (HCN)			
Acute Oral Toxicity			
Rat (Wistar)	LD_{50}	7.5 mg/kg (death within 4 hours of dosing)	USEPA 1994
Rat	LD_{50}	6.44 mg/kg	Timm 1994
Rat	LD_{50}	10 to 15 mg/kg	USFWS 1973
Mouse	LD_{50}	10 mg/kg NaCN	USFWS 1973
Rabbit (female)	LD_{50}	2.49 mg/kg HCN	Ballantyne and Marrs 1987
		5.11 mg/kg NaCN	
Rat (female)	LD_{50}	4.21 mg/kg HCN	Ballantyne and Marrs 1987
		5.72 mg/kg NaCN	
Acute Inhalation Toxicity			
Mice	LD_{50}	177 ppm HCN for 30 minutes with lethal time of 29	Salkowksi and Pennev 1994
Rat	LD_{50}	142 ppm cyanide in air for 30 minutes	Verschueren 1983
Rat	LC_{50}	158 mg/m^3 HCN for 60 minutes; 2,778 mg/m^3 HCN for 10 seconds	Simeonova and Fishbein 2004 cites Ballantyne 1983
Rabbit	LC_{50}	208 mg/m^3 for 35 min; 2,432 mg/m^3 for 45 seconds	Simeonova and Fishbein 2004 cites Ballantyne 1983
Acute Dermal Toxicity			
NZ Rabbit albino	LD_{50}	41 mg/kg males; 50 mg/kg females	USEPA 1994
Rabbit (female)	Dermal intact LD_{50}	6.89 mg/kg HCN solution	Ballantyne and Marrs 1987
		>200 mg/kg NaCN powder	
		11.8 mg/kg NaCN moist	
		14.6 mg/kg NaCN solution	
	Dermal abraded LD_{50}	2.34 mg/kg HCN solution	
		7.7 mg/kg NaCN powder	
		11.3 mg/kg NaCN solution	
Ocular Toxicity			
Rabbit (female)	LD_{50}	1.04 mg/kg HCN (times to death 3-12 minutes)	Ballantyne and Marrs 1987
		5.06 mg/kg NaCN solution	
		4.47 mg/kg NaCN solid	
Dermal Irritation			
Rabbit	Dermal irritation	Corrosive, lethal	USEPA 1994
NZ Rabbit albino		0.5 g NaCN caused death in 4/6 rabbits. Severe dermal	USEPA 1994
Acute Subcutaneous			
Dog	LD_{50}	5.36 mg/kg NaCN	Chen and Rose 1951
Rabbit	LD_{50}	2.2 mg/kg	USFWS 1973
Acute Intramuscular			
Rabbit, male	LD_{50}	1.5 mg/kg HCN	Ballantyne et al. 1971
Rabbit, female	LD_{50}	0.95 mg/kg HCN	Ballantyne et al. 1971

Data suggest NaCN and hydrogen cyanide are not mutagenic (Hébert 1993, USEPA 2010b). Studies on the carcinogenicity of cyanide are lacking (USEPA 2010b).

Câmara (2013) summarized reports of chronic cyanide exposure of mammals with reproductive effects that included abortions, lower birth weight, and malformations. USEPA (2010b) summarized research on the effects of NaCN on reproductive organs which indicated exposure of rats and mice to NaCN in water for three months may cause changes to the thyroid gland, and in turn can cause changes in the male reproductive

organs. Exposure of male rats to sublethal concentrations (30, 100, and 300 ppm) of NaCN in water for 13 weeks caused a reduction in cauda epididymal weight and at 300 ppm cyanide a reduction in testicular spermatid count (Hébert 1993). Adverse effects to the rat reproductive system occurred, but not enough to decrease fertility (Hébert 1993). Sperm motility was lower at all concentrations, but at 300 ppm, male rats had a lower number of spermatid heads (Hébert 1993). Rats fed up to 500-ppm cyanide (potassium cyanide) during gestation did not affect the body weight of offspring or lactation performance (Tewe and Maner 1981). Sheep feeding on grass with a high cyanogenic content developed enlarged thyroid glands, which caused stillbirths or early death to lambs (Towill et al. 1978). Adverse reproductive effects in humans following subchronic exposure to NaCN could occur as humans may be more sensitive to such changes than rats (Hébert 1993).

Symptoms of chronic toxicity in mammals may include uncontrolled body movement and increased urination (Towill et al. 1978). A common sublethal symptom in coyotes is vomiting (Blom and Connolly 2003). A WS biologist observed partial paralysis in coyotes exposed to a sublethal dose of NaCN, with speculation that a lack of oxygen to the body's tissues caused damage to the lower spinal cord or some part of the brain (Blom and Connolly 2003). USEPA (2010b) summarized subchronic and chronic toxicity studies for cyanide in mammals. Male and female miniature pigs given 1.2 mg/kg/day cyanide (sourced from potassium cyanide) by gavage for 24 weeks had a decrease in thyroid hormone levels and changes in behavior (USEPA 2010b Jackson 1988). Based on these effects, research found a LOAEL of 1.2 mg/kg/day and a NOAEL of 0.7 mg/kg/day for cyanide (EPA 2010b). In another study, pigs given 2.4 mg/kg-day cyanide (sourced from potassium cyanide) in their diet for 70 days had an increased thyroid weight and altered thyroid histology (Manzano et al. 2007, USEPA 2010b). A 2.4 mg/kg/day LOAEL is based on the increased thyroid weight in this study (USEPA 2010b, Manzano et al. 2007). Two studies on dogs fed NaCN reported a LOAEL of 1.04 mg/kg/day cyanide. At this dose, USEPA (2010b) summarized several studies and found that changes occurred in the dogs' renal tubules and adrenal gland, as well as a decrease in spermatids and T3 hormone, and an increase in thyroid weight.

In a two-year feeding study, male and female rats exposed daily to food fumigated to contain 300-ppm hydrogen cyanide did not develop observable signs of toxicity (Howard and Hanzal 1955). Exposure of rats and mice (10 males and 10 females in each group) for 13 weeks to NaCN in water with up to 300 ppm was not fatal, and no significant changes in body weight, histopathologic or other pathology were noted (Hébert 1993).

3 DOSE-RESPONSE ASSESSMENT

A dose-response assessment evaluates the dose levels (toxicity criteria) for potential health effects including acute and chronic toxicities.

3.1 Human Health Dose-Response Assessment

In humans, inhalation of 110 to 135 ppm cyanide can cause death within 30 minutes to one hour (Fassett 1963, Towill et al. 1978, while inhalation of 220 to 270 ppm is immediately fatal (Isom 1993, Simeonova and Fishbein 2004, Kopras 2012). The inhalation reference concentration (RfC) is an "*estimate of a continuous inhalation exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime*" (USEPA 2017a). The RfC for hydrogen cyanide is 0.00083 mg/m^3, based on the LOAEL from an occupation exposure study where workers developed symptoms of thyroid enlargement and altered iodide uptake (El Ghawabi et al. 1975, USEPA 2010b). The "*Immediately Dangerous to Life or Health*

Concentration" (IDLH) for hydrogen cyanide is 50 ppm (CDC 1994). The National Institute for Occupational Safety and Health (NIOSH) set the standard of 5 mg/m^3 (4.7 ppm) for cyanide concentrations in air considered harmful to humans and requiring the appropriate respirator equipment (CDC 1994).

A person weighing 154 pounds would have to ingest 0.2 g (200 mg or 2.9 mg/kg) NaCN to receive a dose within the lethal range (Way 1981, Ketcheson and Fingas 2000). The oral LD_{50} in humans of NaCN is about 2.86 mg/kg (Isom 1993). Absorption of an average of 1.4 mg/kg of hydrogen cyanide causes death in humans and the lowest fatal absorbed dose was 0.54 mg/kg of hydrogen cyanide (Gettler and Baine 1938). In another report, death in humans occurs with ingestion of about 3.5 mg/kg of hydrogen cyanide (Towill et al. 1978).

The oral reference dose of 0.001 mg/kg/day for NaCN and 0.0006 mg/kg/day for CN^- is based on observed reproductive effects in male rats and mice given NaCN in drinking water for 13 weeks (USEPA 2010a, b). The USEPA (2016a) set the maximum contaminant level (MCL) for cyanide in drinking water at 0.2 mg/L or 200 ppb. This level in water is not safe for all aquatic species. At half of this concentration, half of the bluegill will die after 48 hours and half of the rainbow trout will die after 144 hours (Ketcheson and Fingas 2000).

Absorption of cyanide through the skin is slower than through inhalation, and is dependent on the duration of skin contact and skin moisture level (Simeonova and Fishbein 2004). The human LD_{50} for absorption through the skin is about 100 mg/kg (Towill et al. 1978). As little as 7 mg/kg of hydrogen cyanide absorbed through the skin has caused death in humans (Towill et al. 1978).

3.2 Ecological Effects Analysis

This section of the risk assessment discusses available ecological effects data for aquatic and terrestrial biota. Available acute and chronic toxicity data are summarized for all major taxa and will be integrated with the exposure analysis section to characterize the risk of NaCN and hydrogen cyanide to nontarget wildlife and domestic animals. Information in this section is from on-line databases and searches for relevant peer reviewed and non-peer reviewed literature.

3.2.1 Aquatic Effects Analysis

Sodium cyanide and hydrogen cyanide toxicity levels in an aquatic environment depend on the size of the water body (dilution), physical and chemical qualities of the water (e.g., temperature, pH, oxygen) (Towill et al. 1978), closeness of the species to the point source, and degradation of cyanide.

Data on the toxicity of cyanide to the aquatic reptiles and amphibians, including the aquatic phase, is lacking. Based on the cyanide toxicity in birds, it is assumed that cyanide would be highly toxic to aquatic reptiles. Similarly, the toxicity of cyanide in fish would be similar to the toxicity of cyanide in amphibians and their aquatic-phase.

Water characteristics affect the toxicity of cyanide in fish, with toxicity increasing with a decrease in dissolved oxygen and increase in temperature (Bridges 1958, USEPA 1976). Concentrations of cyanide from 50 to 200 μg/L are acutely toxic to most fish (USEPA 1976). Sodium cyanide is toxic to rainbow trout with a 96-hr LC_{50} of 0.05-0.09 mg/L (USEPA 1994, Ketcheson and Fingas 2000). Table 4 summarizes several toxicity studies.

Exposure to cyanide can reduce the swimming ability of fish (Ketcheson and Fingas 2000, Gensemer et al. 2006), which can affect reproduction and foraging, and increase vulnerability to predators. Exposure of fish

(species not given) to 5 μg/L hydrogen cyanide has caused harmful nonlethal effects (Leduc 1981). Salmonid fish and brook trout (*Salvelinus fontinalis*) experienced impaired swimming at 10 μg/L (0.01 ppm) of cyanide (USEPA 1976, Towill et al. 1978). Fecundity in fish is a sensitive toxicity endpoint and Ballantyne and Marrs (1987) summarize studies on sublethal effects on fish reproduction. Exposure of brook trout to 0.012 mg/L hydrogen cyanide for 144 days caused a decline in egg viability (Ballantyne 1987). Flagfish (*Jordanella floridae*) exposure to 0.065 mg/L of hydrogen cyanide for five days during the embryonic and juvenile stage lead to a 40% decrease in egg production when the fish reached sexual maturity (Cheng and Ruby 1981).

