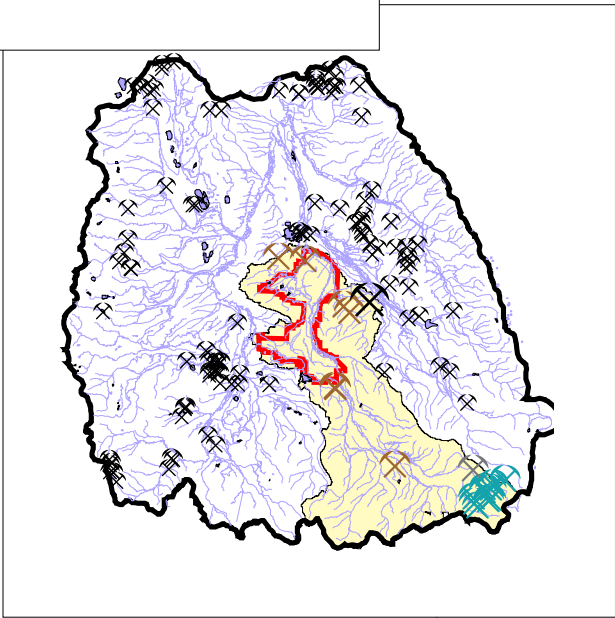
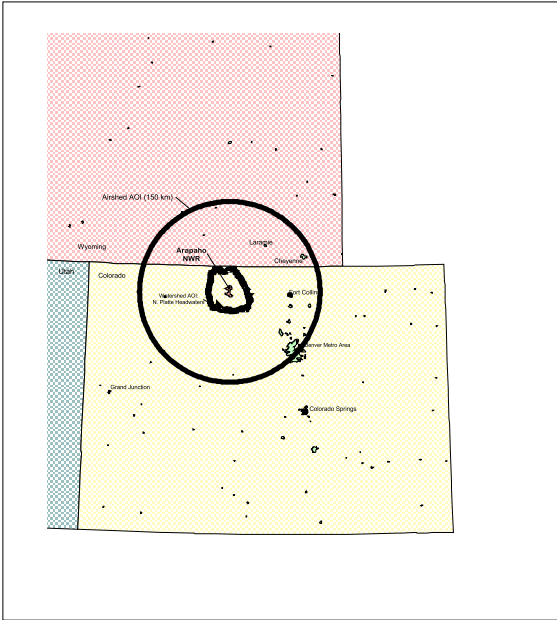
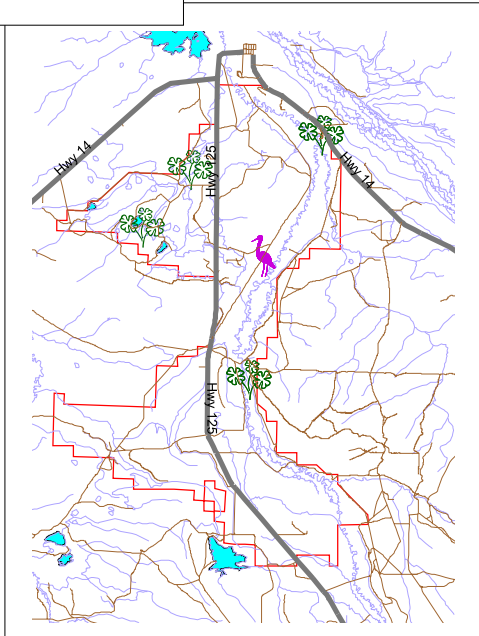


# Contaminant Assessment Process Report for Arapaho National Wildlife Refuge



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U.S. Geological Survey



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## 1.0 Introduction

The Biomonitoring of Environmental Status and Trends (BEST) program identifies and evaluates the effects of environmental contaminants on lands and biological resources managed by the Department of the Interior (DOI). The primary goals of the BEST program are: 1) determine the status and trends of environmental contaminants and their effects on biological resources, 2) identify, assess, and predict the effects of contaminants on ecosystems and biological populations, and 3) provide summary information to managers and the public for guiding conservation efforts. One tool used to reach these goals is the Contaminant Assessment Process (CAP). CAP is a two-part process involving a retrospective analysis of existing information to assess contaminant threats to lands managed by DOI bureaus. On refuges, this analysis is conducted by the U.S. Fish and Wildlife Service and funded by BEST. Secondly, if a likely or suspected contaminant issue is identified in the first part of the CAP process, sampling is conducted to confirm the presence of contaminants or their effects.

The retrospective analysis involves reviewing existing documentation and spatial information for the land unit of interest. Contaminant sources and pathways (i.e. rivers, prevailing wind direction, ground water) are identified. Contaminants of concern (COCs) and potentially sensitive species are described. Areas of likely contamination within the land unit are defined and ranked. The findings are summarized in a preliminary report. If warranted, field sampling is conducted to further evaluate potential threats. Field sampling is of a confirmatory nature, designed to determine if contaminants are present or causing an effect on resources.

Another purpose of the CAP is to identify lands that may be vulnerable to spills of hazardous substances. Once these areas are identified, resources (soils, water bodies, biota) can be targeted for collection of baseline data to support any future natural resource damage assessments.

In 1996, the U.S. Fish and Wildlife Service, Colorado Field Office, Environmental Contaminants Program, Lakewood (CFO) initiated and completed the retrospective analysis of CAP for the Arapaho National Wildlife Refuge (Refuge). In 2001, the retrospective analysis was updated by the CFO using a geographic information system (GIS). The retrospective analysis identified contaminant sources and transport pathways to the Refuge. The contaminant sources and types were prioritized, and areas of potential contamination within the Refuge were delineated. This report summarizes these sources and areas of potential contamination. Spatial and tabular information were incorporated into the CAP and were managed using a GIS. Data were collected from federal and state databases (Appendix A). The products of this assessment include this report and the GIS project that incorporates all information collected.

## ***1.1 CAP Overview***

The contaminant assessment first identifies contaminant transport mechanisms by which pollutants can reach and affect Refuge resources. Secondly, sources releasing contaminants via any one of the mechanisms are identified and ranked. Finally, any contaminant with a high likelihood of affecting Refuge resources, potentially contaminated areas, and receptors are cataloged into a GIS theme.

There are four mechanisms by which contaminants can affect Refuge resources-surface water, ground water, air, and biota. For each mechanism, contaminant transport pathways are defined



(streams, aquifers, prevailing winds, migratory birds) and an area of interest (AOI) is set. Areas of interest are the areas surrounding all pathways associated with a given transport mechanism. For each mechanism, an individual AOI is defined and contaminant sources within each AOI are identified.

Contaminant sources within each AOI are cataloged into the GIS if they have releases that would affect the Refuge via the specified pathway (e.g., facilities with air discharges are cataloged in the air pathway AOI) and ranked. Ranking is based on proximity to the Refuge, direction from the Refuge (upstream, downstream), volume of contaminants released, and reported toxicity of contaminants. Contaminants with the highest ranking are defined as Contaminants of Concern (COCs) and receive additional scrutiny.

Biological receptors within the Refuge are identified for each COC. Criteria for selecting receptors include susceptibility and location. Receptors for each COC must be exposed and susceptible to deleterious effects by that COC. The range of the receptor and boundary of the particular transport mechanism carrying the COC to the Refuge must overlap. The area where such overlap occurs is designated as a potentially contaminated area (PCA) and is the area in which confirmatory sampling may be undertaken. PCAs are sites that are likely to contain elevated concentrations of suspected contaminants or may permit earlier detection of contaminant-related effects compared to randomly selected sites in the Refuge.

As mentioned above, a secondary purpose of the CAP is to identify areas that, due to their proximity to transportation corridors, could be affected by future spills of hazardous materials.

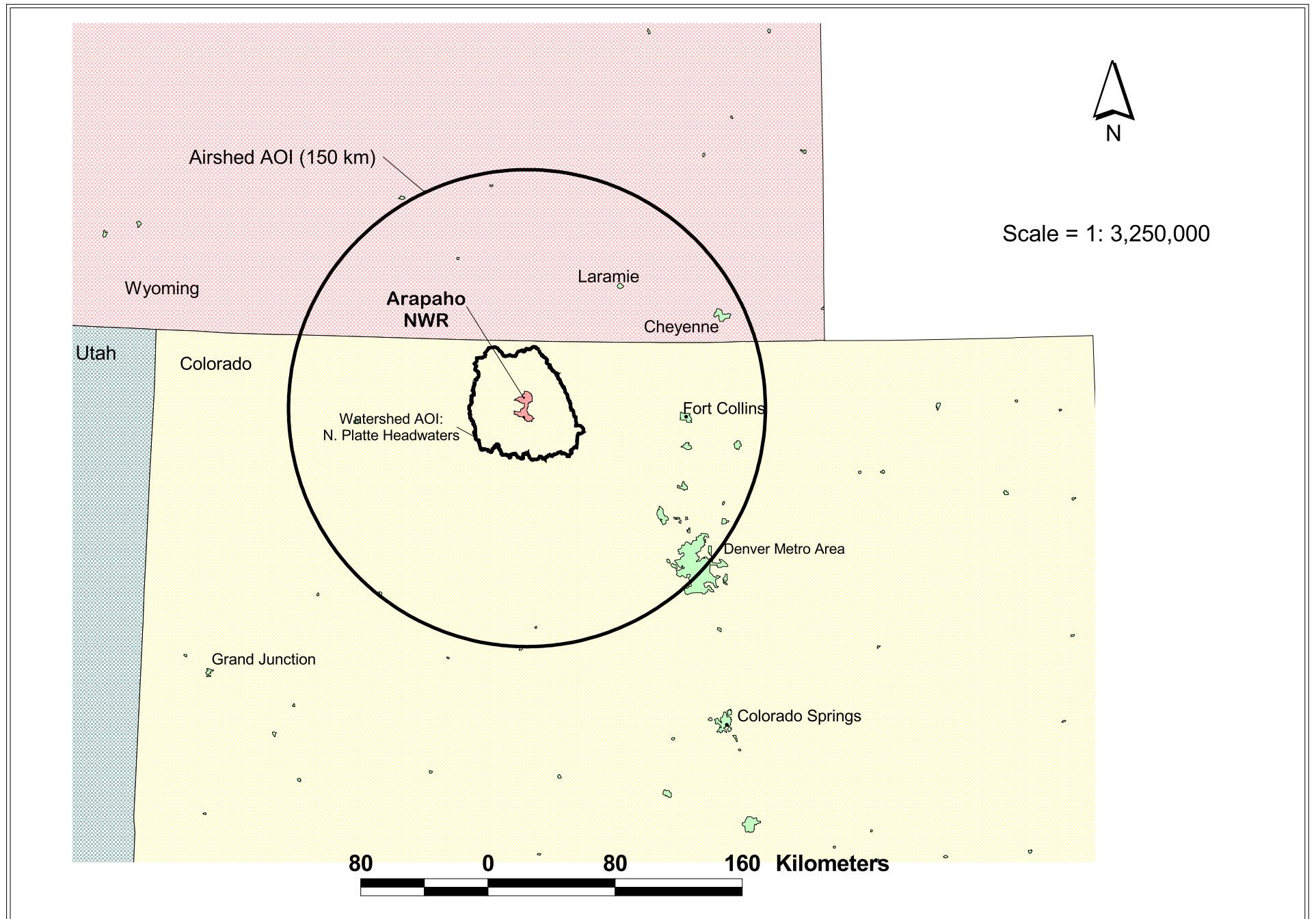
The areas identified are designated baseline sampling areas (BSAs). Measurements taken at BSAs are intended to document pre-spill conditions and could be useful to demonstrate injury to Refuge resources in the event of a hazardous material spill.

## ***1.2 Refuge Overview***

Arapaho National Wildlife Refuge was created in 1967 to provide suitable nesting habitat for waterfowl, in part, to offset losses of nesting habitat for migratory birds in the prairie wetland region of the Midwest. The Refuge is located in an intermountain glacial basin south of Walden, Colorado in an area of the state known as “North Park” (Figure 1). North Park opens north into Wyoming and is rimmed on the west by the Park Range, on the south by the Rabbit Ears Mountains, on the southeast by the Never-Summer Range, and on the east and northeast by the Medicine Bow Range. Numerous slow, meandering streams are interspersed on the basin floor and eventually come together to form the headwaters of the North Platte River.

Encompassing approximately 23,267 acres and ranging in elevation from 8100 to 8700 feet, the Refuge is climactically classified as a cold desert. The Refuge consists of irrigated and sub-irrigated meadows, sagebrush grasslands, natural and manmade wetlands, riparian willow and stream habitats. Because the Refuge does not receive much rainfall (10-15 inches per year), water is diverted from the Illinois River through a complex ditch system to irrigate meadows and fill waterfowl brood ponds.

**Figure 1. Location of Refuge and Areas of Interest (AOIs)**



### 1.2.1 Biological Resources

Arapaho NWR is a major breeding and migratory stopping ground for a large number of migratory birds and waterfowl, making the area a popular bird watching destination. Over 200 species of birds have been documented on the Refuge including sage grouse, black-crowned night-heron, white pelican, prairie falcon, and golden eagle. Peregrine falcons and bald eagles, a Federally listed threatened species, both occasionally visit the Refuge, but are not known to nest there. Greater sandhill cranes, a State species of special concern, nest in the area and frequently visit the Refuge. As an example of the diversity of avian species, the following species were observed during a one day visit to the Refuge in May, 2002:

Western Meadowlark	Killdeer	Wilson's Phalarope	Black-billed Magpie
White Pelican	Green-winged Teal	American Coot	Northern Shoveler
Gadwall	Northern Harrier	Canada Goose	Northern Pintail
Red-winged Blackbird	Prairie Falcon	Mallard	Common Grackle
Tree Swallow	Double-crested Cormorant	Redhead	Horned Lark
American Widgeon	Cliff Swallow	Eared Grebe	Golden Eagle
Swainson's Hawk	White-crowned Sparrow	Lesser Scaup	
Violet-green Swallow	Yellow Warbler	Cinnamon Teal	
American Avocet	Willet	Savannah Sparrow	

Mammals on the Refuge include an abundance of moose, which were reintroduced into the Illinois River drainage and North Park in 1978. Other mammals on the Refuge include elk, white-tailed and mule deer, pronghorn antelope, coyote, Wyoming ground squirrel, and white-tailed prairie dog. River otter, a State listed endangered species, are rarely spotted on the Refuge. However, tracks and slides have been seen on the Illinois River within the Refuge.

In 1995, the wood frog, a State listed threatened species, was found in boggy areas of the Refuge. Due to this observation and many others in northern Colorado, the wood frog was reclassified as a State species of special concern in 1998. Other reptiles and amphibians found on the Refuge include leopard frogs, chorus frogs, and garter snakes.

Upland areas of the Refuge are important to two plants of concern. Wild chives (*Allium schoenoprasum*), which are critically imperiled according to the Colorado Natural Heritage Program, are plentiful in the grassland and meadow habitat on the Refuge. North Park phacelia (*Phacelia formosula*) is a federally listed endangered species endemic to North Park that occurs in the uplands. Sagebrush is the predominant species in the uplands. Riparian plants in the area include willows, sedges, baltic rush, and long-styled rush which are important cover for bird species along the Illinois River and other streams of the Refuge. Cottonwood trees are uncommon on the Refuge. Aquatic plants include cattail and pond weed and the wet meadows are dominated by timothy grass.

