NATURAL HERITAGE RESOURCES OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE AND THEIR CONSERVATION

PHASE II: THE BUFFER ZONE

FINAL REPORT, FINAL REV.

Prepared by:

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ACKNOWLEDGMENTS

The Colorado Natural Heritage Program would like to thank the Environmental Policy and Environmental Remediation staffs at the U.S. Department of Energy's Rocky Flats Field Office for making this report possible. In particular, Dr. John Wegrzyn, SAIC, deserves special thanks, for without his vision, experience, and commitment, this important project would not have been possible. Gail Hill and Annette Marquez, DOE, were instrumental in taking the lead on the project and ensuring the necessary funding and contracting were in place to initiate work. Dr. Fred Harrington, Dr. Mark Bakeman, and Alison Deans of the Pawnee Natural History Society provided invaluable insight into the Preble's meadow jumping mouse and other important aspects of area ecology. Greg Litus, BAI, provided critical information on the study area's hydrology and geology. Marcia Murdock, RMRS, was very helpful in providing bird information. Jody Nelson, RMRS, provided important background information on the *Carex oreocharis* occurrence. Tom Ryon, RMRS, helped clear up information on the 1995 trapping effort for the Preble's meadow jumping mouse. For their general support of the project, we would also like to thank Tricia Powell, Shirley Olinger, Dave Brockman, Howard Rose, DOE, and Laura Johnston, BAI.

INTRODUCTION

Purpose of Study:
In July, 1994, the Colorado Natural Heritage Program (CNHP) was contracted by the U.S. Department of Energy's Rocky Flats Field Office to inventory and rank the natural heritage resources at its Rocky Flats Environmental Technology Site (RFETS) (Purchase Order Number DE-AP34-94RF00900). The project was conducted in two phases: one to study the Rock Creek drainage and the second to study the rest of the facility's open space belt, or Buffer Zone. The project is intended to provide an independent assessment of the ecological values on plant site for consideration in future land-use planning and compliance documents under numerous environmental statutes. Specifically, DOE requested CNHP to aggregate existing biological data into its Conservation Data Center, and apply an established and scientifically sound methodology to prioritize state-wide and globally significant species, populations and functional ecological communities associated with RFETS.

Study Area Overview:
The Rocky Flats Environmental Technology Site (RFETS), formerly the Rocky Flats Plant, is located in northern Jefferson County, bordering Boulder County. It is located 25 miles north west of downtown Denver, 14 miles north of Golden, and 8 miles south of Boulder. The suburban communities of Arvada, Westminster, and Broomfield lie 5 miles to the east. RFETS sits high on the Colorado Piedmont, just 2 miles east of the Rocky Mountain foothills, and 15 miles east of the Continental Divide.

The RFETS is part of the U.S. Department of Energy nuclear weapons manufacturing complex, formerly responsible for producing high-grade metallurgical products, plutonium solution, and plutonium "triggers" or "pits" that initiate detonation sequences in the weapons (U.S. Department of Energy 1980). RFETS' current mission is decommissioning, decontamination, environmental restoration, and economic conversion to other, civilian, uses. RFETS is currently regulated under the Comprehensive Environmental Response Compensation and Liability Act, the Resource Conservation and Recovery Act, and other Federal and State of Colorado statutes. The facility employs 4,500 people (U.S. Department of Energy 1994a).

RFETS was part of the Lindsay Ranch livestock operation until the U.S Government purchased the surface rights to 2,000 acres in 1953. The rest of the current Buffer Zone was transferred to DOE in 1973. Today, RFETS encompasses 6550 acres, although the Industrial Area, not evaluated in this study, totals 300 acres, reducing the effective study area in the Buffer Zone to 6250 acres. Elevation at the facility ranges from approximately 5300' at the eastern boundary at Indiana Street, to over 6120' at the western boundary, three miles distant, near State Highway 93. The topography consists of mesa-like highlands, deeply cut by stream drainages running roughly west to east or northeast, and outwashed, flatter terrain that descends gradually to the east. The three major drainages found at the Site are, from north to south, Rock Creek, Walnut Creek, and Woman Creek.