In streams intentionally poisoned with cyanide (dose not reported) to capture salmon, kill was not 100 percent (Eisler 1991) likely from dilution of cyanide in the water and the distance of fish from the point source. Cyanide concentrations in dead salmon gill tissues ranged from 30 μg/kg fresh weight to 7,000 μg/kg (Eisler 1991). Salmon that survived poisoning usually had less than 1 μg/kg fresh weight in the gill tissue, but occasionally had up to 50 μg/kg (Eisler 1991). Applying 1 ppm NaCN to small ponds was immediately toxic to several fish species, but toxicity in the ponds 48 to 72 hours after application declined and did not cause death to green sunfish (*Lepomis cyanellus*) (Bridges 1958). Applying 1 mg/L NaCN to small lakes and shallow ponds provides initial acute toxic levels, which are negligible after 40 days in cold water and 4 days in warm water (Eisler 1991). USEPA (1985) described the National Water Quality Criteria for cyanide as, "*freshwater aquatic organisms and their uses should not be affected unacceptably if the four-day average concentration of cyanide does not exceed 5.2 ug/L more than once every three years on the average and if the one-hour average concentration does not exceed 22 ug/L more than once every three years on average*". They did find that the chronic value for freshwater organisms is 5.221 ug/L.

Eisler (1991) summarized several studies and found that death occurred in the amphipod *Gammarus pulex* on exposure to 3-7 μg/L (Eisler 1991 summarizes several studies). The 96-hour LC_{50} for opossum shrimp (*Americamysis bahia*) was 113 μg/L cyanide (Lussier et al. 1985). In a lifecycle (chronic) exposure study, opossum shrimp exposed to 70 μg/L cyanide for 29-51 days only affected survival of exposed adults but did not affect the time to sexual maturation, duration of embryonic development, number of young produced, survival of young, or female productivity (Lussier et al. 1985). Chronic exposure of aquatic invertebrates to cyanide affected reproduction with a lowest-observable-affect concentration (LOAC) of 21 μg/L for the amphipod *Gammarus pseudolimnaeus* and 67 μg/L for the cladoceran *Moinodaphnia macleayi* (Gensemer et al. 2006). Sodium cyanide is toxic to freshwater mussel (*Villosa iris*), with a 96-hr EC_{50} of 1.10 mg/L (Pandolfo et al. 2012). Table 4 summarizes the wide range of LC_{50} values from several toxicity studies.

Certain aquatic plants tolerate cyanide with adverse effects beginning at >160 μg/L (Eisler and Wiemeyer 2004). The alga *Scenedesmus quadricauda* had a toxicity threshold of 0.16 ppm cyanide exposure for 4 days at 24 °C and 20 ppm cyanide was toxic (90% kill) to the alga *Microcystis aeruginosa* (Towill et al. 1978). Eisler (1991), a summary of several studies, found that, in general, algae and macrophytes are tolerant of cyanide with adverse effects occurring at cyanide concentrations above 160 μg/L.

3.2.2 Terrestrial Effects Analysis

Sodium cyanide and hydrogen cyanide toxicity levels available in a terrestrial environment can be highly toxic to most wildlife species, but can depend on body size and other characteristics of wildlife as well as physical and chemical qualities of the air and soil (e.g., temperature, moisture).

3.2.2.1 Mammals

In addition to the mammalian effects data summarized in the human health section of this risk assessment, additional mammalian data relevant to the evaluation of nontarget impacts of NaCN and hydrogen cyanide is available (Table 4). Acute oral dosing studies have demonstrated high toxicity to most mammalian species from cyanide exposure. Oral and inhalation exposure to cyanide results in distribution to many organs and tissues in the body, including lungs, blood, and heart in dogs and rabbits; and brain, spleen and kidneys in rabbits (ATSDR 2006, USEPA 2010b). Exposure of mammals to sublethal concentrations of cyanide may cause increased salivation, defecation, urination, labored breathing, muscular tremors and incoordination (Towill et al. 1978). Animals receiving a sublethal dose eventually recover from toxicity, but would be vulnerable to predators or natural elements during the recovery period.

3.2.2.2 Birds

Sodium cyanide is acutely toxic with LD_{50} levels below 10 mg/kg for most bird species (Table 4). The USEPA has waived acute avian studies because toxicity of cyanide to humans and hazards to people conducting NaCN toxicity studies was very high (USEPA 1994). However, in a feeding study, NaCN was acutely toxic to three flesh-eating species (black vulture, American kestrel, and eastern screech owl; LD_{50}s = 4.0-8.6 mg/kg) and three species that fed predominantly on plant material (Japanese quail (*Coturnix coturnix*), European starling, and domestic chicken; LD_{50}s = 9.4-21 mg/kg) (Weimeyer et al. 1986). The oral LD_{50} for quail is 8.5 mg/kg and an oral LD_{50} of 4 mg/kg is reported for wild birds species (not specified) (Ketcheson and Fingas 2000).

Exposure of chickens to a sublethal dose of NaCN (6 mg/kg) caused symptoms of labored breathing, increased eye-blink and salivation, and lethargy (Weimeyer et al. 1986). Nonlethal cyanide poisoning (3 mg/kg) of black vultures caused symptoms of labored breathing and uncoordinated movement (Weimeyer et al. 1986). In a 20-day feeding study, male chicks (*Gallus domesticus*) fed diets containing 136 mg/kg of hydrogen cyanide (sodium nitroprusside the dietary source of cyanide) had reduced food intake and growth (Elzubeir and Davis 1988).

3.2.2.3 Reptiles and Amphibians (Terrestrial Phase)

Sodium cyanide and hydrogen cyanide toxicity data is scarce for reptiles and amphibians. One report mentions that two ounces of calcium cyanide dust (not NaCN) placed as a heap inside a ground squirrel or prairie dog burrow is lethal to a rattlesnake in 30 minutes (Uhler 1944). In a laboratory study, 10 adult male Aruba whiptails (*Cnemidophorus arubensis*) were fed an artificial diet containing approximately 75 μg CN/feeding (cyanide source from potassium cyanide), given every other day for 42 days (Schall and Ressel 1991). The lizards did not show any differences in hematological, physiological, and anatomical measures when compared to the control group and the group given 15 μg CN/feeding (Schall and Ressel 1991). Injection into the body cavity of terrestrial, the yellow-footed tortoise (*Testudo tabulata*), and aquatic, South American river turtle (*Podocnemys* sp.), turtles kept in air with 0.1 M potassium cyanide at a dose of 0.25 percent of the body weight caused death between 5 and 12 hours after injection (Bellamy and Petersen 1968). The authors estimated that the smallest dose toxic to turtles was about fifty times greater than the toxic dose for mammals (Bellamy and Petersen 1968). The authors observed injections of potassium cyanide (dose not specified) affected muscular tone causing the turtles to stop withdrawal movements of limbs and head (Bellamy and Petersen 1968).

3.2.2.4 Terrestrial Invertebrates and Microorganisms

Little data is available regarding the toxicity of cyanide to terrestrial invertebrates. Exposure of adult mealworms (*Tenebrio molitor*) to 8 mg/L hydrogen cyanide for 15 minutes arrested respiration resulting in mortality to 84% of the test organisms (Bond 1961). Exposure of granary weevil (*Sitophilus granarius*) to 8 mg/L of hydrogen cyanide in the air for four hours caused 50% mortality (Bond 1961). In general, exposure to cyanide concentrations between 30 and 100 μg/L caused death in invertebrates (Eisler 1991). Toxicity to pollinators such as honeybees and other above-ground invertebrates is unknown; however, the use pattern for NaCN capsules and its fate in the environment suggests that adverse effects would not occur.

Exposure of invertebrates to between 18 and 43 μg/L caused several nonlethal effects (Eisler 1991). Granary weevils that survived 8 mg/L of hydrogen cyanide for 15 minutes had temporary paralysis, but recovered about 2 hours after treatment (Bond 1961). Southern armyworms (*Spodoptera eridania*) were found to be resistant to cyanide with injections of 800 mg/kg of potassium cyanide (332 mg/kg of hydrogen cyanide), but diets of 3,600 mg/kg of potassium cyanide (1,492 mg/kg of hydrogen cyanide) caused 50% mortality (Brattsten et al. 1983).

Species of bacteria and fungi can uptake, metabolize, or degrade cyanide (Towill et al. 1978, Castric 1981). Towill et al. (1978) summarized several studies and found that some bacteria with exposure to cyanide caused a decrease in growth and motility, and altered cell morphology. A potassium cyanide concentration between 0.4 and 0.8 ppm was toxic to the bacterium *Escherichia coli* exposed for one to two days at 27 °C (Towill et al., 1978).

3.2.2.5 Terrestrial Plants

Little data is available regarding the toxicity of cyanide to terrestrial plants. Some plants, such as barley, pea, red clover, sorghum, common vetch, and flax, can metabolize hydrogen cyanide in the environment (Towill et al. 1978). In contrast, exposure of some plants to hydrogen cyanide can inhibit several enzymatic reactions, affecting respiration, and may cause death (Towill et al. 1978). Low concentrations of cyanide can inhibit seed germination and growth in some plants (Eisler and Wiemeyer 2004), but in others cyanide can enhance germination by stimulating the pentose phosphate pathway and inhibiting catalase (Solomonson 1981).

4 EXPOSURE ASSESSMENT

Between FY11 to FY15, WS used an average of 27,629 NaCN capsules annually in 17 states (Table 2), about 54 pounds of NaCN. Per label, the maximum density of M-44 devices is 10 (10 capsules) per 100 acres and 12 per square mile. These label directions insure that a minimum number of NaCN capsules are used in a given area.

4.1 Human Health

The NaCN used in the M-44 is a restricted-use pesticide that is only for use by certified WS, state, and private applicators. The exposure pathways for NaCN are ingestion, dermal, and inhalation. The contents of an M-44 capsule weigh 0.97 g with 91.06% ai or 0.88 g NaCN.

The public is unlikely to ingest a NaCN capsule, as it is a plastic container that is labeled with a red skull and crossbones, indicating that it is toxic. WS, per label directions, does not use NaCN in areas planted in most

food crops or within 200 feet of any lake, stream, or other body of water. Therefore, residues of NaCN and hydrogen cyanide in food crops and water sources will not occur. The label also prohibits use on Federal lands set aside as recreational areas, other public areas, unless there is a need to protect T&E species, and greater than 50-feet from any public road or pathway; this reduces the chance the public or pets would find an M-44 device. To reduce further public exposure, the applicator places warning signs in English and Spanish at main entrances or access points warning the public that devices are set in the area and WS inspects these signs weekly to ensure their visibility. Additionally, the label requires that applicators check M-44 devices at least once every week (weather permitting) and remove the devices after 30 days if there are no indications the target animal visited the site. These restrictions and precautions reduce to low or negligible oral, inhalation, and dermal exposure pathways for the public.

The public is unlikely to consume animals that receive a lethal dose of cyanide. Even if consumption occurs, the amount of cyanide ingested would not equal the original lethal dose because cyanide rapidly distributes throughout the body, does not concentrate in just one location, and a portion would break down to the less toxic thiocyanate (Gettler and Baine 1938, Ansell and Lewis 1970, ATSDR 2006, Bhandari et al. 2014). Studies show the body removes about 80% of cyanide through the conversion to thiocyanate, which the body then passes in urine (Ansell and Lewis 1970). Cyanide levels reached undetectable levels 12 hours after giving a single nonlethal oral dose of 3 mg/kg potassium cyanide to male rats, pigs, and goats (Sousa et al. 2003). The half-life of cyanide elimination was just over 30 minutes for rats and pigs and around 76 minutes for goats (Sousa et al. 2003).