## **2.0 Contaminant Assessment Rationale, by Pathway**

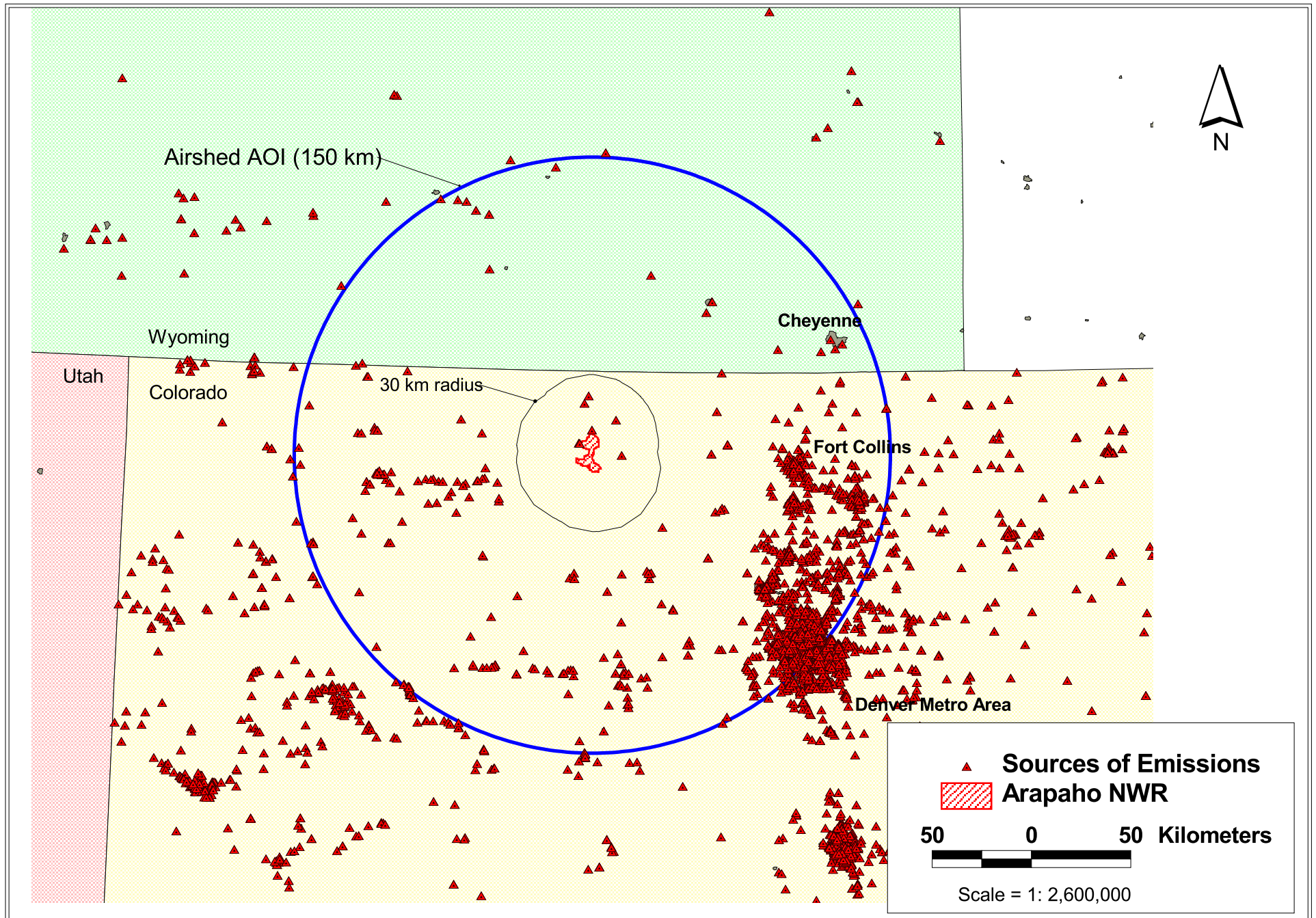
### **2.1 Air Pathway**

#### **2.1.1 Summary**

The air transport of pollutants is one mechanism by which the Refuge receives some of its pollutant load. The significance of this pathway is minimal due to the remote and upwind location of the Refuge from major pollutant sources in the Colorado- Wyoming region (Figure 2).

To catalog all emissions potentially affecting the Refuge and create a region that would encompass all emissions that may influence the Refuge, the airshed for the Refuge would have to be hemispheric or global. Cataloging emissions sources within such an area and calculating their

Figure 2. Airshed AOI and Sources of Emissions



relative pollutant effect on the Refuge would be impossible. Therefore, for this assessment, an air-pathway Area of Interest (AOI) or airshed extending from the Refuge is defined as a 150 km radius for stack emissions and 30 km radius for fugitive emissions (Figure 2). This is the general standard set within the guidelines for CAP. Although this AOI may contain sources that reach the Refuge, some pollutants (e.g., sulfur oxides, nitrogen oxides, mercury) are known to be transported much longer distances. The long-range transport and deposition of air pollutants was addressed by evaluating isopleth maps developed by the National Acid Deposition Program (NADP) and the Mercury Deposition Network (MDN). (Appendix B)

Within the 150 km AOI, over 1800 point sources emitting criteria pollutants were cataloged. Criteria pollutants are air pollutants for which the Environmental Protection Agency (EPA) has established “primary” standards to protect public health, and “secondary” standards to protect other aspects of public welfare, such as preventing materials damage, preventing crop and vegetation damage, or assuring visibility. These standards are the National Ambient Air Quality Standards (NAAQS) (Appendix C). Carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), lead (Pb), particulate matter (PM<sub>10</sub>), and sulfur dioxide (SO<sub>2</sub>) are criteria pollutants.

Air toxics, also known as hazardous air pollutants (HAPs), include pollutants that are known or suspected to cause cancer and/or other serious health effects, such as birth defects or reproductive effects. The EPA lists 189 air toxics. Stack or point air emissions are releases that occur through stacks, vents, ducts, pipes, or other confined air streams, as well as storage tank emissions and air releases from air pollution control equipment. Fugitive or Non-Point Air Emissions are those not released through stacks, vents, ducts, pipes, or any other confined air

stream. Included in this category are equipment leaks from valves, pump seals, flanges, compressors, sampling connections, open ended lines, etc.

There are no sources of fugitive emissions of air toxics within 30 km of the Refuge provided in the GIS system from the USGS, therefore there are no threats to the Refuge from fugitive emissions.

### **2.1.2 Prevailing Wind Direction**

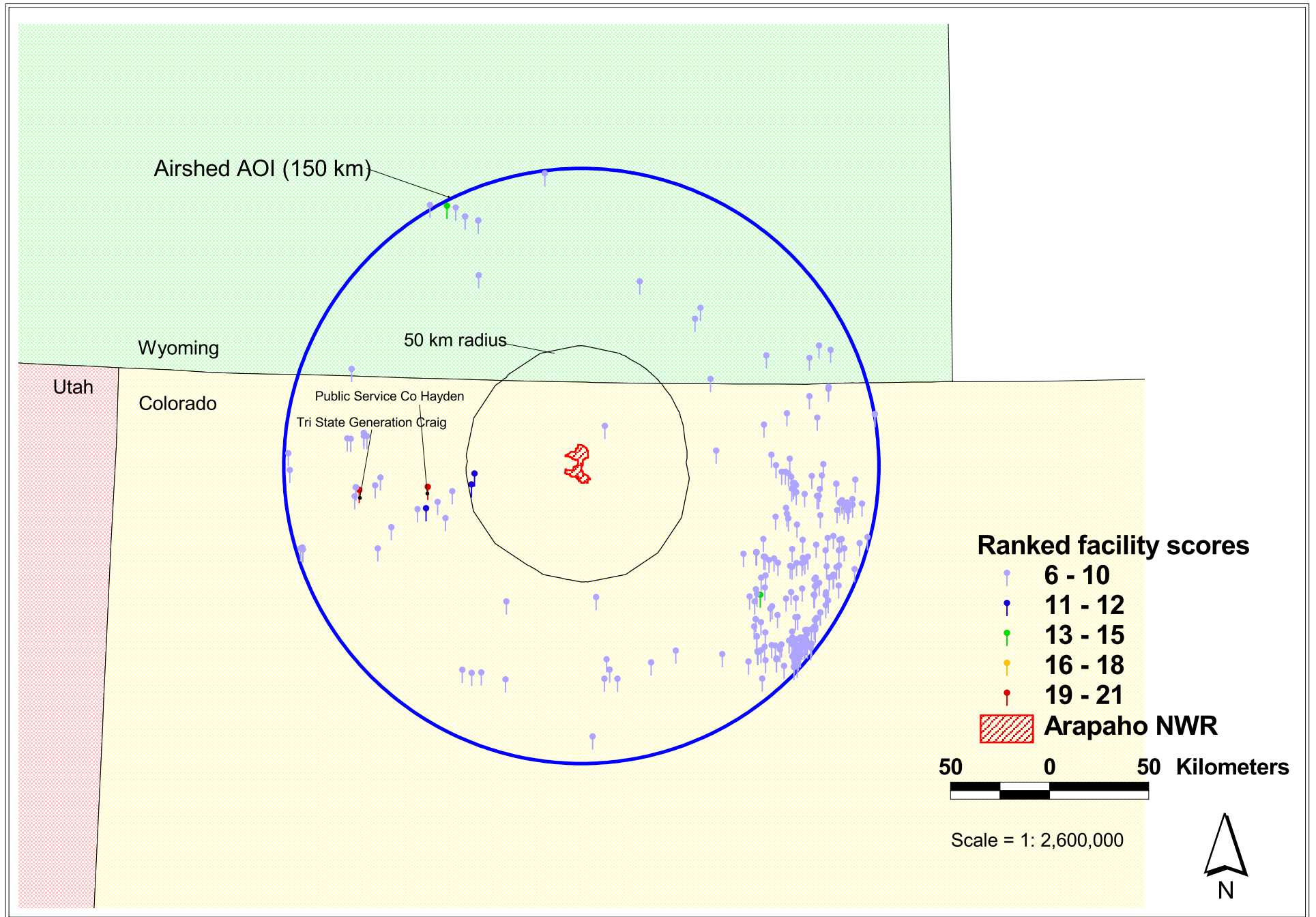
As described by Refuge staff, the prevailing wind direction for the Refuge is from the southwest. No wind data have been collected on the Refuge or nearby. Pollutant sources from the southwest are most likely to contribute pollutants to the Refuge.

### **2.1.3 Ranking Scheme**

Of the 1881 sources of pollutants within the 150 km AOI, 256 sources were selected based on the mass of pollutants emitted per year (Figure 3). These sources were chosen because they emitted greater than 10 tons per year of any criteria pollutants named above. These 256 sources were ranked based on volume of pollutant emitted, proximity to the Refuge, and direction from the Refuge (Table 1). Each criteria pollutant was scored separately and added for a total score for the source. The total scores for the sources ranged from 7 to 21. There were 10 sources with a score of 11 or higher which were considered the sources of highest concern (Table 2).



Figure 3. Airshed AOI and Ranked Emissions



**Table 1.** Scoring scheme for criteria pollutant sources within 150 km of Refuge

Volume	Score	Distance	Score	Direction	Score
>10,000 tpy	6	<50 km	3	SW	4
5000-10,000 tpy	5	50-100 km	2	NW	3
2000-5000 tpy	4	100-150 km	1	SE	2
1000-2000 tpy	3			NE	1
500-1000 tpy	2				
<500 tpy	1				

tpy – tons per year

**Table 2.** Air sources with ranking score greater than 10

Facility Name	State	County	Standard Industrial Classification	Facility ID	Volume Score	Direction Score	Distance Score	Total Score
Tri State Generation Craig	CO	Moffat Co	4911 - Electric Services	80810018	16	4	1	21
Public Service Co Hayden	CO	Routt Co	4911 - Electric Services	81070001	15	4	2	21
Trigen - Colorado Energy Corporatio	CO	Jefferson Co	4961 - Steam Supply	80590820	10	2	1	13
Public Service Co Valmont	CO	Boulder Co	4911 - Electric Services	80130001	10	2	1	13
Sinclair Oil Corp	WY	Carbon Co	2911 - Petroleum Refining	560070001	9	3	1	13
Conoco Inc Denver Refinery	CO	Adams Co	2911 - Petroleum Refining	80010003	8	2	1	11
Southwestern Portland Cement	CO	Boulder Co	3241 - Cement, Hydraulic	80130003	7	2	2	11
Seneca Coal Co	CO	Routt Co	1221 - Bituminous Coal & Lignite -	81070069	5	4	2	11
Routt Cnty Road & Bridge Dept Carve	CO	Routt Co	1442 - Construction Sand And Grave	81070033	4	4	3	11
Duckels Const Inc	CO	Routt Co	1442 - Construction Sand And Grave	81070032	4	4	3	11

\* total score &gt;10 = highest concern – per ranking

## **2.2 Surface Water Pathway**

### **2.2.1 Summary**

The surface water AOI boundary for the Refuge is the North Platte Headwaters watershed (Hydrologic Unit Code (HUC)# 10180001). Federal RCRA, CERCLA, TRI, PCS, mining, and oil and gas well sites within the watershed were cataloged into the GIS (Figure 4). RCRA (Resource Conservation and Recovery Act, 1976) sites are those facilities that are permitted to generate, transfer, treat, store or dispose of hazardous waste (as defined by federal hazardous waste codes). CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act, 1980) sites are sites with known hazardous waste contamination which are listed on the National Priorities List (NPL), or sites which are considered for listing. TRI (Toxic Release Inventory, as mandated by the Emergency Planning and Community-Right-to-Know Act, 1986) sites are facilities that release or transfer any of 650 toxic chemicals and compounds to the water. PCS (Permit Compliance System, as mandated by the Clean Water Act, 1977) sites are those facilities holding permits (National Pollutant Discharge Elimination System, NPDES permits) to discharge effluent into navigable waters. At the local level, other potential contaminant sources were also examined such as pesticide use and roadways.

### **2.2.2 Surface Water Flow Direction**

In general, water in the Refuge flows from south to north. The primary waterway through the Refuge is the Illinois River. It drains rangeland, pasture, and hayed meadows, and its water is diverted by fifteen headgates into about 70 miles of primary irrigation ditches. Secondary and spreader ditches flood irrigate up to 8,000 acres of meadow to create wetlands. Tributaries to the Illinois, Potter Creek and Antelope Creek, are also used for irrigation on the Refuge. Deer Creek and Spring Creek also flow into the Refuge (Figure 5).