Flora: The vegetative component of RFETS is representative of the High Plains bioregion, with extensive grasslands bisected by riparian shrublands and occasional wet meadows (Vestal 1919; Mutel and Emerick 1992). However, because of RFETS' unique location in the transition, or ecotone, between mountains and plains, many species indicative of montane ecosystems are also found in the study site. These montane representatives are mostly woody species, but herbaceous species typical of higher elevations are also present. The cessation of livestock production at RFETS has probably contributed heavily to the vegetative species mixture and total biomass present today. Furthermore, many exotic species are present, some completely dominating some areas.

Fauna: The faunal community of RFETS has been impacted by regional urban and rural development and its associated habitat loss. Extirpations of upper-trophic mammals such as wolves (*Canis lupus*), grizzly-bears (*Ursus arctos horribilus*), black-footed ferrets (*Mustela nigripes*), and mid-level trophic mammals such as American bison (*Bison bison*) from the area are well documented (Armstrong 1972; Fitzgerald et al. 1995). Other mammals, such as pronghorn antelope (*Antilocarpa americana*), historically used the area but have since been restricted to more remote areas. Some mammals are currently well represented at the Site, particularly coyotes (*Canis latrans*) and mule-deer (*Odocoileus hemionus*), as well as smaller mammals such as muskrat (*Ondatra zibethicus*), eastern cottontail rabbit (*Sylvilagus floridanus*), and porcupine (*Erethizon dorsatum*) (U.S. Department of Energy 1995c).

Bird species have been less severely impacted, but the sharp-tailed grouse (*Tympanuchus phasianellus* ssp. *jamesii*) is locally extirpated and a candidate for Colorado Division of Wildlife reintroduction to the area (Braun 1992; Weber 1994). Many bird species from sparrows to hawks breed at RFETS. Eagles and falcons use the area for hunting and migration (U.S. Department of Energy 1994a).

Climate: The RFETS' climate is generally dominated by continental air masses, with local events generated by orographic effects to the west. RFETS receives approximately 15 inches of precipitation annually, most (70%) in the form of rainfall in the late spring and summer (U.S. Department of Energy 1992). The mean temperature in January is 31°F and 72°F in July, the coolest and warmest months, respectively. Winds at RFETS are moderate, but due to its elevated and exposed nature and its close proximity to the foothills, winds can approach destructive levels of roughly 80 mi/hr (U.S. Department of Energy 1980). This occurs particularly in the winter when steep pressure gradients accompany the passage of deep low-pressure systems well to the north in Montana or Manitoba (Hansen 1978).

Soils: Soils at RFETS are typically well-drained clay and cobble loams of variable, but generally moderate, permeability. Upland soils are some of the oldest in the southern Rocky Mountains, estimated to be almost 1 million years old (U.S. Department of Interior 1994a). They are within the Flatirons-Veldkamp association on the pediments and the Denver-Kutch association below the terraces (U.S. Department of Agriculture 1980).

list of potential elements was derived by consulting local museums, herbaria, literature, technical experts, and the CNHP's Biological Conservation Database.

Some of the highest priority elements CNHP was interested in identifying were the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), Ottoe skipper (*Hesperia ottoe*), regal fritillary (*Speyeria idalia*), Ute's ladies' tresses (*Spiranthes diluvialis*), Colorado butterfly weed (*Gaura neomexicana ssp. coloradensis*), and the natural communities of great plains mixed grass prairies (*Stipa comata*- east) and xeric tallgrass prairies (*Andropogon gerardii-Schizachyrium scoparium*).