From FY84 to FY19, 44 human exposures with NaCN occurred as reported on WS 6(a)(2) Adverse Effects Incident Information Reports (1.2/year). None involved lethal cases. In all, 26 incidents involved WS employees (0.7/year) and 18 involved the public (0.5/year). Medical treatment was sought in 25 incidences (57%), no treatment in 8 incidences (18%), and 11 had unknown medical treatments (25%). Of the incidences, seven involved multiple symptoms including dizziness, headache, racing heart, chest pains, and tingling extremities (all of these symptoms could also be associated with panic attacks or anxiety from the situation). However, three of these additionally involved burning eyes and two involved one or more of these, stinging sensations, bitter taste, swollen tongue, and cyanide blisters. Other medical conditions included two incidences of nausea, one a cyanide rash, nine burning or irritated eye(s), and three caused a bad taste in mouth (which is also a common anxiety symptom). Ten of the exposures did not cause any problems (3 did seek medical attention as a precaution) and 12 had undocumented medical consequences. Over the 36 years, the majority of exposures were from 26 accidental discharges that occurred while employees were setting, inspecting, or pulling M-44s; one discharge was an improper action of an employee involving transporting a set M-44 from one location to another. Of the 18 public exposures, ten were from tampering (two of these involving known trespassing), five were accidental (stepping on), and 4 involved dogs that had been exposed and subsequently the people were exposed by touching the dog or giving the dog CPR (two of these involved known trespass). One of the human exposures was not from a WS set M-44 after investigation, but an illegally set M-44. Of the public exposures, three involved multiple symptoms, five involved contact with skin or eyes, two caused bad taste, one caused nausea, six caused no symptoms, and one resulted in unknown symptoms. Other than NaCN exposures from the WS M-44, the American Association of the Poison Control Centers' National Poison Data System recorded a cyanide exposure in 2013 of one adult from a rodenticide (the product and use pattern not specified), with an outcome of minor injury but not death (Mowry et al. 2014).

Sodium cyanide capsules have minimal potential for off-site transport that would expose the public. The release of the capsule occurs only when an animal with a proper bite size and tug strength triggers the device, it is accidentally discharged by stepping or rubbing across the M-44, or it accidentally is discharged. Typically,

the device sprays the capsule contents into the mouth of the animal that pulls on the capsule holder with no significant residues remaining in the animal or environment. The target or nontarget animal that pulls on the M-44 may not receive the full amount of NaCN because of variations in the M-44 device and the way the capsule contacts the animal's mouth (Blom and Connolly 2003). The NaCN could miss the animal's mouth, especially when an animal pulls from the side. It could also be discharged by an animal that walks on it or while a WS employee is setting, inspecting or pulling it. From Section 2.2 and Table 3, if 50% of the capsules that fired with unknown take took animals that were not found, then the other 50% would be discharged into the environment. This would result in 4,878 M-44 capsules fired into the environment, which is 9.5 pounds of NaCN (ai). Since this occurred over 17 states, the amount of NaCN at any one site would be limited to the 0.88 g ai. The environmental fate of the NaCN shows minimal risk to the environment such as leaching into surface or groundwater (see section 2.3 Environmental Fate). Sodium or hydrogen cyanide seldom remains in soils because it complexes with trace metals, is taken up by microorganisms, or escapes through volatilization (Towill et al. 1978, Kjeldsen 1998, NIH 2016).

WS restricts use to applicators that complete training on the safe handling and use of NaCN capsules, M-44 devices, and the required personal protection equipment. Applicators must long-sleeved shirts, pants, shoes, socks, waterproof gloves, and a full face shield. This will reduce dermal exposure to NaCN and hydrogen cyanide. The skin does not rapidly absorb dry sources of cyanide; rather, absorption more readily occurs when cyanide is in solution, is in the presence of moisture, or the skin surface is broken (Isom 1993). Per label directions and WS Policy, WS stores NaCN capsules and M-44 devices under lock and key to restrict access to the product. Disposal of used NaCN capsules is through deep burial at a landfill or incineration.

4.2 Ecological

4.2.1 Aquatic Exposure Assessment

The label restricts placement of M-44 devices to 200 feet or greater from any body of water which reduces the potential for exposure to the aquatic environment. The amount of cyanide in one capsule and its distance from a water source suggest no off-site transport of cyanide to a water source. Thus, exposure of aquatic species to cyanide according to the WS use pattern is negligible. It is possible a poisoned animal dies near or in a water source. However, as discussed in Section 4.2.4, secondary exposure risks are negligible.

4.2.2 Terrestrial Mammal and Bird Exposure Assessment

WS baits the capsule holders of M-44 devices to attract coyotes, foxes, and feral dogs. Nontarget animals attracted to the bait may activate the M-44 ejector device and may receive a lethal dose of cyanide. Small animals may trigger the device but because their mouth will not be in the correct position above the device, the cyanide powder from a capsule is unlikely to enter the mouth or contact mucus membranes.

In a study using baited M-44 devices, 18 nontarget animal species visited device sites equal to or more than targeted coyotes (Shivik et al. 2014). Either nontarget animals passively meandered through the site or the bait's scent attracted the animal to the site. The nontarget species that visited the site (came within 1m of the M-44) were Virginia opossum, domestic dog, red fox, bobcat, domestic cat, black bear, raccoon, skunk, squirrel, cottontail rabbit, domestic cow, domestic sheep, white-tailed deer, domestic horse, domestic donkey, wild turkey, American crow, and passerines. Of these animals, the opossum, dog, raccoon, squirrel, cow, sheep, deer, donkey, and wild turkey investigated the M-44 device by touching the capsule holder with their nose or mouth. However, only canid species triggered the M-44 devices.

From FY11 to FY15, WS reported the take of 362 nontarget species through direct exposure to NaCN with none being T&E species. WS reported no take of nontarget species through indirect exposure. Ejector modifications and commercial baits (ensuring consistency and attractiveness) have likely led to reduced nontarget take. In FY88, nontarget take was 5.9% (USDA 1997), from FY96 to FY06 it was 4.7% (USDA 2008), and from FY11 to FY15 it was 2.5% (Table 3). Thus, nontarget take by WS with M-44s has declined. Other than carnivores, WS took few nontarget animals. Of the species found to investigate M-44 devices by Shivik et al. (2014), WS did not take any of the domestic livestock, squirrels, rabbits, white-tailed deer, or turkeys from FY11 to FY15 (Table 3). The nontarget species taken from FY11 to FY15 are shown in Table 3. Additionally, from FY96 to FY10 WS targeted arctic fox and accidentally took coyotes, mountain lions, a white-tailed deer, turkey vultures, Chihuahuan ravens (*Corvus cryptoleucus*), and a Woodhouse's scrub-jay (*Aphelocoma woodhousei*)[6] as nontarget species. Thus, nontarget take between FY96 and FY15 consisted of 23 mammalian species and 8 avian species and has remained consistent at low levels. Likely some of the primary reasons for the reduction of nontarget species take was the increased pull weight to activate an M-44 and the consistent quality of M-44s and lure baits made.

WS evaluated cases of domestic dog poisoning between 1999 and 2007 (USDA 2008). The 31 incidents with 34 pet dogs (2 survived, 32 died) usually involved one dog pulling a set M-44 device. The most common cause of unintentional exposure occurred when the person supervising the animal failed to obey the laws (e.g., leash laws, trespassing) and signs warning not to enter the area because of poison (45.2% of incidents resulting in 50% of animals exposed). In 2001, a WS applicator failed to remove all the M-44 devices from a property, leaving two behind. A neighbor's dog died when the handler took the dog for a walk on the property without asking the landowner permission to access the property. Although the dog's owner was at fault for trespassing, the failure to remove the devices contributed to the dog's poisoning. The second most common cause of unintentional exposure occurred when unaccompanied free-roaming dogs found the M-44 device (32.3% of incidents). In a separate case, in 1999, a WS applicator used mistaken property boundaries and accidentally placed two M-44 devices on a bordering landowner's property. The landowner's dog died after it triggered the M-44 device. Of the annual average of 30 feral or free-roaming dogs taken as nontarget species from FY11 to FY15, 6 were domestic dogs running at large[7] while the others were feral dogs or unidentifiable dogs without a collar.

WS conducts research on M-44s to reduce the take of nontarget species. NWRC researchers tried to use varying M-44 ejector heights to reduce take of swift fox. Height modifications appeared to reduce nontarget activations, but also greatly reduced coyote activations; thus, height modifications may not be practical or efficient especially where little risk to nontarget canids occurs (Young 2016).

The labels for the two products used by WS prohibit the use of the product in areas that might harm T&E species. The endangered species protection language on the current labels is based on information from a 1993 Biological Opinion prepared by the U.S. Fish and Wildlife Service (USFWS) (1993). The current labels do not include new species that have been listed since that time and should not be used to comply with the Endangered Species Act. In 2011, USEPA initiated consultation with USFWS on the use of M-44 devices. The consultation will include an evaluation of listed species and their habitats that were covered in the 1993 Biological Opinion, as well as include species that were listed since that consult (USEPA 2011a). WS

[6] Western scrub-jay was listed in MIS reports, but it was split into two species in 2016. Since the scrub-jay was taken in New Mexico, it was in the range of the Woodhouse's scrub-jay.

[7] These incidents are kept on Adverse Effects Incident Information Reports – 6(a)(2)s. Owners are contacted, if possible, but if a collar has no contact information or the landowner or neighbors do not know whose dog it is, it can be difficult to find the owner.

applicators should contact the local USFWS office to find the locations of habitats occupied by endangered species and consult, where appropriate. WS did not take any T&E species from FY11 to FY15. Prior to FY11, wolves (before delisting and relisting), bald eagles (before delisting), and a possible grizzly bear, had been taken. Bald eagles were removed from the Endangered Species Act in 2007 but are still protected under the Bald and Golden Eagle Protection Act that requires an incidental take permit; the final rule was completed in December 2016 (FRN Dec. 16, 2106 81(242) 91494-91554) and USFWS is in the process of determining the rules for the new regulations).

Dietary exposure to nontarget mammals and birds from drinking water is negligible as surface water contamination from NaCN is unlikely to occur from WS use pattern and the environmental fate of cyanide (USEPA 1994).

4.2.3 Other Terrestrial Species Exposure Assessment

Exposure of invertebrates and plants to NaCN capsules is unlikely given the use pattern and environmental fate of the product. Sodium cyanide is within capsules, which the M-44 device releases when an animal triggers it. Sodium cyanide, the contents of the capsule, is sprayed into an animal's mouth or on the ground. As described in the Environmental Fate section (Section 2.3), hydrogen cyanide seldom remains in soils because it complexes to trace metals, is taken up by microbes, or volatizes (Towill et al. 1978, Castric 1981, Kjeldsen 1998, NIH 2016).

4.2.4 Secondary Exposure of Nontarget Animals to Cyanide

Secondary exposure of predators and scavengers who may feed on animals exposed to NaCN and hydrogen cyanide is unlikely to occur for several reasons. The fate and distribution of NaCN in the environment does not indicate a risk of secondary exposure (USEPA 1994) and as discussed in Section 2.2. Bioaccumulation of hydrogen cyanide in animals does not occur because most species can detoxify low doses and large doses cause death (Towill et al. 1978, USEPA 2010b). Humans are unlikely to consume animals poisoned with cyanide from an M-44 device (98% are canids which are usually not eaten). Animal scavengers could eat an animal poisoned with cyanide; however, cyanide metabolism (and excretion) reduces cyanide levels in tissue (Towill et al. 1978, Bhandari et al. 2014) and cyanide does not concentrate in one location in the body (Gettler and Baine 1938, Ansell and Lewis 1970, ATSDR 2006, Bhandari et al. 2014). Should an animal poisoned by cyanide die near or in a water source, as for the reasons given above for animal scavengers, cyanide is unlikely to escape the animal and harm aquatic species. In one study, the half-life of cyanide in the rat, depending on the sublethal dose of potassium cyanide, was between 1,200 and 1,510 minutes (Bhandari et al. 2014). In rabbits, the half-life of cyanide (given as NaCN) was 177 minutes and in swine (given as potassium cyanide) was 26.9 minutes (Bhandari et al. 2014). Cyanide exposure of animals, such as small mammals and birds, which eat soil-dwelling invertebrates, could occur; however, no data is available on the ingestion of cyanides from soil or soil organisms (Lanno and Menzie 2006). Per label directions, WS applicators check M-44 devices weekly, and remove and dispose of animal carcasses found near the device, as possible, which reduces the potential for secondary exposure (see the WS Carcass Disposal Directive 2.5.1.57[8]).