Figure 4. Potential Sources of Contamination Within N. Platte Headwaters Watershed

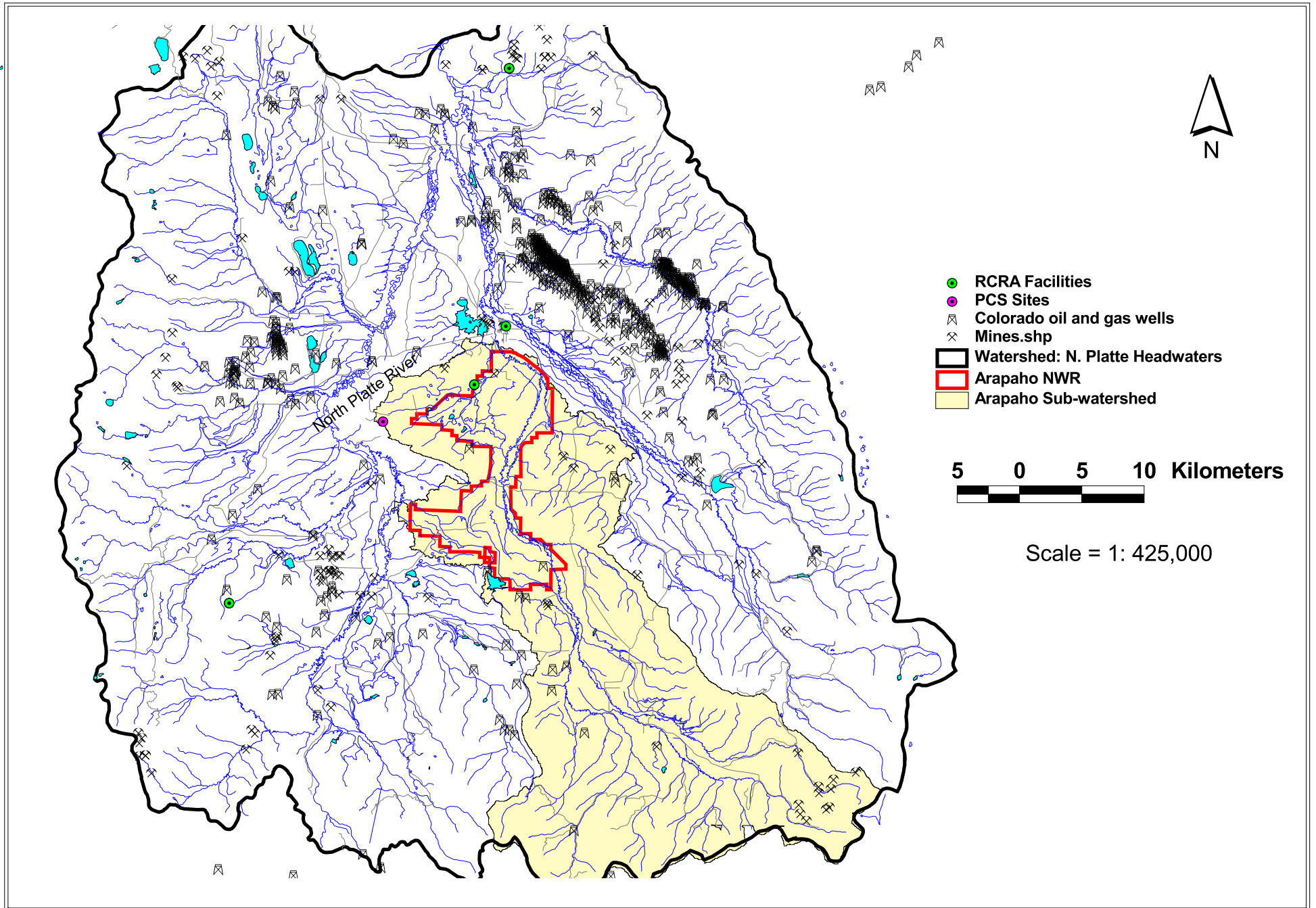
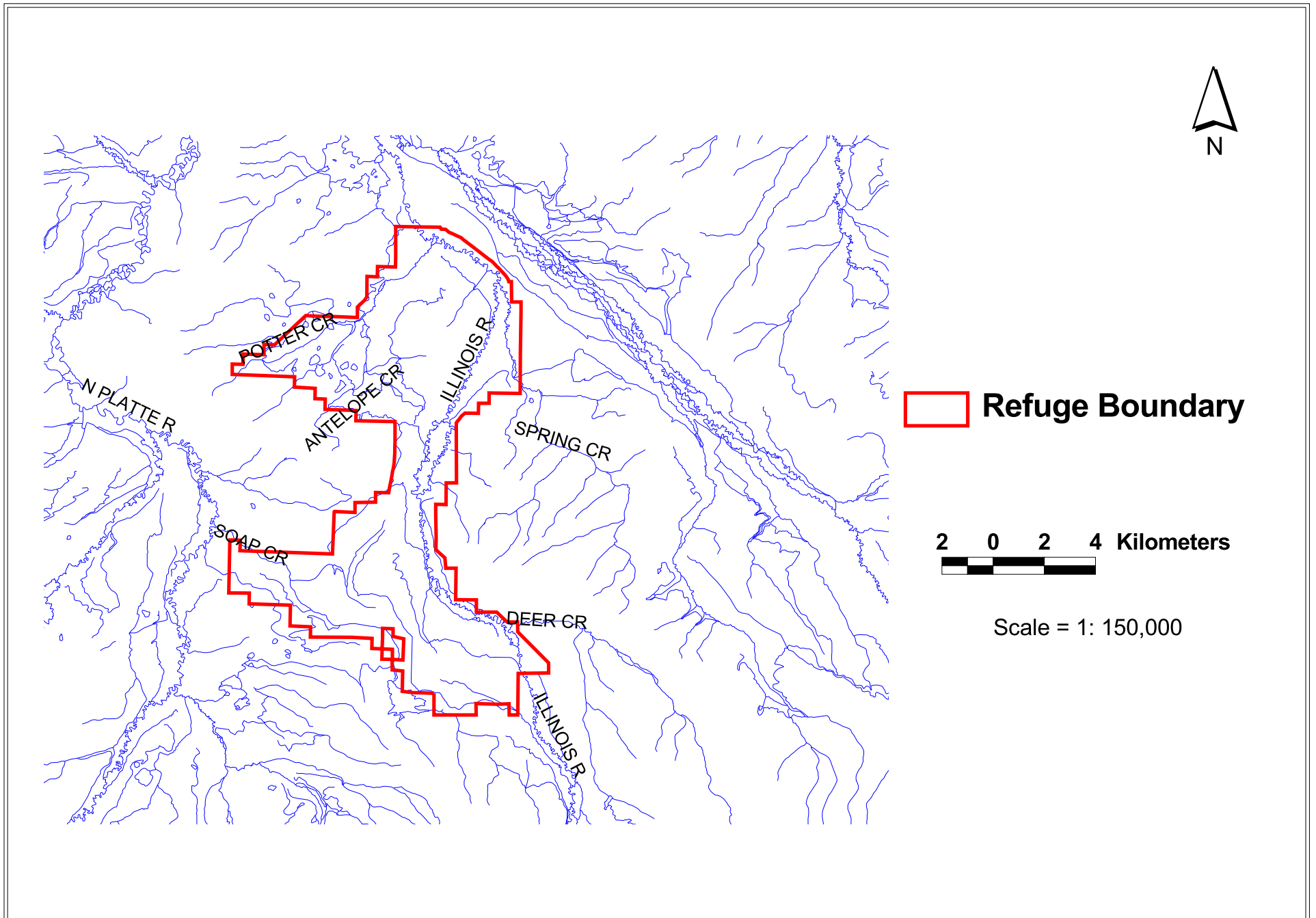


Figure 5. Surface water streams entering the refuge



### **2.2.3 Ranking Scheme**

A sub-watershed was created from the watershed digital elevation model (DEM) using ArcView's Spatial Analyst Extension which shows all areas providing surface flow onto the Refuge (Figure 4). Sources within this sub-watershed were ranked based on their proximity to the Refuge, proximity to surface water flows, and type of production.

## **2.3 Ground Water Pathway**

### **2.3.1 Summary**

The ground water AOI is the North Platte Headwaters watershed. For this AOI, we evaluated landfills and underground storage tanks.

### **2.3.2 Ground Water Flow Direction**

As with the surface water, the groundwater flows generally from south to north.

### **2.3.3 Ranking Scheme**

Landfills and underground storage tanks were reviewed on an individual basis. Neither of these source types were entered in the GIS since State databases do not provide sufficient location information to enter the sites spatially. Sites listed within the State databases were reviewed based on proximity and direction from the Refuge.

### **3.0 Contaminant Assessment Findings, by Pathway**

#### **3.1 Air Pathway**

##### **3.1.1. Pollutant Sources of Highest Concern**

###### **3.1.1.1. 50 km**

Within 50 km of the Refuge, 16 sources of pollutants were identified. Three of these locations met the ranking criteria of emitting more than 10 tons of any criteria pollutant per year (Figure 3). The lowest ranking site, Rocky Mountain Natural Gas Company, is located northeast (downwind) of the Refuge, emits small amounts of pollutants, most notably NO<sub>x</sub> (17 tons per year), and received a ranking score of 7. Therefore, this site is of low concern.

The other two locations, Routt County Road & Bridge Department and Duckels Construction, Inc., are considered sources of highest concern per the ranking criteria. They received highest scores in distance (<50 km) and direction (SW), however, both received the lowest possible score for volume of pollutants emitted (score of 4). Their only pollutant that fit the criteria was PM<sub>10</sub> (15 and 24 tons per year respectively). Although the ranking scores suggest high concern, because of the low volume of pollutants, these two sites are of low concern.

###### **3.1.1.2. 150 km**

There are eight sources of highest concern beyond 50 km but within the 150 km AOI. (Table 3) Three sources are southwest of the Refuge. One source is located to the northwest, and four sources are located to the southeast of the Refuge. (Figure 3)

Two sources of highest concern for the Refuge are Tri State Generation in Craig and Public Service Company in Hayden. Both have high NO<sub>x</sub> emissions and are located southwest of the

Refuge. These sources have the greatest potential to affect Refuge resources. However, their direction is more directly west from the Refuge than southwest. Since the prevailing winds are primarily from the southwest, it is likely that the impacts are reduced. Although additional air pattern data may help indicate where pollutants from these locations may migrate to, National Atmospheric Deposition Program sampling sites indicate no problems.

**Table 3.** Emissions of pollutants from sources of highest concern between 50 km and 150 km (tons per year)

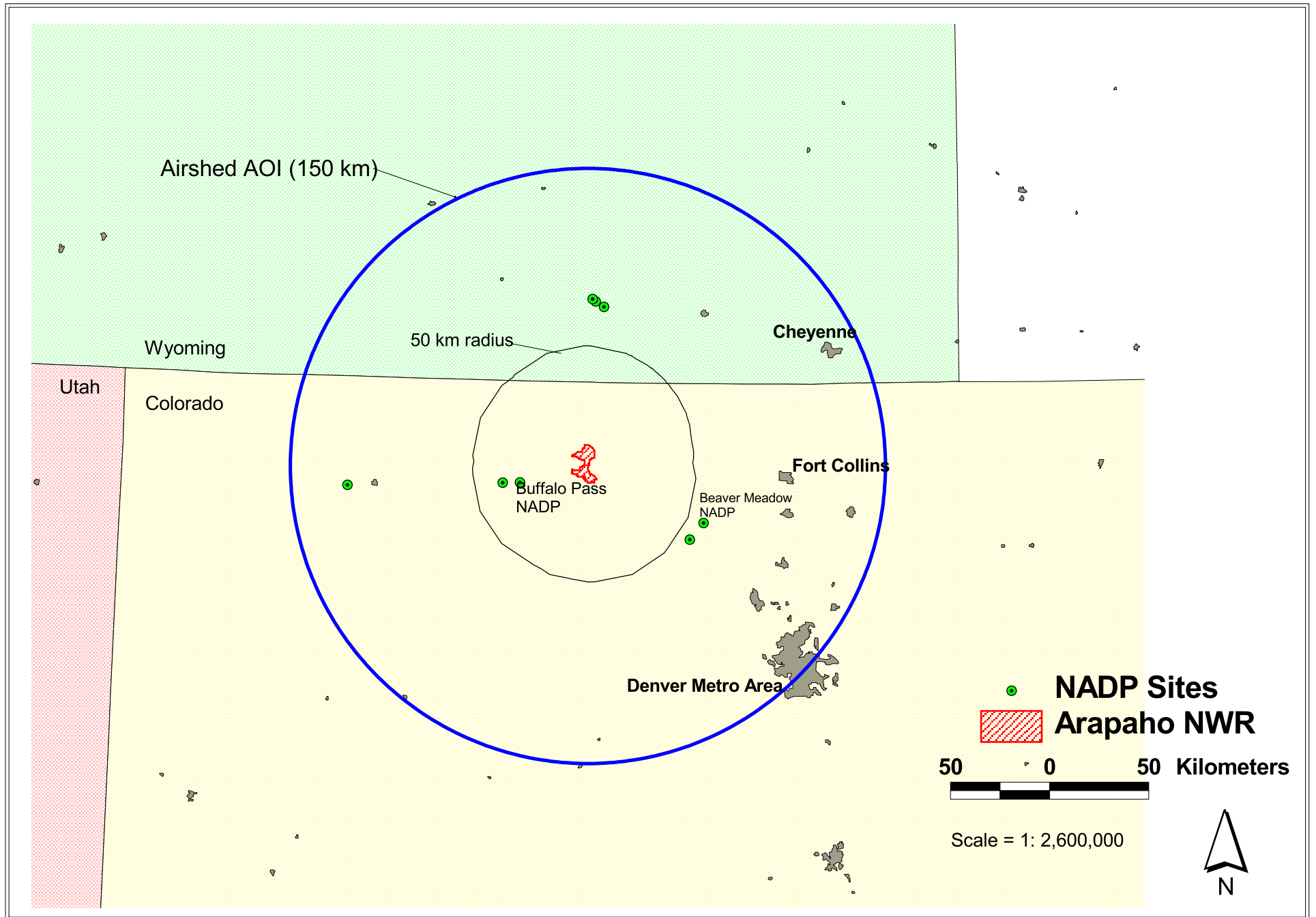
Facility Name	CO Emissions	NOX Emissions	PM10 Emissions	SO2 Emissions	State	County	Total Score
Tri State Generation Craig	1096.0000	13838.0000	728.0000	9068.0000	CO	Moffat Co	21
Public Service Co Hayden	394.0000	13163.0000	666.0000	13985.0000	CO	Routt Co	21
Trigen - Colorado Energy Corporation	279.0000	2442.0000	30.0000	4574.0000	CO	Jefferson Co	13
Public Service Co Valmont	138.0000	2215.0000	282.0000	4780.0000	CO	Boulder Co	13
Sinclair Oil Corp	362.0000	1474.0000	210.0000	3990.0000	WY	Carbon Co	13
Conoco Inc Denver Refinery	340.0000	998.0000	206.0000	2617.0000	CO	Adams Co	11
Southwestern Portland Cement	121.0000	1708.0000	552.0000	160.0000	CO	Boulder Co	11
Seneca Coal Co	0.0000	0.0000	545.0000	0.0000	CO	Routt Co	11

Total Score derived from emissions, direction and distance from the Refuge. See section 2.1.3

Two National Atmospheric Deposition Program (NADP) sampling sites were examined for pollutant concentrations of ammonium (NH<sub>4</sub>), nitrate (NO<sub>3</sub>) and sulfate SO<sub>4</sub> (Figure 6). Buffalo Pass and Beaver Meadow – Rocky Mountain National Park stations are located approximately 35 km west and 65 km southeast of the Refuge respectively. They were chosen because of proximity to the refuge and availability of quality data. Although NADP data criteria were not met for many of the years, trends in the data can still be seen (Figure 7). Ammonium trends at