Table 1: Potential Natural Elements in the Study Area

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL[1] STATUS	STATE[2] STATUS
Birds					
BUTEO REGALIS	FERRUGINOUS HAWK	G4	S3B, S5N		
NYCTANASA VIOLACEA	YELLOW-CROWNED NIGHT-HERON	G5	S1B, SZN		
CATOPTROPHORUS SEMIPALMATUS	WILLET	G5	S1B, SZN		
SAYORNIS PHEOBE	EASTERN PHEOBE	G5	S1B, SZN		
COCCYZUS ERYTHROPTHALMUS	BLACK-BILLED CUCKOO	G5	S2B		
SIALIA SIALIS	EASTERN BLUEBIRD	G5	S2		
LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	G5	S3	C2	
IXOBRYCHUS EXILIS	LEAST BITTERN	G5	3B,S ZN		
BUTORIDES STRIATUS	GREEN-BACKED HERON	G5	S3B, SZN		
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	G5	S3B, SZN		
COCCYZUS AMERICANUS AMERICANUS	EASTERN YELLOW-BILLED CUCKOO	G5TU	S3B		
BOMBYCILLA CEDRORUM	CEDAR WAXWING	G5	S3B, S5N		
DOLICHONYX ORYZIVORUS	BOBOLINK	G5	S3B, SZN		
Fish					
none					

Vascular plants

SPIRANTHES DILUVIALIS	UTE LADIES' TRESSES	G2	S1	LT	1
GAURA NEOMEXICANA SSP COLORADENSIS	COLORADO BUTTERFLY WEED	G5T1	S1	C1	1
CAREX OREOCHARIS	MONTANE SEDGE	G3	S1?		
MALAXIS BRACHYPODA	WHITE ADDER'S-MOUTH	G4	S1	C2	2
CAREX TORREYI	TORREY SEDGE	G4	S?	3	
RIBES AMERICANUM	AMERICAN CURRANT	G5	S1	2	
CRATAEGUS CHRYSOCARPA	YELLOW HAWTHORN	G5?	S1S2	2	
VIOLA PEDATIFIDA	PRAIRIE VIOLET	G5	S2	3	
EUSTOMA RUSSELLIANUM	SHOWY PRAIRIE GENTIAN	G5	S3	C2	2
ROTALA RAMOSIOR	TOOTHCUP	G5	S?	3	
ARISTIDA BASIRAMEA	FORKTIP THREE-AWN	G5	S?	3	

Natural communities

STIPA COMATA - EAST	GREAT PLAINS MIXED GRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII-SCHIZACHYRIUM SCOPARIUM	XERIC TALLGRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII -SORGHASTRUM NUTANS	WET PRAIRIES	G3	S1
CAREX NEBRASCENSIS WETLAND	GREAT PLAINS WET MEADOWS	G4	S?
POPULUS DELTOIDES-SALIX AMYGDELOIDES/SALIX EXIGUA	GREAT PLAINS RIPARIAN	G2	S2

1 Abbreviations are as follows:
C2 = Category 2 Candidate
LE = Listed Endangered
LT = Listed Threatened

2 Abbreviations are as follows:
1 = federal threatened or endangered that are rare throughout their range
2 = plant species which are rare in Colorado but relatively common elsewhere within their range
3 = species which appear to be rare but for which conclusive information is lacking;

agency special area designations or ownership). The ranks range from P1 (immediate urgency; within a one-year time frame) to P5 (no known urgency).

MANAGEMENT URGENCY RANK: The time frame in which a change in management of the element or Conservation Site must occur. Using best scientific estimates, this rank refers to the need for management in contrast to protection (e.g. increased fire frequency, decreased herbivory, weed control, etc.). The ranks range from M1 (immediate urgency; within one year) to M5 (no known urgency).

LOCATION: The USGS 7.5' (1:24,000) topographic quadrangles that include the Conservation Site. The Natural Heritage Program code for the quadrangle is noted in parentheses.

GENERAL DESCRIPTION: A brief narrative picture of the topography, vegetation, and current use of the Conservation Site. Common names are used along with the scientific names.

NATURAL HERITAGE RESOURCE SIGNIFICANCE: A synopsis of the rare species and significant natural communities that occur on the Conservation Site.