[8] Directives can be found @t https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/SA_WS_Program_Directives.

5 RISK CHARACTERIZATION

For the human health and aquatic and ecological risk characterizations, the risk estimates and descriptive definitions of qualitative results of risk estimates are as follows:

5.1 Human Health

Each cyanide capsule contains about 88 mg of NaCN (0.97 g capsule contents x 91.06% NaCN). One cyanide capsule contains enough cyanide to be lethal to humans; however, the WS use pattern and the label restrictions minimize the risk to a level of low for applicators and the public. Sub-lethal exposure to cyanide is low for the public and WS applicators.

The public is unlikely to encounter M-44 devices, and therefore, the risk of exposure to NaCN is low as described in the exposure section (sections 4.1 and 4.2.4). As discussed in Section 4.1, 18 public exposures occurred from FY84 to FY19, but other than a burning eye sensation, only two had severe reactions (one from giving a dog CPR and the other from an illegally set, non-WS, M-44. In addition, the public is unlikely to eat animals recently killed by a NaCN.

The risk to applicators is slightly greater than the risk to the public because they handle the cyanide capsules and set the M-44 devices. Dermal contact and inhalation are the two potential routes of exposure to applicators. The absorption through the skin occurs when hydrogen cyanide is liquid or vapor and absorbs more rapidly through a skin wound or moist skin (Towill et al. 1978). An LD_{50} for hydrogen cyanide adsorption through the skin is 100 mg/kg (Towill et al. 1978). One breath of air with 2,000 ppm hydrogen cyanide can cause collapse, convulsions, and stoppage of breathing within one minute, with an estimate total absorbed lethal dose of 7 mg/kg (Towill et al. 1978). In a study, hydrogen cyanide concentrations were measured from the moistening of 1 g/m^3 NaCN-formulation (39.2% NaCN with 60.8% kaolin) by placing air sampling tubes 20 cm lateral to the formulation and 2 m above the formulation (Ballantyne 1988). After one hour, the hydrogen cyanide reached a maximum concentration of 40 mg/m^3 at the lateral location and 15 mg/m^3 above the formulation. An increase in the application rate to 5 g/m^3 resulted in a concentration of 100 mg/m^3 of hydrogen cyanide within 10 minutes. For reference point, the 30-minute LC_{50} for hydrogen cyanide vapor in human males' ranges 220-688 mg/m^3 (Ballantyne 1988). Symptoms of incapacitation and unconsciousness may occur at 100-150 mg/m^3 (Ballantyne 1988). At the lower application rate, which resulted in 40 mg/m^3, symptoms of respiratory stimulation and dizziness may occur but serious toxicity is unlikely (Ballantyne 1988). Hydrogen cyanide concentrations will decrease with increased distance from the point source; however, moving away from the point source is unlikely to reduce the risk to applicators because hydrogen cyanide is lethal to humans at low concentrations and reacts rapidly in the human body. The symptoms of cyanide exposure may also interfere with the person's mobility.

APHIS requires applicators to receive training on the proper use of M-44s and the cyanide capsules before they may use the product. Applicators that follow the safety precautions reduce their risk of exposure. Applicators must wear personal protective equipment to set, maintain, and pull M-44s including long-sleeved shirts, pants, shoes, socks, waterproof gloves, and a full face shield, which reduces potential exposure.

The release of cyanide to the environment is negligible. Release of a capsule from the M-44 device occurs when an animal with enough pull strength tugs on the device; otherwise, the capsule remains separate from the surrounding environment. Label restrictions prevent use near water sources and WS use patterns make it unlikely that NaCN contaminates drinking water resources. The label restricts the product's use in food crop

areas so exposure to food treated with cyanide would not occur. In the environment, cyanide breaks down into nonlethal components, which reduce the risk of acute and sublethal toxicity as discussed in Section 2.3.

5.2 Ecological

Each M-44 device holds one NaCN capsule with a dose lethal to aquatic vertebrates and invertebrates, and terrestrial mammals, birds, and other terrestrial vertebrates and invertebrates that ingest, inhale, or come in direct contact with the NaCN. The fate of NaCN and hydrogen cyanide in the environment suggest the cyanide from a capsule would undergo biotic and abiotic degradation to nonlethal compounds.

The risk to aquatic animals and plants is negligible because the label prohibits the use of the product within 200 feet of a water source. A terrestrial animal that receives a lethal dose of cyanide could wander into a water source and die, but the release of cyanide from the animal's body into the water is a negligible risk because of the metabolism and breakdown of cyanide in the body (see secondary exposure section 4.2.4, Towill et al. 1978, Bhandari et al. 2014). The aquatic life criteria for cyanide, which is the concentration "not expected to pose a significant risk to the majority of species in a given environment" in freshwater is 22 μg CN/L for acute effects and 5.2 μg CN/L for chronic effects (USEPA 1985, USEPA 2017). WS use pattern for NaCN would not result in cyanide concentrations exceeding these amounts in a water source unless under an accidental release.

The risk to terrestrial plants, invertebrates, and other microorganisms is negligible given the product's use pattern. Although it is possible for a NaCN capsule to land on the ground the risk of exposure to these organisms is low. In addition, any risk would be localized and of short duration. In plants, hydrogen cyanide can inhibit respiration, germination and growth and cause death (Towill et al. 1978). Some plants uptake cyanide compounds (Towill et al. 1978). Exposure of seeds to cyanide stimulated seed germination (Towill et al. 1978 and Solomonson 1981 summarize several studies).

The M-44 devices are set in areas where many animal species, not just the target species, pass through (Phillips and Gruver 1996, Shivik et al. 2014). About 80-91 mg of NaCN is lethal to a 25-pound coyote, which translates to each cyanide capsule containing about 10 to 11 lethal doses (Blom and Connolly 2003). Risk is a function of exposure and effects. In the case of M-44 devices where there is exposure to a nontarget terrestrial vertebrate the risk is high. The high risk is due to the high acute toxicity of M-44 devices when exposure occurs. However, the potential exposure for most nontarget terrestrial vertebrates is low because of the WS use pattern for M-44 devices, such as the use of specific bait, setting the trigger to a certain pull strength, the size and position of the device, and following protections for T&E species reducing risk to many, but not all, nontarget animal species. Weimeyer (1986) found the associated dose-response curve was steepest for the birds that are flesh-eaters than for plant-feeders, which suggests a further increase in hazard to species attracted to M-44 bait. The delivery of one capsule to one animal and the limit on the number of M-44 devices set on one-acre limits the number of nontarget animals potentially taken in an area. Overall, WS annually averaged the take of 362 nontarget animals and potentially 123 more from discharged capsules with no known take from FY11 to FY15 (Table 3).

6 UNCERTAINTIES AND CUMULATIVE EFFECTS

Sodium cyanide is a product WS uses in its Predator Damage Management programs and the only toxicant that contains cyanide in all its programs. Seventeen WS State Programs used M-44s (NaCN). The product labels specify the maximum number of M-44 devices allowed on one acre, regardless of whether WS or a

state agency sets the device. Both Federal and State agencies must comply with endangered species regulations. Sodium cyanide has other minor agricultural uses. It is registered under Section 24(c), special local needs registration, for use as an insecticide for quarantine fumigation of surface pests on citrus for shipment to Arizona (USEPA 2011b).

Establishing tolerable daily intakes or concentrations for cyanide is on limited data in human populations because most studies are based on acute effects, not long-term effects (Simeonova and Fishbein 2004). A 10-fold uncertainty factor has been incorporated into the estimate of reference doses for humans because of the extrapolation of results from acute animal studies to human health impacts (USEPA 2010a, b).

Cyanide in the environment comes from natural and manmade sources. Natural sources of cyanide include biological organisms and growing plants (Castric 1981, Way 1984). Ingestion of plants that contain cyanide (in the form of cyanogenic glycosides) exposes people and animals to cyanide. Livestock ingesting plants containing cyanogenic glycosides have experienced acute and chronic toxicity (Towill et al. 1978). Over 2,000 plants produce cyanogenic glycosides including sorghum, corn, lima bean, flax, pits of stone fruit (e.g., cherry, apricot, and peach), sweet potatoes, cassava, and almonds (Towill et al. 1978, Eisler 1991, Simeonova and Fishbein 2004).

In 2001, hydrogen cyanide production in the United States was 750,000 tons (Wong-Chong et al. 2006). The industries that are main contributors of cyanide in the environment are former gas work sites, electroplating factories, paint industries, and gold mine sites (Way 1984, Eisler 1991, Kjeldsen 1998). For example, in 2001, industrial sources in the United States emitted 540 tons of hydrogen cyanide to the atmosphere, 0.1 tons to surface waters, and 0.42 tons to land (Simeonova and Fishbein 2004). Other anthropogenic sources of cyanide include tobacco smoke, cyanogenic drugs, and house fires (Ballantyne and Marrs 1987 Eisler 1991, Isom 1993, Simeonova and Fishbein 2004). WS estimated use was 54 pounds of NaCN annually from FY11 to FY15. This is 0.005% of the hydrogen cyanide released to the atmosphere in 2001.

The estimate of daily hydrogen cyanide inhalation for people who live in non-urban areas and are non-smokers is 3.8 μg/day based on hydrogen cyanide atmospheric concentrations (ATSDR 2006). Estimates of daily intake of cyanide in drinking water are 0.4 to 0.7 μg (ATSDR 2006). Adverse effects on humans are unlikely for both of these estimates.

The amount of NaCN WS uses to control canid predators contributes a negligible amount to the environment in comparison with industry production and release, making cumulative effects to the environment, WS applicators, and nontarget terrestrial vertebrates unlikely.

Finally, every year, M-44 devices are triggered but no animal is recovered from the treatment area. WS personnel document their best guess of the species that triggered the device from tracks and teeth marks or what possibly occurred, but this information is not available easily. In section 1.1, we describe the process we used to estimate the level of nontarget take when no carcass was recovered. We used the conservative assumption that 50% of the M-44 discharges resulted in the take of nontarget species, 45% of the capsules discharged exposed a nontarget species but did not deliver a lethal dose, and 5% of the capsules discharged did not contact an animal. We base these percentages on field observations of animals that frequent a treatment area and the type and number of actual nontarget animals taken. Even with the additional take, no species take would be high enough to have a significant impact on their population. However, we believe this to be one of the uncertainties.

7 SUMMARY

The NaCN capsules WS uses to manage canid species that prey on livestock, poultry, and threatened or endangered species or animals that are vectors of disease contain enough cyanide to be lethal to humans and animals. However, the WS use pattern reduces the risk to negligible for the public. The risk to WS applicators is low because they receive training in the product's use, are certified by the State, follow label instructions, including the appropriate personal protective equipment. The release of a NaCN capsule in the environment will result in its breakdown and dissociation into less toxic or non-toxic compounds relatively rapidly reducing the potential for any environmental impacts.

The risk to aquatic animals and plants is negligible because the label prohibits the use of the product within 200 feet of a water source. The risk to nontarget terrestrial vertebrates is low. The WS use pattern, precautions, and label restrictions reduces exposure to most terrestrial vertebrates.

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9 PREPARERS

9.1 APHIS-WS Methods Risk Assessment Committee

Writers for "Use of Sodium Cyanide in Wildlife Damage Management Risk Assessment":

Primary Writer: Andrea Lemay
Position: USDA-APHIS-Policy and Program Development (PPD), Environmental and Risk Analysis Services (ERAS), Biological Scientist, Raleigh, NC
Education: BS Plant and Soil Science (Biotechnology) - University of Massachusetts; MS Plant Pathology -North Carolina State University
Experience: Twelve years of service in APHIS conducting risk analysis. Four years of experience in preparing environmental analyses in compliance with the National Environmental Policy Act.