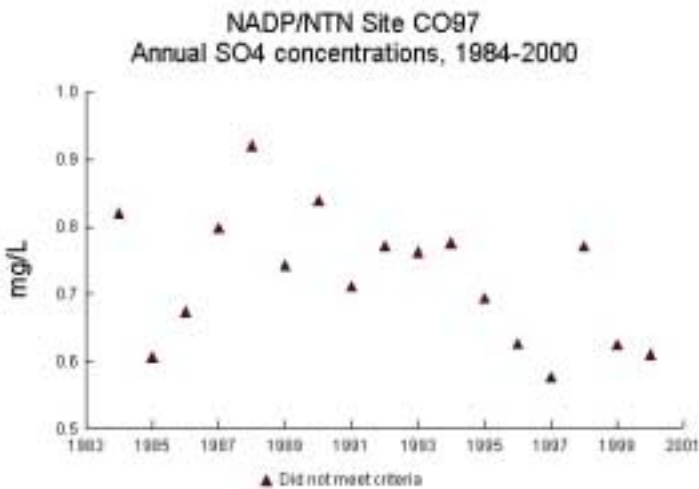
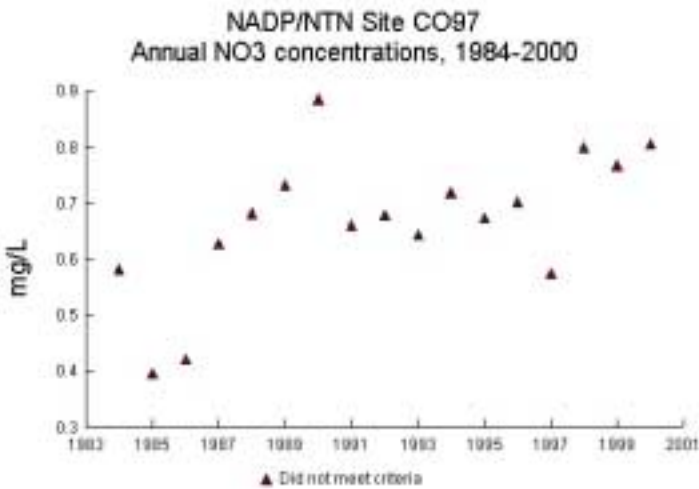
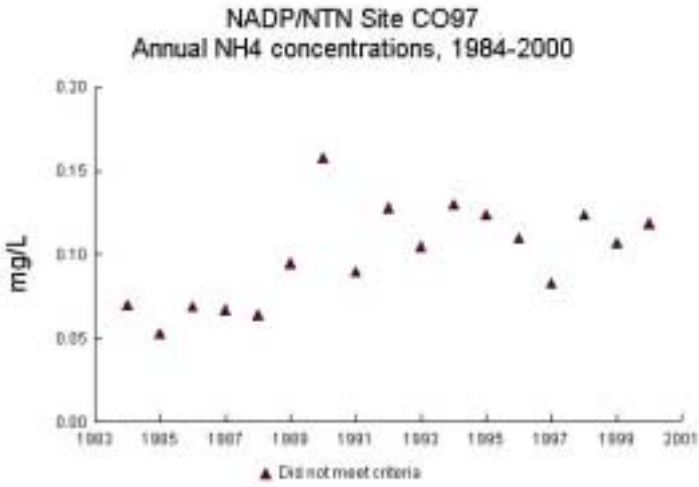


Figure 6. NADP Locations within Air AOI

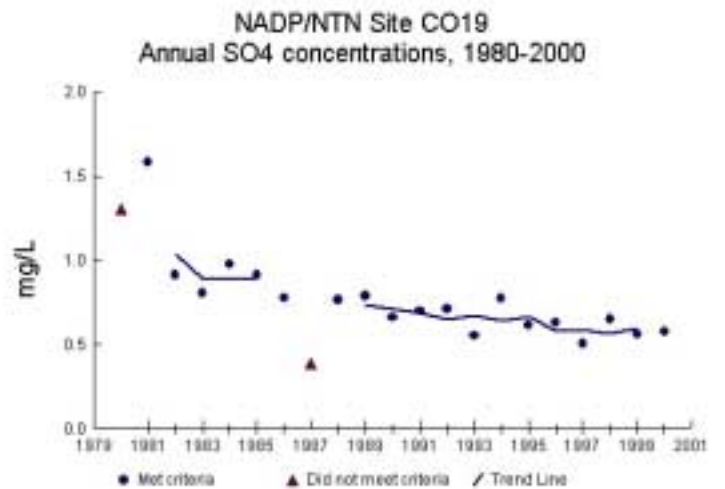
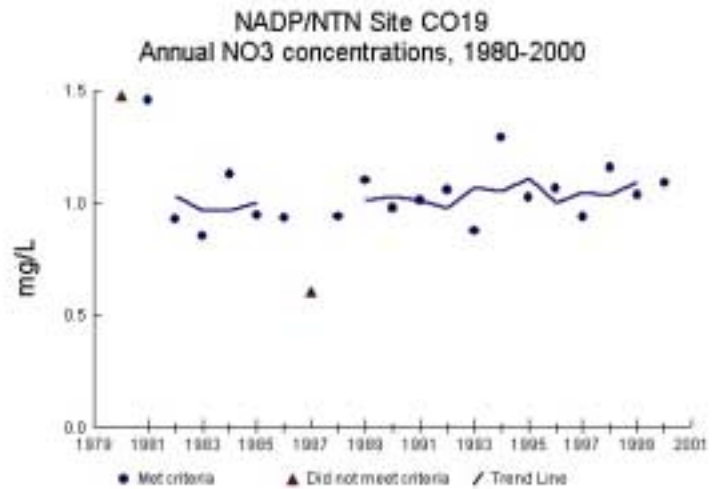
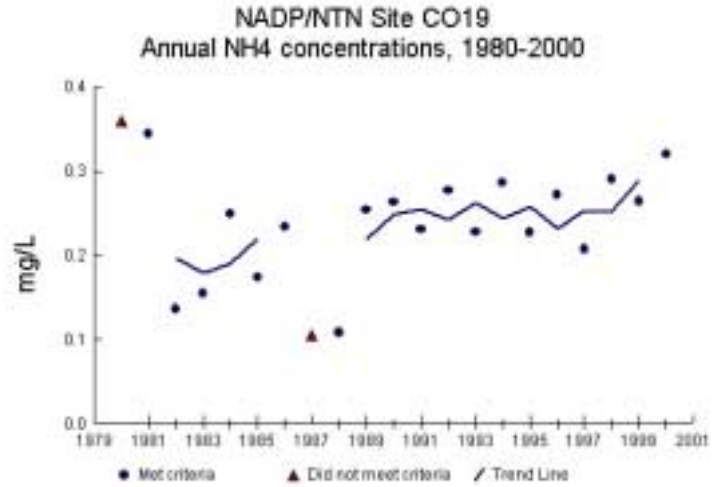


**Figure 7 - National Atmospheric Deposition Program Graphs**

**Buffalo Pass**



**Beaver Meadow**



both Buffalo Pass and Beaver Meadow show a gradual increase in concentration, with higher concentrations at the Beaver Meadow station. Nitrate concentrations show a gradual increase while sulfate concentrations show a declining trend. Again, the Beaver Meadow concentrations were higher than Buffalo Pass. Although there are no major emitters between the two stations, the Beaver Meadow station may have higher concentrations of pollutants due to its closer proximity to larger Front Range cities (e.g. Denver, Fort Collins), and because upslope winds may carry those pollutants from the east.

#### 3.1.1.3 Greater than 150 km

It is nearly impossible to predict specifically where air contaminants come from over a large distance. However, deposition and current nationwide air sampling concentrations are used to model predicted concentrations. The National Atmospheric Deposition Program and National Trends Network has created a series of nationwide isopleth maps (Appendix B) that show estimated deposition and concentrations of various contaminants. These maps show low estimated hydrogen, sulfate, nitrate, ammonium, calcium, magnesium, potassium, and chloride ion deposition in the vicinity of the Refuge. The maps also show low concentrations of these elements in the area. Therefore, there appears to be no or very little threat to the Refuge from sources greater than 150 km away.

## **3.2 Surface Water Pathway**

### **3.2.1 Pollutant Sources of Highest Concern**

#### 3.2.1.1 RCRA Facilities

RCRA Facilities may potentially affect the environment by accidental releases of hazardous waste. They are potential sources of contamination, but not necessarily current sources. There are 10 RCRA facilities within the North Platte Headwaters watershed (Figure 4). None of these facilities are large quantity generators (>1000 kg hazardous materials per month) that are required to report to the EPA Biennial Reporting System (42 USC § 9621).

Three sites (Louisiana Pacific, Conoco Walden Transport Terminal, and Walden WYO Fuel Co.) found in the same location on the map, have the potential to impact the extreme northwest section of the Refuge. Because these sites are small generators of hazardous materials, and unless there is a release of hazardous materials that may enter the adjacent waterways, the threat of contamination from these sites is small. The other seven facilities are downstream of the Refuge, therefore, their impact is non-existent.

#### 3.2.1.2 CERCLA Sites

There are no CERCLA or CERCLIS sites within the North Platte Headwaters watershed, therefore, there are no threats from CERCLA sites to the Refuge.

#### 3.2.1.3 TRI Facilities

There are no TRI facilities within the North Platte Headwaters watershed, therefore, there are no threats from TRI facilities to the Refuge.

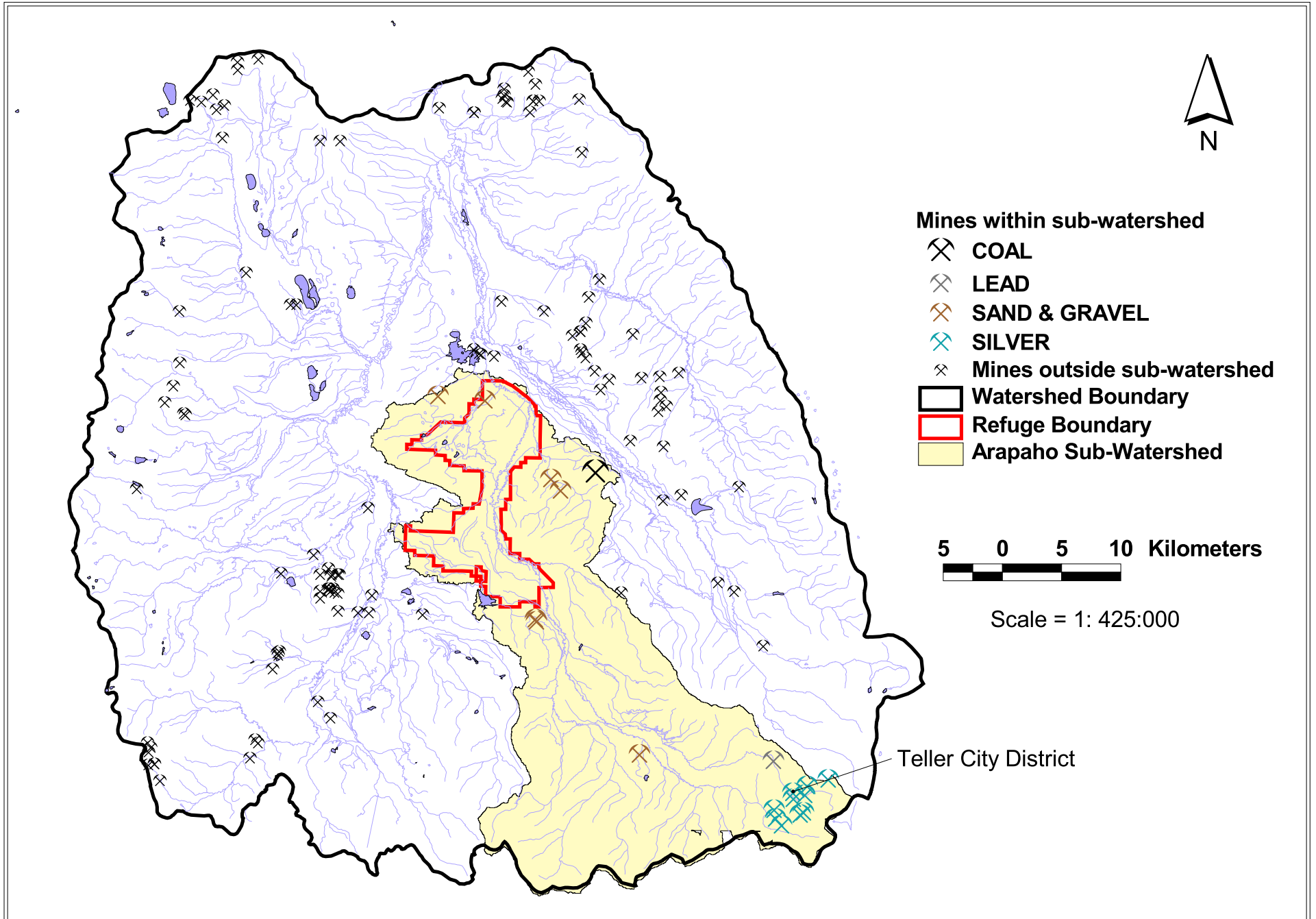
#### 3.2.1.4 PCS Facilities

Each PCS facility permit is based on the allowable discharge load for specific constituents and the flushing rate of the receiving water. Maximum allowable load will differ with different flushing rates. The permit does not take into account other PCS facilities also discharging into the same body of water. There is one PCS site (R & G Oil, LLC) within the AOI (Figure 4). Although the facility is located within the Refuge sub-watershed, the permit states that discharges flow into the North Platte drainage west of the Refuge sub-watershed. Therefore, there is no threat of contamination from PCS facilities to the Refuge.

#### 3.2.1.5 Mining Sites

Environmental consequences of mining may include acidification and sedimentation of local water bodies, elevated levels of heavy metals, and accidental releases of process chemicals such as cyanide. There are 129 mine sites reported by the EPA's BASINS (Better Assessment Science Integrating point and Nonpoint Sources) program in the AOI (Figure 8). Of the 129 mine sites, 19 are within the sub-watershed and have the potential to impact streams that flow through the Refuge (Table 4). Eleven of the 19 mines are inactive, potential metal producing mines that are located in what was once called Teller City, greater than 10 miles upstream from the Refuge. There is risk to waterways from tailings and other mining by-products at abandoned metal producing mines. BASINS does not provide information about how long each of the mines was in operation, or how much ore was produced, however Teller City existed from 1879 to 1884 when it was abandoned as silver prices dropped (Warburton, 2000). There have been no reports of contaminated water in the area and the distance traveled to the Refuge is greater than 10 miles which would aid in the dilution of any contaminant. For these reasons, the risk to the Refuge

Figure 8. Mining Activity within Watershed



from metal producing mines is small. However, to verify that no long term effects or potential future threats will occur, field reconnaissance to these mines is recommended.

Seven mines are sand and gravel pits, status unknown. One of these mines is located in the northwest section of the Refuge and is no longer producing. The final mine of the 19 is a subbituminous coal mine located to the east of the Refuge. No other details (e.g., time of production, how much was produced) are available for these mines from BASINS. Although these mines may be potential threats to the Refuge, data do not indicate problems on the Refuge.

**Table 4.** Mines within the Arapaho NWR Sub-Watershed

Name	Type	Current Status	Commodities
Unknown	Underground	Past Producer	Silver, Lead, Zinc
Jack Park	Unknown	Raw Prospect	Silver
Unknown	Unknown	Raw Prospect	Silver
Silver King	Underground	Raw Prospect	Silver
Hi Ho	Underground	Raw Prospect	Silver, Lead, Zinc
Unknown	Unknown	Raw Prospect	Silver, Lead, Zinc
Gaslight	Unknown	Mineral Location	Silver, Copper
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Gravel Pit	Surface	Unknown	Sand & Gravel
Orifeno	Underground	Past Producer	Silver, Copper
Teller City District	Underground	Unknown	Lead, Copper, Silver
Unknown	Surface	Unknown	Coal, subbituminous
Upper Jack Creek	Underground	Past Producer	Silver, Lead, Zinc
Endomile	Underground	Past Producer	Silver, Copper, Gold

### 3.2.1.6 Oil and Gas Wells

Oil spills from oil and gas well operations may impact aquatic species if there is runoff into waterways. Within the AOI, there are 571 oil and gas wells (Figure 9). The vast majority of these wells are located north of the Refuge (downstream), so the risk from those wells is virtually non-existent. There are twelve wells which are either dry and abandoned or have been plugged and abandoned located within the sub-watershed that enters the Refuge. Therefore, the risk to the Refuge is small.

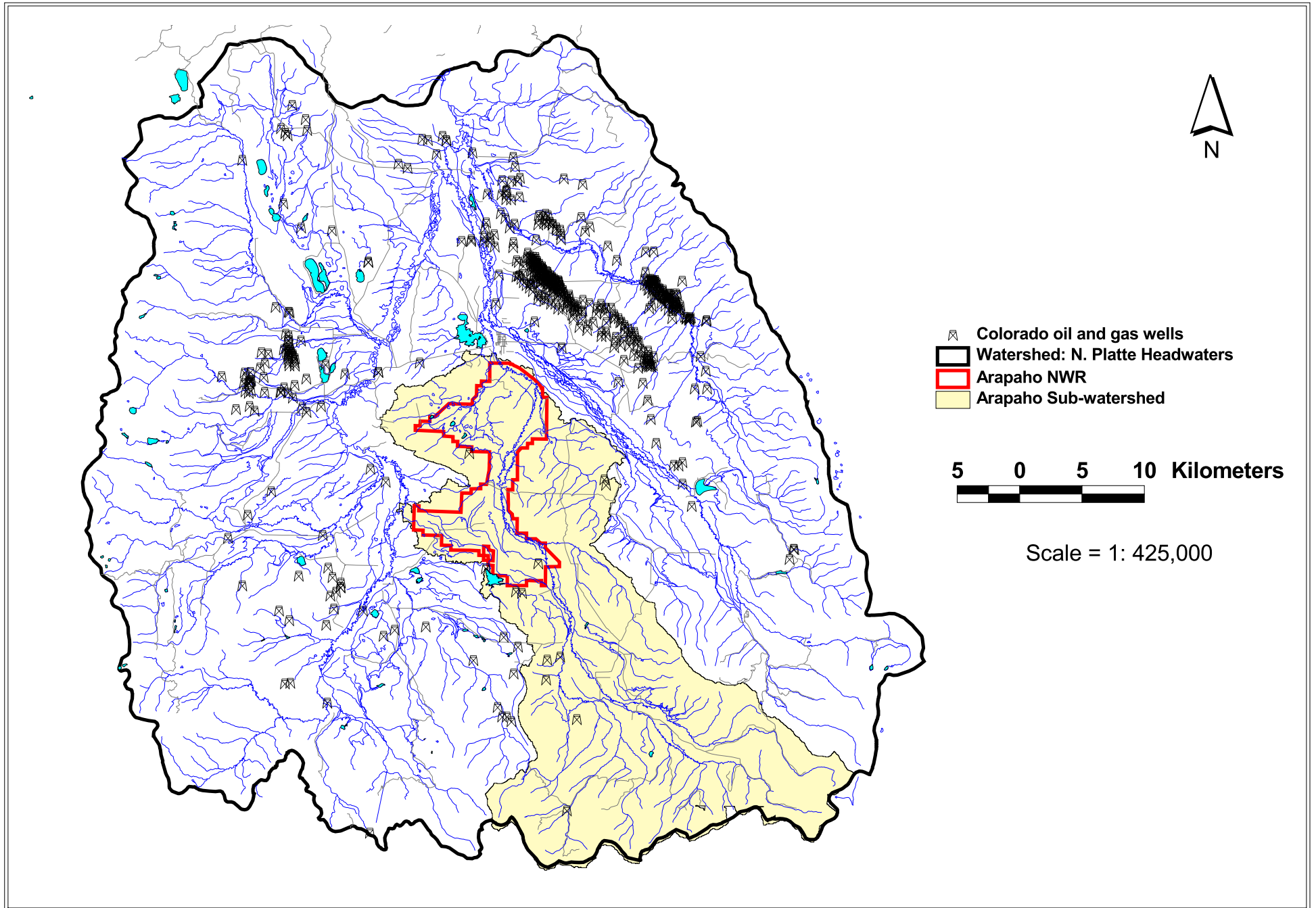
### 3.2.1.7 Local Pesticide Use

Direct runoff from pesticide application or drifting pesticides may impact non-target species. Pesticide drift is of concern when the application of pesticides is aerial. According to Refuge staff there is no aerial application of pesticides in the region. Livestock spraying for mosquitoes is not practiced, however the town of Walden “fogs” with Malathion approximately 10-15 times per year. According to town staff, it is applied from a truck at night when wind is minimal. During 2002, due to dry conditions, mosquito control was not used. Due to Walden’s northern location and the northwesterly prevailing wind direction, there is little chance of drift onto the Refuge.

The Refuge uses Clopyralid and 2,4-D Amine for the control of the noxious weeds Canada thistle (*Cirsium arvense*) and yellow toadflax (*Linaria vulgaris*). Clopyralid is a synthetic plant hormone that causes abnormal plant growth leading to the death of target broadleaf plants. Although it is highly soluble in water, it is of low toxicity to fish, birds, and mammals. The amine form of 2,4-D is a systemic herbicide used to control broadleaf plants. It is slightly toxic to waterfowl and low to highly toxic to aquatic organisms depending on the form. (U.S.D.A,



Figure 9. Oil Well Locations within Watershed AOI



2002) With proper application and use of the best management practices stated in the Refuge's Pesticide Use Proposals, the threat of contamination to the Refuge is small.

#### 3.2.1.8 Roadways/Parking Lots/Machine Shop

Various contaminants may occur in runoff from parking lots and roadways, including petroleum products and other organic chemicals such as ethylene glycol. These products may come from vehicles, wear products from tires and brake linings, exhaust residue, breakdown products from paving materials, chemicals from wet and dry atmospheric deposition, deicing compounds, fertilizers, pesticides and herbicides from maintenance of adjacent areas, accidental spills, and littering. (Thomson, 1997) The type and quantity of contaminants produced is dependent on rainfall characteristics (amount, duration, season, etc.), traffic density, maintenance practices, drainage design, and atmospheric deposition (Marsalek, 1999). Contaminants in the runoff can affect terrestrial and aquatic plant and animal species within and near these sites.

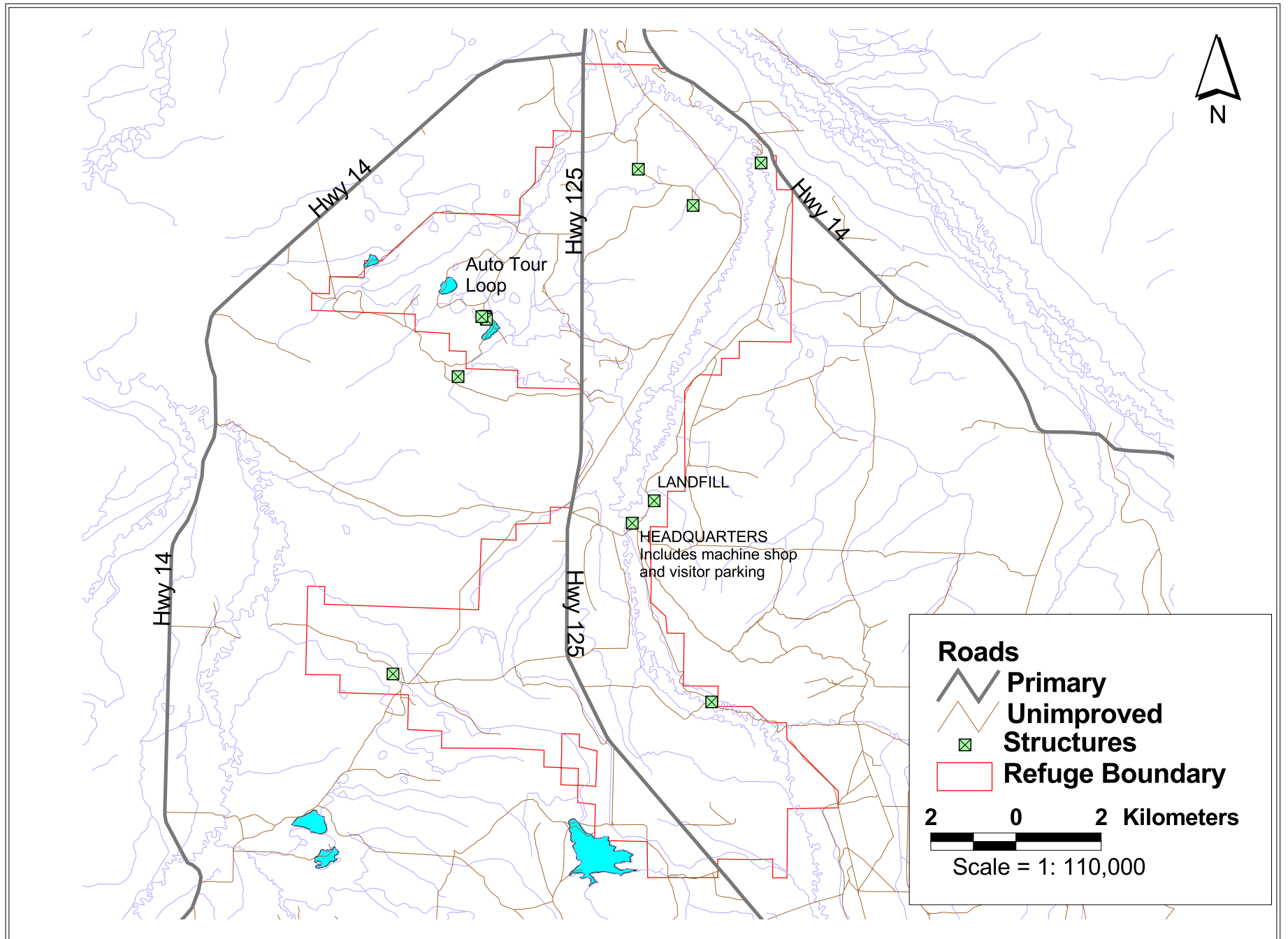
Highway 125 dissects the Refuge from north to south, crossing many of the waterways (Figure 10). The auto tour loop encircles and runs in proximity to the wetlands on the Refuge. The machine shop and visitor center parking lot are in close proximity to the Illinois River. Because these roadways and parking areas are in proximity to streams and wetlands on the Refuge, they are of concern to the Refuge.

### **3.2.2 Potentially Contaminated Areas, Surface Water-borne Contaminants**

#### 3.2.2.1 Roadways

Highway 125 dissects the Refuge from north to south crossing many of the waterways (Figure 10). According to Refuge staff, in 2001, a semi-truck crashed through a fence and spilled 100

Figure 10. Roads and Structure Locations



gallons of diesel fuel. There was no spill response plan in place. Fortunately, the insurance company hired an emergency response team that showed up in hours, over excavated, and removed the material. Because this road is a major thoroughfare from Walden to Granby, Colorado and beyond, with heavy truck and tanker truck transport, the potential for future major spills exist. Heavy traffic on Highway 125 increases the amount of wear materials such as exhaust residues, tire wear and brake linings that may be deposited on the road. During precipitation and storm events these products will run off the roadway into adjacent streams.

The Refuge has 7,000 to 10,000 visitors annually including all auto tour visitors and hunters. Vehicle wear materials and littering from these visitors is also of concern. The Refuge is currently evaluating accessibility to the Refuge as part of their Comprehensive Conservation Plan (CCP).

#### 3.2.2.2 Machine Shop

The machine shop is located near the center of the Refuge and adjacent to the Illinois River. In the past, this shop had a dirt floor which would absorb oil spills and other chemicals. This site was cleaned up in 2000, and the shop area now has a concrete floor. The site has also gone through a safety review, including correct disposal procedures. For these reasons, the threat of runoff entering the river is reduced.

### **3.3 Ground Water Pathway**

#### **3.3.1 Pollutant Sources of Highest Concern**

##### 3.3.1.1 Landfills

Leachate from active landfills or landfills that have not been properly closed may contain a variety of toxic chemicals that will affect nearby water bodies and the biota therein. According to Refuge personnel, there are eight buried sites that were historically used for refuse dumping

and burning. Seven of the sites are associated with the old ranches that make up the Refuge. The sites were burned and buried. The remaining site, located just east of the Refuge headquarters was also used as a practice shooting range (Figure 10). However, this site was cleaned up by removing the soils from the Refuge, therefore, potential threats to the Refuge are minimal.

### 3.3.1.2 Underground Storage Tanks

As USTs age the potential exists for the tank material to degrade and for leaks to develop. Spills and overfills are also common. Prior to December 22, 1998 tank owners were not required to maintain leak detection, corrosion protection or overfill/spill protection. Prior to the 1998 regulations it was possible for leaks to go undetected for years. The leaked fuels could contaminate groundwater or migrate to surface water bodies.