Writer: Thomas Hall
Position: USDA-APHIS-WS, Operational Support Staff, Staff Wildlife Biologist, Fort Collins, CO
Education: BS Biology (Natural History) and BA Psychology – Fort Lewis College; MS Wildlife Ecology – Oklahoma State University
Experience: Special expertise in wildlife biology, identification, ecology, and damage management. Thirty-two years of service in APHIS Wildlife Services including conducting research in CO and WY and conducting operations in OR, GU, CA, OK, and NV. Involved in a wide variety of programs including bird damage research and management, livestock protection (predators and birds), invasive species management, wildlife hazard management at airports, property and natural resource protection including waterfowl, brown tree snake, feral swine, rodent, and beaver damage management. Have applied and supervised the use of M-44s in the course of duties.

Editors/Contributors for "Use of Sodium Cyanide in Wildlife Damage Management Risk Assessment":

Editor/Contributor: Jeanette O'Hare
Position: USDA-APHIS-Wildlife Services (WS), National Wildlife Research Center (NWRC), Registration manger, Fort Collins, CO

Education: B.S. Biology – College of Saint Mary; M.A. Biology – University of Nebraska - Omaha

Experience: 13 years of experience working for WS NWRC providing regulatory compliance support for the development of wildlife damage management tools. Prior experience before joining APHIS includes assessing the environmental fate of pesticides and providing the agency guidance on water quality issues at the state government level, and laboratory experience in the fields of pharmacology and toxicology, and immunology.

Editor/Contributor: Emily Ruell

Position: USDA-APHIS-WS, NWRC, Registration Specialist, Fort Collins, CO

Education: B.S. Zoology and Biological Aspects of Conservation – University of Wisconsin - Madison; M.S. Ecology – Colorado State University (CSU); M.A. Political Science – CSU

Experience: Three years of experience with APHIS WS NWRC preparing and reviewing vertebrate pesticide registration data submissions and other registration materials, and providing pesticide regulatory guidance to WS, WS NWRC, and collaborators. Prior experience before joining APHIS includes seven years of conducting field and laboratory wildlife research at CSU, and environmental policy research for the U.S. Geological Survey.

Editor/Contributor: Fan Wang-Cahill

Position: USDA-APHIS-Policy and Program Development (PPD), Environmental and Risk Analysis Services (ERAS), Environmental Health Specialist, Riverdale, MD

Education: B.S. Biology and M.S. Hydrobiology - Jinan University, Guangzhou, China; Ph.D. Botany (Ultrastructure/Cell Biology) – Miami University

Experience: Joined APHIS in 2012, preparing human health risk assessments and providing assistance on environmental compliance. Prior experience before joining APHIS includes 18 years environmental consulting experience specializing in human health risk assessments for environmental contaminants at Superfund, Resource Conservation and Recovery Act (RCRA), and state-regulated contaminated facilities.

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Position: USDA-APHIS-Policy and Program Development (PPD), Environmental and Risk Analysis Services (ERAS), Environmental Toxicologist, Little Rock, AR

Education: B.S. Forest Ecology and M.S. Entomology – University of Missouri; Ph.D. Environmental Toxicology – Clemson University

Experience: Seven years of experience working for APHIS preparing ecological risk assessments and providing assistance on environmental compliance. Prior experience before joining APHIS includes other government and private sector work regarding ecological risk assessments related to various environmental regulations.

Editor/Contributor: Ryan Wimberly

Position: USDA-APHIS-WS, Operational Support Staff, Staff Wildlife Biologist, Madison, TN

Education: BS Wildlife Management and Ecology – Northwest Missouri State University

Experience: Special expertise in wildlife biology, ecology, and damage management. Sixteen years of service with APHIS Wildlife Services, including operations and research, conducting a wide variety of programs, including bird damage research and management, livestock protection, invasive species management, wildlife hazard management at airports, property, and natural resource protection. Expert in preparing environmental documents for WS programs to comply with the National Environmental Policy Act and the Endangered Species Act.

Data Contributor: Joey Millison

Position: USDA-APHIS-WS Information and Technology (IT), Junior Applications Developer

Education: Information and Technology coursework from various sources

Experience: Eleven years of experience in APHIS, WS Management Information System (MIS) Group. Retrieves WS field data from the MIS for writers, reviewers, and editors.

9.2 Internal Reviewers

USDA APHIS Wildlife Services

Reviewer: Michael Green
Position: USDA-APHIS-Wildlife Services (WS), Environmental Coordinator, Fredrick, MD
Education: BS Wildlife and Fisheries Sciences, University of Tennessee
Experience: Special expertise in wildlife biology, ecology, and damage management. Eleven years of work experience with WS in MD and VA. Experienced in a wide range of program activities including nutria eradication, airport wildlife management, and wildlife damage management to protect livestock, aquaculture, public safety, and natural resources. Served as staff biologist in WS Headquarters for 2 years.

Reviewer: Jeff Jones (retired)
Position: USDA-APHIS-WS, Staff Wildlife Biologist, Riverdale, MD
Education: BS Wildlife and Fisheries Sciences, Texas A&M University
Experience: Special expertise in wildlife biology, ecology, and damage management including overseeing the WS Pesticide Program. Thirty years of Federal time and six years of State program service in TX, AR, CA, OR and MD with experience in a wide variety of programs (livestock, aquaculture, property, public safety and natural resource protection) including predator, bird, beaver, feral swine, and rodent damage management activities including supervising and monitoring the use of and applying M-44s in the course of duties.

Reviewer: Michael Yeary
Position: USDA-APHIS-WS, State Director/Supervisory Wildlife Biologist, Lakewood, CO
Education: BS in Wildlife Ecology, Texas A&M University
Experience: Special expertise in wildlife damage management including applying and supervising M-44s and their use. Thirty eight years of service in APHIS Wildlife Services in TX, KS, CO, and WS Regional Office with experience in a wide variety of programs (livestock , aquaculture, dairy, property, natural resources, and human health and safety protection) including predator, bird, beaver, feral swine, and rodent damage management activities.

9.3 Peer Reviewers

The Office of Management and Budget requires agencies to have peer review guidelines for scientific documents. The APHIS guidelines were followed to have "*The Use of Sodium Cyanide in Wildlife Damage Management Risk Assessment*" peer reviewed. WS worked with the Association of Fish and Wildlife Agencies to have experts review the documents.

9.3.1 Peer Reviewer Agencies Selected by the Association of Fish and Wildlife Agencies

Arizona Game and Fish Department
Association of Fish and Wildlife Agencies (DC)
California Department of Fish and Wildlife
South Dakota Game, Fish and Parks
Tennessee Wildlife Resources Agency
Wyoming Game and Fish Department

9.3.2 Comments

Comments with concerns and a response regarding the risk assessment:

1. **Comment:** Eagles possibly should be mentioned in the Executive Summary as take can happen.
   Response: Eagles are sensitive species and periodically taken with sodium cyanide. From FY11 to FY15, two golden eagles and one bald eagle (Table 3) or an annual average of 0.4 and 0.2, were taken and was disclosed on page 3 and Table 3. WS personnel try to avoid taking eagles with measures such as not placing M-44s within 30 feet of exposed carcasses, covering M-44s with "cow chips" or other natural debris to hide them from eagles, or not using them where eagles roost/nest. This was not mentioned in in the Executive Summary as it is a relatively minimal risk. WS is concerned with nontarget take, especially T&E species; no T&E species were taken from FY11 to FY15.

2. **Comments:** Several items are outdated in the risk assessment such as the amyl nitrate antidote kit can no longer be used and a face shield must be used. The WS Directive is outdated and an adverse incident with a boy and his dog in Idaho that occurred in March 2017 was not included.
   Response: WS is aware that several changes occurred in 2018 since the risk assessment was written and sent out for peer review. The document was completed in January 2017, amended in June 2017 to include a new WS Directive and sent out for peer review. We believe the new changes did not have an effect on the analyses in the risk assessment and, thus, continued to get that document peer reviewed. The WS Directive and Policy were amended again in February 2018 and the labels in January and July of 2018, and thus were not included in the document because it was out for peer review. The human exposure occurred in March 2017, but was not completely investigated by the time the document was sent out and is currently pending a decision. Thus, this was not included in the document. Another human exposure occurred in FY17 to a WS employee from setting an M-44 that accidentally discharged; the employee turned his face, but apparently got some in an eye. However, this document was amended to include the new human exposures, labeling requirements, states where NaCN is registered, and the newest WS Directive and Policy, but these did not change the analyses other than new personal protection equipment replaced the loss of the antidote kit. We believe the new information does not have an effect on the analyses in the risk assessment and, thus, believe the currently peer-reviewed document is still valid with amendments to reflect current uses. Lastly, the internet links in Section 8 were updated since they had not been visited for nearly two years.

3. **Comment**: Assumptions and uncertainties have been described but some of the data (Table 2) regarding the use of NaCN by WS is suggestive of underlying issues. Specifically, for several states (TX, VA, WV, and WY) the ratio of unknown take to target take is exceptionally high. This suggests the placements were interfered with or not properly monitored and that the amount of nontarget take was extremely underestimated.
   Response: WS personnel record target and nontarget species found taken by M-44s. It is possible that nontarget take was underestimated. Usually the biggest hindrance to finding animals taken is the habitat. For example, dense forests as in east TX, VA, and WV, thorny scrub as in southern TX, and tall shrubs like sagebrush as in WY are typically the primary reason an animal is not found, if it was killed. Smaller nontarget animal may be more difficult to find or more likely to be taken by scavengers. WS personnel are responsible for notating what species or incident they believe caused an M-44 to discharge, but this is kept in a field diary. The current MIS system has no way of documenting this except as a remark. The M-44 heads are wrapped in something like gauze to help visualize teeth marks (large vs small); these along with tracks and other sign often indicates which species was likely responsible for causing the M-44 to discharge. While there is no way to capture that information yet, it is believed that most discharges are caused by animals that did not get a toxic dose of cyanide; this is typical of smaller animals that pull from the side rather than over the M-44. Therefore, without knowledge to the contrary we believe the best estimates of unknown nontarget take should be based on known target and nontarget take rates.

4. **Comment**: Given the extremely toxic nature of this compound, the mitigation steps need to be adhered to completely.
   Response: WS personnel are responsible for abiding by all labeling requirements and WS policies. We believe that these have helped mitigate accidental exposures and nontarget take greatly.

5. **Comment**: Warning signs should be constructed of durable, weather-proof material, and of a size and number which cannot be overlooked by persons entering the area from any direction.
   Response: Warning signs are made of durable, weather-proof materials that are waterproof and untearable, but problems in freezing weather as it can crumble. This is being researched. With that said, WS personnel adhere to the labeling requirements and WS Policy for signage. All faded, torn, or illegible signs are to be replaced. One elevated sign is placed within 15 feet of the device and elevated so that it is clearly visible. A large sign(s) is placed at the entrance(s) to a property. These are being modified continually to ensure they are durable and clearly readable for the general public.

6. **Comment**: The percentage of capsules which result in Unknown Take (greater than 40%) is high enough to warrant more research into the final destination of these capsules in order to adequately address the Exposure Assessment. This data gap should be addressed in the document.
   Response: The reasons for Unknown Take were discussed in Section 1.1 and in our response to Comment 3. We believe that the majority of the unknown discharges are actually discharges resulting in nonlethal doses (devices are pulled from the side rather than over the top). However, to ensure that potential impacts were analyzed, we still estimated take with discharged capsules and assumed 50% resulted in lethal take. Added to the percentages of species known taken (we believe that known animal take provides the best example of species that would be taken because these are the species in the areas of NaCN use), unknown nontarget impacts could be analyzed. We believe that the devices are still highly selective for canids. Shivik et al. (2014) documented the selectivity of the M-44 device for canids even though visitations near the sets were much higher for nontarget species than target species.