According to the Colorado Storage Tank Information System (COSTIS), there are 57 USTs within the AOI. The locations of the USTs are not mapped, because COSTIS does not give sufficient location information. Nine of the 57 USTs are active, while the other 48 tanks are classified with a status of permanently out of use. In order to attain this status, “owner/operators must empty and clean it by removing all liquids and accumulated sludges. All tanks taken out of service permanently must also be either removed from the ground or filled with an inert solid material.” Owners are also required to “measure for the presence of a release where contamination is most likely to be present at the UST site.” (7 C.C.R. 1101-14)

Historically, Arapaho NWR had four USTs. Three of them operated from 1979 until 1994, and the other was closed in 1976. These USTs were dug up and removed. COSTIS reports a

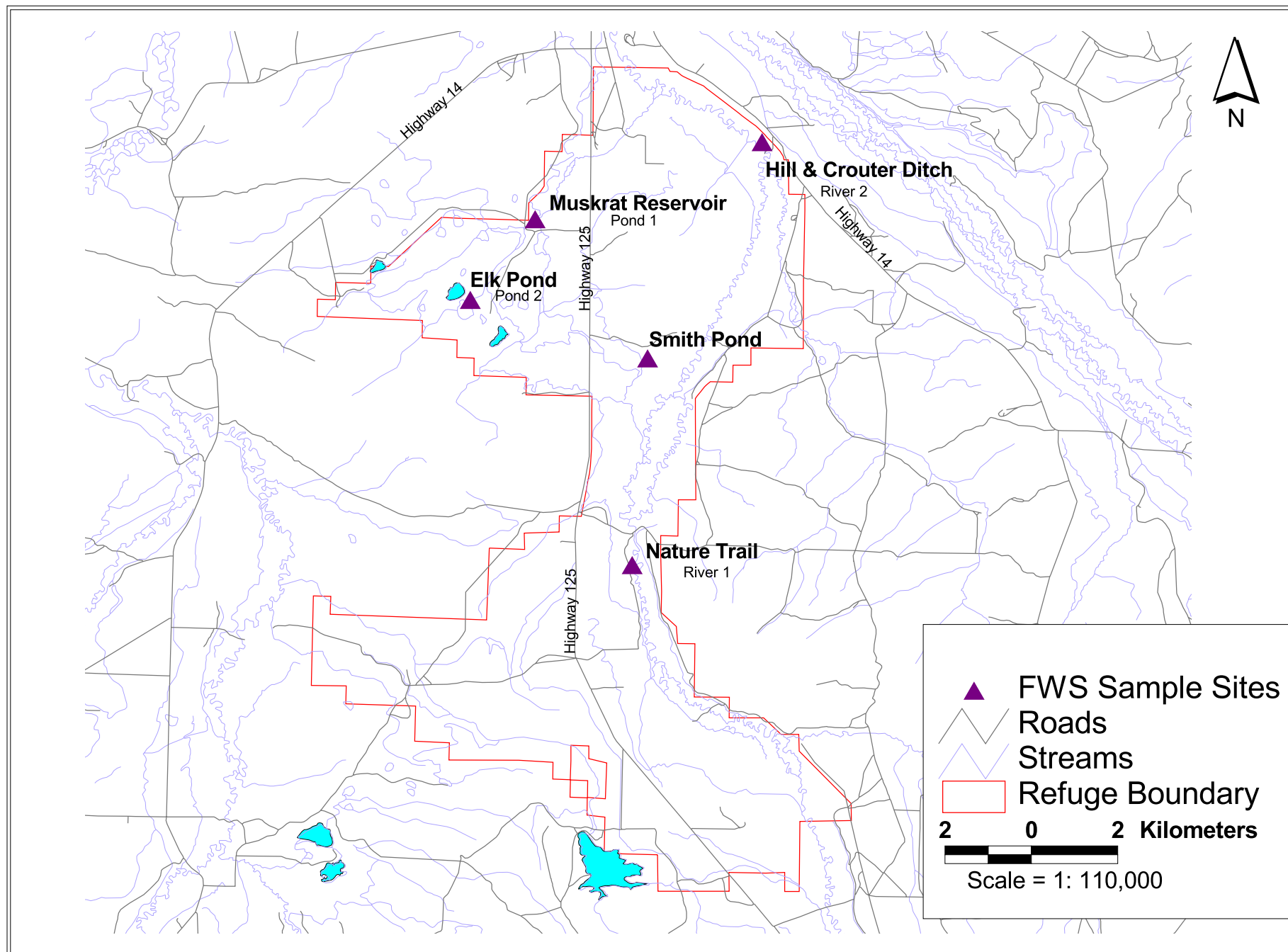
petroleum release in 1989 on the Refuge that is still being monitored. After speaking with Refuge personnel and the Colorado Department of Labor and Employment, Division of Oil and Public Safety, it was determined the location was in the town of Walden, and not related to the Refuge. Therefore, releases would not impact the Refuge since Walden is downstream.

The nine active USTs are located in the town of Walden. Three of the tanks were installed in 1973. Two locations of gasoline storage, Blanton Mountain Mart and Corkle's Mini Mart in Walden were reported to have suspected leaking tanks in 1999. These should not impact the Refuge since Walden is located downstream from the Refuge.

## **4.0 Contaminants Survey**

In 1991, the U.S. Fish and Wildlife Service's Colorado Field Office, Environmental Contaminants Program conducted a background survey for inorganic and organic elements at the Refuge. Because they integrate contamination over a long period of time as compared to water, sediments, aquatic vegetation, invertebrates, and fish, were sampled from four locations on the Refuge. Two sites were chosen on the Illinois River where it enters and exits the refuge, and two significant wetland areas were chosen. In addition, a black-crowned night-heron rookery on the Refuge was being used as a reference site for a separate study of black-crowned night-heron eggs (Figure 11). Not all types of samples were taken from each location. Each sample was analyzed for fifteen inorganic elements, and the black-crowned night-heron eggs were also analyzed for twelve organic compounds. Five inorganic elements (arsenic, cadmium, copper, lead, and zinc) and one organic compound (DDE) were reviewed for this CAP.

Figure 11. Sampling Locations for Contaminants Data from Archuleta et al. 1992



## 4.1 Sediments

Four sediment samples from 2 riverine and 2 pond locations were collected within the Refuge (Figure 12). All sample concentrations were below threshold effects levels, therefore, the threat to Refuge resources from contaminated sediment is low (Table 5).

**Table 5.** Sediment Metal Concentrations (ppm, dw) Compared to Literature Threshold Guidelines

Metal	WSGM	ERL	TEL	TEC	River 1	River 2	Pond 1	Pond 2
Arsenic	5.5	33.0	5.9	9.79	4.77	4.56	3.17	3.68
Cadmium	NA	5.0	0.596	0.99	< 0.1992	0.329	<0.4854	0.4854
Copper	21	70.0	35.7	31.6	7.09	18.7	28.8	19.5
Lead	17	35.0	35	35.8	12	21.2	17.6	13.2
Zinc	55	120	123	121	57.3	102	75	56.3

WSGM = Western United States Soils geometric mean; dry weight, ppm (Shacklette and Boerngen, 1984)

ERL = Effects Range-Low; dry weight, ppm (Long and Morgan, 1991)

TEL = Threshold Effect Level, dry weight, ppm (Smith et al., 1996)

TEC = Consensus Based Threshold Effects Concentration, dry weight, ppm (MacDonald et al., 2000)

NA = Not available

## 4.2 Aquatic Vegetation

Six samples were collected from four locations on the Refuge (Figure 13). Values were below literature thresholds for tissue metal concentrations considered to be toxic to vegetation for As, Cd, Cu, Pb, and Zn (Table 6). Although literature threshold concentrations (Kabata-Pendias and Pendias, 1984) were developed for terrestrial plants, sample concentrations were well below those levels. Further, all sample concentrations were less than or within no observed adverse effects levels (NOAEL) (USDOJ, 1998 and Eisler, 2000). The data indicate that aquatic vegetation is not accumulating harmful concentrations of the inorganic elements analyzed.



Figure 12. Sediment Sampling Locations

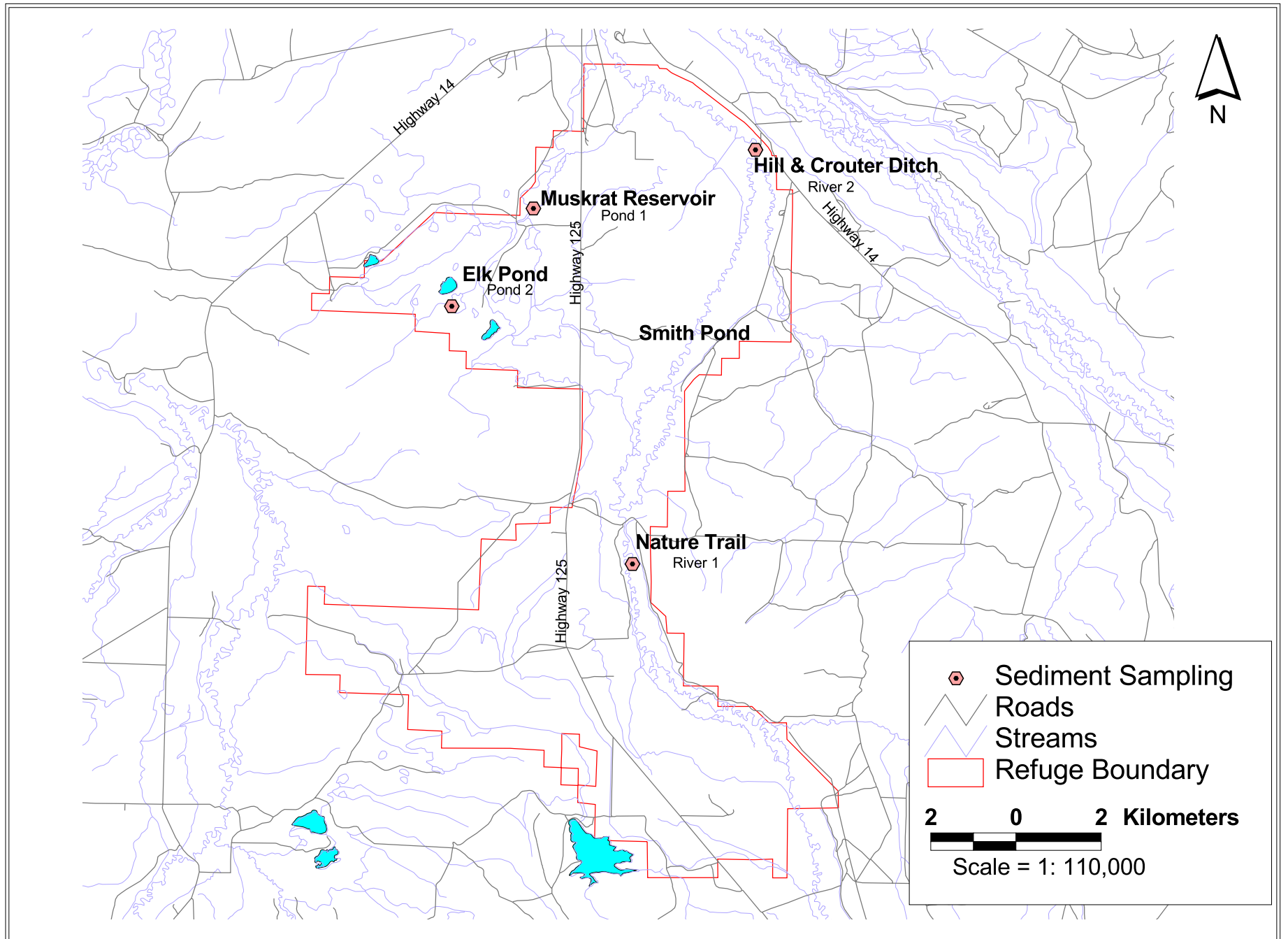
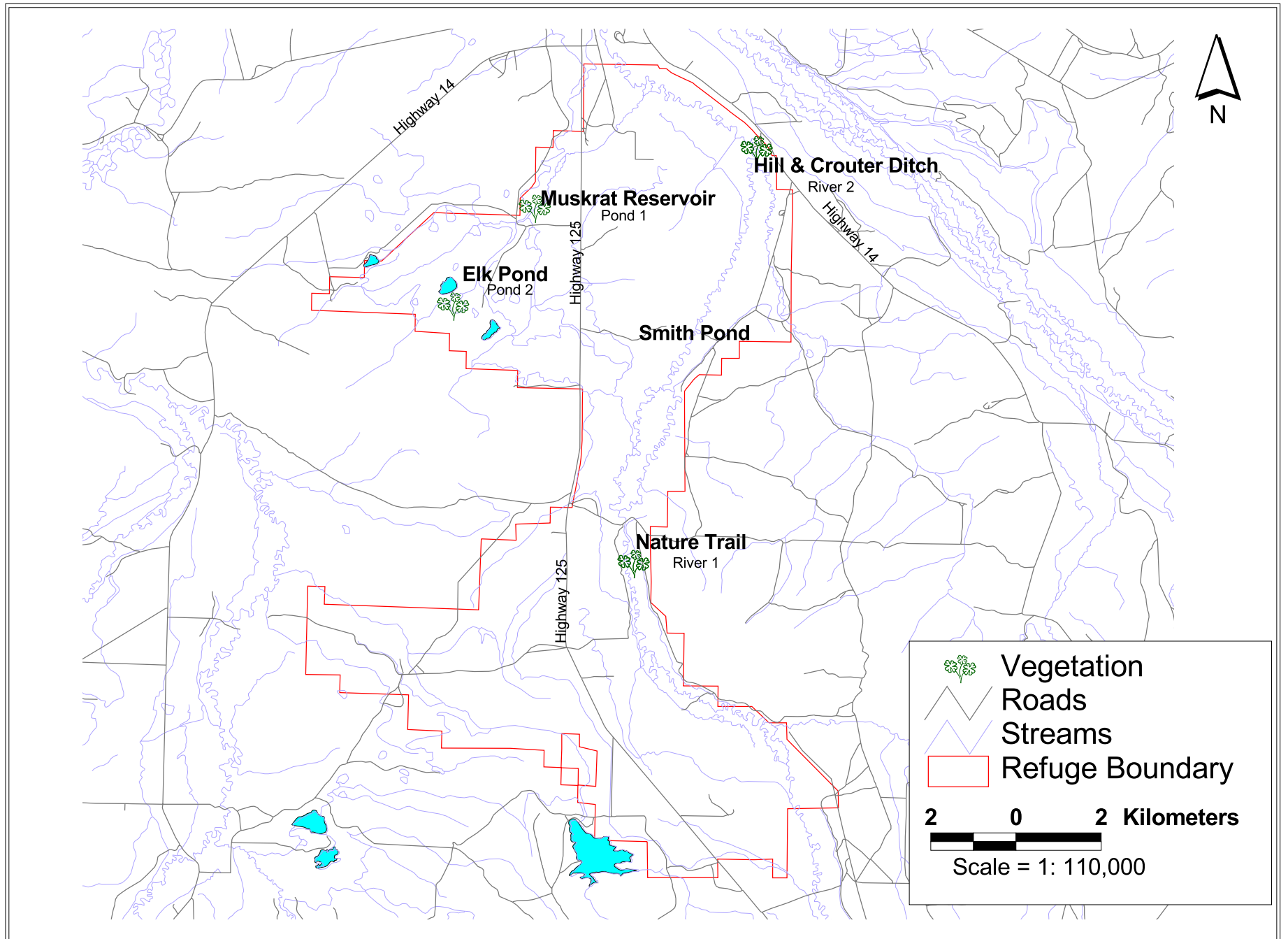


Figure 13. Vegetation Sampling Locations



**Table 6.** Literature Thresholds for Tissue Metal Concentrations Considered to be Toxic to Vegetation (ppm, dw) Compared to Aquatic Vegetation Samples from the Refuge

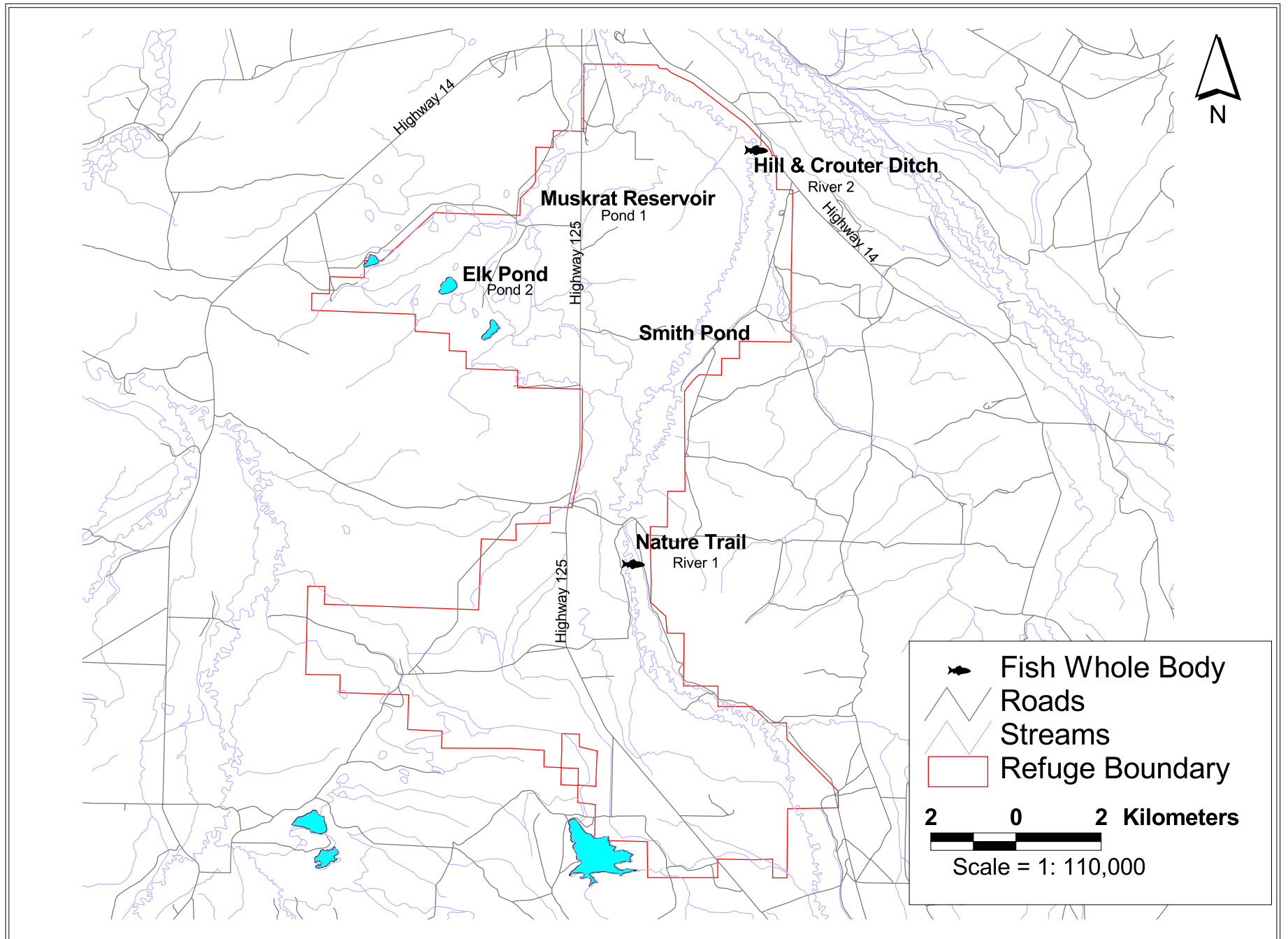
Analyte	LTC <sup>1</sup>	River 1 Sample 1	River 1 Sample 2	River 2 Sample 1	River 2 Sample 2	Pond 1	Pond 2
Arsenic	20	4.94	7.9	6.76	9.68	2.23	1.29
Cadmium	30	<0.708	<0.7619	<0.3941	<0.7843	<0.3902	<0.396
Copper	100	8.02	8.59	7.05	11.7	9.96	6.86
Lead	300	8.02	43.3	7.06	14.9	7.73	2.79
Zinc	400	49.8	51.3	47	128	27.5	48.4

<sup>1</sup> LTC = Literature Threshold Concentration (Kabata-Pendias and Pendias, 1984)

### 4.3 Fish

Eight composite whole body fish samples (Table 7) were collected from two river locations on the Refuge (Figure 14). Arsenic, Cd and Zn concentrations were below literature based threshold values (Table 8). However, two samples of white suckers (*Catostomus commersoni*) from River 1 (nature trail) and one sample of darters (*Etheostoma* spp.) from River 2 (near Hill and Crouter Ditch) had Pb concentrations that exceeded the 85<sup>th</sup> percentile concentrations reported by Schmitt and Brumbaugh (1990) (Table 9). Darters, which had a significantly higher concentration of lead (2.26 ppm, ww) than the 85<sup>th</sup> percentile concentrations, present the greatest concern among these three samples. However, it is difficult to draw any conclusions because only one composite sample of darters was analyzed. Further sampling of darters may provide a better idea of potential exposure contaminants. However, food sources (invertebrates), sediment samples, and other fish samples did not exhibit increased levels of lead. In addition, due to the darters feeding habits and bottom dwelling lifestyle, any of the individuals in the composite sample may have ingested a piece of lead shot, which would elevate the lead concentration in the sample. Therefore, an anomaly in this sample is suspected.

Figure 14. Fish Whole Body Sampling Locations



**Table 7.** Types of Fish and Location for Each Sample

Sample #	Location	Type of Fish
AR-SU-01	River 1 (nature trail)	3 White Suckers ( <i>Catostomus commersoni</i> )
AR-SU-02	River 1 (nature trail)	3 White Suckers
AR-DC--05	River 1 (nature trail)	20 Dace – Longnose ( <i>Rhinichthys cataractae</i> )
AR-WS-06	River 2 (near Hill and Crouter Ditch)	2 White Suckers
AR-WS-07	River 2 (near Hill and Crouter Ditch)	5 White Suckers
AR-WS-08	River 2 (near Hill and Crouter Ditch)	25 White Suckers (small)
AR-FH-09	River 2 (near Hill and Crouter Ditch)	35 Fathead Minnows ( <i>Pimephales promelas</i> )
AR-DR-10	River 2 (near Hill and Crouter Ditch)	10 Darters ( <i>Etheostoma</i> spp.)

**Table 8.** Fish metal concentrations (ppm, dw) compared to No Effect and Toxicity Threshold Values

Analyte	No Effect	Toxicity Threshold	River 1 (nature trail)			River 2 (Near Hill and Crouter Ditch)				
			AR-SU-01	AR-SU-02	AR-DC-05	AR-FH-09	AR-DR-10	AR-WS-06	AR-WS-07	AR-WS-08
Arsenic	1.0 <sup>1</sup>	12 <sup>1</sup>	0.98	0.85	0.98	1.14	0.96	0.82	1.08	1.07
Cadmium	NA	NA	<.25	<.2	<.0998	<.0996	<.099	<.0992	<.0994	<.0992
Copper	9.8 <sup>1</sup>	13.3 <sup>1</sup>	2.8	3.02	4.35	4.7	3.64	4.03	2.99	4.53
Lead	NA	NA	1.99	1.23	0.762	0.604	11.2	0.603	<.497	<.496
Zinc	98-122 <sup>2</sup>	NA	56.4	65.8	117	108	137	43.7	48.8	109

<sup>1</sup> U.S. DOI, 1998<sup>2</sup> Eisler, 2000

NA=Not Available

**Table 9.** Fish metal concentrations (ppm, ww) compared to No Effect and Toxicity Threshold Values

Analyte	No Effect	Toxicity Threshold	River 1 (nature trail)			River 2 (Hill and Crouter Ditch)				
			AR-SU-01	AR-SU-02	AR-DC-05	AR-FH-09	AR-DR-10	AR-WS-06	AR-WS-07	AR-WS-08
Lead (ww)	NA	0.22 <sup>1</sup>	0.52	0.328	0.173	0.123	2.26	0.163	<.121	<.105
Zinc (ww)	NA	34-46 <sup>1</sup>	14.72	17.57	26.56	22.03	27.68	11.84	11.91	23.212

<sup>1</sup> Schmitt and Brumbaugh, 1990, 85<sup>th</sup> percentile for all fish

NA=Not Available

#### 4.4 Invertebrates

Five invertebrate samples including snails, scuds (*Gammarus* spp.), and daphnia (*Daphnia* spp.) were collected from one river and two pond locations on the Refuge (Figure 15) (Table 10).

There are no guidelines established for Cu and Zn in invertebrates because it is homeostatically regulated. Literature review also found no guidelines for Pb.

Although literature guidelines were not found for Cu, Pb, and Zn concentrations in invertebrates, the best indicator for the health of invertebrates would be to calculate exposure to concentrations of contaminants in water (Eisler, 2000). Water samples were not included in the original study plan.

**Table 10.** Invertebrate metals concentrations compared to No Effects Levels. (ppm, dw)

Analyte	No Effects	AR-DA-19 Pond 1	AR-SC-20 Pond 1	AR-DA-22 Pond 2	AR-SC-14 River 2	AR-SN-15 River 2
As	30 <sup>1</sup>	4.96	4.67	4.16	3.86	5.98
Cd	<1 <sup>2</sup>	<.3546	0.118	0.231	0.102	0.221
Cu	NA <sup>3</sup>	13.7	44.2	8.77	50.2	63.2
Pb	NA	5.98	1.94	3.29	1.99	3.96
Zn	NA <sup>3</sup>	73.2	64.4	53.8	56.8	30.7

<sup>1</sup> U.S. DOI, 1998.

<sup>2</sup> Eisler, 2000.

<sup>3</sup> Copper and Zinc levels are regulated homeostatically.

NA=Not Available

#### 4.5 Black-crowned Night-heron Eggs

Twelve black-crowned night-heron eggs were collected from a rookery on the Refuge (Figure 16). They were analyzed for inorganic and organic elements (Table 11, 12). Most eggs were below detection limits for As, Cd, and Pb concentrations. All but a few egg samples fell below no effects levels for Cu and Zn.

Figure 15. Invertebrate Sampling Locations

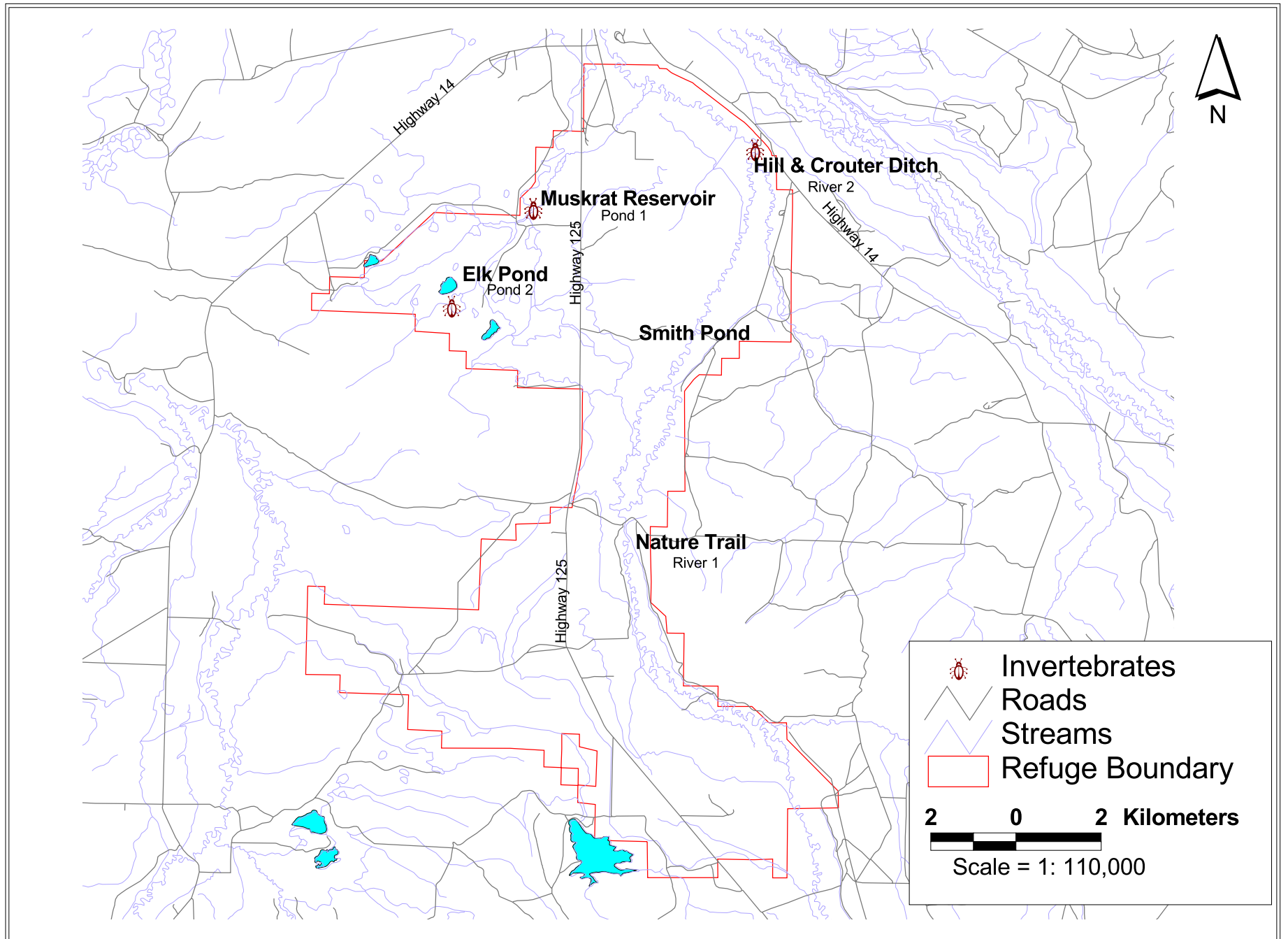
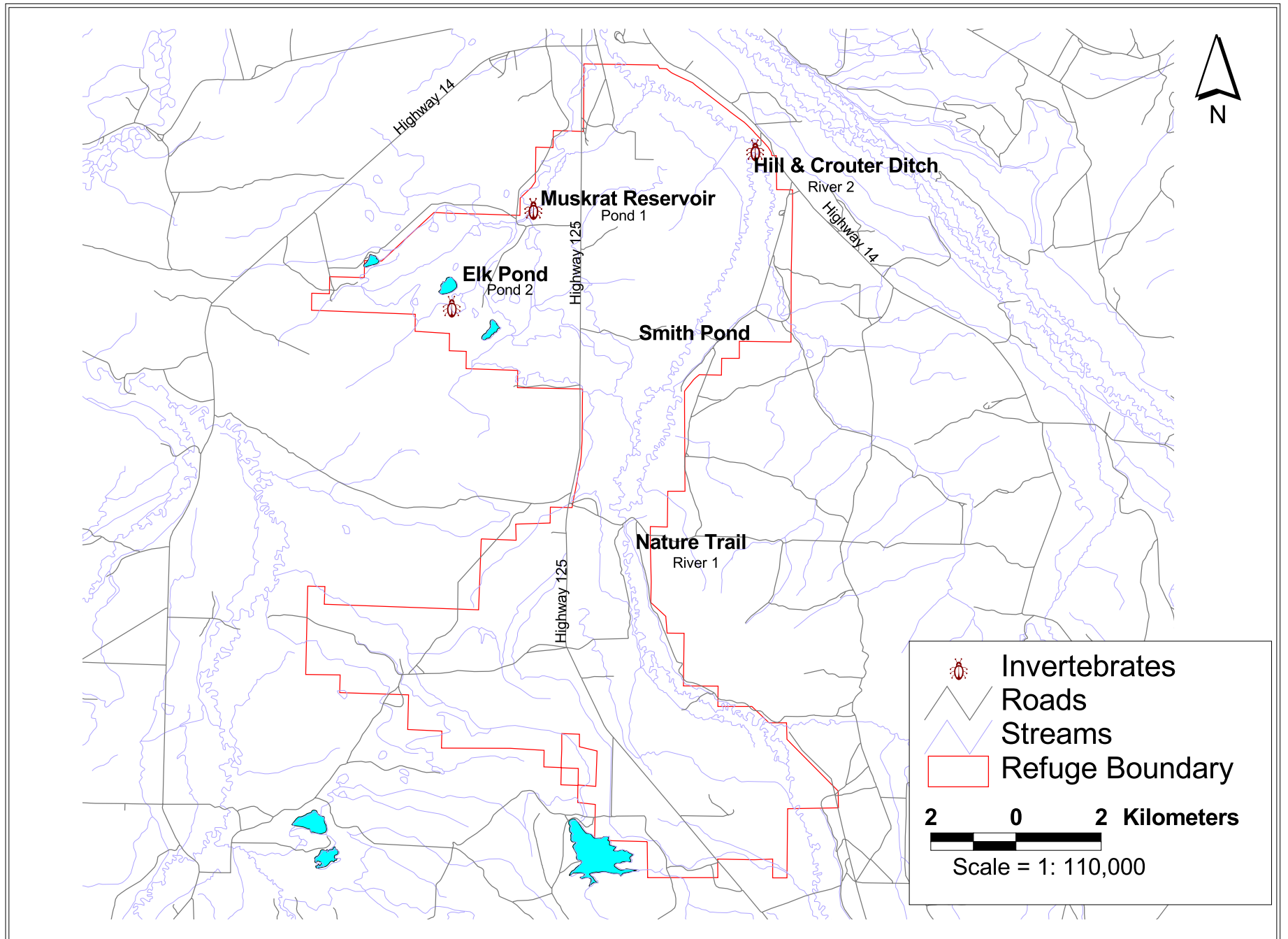


Figure 16. Black-crowned Night-heron Sampling Locations





No effects levels refer to the concentrations at which below the value there would be no effects to biota. Although a few concentrations of Zn and Cu exceeded the no effects levels, these samples are assumed to be at low risk because they slightly exceeded the no effects level and because birds are relatively tolerant to Zn (USDOI, 1998) and Cu (Eisler, 2000).