7. **Comment**: Sodium cyanide reacts readily to form hydrogen cyanide gas which is highly toxic to humans and other vertebrate animals and thus proper device placement is essential to minimizing risks to non-target organisms.
   Response: WS personnel place M-44s in areas where target canid visitation is likely while reducing nontarget visitation. M-44s may be recessed (where flooding is unlikely), covered, or off game trails (draw with scent) to minimize the potential for nontarget take. Use and placement of M-44 devices is similar to use of foothold traps or cable devices, and most personnel that use M-44s use the other devices as well. We believe these placement strategies reduce nontarget take.

8. **Comment:** I understand that further review is currently underway regarding guidelines and best practices for the deployment of the M-44 device
   Response: Yes, the 26 Use Restrictions have been modified since the first Sodium Cyanide Risk Assessment was sent out for peer review. The updated Use Restrictions include new advisory protocols and best management practices (e.g., different personal protection equipment being used). WS has updated this risk assessment to include the updated Use Restrictions and WS Directive.

9. **Comment:** The public is likely to consider a take rate of 2.9/1000 M-44 nights very ineffective
   Response: While we believe that many people will think this is minimal, it is actually a highly effective take rate. Take rates for other methods used in WDM can be higher (e.g., foothold traps for the same time period was 10.3/1000 trap nights), but the methods usually require much more time to apply. The M-44, the toxicant delivery device, is a highly effective and time efficient tool.

10. **Comment:** I would encourage USDA APHIS to carefully consider whether additional measures may be necessary to increase public safety and minimize accidental poisonings of humans and nontarget organisms, while at the same time balancing the needs of the user communities that rely on these devices for wildlife damage control and management.
    Response: WS continually evaluates the use of NaCN and implements procedures to reduce exposures and nontarget species take as possible while maintaining efficacy. Human exposure and nontarget species take are our greatest concern. In addition, NaCN is undergoing registration review by USEPA. APHIS will work with USEPA to develop label language to increase human and environmental safety.

Comments regarding the quality of the risk assessment not needing a comment:

1. **Comment:** I found the review of literature to be adequate and sufficiently detailed to document the range of possible risks and hazards associated with the deployment of this technology.

2. **Comment**: The qualitative risk assessment for the use of Sodium Cyanide ejectors in WDM activities accurately describes the potential risks to humans and nontarget species and methods used for mitigating those risks.

3. **Comment:** We believe the methods and techniques described are safe and comprehensive. We have no other comments.

4. **Comment:** I have thoroughly reviewed the risk assessment believe the methods described are adequate and safe. Thank you for the opportunity to participate in this review.

5. **Comment:** The Exposure Assessment of the NaCN capsules that have a known result (either Target Take, Nontarget Take, or Destruction) provides a sound basis for the conclusion that the use of this method is unlikely to pose a risk to either human health or to aquatic or terrestrial organisms.

Peer reviewers provided a few editorial comments on the manuscript. These were appreciated and incorporated into the final document.

APPENDIX 1. WS Directive for M-44 Use and Restrictions

United States Department of Agriculture
Animal and Plant Health Inspection Service

WS Directive

2.415 2/27/2018

M-44 USE AND RESTRICTIONS

1. PURPOSE

To establish guidelines for the use of the M-44 device by WS personnel.

2. REPLACEMENT HIGHLIGHTS

This directive revises WS Directive 2.415 dated 06/15/2017.

3. POLICY

M-44 sodium cyanide capsules labeled with U.S. Environmental Protection Agency (USEPA) registration No. 56228-15 and M-44 devices may only be used for control of coyotes, red and gray foxes, and wild dogs that are vectors of communicable diseases or suspected of preying upon livestock, poultry, and federally designated threatened and endangered (T/E) species. M-44 sodium cyanide capsules labeled with USEPA Registration No. 56228-32 and M-44 devices may also be used for control of arctic fox that depredate federally designated T/E species in the Aleutian Islands, Alaska. M-44's must be used in accordance with the USEPA pesticide label including the 26 Use Restrictions, and the Wildlife Services Implementation Guidelines (Attachment 1).

M-44 sodium cyanide capsules labeled with USEPA Registration Nos. 56228-15 and 58228-32 containing blaze-orange marker particles produced by the Pocatello Supply Depot (PSD) are for WS official use only. M-44 capsules labeled with an individual State's registration containing light yellow marker particles produced by the PSD are not authorized for WS use.

All M-44 ejectors used by WS personnel will be stamped, marked, or engraved with "US Gov't" or "Property of U.S."

All M-44 applicators will physically inventory M-44 capsules under their control at least quarterly during the year using the Controlled Material Inventory Tracking System. Supervisors will review inventory records for accuracy during yearly field inspections and physical inventory. Inventory records may be reviewed more often by supervisors and managers when deemed necessary. For inventory purposes, only capsules that contain sodium cyanide will be reported as part of the available inventory.

Any toxic or adverse human effect which occurs to WS personnel, cooperators, or the public involving the use, storage, or disposal of sodium cyanide is to be immediately reported to the appropriate State Director and Director (as defined in Directive 1.101). The Director will refer all incidents to the Director of Operational Support Staff (or their designated delegate to the Pesticide Coordination Committee) for determining whether or not it is an incident that should be reported to the USEPA and to the Director of Environmental Services, APHIS.

Applicators must comply with all label requirements, including those related to PPE.

When setting M-44s, applicators must possess the USEPA label with 26 Use Restrictions. WS provides additional instruction on complying with the 26 use restrictions in Wildlife Services Implementation Guidelines (attachment #1 of this document), and applicators should pay particular attention to the following clarifications and refinements of Use Restrictions and Implementation Guidelines 1, 8(2), 23, and 24:

Additional Guidelines for Complying with M-44 Use Restriction 1.
State Directors and subordinate supervisors must ensure that all M-44 use by personnel under their jurisdiction is in compliance with NEPA (National Environmental Policy Act) documents and decisions, agreements, and federal agency work plans.

Additional Guidelines for Complying with M-44 Use Restriction 8(2) include:
M-44s will not be placed within 0.5 mile of occupied residences except for those belonging to a cooperator who has requested the use of M-44s and has signed a Work Initiation Document. Within properties where its use is authorized, the M-44 device shall only be used in areas where exposure to the public and family and pets is not probable, per Use Restriction 8(2). In certain situations, applicators may request a variance to the 0.5 mile restriction to allow for M-44 devices to be placed between 0.25 and 0.5 mile of an occupied residence. After applying the WS Decision Model (WS Directive 2.201) and determining that the use of an M-44 is acceptable and practical for the situation, the applicator may request a variance by completing WS Form 205. The applicator will use the WS Form 205 to document the characteristics of the Cooperator's property and surrounding area.

WS Form 205 must be submitted by the applicator through their supervisor to the Regional Director, who will evaluate each WS Form 205 on a site-by-site basis and render a decision based on the totality of information provided. Variance applications will be granted only if they demonstrate that potential for human or pet exposure to M- 44s at the site is not probable. The Regional Director will evaluate a variance approval annually, or more frequently as appropriate. If approved, copies of WS Form 205 will be maintained by the applicator, District Supervisor, State Director, and Regional Director.

Variance requests approved by the Regional Director are contingent on the subsequent notification of residents located within 0.5 miles of the proposed M-44 location(s). It is the supervisor's responsibility to ensure that resident notifications are performed a documented by WS staff prior to setting M-44s in the area covered by the variance. Additional Guidelines for Complying with M-44 Use Restriction 23

WS will notify the owner or lessee occupying any residence between 0.25 and 0.5 miles of an M-44 device prior to their use in the area. Documentation of the notification will be maintained by the WS State Director.

The identity of the Cooperator and of the Cooperator's property, must not be shared directly with the notified individuals unless the Cooperator has authorized disclosure in writing.

WS personnel are expected to accurately identify property boundaries where M-44 devices are to be placed. If the property boundaries are not clearly posted, or the landowner or lessor is unable to accurately identify the property boundaries, WS personnel shall use electronic mapping or aerial imagery to identify: a) cooperator property boundaries to ensure devices are placed on the property covered by the agreement; and b) non-cooperator residences, to ensure none are within 0.5 mile of the device and/or residences that may require a variance using WS Form 205. Buildings that are obviously abandoned or not actively occupied are not residences for purposes of this interpretation.

Additional Guidelines for Complying with M-44 Use Restriction 23
On properties where no fence lines exist to identify property boundaries or display warning signs, appropriate warning signs shall be erected to indicate that M-44 devices have been placed on the property ("premise sign") per Use Restriction 23(a). A WS authorized elevated sign ("device sign") as required by Use Restriction 23(b), must be securely anchored to a stake, post or wire and positioned vertically above ground level or hung from a low hanging tree limb in a manner that renders it clearly visible and legible from the device. One elevated device sign will be required for each M-44 device set. WS requires elevated device signs to be placed within 15 feet of each individual M-44 Device, a more stringent requirement than the USEPA label Use Restriction. Applicators should use the most recent version of the device and premise signs available through the Pocatello Supply Depot. Signs that become faded, ripped, or otherwise illegible must be replaced.

Label Change in M-44 Use Restriction 24
Amyl nitrite inhalants are not approved as an antidote for cyanide poisoning by the Food and Drug Administration. The USEPA label Use Restrictions revised on 1/26/2018 eliminates the requirement to carry amyl nitrite ampules as an antidote to sodium cyanide
poisoning.

4. REFERENCES

WS Directive 2.401, Pesticide Use (12/08/09).
WS Directive 2.201, WS Decision Model (07/15/14)
Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 et seq.), as amended. 40 CFR Part 153.75 - Toxic or Adverse Effect Incident Reports (a)(1)(i) through (iii).

5. ATTACHMENTS

APHIS Wildlife Services Implementation Guidelines for the 26 Use Restrictions for M-44 Sodium Cyanide Capsules. February 2018.

APHIS Wildlife Services Implementation Guidelines for the 26 Use Restrictions for M-44 Sodium Cyanide Capsules

EPA Registration No. 56228-15

Revised: February 27, 2018

Note to Applicators: Although these guidelines contain verbiage from the USEPA Label's 26 Use Restrictions for M-44 Sodium Cyanide capsules, possession of this document in the field does not fulfill label requirements to possess the full USEPA Label, which includes the 26 use restrictions, with you in the field.

EPA Use Restriction (as written on Label)	WS Implementing Guideline
1. Use of the M-44 device shall conform to all applicable Federal, State, and local laws and regulations.	State Directors are responsible for ensuring that WS employees under their supervision are fully aware of all relevant Federal, State, and local laws and regulations, and individual M-44 applicators are responsible for complying with these laws and regulations. Applicable laws will vary from state to state as well as within states. WS M-44 applicators are subject to inspection by USEPA or State regulatory enforcement officials to ensure that applicable laws and regulations are being followed. State Directors and subordinate supervisors must ensure that all M-44 use by personnel under their jurisdiction is in compliance with NEPA (National Environmental Policy Act) documents and decisions, agreements, and federal agency work plans.
2. Applicators shall be subject to such other regulations and restrictions as may be prescribed from time-to-time by the U.S. Environmental Protection Agency (USEPA).	Additional regulations and restrictions prescribed by USEPA will be provided by the WS Operational Support Staff through normal supervisory channels. Each State Director is responsible to ensure that all M-44 applicators in the state are properly trained and individual M-44 applicators are responsible for complying with all State and Federal regulations regarding M-44 use.
3. Each applicator of the M-44 device shall be trained in: (1) safe handling of the capsules and device, (2) proper placement of the device, and (3) necessary record keeping.	Applicators of pesticides will be trained and certified by the appropriate State regulatory agency. If the State regulatory agency training includes specific M-44 application that covers use, safety precautions, and record keeping, this training meets WS requirements. However, in those states where generalized pesticide training lacks specific M-44 training, the State Director will be responsible for supplementing the training to meet specific training needs on use, safety precautions, and record keeping requirements. WS State Directors are responsible to assure that all M-44 applicators they supervise are adequately trained and certified as often as the State pesticide agency requires. The "Annual M-44 Sodium Cyanide Training Certification" form (WS Form 40) will be used to document applicator knowledge through the completion of this form by the supervisor during annual field inspections.