Four eggs showed elevated levels of DDE. Levels between 1.01 and 4 ppm wet weight have been associated with a 5.1% decrease in eggshell thickness. However, this is probably not biologically significant as a 10% decrease is seldom associated with egg breakage or population decline. Levels of DDE greater than 8 ppm wet weight are associated with decreased productivity and hatching success (USDOI, 1998). DDE is a metabolite of the insecticide DDT, forming as DDT breaks down in the environment. DDE, therefore, comprises most of the dietary exposure of wild birds with eggshell thinning, and is more toxic to birds than DDT (Beyer, 1996). Black-crowned night-herons accumulate DDE in their fatty tissues as they consume fish that contain DDE residues. It is unlikely these birds were exposed to DDT on the Refuge since DDT was banned from use in the United States in 1972, and use of DDT in North Park was historically very limited (pers. comm. with Refuge staff).

**Table 11.** Black-crowned night-heron egg metal concentrations compared to No Effects Levels. (ppm, dw)

Analyte	No effects <sup>1</sup>	BN-AP-01	BN-AP-02	BN-AP-03	BN-AP-04	BN-AP-05	BN-AP-06	BN-AP-07	BN-AP-08	BN-AP-09	BN-AP-10	BN-AP-11	BN-AP-12
As	1.3	0.97	<.495	<.495	<.5	<.495	<.8333	0.56	<.495	<.5	<.497	<.5	<.499
Cd	NA	<.099	<.1	<.0998	<.0998	<.0996	<.0992	<.0992	<.0994	<.0994	<.099	<.099	<.0994
Cu	5.5	5.21	5.89	4.73	6.41	7.34	6.29	5.03	4.99	6.44	5.44	6.16	5.02
Pb	NA	<.495	<.5	<.499	<.499	<.498	<.496	<.496	<.497	.53	<.495	<.495	<.497
Zn	50	36.8	55.2	39.1	40.3	49	42.7	42.7	36.2	44.7	39.4	33.4	50.4

<sup>1</sup>USDOI, 1998

NA = Not Available

**Table 12.** Black-crowned night-heron egg DDE concentrations compared to No Effects Levels. (ppm, ww)

Analyte	No effects <sup>1</sup>	BN-AP-01	BN-AP-02	BN-AP-03	BN-AP-04	BN-AP-05	BN-AP-06	BN-AP-07	BN-AP-08	BN-AP-09	BN-AP-10	BN-AP-11	BN-AP-12
DDE (ww)	<1	0.212	1.386	0.627	0.146	1.044	3.84	0.1716	0.228	1.38	0.437	0.117	0.506

<sup>1</sup>USDOI, 1998

## 4.6 Dietary Exposure Risk

Wildlife exposed to elevated concentrations of metals may exhibit deleterious effects including death. In order to determine if wildlife in the Refuge may be harmed by elemental concentrations in their diet, lowest observed adverse effects levels (LOAEL) and NOAEL-based Benchmarks (Sample, 1996) for food and dietary intake values (Eisler, 2000 and U.S. DOI, 1998) were compared to the data collected in the contaminants study (Table 13, 14, 15). If the concentration of the dietary exposure (sample concentration) exceeds the benchmarks or the recommended dietary intake values, there is potential risk to an organism, and further study may be warranted.

**Table 13.** Dietary Exposure Benchmarks for birds compared to potential exposures on the Refuge (ppm, dw)

Analyte	NOAEL-Based Benchmark – Food (ppm) <sup>1</sup>	LOAEL-Based Benchmark – Food (ppm) <sup>1</sup>	Dietary Intake Values (ppm)	Aquatic Vegetation Data Range	Invertebrate Data Range	Fish Data Range
As	4.3 – 29.2 <sup>2</sup>	10.6 – 73.1 <sup>2</sup>	<30 mallards <sup>3</sup>	1.29-9.68	3.86-5.98	0.82-1.14
Cd	1.2 – 14.98 <sup>4</sup>	16.56 – 206.61 <sup>4</sup>	<2 birds <sup>3</sup>	<0.3902-<.7843	0.102-<0.3546	<.0992-<.25
Cu	38.9 – 485.5 <sup>4</sup>	51.1 – 637.4 <sup>4</sup>	<200 poultry <sup>3</sup>	7.05-14.9	8.77-63.2	2.8-4.7
Pb	0.94 – 11.67 <sup>5</sup> 3.19 – 39.77 <sup>6</sup>	9.36 – 116.73 <sup>5</sup>	<5 birds <sup>3</sup>	2.79-43.3	1.94-5.98	<.496-11.2
Zn	12.0 – 149.8 <sup>4</sup>	108.5 – 1353.3 <sup>4</sup>	<178 birds <sup>3</sup> , 150-200 recommended <sup>3</sup>	27.5-128	30.7-73.2	43.7-137

<sup>1</sup>Sample et al., 1996<sup>2</sup>Low value for sodium arsenite in American Robin. High value for sodium arsenite in Great Blue Heron.<sup>3</sup>Eisler, 2000<sup>4</sup>Low value for American Robin. High value for Red-tailed Hawk.<sup>5</sup>Lead acetate. Low value for American Robin. High value for Red-tailed Hawk.<sup>6</sup>Metallic Lead. Low value for American Robin. High value for Red-tailed Hawk.

**Table 14.** Dietary Exposure Benchmarks for mammals compared to potential exposures on the Refuge (ppm, dw)

Analyte	NOAEL-Based Benchmark – Food (ppm) <sup>1</sup>	LOAEL-Based Benchmark – Food (ppm) <sup>1</sup>	Dietary Intake Values (ppm)	Aquatic Vegetation Data Range	Invertebrate Data Range	Fish Data Range
As	.250 – 1.008 <sup>2</sup>	2.497 – 10.076 <sup>2</sup>	5-58 (rats to sheep) <sup>3</sup>	1.29-9.68	3.86-5.98	0.82-1.14
Cd	3.533 – 14.255 <sup>4</sup>	35.333 – 142.554 <sup>4</sup>	3.5-7.5 mammals <sup>5</sup>	<0.3902- <.7843	0.102- <0.3546	<.0992- <.25
Cu	55.7 – 224.8 <sup>4</sup>	73.3 – 295.9 <sup>4</sup>	20-30 adequate for livestock <sup>5</sup> , 100-800 mammals <sup>3</sup>	7.05-14.9	8.77-63.2	2.8-4.7
Pb	29.30 – 118.23 <sup>4</sup>	293.04 – 1182.30 <sup>4</sup>	<20 ppm BW mammals <sup>5</sup>	2.79-43.3	1.94-5.98	<.496-11.2
Zn	586.1 – 2364.6 <sup>4</sup>	1172.2 – 4729.2 <sup>4</sup>	mammals tolerate up to 100 times daily requirement <sup>3</sup>	27.5-128	30.7-73.2	43.7-137

<sup>1</sup>Sample et al., 1996<sup>2</sup>Low value for arsenite in Short-tailed Shrew. High value for arsenite in Meadow Vole.<sup>3</sup>U.S. DOI, 1998<sup>4</sup>Low value for Short-tailed Shrew. High value for Meadow Vole.<sup>5</sup>Eisler, 2000**Table 15.** Dietary Exposure Benchmarks for fish compared to potential exposures on the Refuge (ppm, dw)

Analyte	NOAEL-Based Benchmark – Food (ppm) <sup>1</sup>	Dietary Intake Values (ppm)	Aquatic Vegetation Data Range	Invertebrate Data Range	Fish Data Range
As	NA	<10 fish <sup>4</sup>	1.29-9.68	3.86-5.98	0.82-1.14
Cd	NA	Waterborne concentration most important for fish <sup>3</sup>	<0.3902-<.7843	0.102-<0.3546	<.0992-<.25
Cu	NA	<93 fish <sup>3</sup>	7.05-14.9	8.77-63.2	2.8-4.7
Pb	NA	Waterborne concentration most important for fish <sup>3</sup>	2.79-43.3	1.94-5.98	<.496-11.2
Zn	NA	<683 fish <sup>4</sup>	27.5-128	30.7-73.2	43.7-137

<sup>1</sup>Sample et al., 1996<sup>2</sup>Low value for arsenite in short-tailed shrew. High value for sodium arsenite in Red-Tailed Hawk<sup>3</sup>Eisler, 2000<sup>4</sup>U.S. DOI, 1998

NA=Not Available

#### **4.6.1 Arsenic**

Arsenic concentrations in the invertebrate and fish samples are below benchmark concentrations that would affect target species (Table 11). Therefore, there is no risk to species that use these as a food source. Arsenic concentrations in river vegetation (Table 6) could affect small mammals, however the likelihood of the mammals eating aquatic vegetation is low.

#### **4.6.2 Cadmium**

Cadmium concentrations in invertebrate, fish, and vegetation samples are below benchmark and dietary levels presented in the literature. Therefore, there is no dietary risk from cadmium to animal species on the Refuge.

#### **4.6.3 Copper**

Copper concentrations in fish and vegetation samples are below benchmark and dietary levels presented in the literature. However, concentrations in 3 invertebrate samples exceeded the lower NOAEL values for birds in the benchmarks, but only one invertebrate sample exceeded the LOAEL for robins. Because robins' diets consist primarily of terrestrial invertebrates and fruits, they are unlikely to be affected by an exceedance of copper from the sampled aquatic invertebrates. One sample of invertebrates exceeded the NOAEL value for short-tailed shrew in mammals, however, it does not exceed the LOAEL value. Because copper sensitivity varies due to various environmental conditions, and the sample concentrations fall within the benchmark ranges, it is unlikely that the sample concentrations would significantly impact the Refuge resources.

#### **4.6.4 Lead**

Lead concentrations in invertebrate, fish, and vegetation samples all fell within the benchmark range in Sample, et al. (1996). However, one invertebrate sample (AR-DA-19), one fish sample (AR-DR-10), and five of six vegetation samples exceeded the proposed dietary lead criteria of

less than 5 ppm for birds (Eisler, 2000). Except for vegetation sample 2 at river site 1 which had a concentration of 43.3 ppm, significantly exceeding the benchmark criteria for robins, the other elevated levels probably will not have deleterious effects on receptor species, as the dietary value was created as a NOAEL. The single high vegetation sample exceeds the LOAEL for robins, therefore, may cause ALAD inhibition and effects of lead poisoning such as impaired reproduction, tissue damage or death. However, even though robins will not consume aquatic vegetation, waterfowl on the refuge may. It is unlikely to affect receptor species on the refuge because it is unlikely that they will only consume vegetation at the elevated sample levels. Also, other inorganic and organic samples from River 1 did not have elevated concentrations of lead. Further evaluation of River 1 vegetation, sediment, and water may be considered.

#### **4.6.5 Zinc**

Zinc concentrations in invertebrate, fish, and vegetation samples are below benchmark and dietary levels presented in the literature. Therefore, there is no dietary risk from zinc to animal species on the Refuge

### ***4.7 Contaminants Survey Summary***

With the exception of the few black-crowned night-heron egg samples that had slightly elevated levels of DDE, and one lead concentration in fish that is higher than proposed dietary guidelines, the Refuge is not significantly affected by contaminants. Generally, inorganic concentrations in samples of vegetation, sediments, fish, and invertebrates were below levels that may impact species and the Refuge. These results show that outside sources minimally affect the Refuge.

## **5.0 CCP Integration**

Currently, Arapaho National Wildlife Refuge is creating a Comprehensive Conservation Plan (CCP) in order to guide the Fish & Wildlife Service in developing and managing the Refuge for

the next 15 years. It will include goals and objectives that define, in broad terms, for what and how the Refuge will be managed. The CCP will also identify opportunities for other agencies, organizations, businesses, and citizens to take part in implementing the vision for the Refuge. Based on the findings of this CAP, there are no hindrances to any of the proposed management alternatives. However, threats such as potential tanker truck oil spills, and other chemical spills from nearby sources should be taken into consideration. Contingency plans for these types of events should be developed.

## 6.0 Summary

Air monitoring sites in proximity to the Refuge have low readings of contaminants and there are no major air emitters between the monitoring sites and the Refuge. Therefore, airborne contaminants are very little threat to Refuge resources. Monitoring of airborne pollutants directly on the Refuge would provide the best possible data for the Refuge, but, this would be time consuming and costly.

Contaminants arriving via surface water pathways are also of little threat to the Refuge. The following concerns should be monitored and examined further to ensure water quality within the Refuge is acceptable for continuing the goals of the Refuge:

- Monitoring and safety checks of the headquarters' machine shop should be continued to prevent oil and other chemical spills
- A cursory investigation of surrounding mines, particularly the metal producing mines southwest of the Refuge. Based on current data and distance from the Refuge, there appears to be no threat. However, if the mines are large and exposed, there may be potential risk in the future.

- Pesticide use should be self-monitored. Safe and proper use of pesticides should continue to be followed.
- Sediments and biota within waterways adjacent to roadways should be sampled to evaluate whether contaminant loads from traffic through the Refuge are affecting Refuge resources and to determine baseline conditions in the event of a future spill of hazardous material.
- The USTs within the AOI should be mapped to have a better grasp on where soil and groundwater contamination may be a problem. There should be no problems within the Refuge.

In addition, we recommend that the Refuge create a contingency plan in the event of an oil or chemical spill both inside and outside of the Refuge boundaries.

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