WS Implementation guidelines for M-44 Use Restrictions

EPA Use Restriction (as written on Label)	WS Implementing Guideline
4. M-44 devices and sodium cyanide capsules shall not be sold or transferred to, or entrusted to the care of any person not supervised or monitored, by Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) or any agency not working under a WS cooperative agreement.	M-44 cyanide capsules and ejectors will be used only by WS program employees who are Certified Applicators, and who have received specific M-44 training as described in Use Restriction #3. This includes both cooperatively funded employees and official volunteers who are supervised by WS personnel. WS personnel will transfer M-44 capsules or equipment only to other WS employees who are certified M-44 applicators. When transfer of sodium cyanide is necessary, the capsules shall be tracked using the WS Controlled Materials Inventory Tracking System (CMITS).
5. The M-44 device shall only be used to take wild canids: (1) suspected of preying on livestock or poultry; (2) suspected of preying on federally designated threatened or endangered species; or (3) that are vectors of a communicable disease.	M-44s may not be used to protect wildlife other than Federally designated threatened or endangered species. "Livestock or poultry" includes the species listed in "Livestock" and "Commercial Game Animals (Pen-raised)" subcategories of MIS Resources Protected codes. "Wild canids" for which M-44s may be used include coyote, red fox, gray fox, and wild (feral) dogs (see label and WS Directive 2.340 "Feral, Free Ranging, and Hybrid Dog Damage Management"), subject to further restrictions by State or local regulations. States can restrict but cannot expand the list of approved target species. Additional target species can be designated only with USEPA approval.
6. The M-44 device shall not be used solely to take animals for the value of their fur.	This restriction reinforces long-standing WS policy against any taking of animals solely for the value of their fur by M- 44 or any other method. However, fur may be salvaged from animals taken by M-44s in compliance with WS Directive 2.510 "Fur, Other Animal Parts, and Edible Meat."
7. The M-44 device shall only be used on or within 7 miles of a ranch unit or allotment where losses due to predation by wild canids are occurring or where losses can be reasonably expected to occur based upon recurrent prior experience of predation on the ranch unit or allotment. **Full documentation of livestock depredation, including evidence that such losses were caused by wild canids, will be required before applications of the M- 44 are undertaken. This use restriction is not applicable when wild canids are controlled to protect federally designated threatened or endangered species or are vectors of a communicable disease.**	The 7-mile rule applies only to M-44 use for the protection of livestock or poultry. "Recurrent prior experience of predation on the ranch unit or allotment" means a history of predation that has been documented in MIS records. MIS documentation of reported or confirmed livestock or poultry losses, on a MIS Direct Control Work Task or a MIS Technical Assistance Work Task, constitutes "full documentation of livestock depredations, including evidence that losses were caused by wild canids." WS personnel will place M-44s only on properties identified in "Work Initiation Document for Wildlife Damage Management" (WS Forms 12A, 12B, and 12C) signed by the property owner or manager, or as developed in work plans for work on public lands. M-44 use must be specifically authorized through a signed written agreement or through provisions in work plans with cooperating agencies. Each WS Specialist is responsible for determining the boundaries of properties covered by control agreements, and to place M-44s only where authorized by the agreement.

WS Implementation guidelines for M-44 Use Restrictions

EPA Use Restriction (as written on Label)	WS Implementing Guideline
8. The M-44 device shall not be used: (1) in areas within national forests or other Federal lands set aside for recreational use, (2) in areas where exposure to the public and family and pets is probable, (3) in prairie dog towns, or (4) except for the protection of federally designated threatened or endangered species, in National or State Parks; National or State Monuments; federally designated wilderness areas; and wildlife refuge areas. **To determine whether the applicable land management agency has set aside any area on Federal Lands for recreational use either on a permanent or temporary basis, the APHIS State Director or his/her designated representative who are considering authorizing or are responsible for ongoing use of M-44 capsules on public lands, must contact each applicable land management agency quarterly to determine whether any portions of the projected or current M-44 use areas are, or are to be, set aside for recreational use. Within 30- days of that contact, the APHIS State Director, or his/her designated representative, must provide the applicable land management agency with written documentation specifying the applicable land management agency's determinations of what projected or current M-44 use areas are to be set aside for recreational use. For purposes of this Use Restriction, areas set aside for recreational use include areas where and when there are scheduled recreational events, areas identified on maps with "recreation" in the title, areas where developed or known camping occurs, areas near designated or known recreational trail heads and designated or known vehicle access sites.**	Compliance with this rule requires common sense and good judgment as well as input from local sources regarding public use and seasonal variations in such use. Regardless of any other consideration, every effort will be made to avoid areas of heavy public use and unnecessary public exposure. The exclusion of M-44s from prairie dog towns (item 3) is intended to protect black-footed ferrets. M-44s may be used on Federal lands except in areas specifically designated for recreational use. M-44 non-use areas on public lands will be identified through interagency consultations at the WS State office or District office level; such non-use areas will include beaches, campgrounds and locations where seasonal use such as hunting occurs. M-44s may be used on Federal lands except in areas specifically designated for recreational use. M-44 non-use areas on public lands will be identified through interagency consultations at the WS State office or District office level; such non-use areas will include beaches, campgrounds and locations where seasonal use such as hunting occurs. Consultations are not needed for types of lands where M-44s will never be used; see list in Use Restriction #8, item (4). "Wildlife refuge areas" means officially designated Federal or State wildlife refuges or wildlife management areas that are identified as such by appropriate signs and maps. WS will coordinate quarterly with the land management agency to determine where M-44s may or may not be used on public lands in certain areas. These quarterly contacts can be made through workplan meetings, telephone conversations, in person, or email. Within 30 days after each quarterly contact, WS needs to provide written documentation of the land management agency's determination of any identified set aside recreation areas (i.e. projected or current areas). Quarterly contacts will also allow for addressing the use of M-44's and unscheduled events that were not planned or discussed during the annual workplan meetings. For WS offices with no plans for use of M-44s on public lands, quarterly contacts are not necessary. M-44s will not be placed within 0.5 mile of occupied residences except for those belonging to a cooperator who has requested the use of M-44s and has signed a Work Initiation Document. Within properties where its use is authorized, the M-44 device shall not be used in areas where exposure to the public and family and pets is probable per Use Restriction 8(2). WS applicators can use WS Form 205 to request a variance to allow placement of M-44s between 0.25 and 0.5 miles of a neighboring residence. M-44s cannot be placed within 0.25 mile of a residence other than that of the cooperator. WS will notify the owner or lessee occupying any residence between 0.25 and 0.5 miles from an M-44 device of their use in the area. Documentation of the notification will be maintained by the WS State Director. The identity of the Cooperator and of the Cooperator's property, must not be shared directly with the notified individuals unless the Cooperator has authorized disclosure in writing.

8. Continued	WS personnel should accurately identify property boundaries where M-44 devices are to be placed. If the property boundaries are not clearly posted, or the landowner or lessor is unable to accurately identify the property boundaries, WS personnel shall use electronic mapping or aerial imagery to identify: a) cooperator property boundaries to ensure devices are placed on the property covered by the agreement; and b) non-cooperator residences, to ensure none are within 0.5 mile of the device and/or residences that may require a variance using WS Form 205. Buildings that are obviously abandoned or not actively occupied are not residences for purposes of this interpretation.
9. The M-44 device shall not be used in areas where federally listed threatened or endangered animal species might be adversely affected. Each applicator shall be issued a map, prepared by or in consultation with the U.S. Fish and Wildlife Service, which clearly indicates such areas. **(1) Except as provided in paragraph (2) below, the M-44 device shall not be used in areas occupied by any federally listed threatened or endangered species or any federally listed experimental populations as set forth in the most current versions of maps that have been prepared or approved by the U.S. Fish and Wildlife Service (FWS). At the time of application, the applicator must be in possession of the most current map, if such map exists, that covers the application site. If maps covering the application site do not exist, then the M-44 applicator must, prior to application, consult with FWS to determine whether the application site is in an area occupied by listed animal species. Any use of the M-44 thereafter shall be consistent with any conditions or limitations provided by FWS through such consultation.** **(2) Notwithstanding paragraph (1), the M-44 device may be used in areas occupied by endangered, threatened, or experimental populations if use in such areas a) has been addressed by FWS in special regulations pursuant to section 4(d) of the ESA, in requirements imposed through incidental take statements or incidental take permits, or in other applicable agreements with the FWS, and b) the applicator's use of the M-44 is consistent with any conditions or limitations provided by FWS for such use.**	WS personnel will use all control methods including M-44s in ways that minimize adverse impacts to nontarget animals and the environment and will conduct Section 7 consultations with U.S. Fish and Wildlife Service as required. In addition to consideration of potential impacts to federally listed threatened and endangered species before placing M-44s (see the label), WS applicators also will consider impacts on State-listed species as well as Federal and State species that are candidates for listing. Maps for listed threatened and endangered species or experimental populations will be obtained by each State Director from appropriate FWS Endangered Species personnel if possible. Alternatively, maps may be prepared jointly by WS and FWS personnel. Where FWS personnel are unavailable or unable to cooperate in this activity, the State Director will prepare appropriate maps and will provide copies to FWS Endangered Species and State wildlife agency offices whenever new or updated maps are distributed to M-44 applicators. Also, each applicator must be aware of specific areas closed to M-44 use, as shown in "Endangered Species Considerations" on the label. Endangered species maps are not needed in states or areas where no vulnerable threatened or endangered species exist, as determined by informal consultations between WS and Federal and/or State endangered species offices.
10. One person other than the individual applicator shall have knowledge of the exact placement location of all M-44 devices in the field.	This rule will be met by WS personnel providing copies of the initial placement and any subsequent changes of M-44 GPS locations as soon as possible, but no later than 14 days after placement. This M-44 coordinate information shall be sent to the applicator's supervisor by electronic or hard copy delivery. It is not required that anyone beyond the certified applicator be present during placement or replacement of M-44 devices.

EPA Use Restriction (as written on Label)	WS Implementing Guideline
11. In areas where more than one governmental agency is authorized to place M-44 devices, the agencies shall exchange placement information and other relevant facts to ensure that the maximum number of M-44s allowed is not exceeded.	As a general policy, WS will not use M-44s on any property where persons other than WS personnel are using them. Each exception to this rule will be authorized in writing by the supervisor or State Director before any M-44s are set by WS personnel. In such exceptional cases where WS and other governmental agencies or private individuals are using M-44s concurrently, WS personnel will communicate with other users sufficiently to ensure that the maximum number of M-44s placed by all users does not exceed the totals set forth in Use Restrictions # 15 and #16.
12. The M-44 device shall not be placed within 200 feet of any lake, stream, or other body of water, provided that natural depression areas which catch and hold rainfall for short periods of time shall not be considered "bodies of water" for purposes of this restriction.	This rule is designed to protect nontarget animals, including humans and their pets, which may be attracted to bodies of water. In addition to avoiding M-44 placements within 200 feet of water bodies, WS personnel will avoid using M-44s where exposure to nontarget animals, the public and family pets is probable. Dry irrigation ditches and water troughs are not "bodies of water" for purposes of this Use Restriction. Avoidance of hazard to humans and nontarget animals may require at times that M-44 sets be more than 200 feet away from water. Wherever uncertainty exists about the suitability of specific placement locations, applicators should consult with their supervisors before placing M-44s. (See Use Restriction #14).
13. The M-44 device shall not be placed in areas where food crops are planted.	In 40 FR 44726-44739 (9/29/75), USEPA Administrator Russell Train indicated: *"4. ...there was no basis in the record for extending the use of the M-44 to protect "agricultural crops," since that would encompass a rather large, undefined area of use. The purpose of this Restriction #8 is not to protect crops, but to protect people who work in the field and, in some cases, those people who eat food products from the field. This restriction does not prohibit placement in areas adjacent to the field which are less likely to result in human exposure to injury."* (Note: The M-44s can be placed in areas only for the purposes identified in Use Restriction #5.)
14. The M-44 device shall be placed at least at a 50-foot distance or at such a greater distance from any public road or pathway as may be necessary to remove it from sight of persons and domestic animals using any such public road or pathway.	"Public road or pathway" generally means a road or trail that is identified as such on maps, is open to unrestricted public access and maintained by a government or public entity. A pickup track or livestock path is not a "public road or pathway" for purposes of this rule. Any uncertainty about specific public roads or pathways on public lands should be resolved through informal consultation with local land management agency personnel. In this regard, WS personnel will avoid placing M-44s in any location where exposure to the public and family pets is probable (Use Restriction #8). The out-of-sight rule means that if a person using only the un-aided eye, that is standing on the road could direct another person in the field directly to the M-44 device; this would not meet the out-of-sight rule. This rule applies to M- 44 devices, not warning signs. An applicator who is uncertain as to whether or not a specific road or pathway is considered public will consult with the supervisor before placing M -44s in that area.

EPA Use Restriction (as written on Label)	WS Implementing Guideline
15. The maximum density of M-44s placed in any 100 acre pasture land areas shall not exceed 10; and the density in any 1 square mile of open range shall not exceed 12.	"Pasture land" is fenced land that produces forage for consumption by grazing animals. Fence rows around the pasture are considered as part of the pasture for purposes of this rule. "Open range" is unfenced grazing land, and one (1) square mile contains 640 acres. Application of this standard to field situations requires that WS specialists know property boundaries where M-44s are being placed. In general, WS personnel will use the minimum number of M-44s needed to achieve project objectives. This Use Restriction could be interpreted to allow a maximum of 64 M-44s to be placed in one square mile of fenced pasture. However, rarely, if ever, would a WS specialist use so many M-44s. In the unlikely case where WS specialists need to set a number of M-44s, approaching the limits specified in this restriction, specialists will not place more M-44s than are authorized here and in Use Restriction #16. Apparent contradictions between these rules will be resolved by complying with the more restrictive rule.
16. No M-44 device shall be placed within 30 feet of a livestock carcass used as a draw station. No more than four M-44 devices shall be placed per draw station and no more than five draw stations shall be operated per square mile.	This restriction is intended to protect nontarget animals that, like target predators, also may be attracted to a carcass. WS applicators will not place M-44s within 30 feet of any livestock or other animal carcass with meat or viscera attached, regardless of whether or not the carcass is intended to be a draw station. M-44s placed more than 30 feet away from livestock carcasses may, over time, come to violate this rule if scavengers drag the carcasses toward M-44 sets. This problem can be minimized by staking carcasses to keep them from moving. M-44 applicators are responsible for taking all reasonable precautions to ensure that no carcass or parts of any carcass are moved to within 30 feet of any M-44 device. The number of M-44 devices used with draw stations will not exceed the number authorized in either Use Restriction #15 or #16. Apparent contradictions between these rules will be resolved by using the limit imposed under the more restrictive rule.
17. Supervisors of applicators shall check the records, warning signs, and M-44 devices of each applicator at least once a year to verify that all applicable laws, regulations, and restrictions are being strictly followed.	Required checks will be conducted as part of supervisors' regular oversight, and will be documented on the "Field Inspection Report" (WS Form 82). Additionally, supervisors will complete the "Annual M-44 Sodium Cyanide Training" form (WS Form 40) during annual field inspections to document review of applicator's knowledge of M-44 guidelines and restrictions. Checks may be conducted more often, as necessary in the supervisors' opinion, but each applicator will be checked at least once each year. Inventory and use records of sodium cyanide will be in accordance to the CMITS requirements.
18. Each M-44 device shall be inspected at least once every week, weather permitting access, to check for interference or unusual conditions and shall be serviced as required.	This restriction means that M-44 devices must be inspected once during each calendar week. Weekly checks will be made and documented by each applicator using regular MIS (or equivalent replacement in the MIS 2000 system) reporting procedures. Each required M-44 check will be recorded on an MIS "Direct Control Work Task" showing the number of M-44s checked and fired (including 0 if none were fired). M-44s may be checked by cooperating ranchers. Cooperator checks will be limited to visual inspection to determine if devices have been disturbed or pulled, followed by verbal report to the applicator who will submit appropriate MIS documentation. Cooperators may not reset or handle the device and they should not disturb any animal taken with the device. Each required check that cannot be made due to adverse weather or for any other reason should be documented specifically for each property or agreement in MIS.

EPA Use Restriction (as written on Label)	WS Implementing Guideline
19. Damaged or nonfunctional M-44 devices shall be removed from the field.	Damaged or unserviceable devices (ejector, shell holder, and/or tube) will not be discarded in the field. They will be either removed or replaced by working units, as deemed appropriate by the applicator. Removal or replacement of damaged or nonfunctional M-44 devices requires no special documentation beyond routine reporting in an MIS Direct Work Task of the numbers of units set on the property.
20. A M-44 device shall be removed from an area if, after 30 days, there is no sign that a target predator has visited the site.	"Site" in this context means the property described in the work initiation document for wildlife damage management (WS Form 12A, 12B, and 12C). Documentation of predator damage to livestock anywhere on the ranch unit or allotment or other physical evidence of their presence will be regarded as evidence that a target predator has visited the site. M-44s will be removed when they are no longer needed. This decision will be made consistent with Use Restriction #7.
21. All persons authorized to possess and use sodium cyanide capsules and M-44 devices shall store such capsules and devices under lock and key.	M-44 capsules and devices will be stored under lock and key at all times when unattended, including when in transit. WS personnel will use locking metal boxes for this purpose. M-44 capsules may be transported in the cab or passenger compartment of a vehicle when in a locked pesticide storage box. At the end of the day, M-44 capsules will be locked in a pesticide storage box.
22. Used sodium cyanide capsules shall be disposed of by deep burial or at a proper landfill site. Incineration may be used instead of burial for disposal. Place the capsules in an incinerator or refuse hole and burn until the capsules are completely consumed. Capsules may be incinerated using either wood or diesel fuel.	The State Director shall consult with the local state pesticide authority to determine the proper disposal procedures of spent and/or defective capsules. If state pesticide regulations allow deep burial of defective capsules, the capsule shall be pinched with pliers to break the seal prior to burial. M-44 capsules disposal will be documented using the disposal transaction in CMITS. State-sponsored pesticide collection/container disposal programs qualify as proper disposal of M -44 capsules. Also, assistance for M-44 capsule disposal can be provided by the APHIS Safety Health and Environmental Protection Branch (SHEPB) at 301-436-3114.
23. Bilingual warning signs in English and Spanish shall be used in all areas containing M-44 devices. All such signs shall be removed when M-44 devices are removed. **a. Main entrances or commonly used access points to areas in which M-44 devices are set shall be posted with warning signs to alert the public to the toxic nature of the cyanide and to the danger to pets. Signs shall be inspected weekly to ensure their continued presence and ensure that they are conspicuous and legible.** **b. An elevated sign shall be placed within 25 feet of each individual M-44 device warning persons not to handle the device.**	Most people know nothing about M-44s and their hazards. Warning signs are the first line of defense against accidents. M-44 applicators should use as many warning signs as are needed to adequately post an area. Weekly inspections of proper placement and legibility of all warning signs is necessary to maintain proper signage and public notification requirements. All warning signs shall be removed when M- 44 devices are taken from the field. Be sure to place individual device signs so that the arrow points toward the device. In addition to placing warning signs, applicators must advise resource/land owners of the dangers of sodium cyanide, and the potential for death or injury to people, pets, and livestock if M-44s are misused. Ranchers and landowners are responsible to inform any persons entering their property of the presence and hazards of M-44 devices. In addition, applicators or cooperating landowners should personally warn neighbors and other persons in the area whose free-roaming pets might encounter M-44 devices. The USDA/APHIS/WS "M-44 Device for Local Predator Control" Fact Sheet can be used for these educational purposes. On properties where no fence lines exist to identify property boundaries or display warning signs, appropriate warning signs shall be erected to indicate that M-44 devices have been placed on the property ("premise sign") per Use Restriction 23(a). A WS authorized elevated sign ("device sign") as required by Use Restriction 23(b), must be securely anchored to a stake, post or wire and positioned vertically above ground level or hung from a low hanging tree limb in a manner that renders it clearly visible and noticeable from the device. One elevated device sign will be required for each M-44 device set. WS requires elevated device signs to be placed within 15 feet of each individual M-44 Device, a more stringent requirement than the Use Restriction.

EPA Use Restriction (as written on Label)	WS Implementing Guideline
24. Each authorized or licensed applicator shall also carry on his person instructions for obtaining medical assistance in the event of accidental exposure to sodium cyanide.	The M-44 applicator shall keep the phone number of the poison control center or local medical treatment facility readily available on their person.
25. In all areas where the use of the M-44 device is anticipated, local medical people shall be notified of the intended use. This notification may be through a poison control center, local medical society, the Public Health Service, or directly to a doctor or hospital. They shall be advised of the antidotal and first-aid measures required for treatment of cyanide poisoning. It shall be the responsibility of the supervisor to perform this function.	Where local hospitals and medical centers rely on poison control centers for help in treating poisoning cases, notification of the poison control centers will meet this requirement. If hospitals in an applicator's area do not use or have access to a poison control center, hospitals and medical clinics should be notified individually. Such written notifications will be made by State Office personnel, District Supervisors, or the designated field personnel in the local area where M-44s are to be used. Copies of written materials serving as proof that the required notifications were made should be kept at the State Office. Notifications should be made annually or at intervals deemed sufficient by the State Director.
26. Each authorized M-44 applicator shall keep records dealing with the placement of the device and the results of each placement. Such records shall include, but need not be limited to: **a) The number of devices placed.** **b) The location of each device placed.** **c) The date of each placement, as well as the date of each inspection.** **d) The number and location of devices which have been discharged and the apparent reason for each discharge.** **e) Species of animals taken.** **f) All accidents or injuries to humans or domestic animals.**	In general, applicator's records must be detailed enough to account for the whereabouts of all M- 44 equipment and capsules, as well as for all results of M-44 use. Items 26 (a), (c), and (e) will be recorded in MIS "Direct Control Work Task section". For purposes of items (b) and (d), location is defined as the GPS locations and by MIS agreement number, respectively. Each date of inspection (item c) of M-44s set on each property will be recorded on a separate work task. Each required check that cannot be made due to adverse weather or for any other reason will be documented, specifically for each property or agreement. If a State pesticide regulatory agency requires M-44 location information to be recorded in a different format, then the applicator must adhere to that requirement unless concurrence to do otherwise has been obtained. The apparent reason for discharge (item d) normally will be recorded only when the applicator can identify the apparent reason. Applicators will not speculate about apparent reason(s) for discharge when evidence is lacking. When the applicator does not report a reason for a discharge, this will be interpreted to mean that the cause was unknown. If the State Director or supervisor determines that reasons for discharge need to be documented in greater detail than is possible in MIS, the supervisor will direct the employee as to what report format to use. Accidents or injuries to humans or non-target domestic animals (item f) will be reported verbally to the supervisor and thereafter in writing on 6(a)(2) Adverse Incident Report (WS Form 160), and as further directed by the supervisor. Accidents or injuries to humans or non-target domestic animals (item f) will be reported verbally to the supervisor and thereafter in writing on 6(a)(2) Adverse Incident Report (WS Form 160), and as further directed by the supervisor. In addition to the records mandated by this Use Restriction, WS applicators are required to provide pesticide application records to each cooperator or landowner within 30 days of applying pesticides. WS M-44 applicators can comply with this regulation by notifying the landowner/cooperator in writing that WS will maintain these records, if the landowner agrees, and will provide copies upon request. The "Agreement for Control" form (WS Form 12A, JUL 09 edition) includes the above notification.