CURRENT STATUS: A summary of the ownership, degree of protection currently afforded the Conservation Site, and threats to the site or natural heritage resources as determined to date.

BOUNDARY JUSTIFICATION: The preliminary conservation planning boundary delineated in this report includes all known occurrences of natural heritage resources and the adjacent lands required for their protection.

PROTECTION AND MANAGEMENT CONSIDERATIONS: A summary of the major issues and factors that are known or likely to affect the protection and management of the Conservation Site.

ROCKY FLATS CONSERVATION SITE

SIZE: approx. 4000 acres

BIODIVERSITY RANK: B2
PROTECTION URGENCY: P1
MANAGEMENT URGENCY: M2

LOCATION: Louisville Quadrangle (3910582)
Eldorado Springs Quadrangle (3910583)
Golden Quadrangle (3910572)
Ralston Buttes Quadrangle (3910573)
T2S, R70W, Sections 2,3,4,9,10,14,15,16,17,20,21

GENERAL DESCRIPTION: The Rocky Flats Conservation Site occurs on the south and west portions of the Rocky Flats alluvial fan and, to some extent, down into the colluvial valleys that dissect it. Most of the Conservation Site is located on the Rocky Flats Environmental Technology Site (RFETS), a former nuclear weapons manufacturing facility overseen by the U.S. Department of Energy. RFETS is listed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The flora is similar to other alluvial fans in the region, although many of these natural communities are increasingly threatened by urban development. The fauna of the Conservation Site has been more highly impacted by regional extirpations of some high trophic level mammals, but still retains many common animals and some rarer ones.

The Rocky Flats Conservation Site is bounded by Highway 128 on the north, Coal Creek to the west, and the RFETS boundary to the south. The eastern boundary follows a rough line that follows the eastern extent of the Rock Creek watershed, curves around to the west of the facility's industrial area, and runs southeast to include the wetland complexes of upper Woman Creek. Much of this Conservation Site includes a previous Site, "Rock Creek," identified in Phase I, but includes new element occurrences identified in Phase II, warranting a revision of the previous Site boundary.

Additionally, this Conservation Site is part of the larger Rocky Flats Macrosite, a landscape level boundary that includes a reach of Coal Creek below Coal Creek Canyon, the Quarter Circle area below Coal Creek Peak, the previous Rock Creek boundary, and the Walnut Creek site. This information is based on previous surveys conducted by CNHP (Pague et al. 1993).

NATURAL HERITAGE RESOURCE SIGNIFICANCE: This Conservation Site has retained much of its native character due to the general exclusion of the public that occurred during the Cold War. Although RFETS operations and activities have impacted some of the targeted natural elements, particularly on the facility's eastern half, much of the study area remains in relatively natural condition and only moderately fragmented. These areas are included in the Conservation Site.

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EXECUTIVE SUMMARY

The Colorado Natural Heritage Program has completed its inventory and ranking of the natural heritage resources found at the U.S. Department of Energy's Rocky Flats Environmental Technology Site (RFETS). The exclusion of the general public over the last 20 to 40 years has preserved some native habitats and conditions. Several rare and imperiled species and natural communities are documented in the following report. These include the globally imperiled xeric tallgrass prairie, Preble's meadow jumping mouse, and hops blue. Two declining bird species. loggerhead shrike and grasshopper sparrow, breed at RFETS. Some previously unclassified vegetation communities also exist there.

CNHP has identified two conservation sites at RFETS: the Rocky Flats Conservation Site and the Walnut Creek Conservation Site. Conservation sites are designed to include known rare species and communities from an area as well as the ecological processes needed for their continued existence. The Rocky Flats Conservation Site encompasses the western third of RFETS, plus some state land and private land. It supports important components of the total biological diversity of the nation, particularly xeric tallgrass prairie and a large Preble's meadow jumping mouse population. Rare invertebrates and populations of regionally declining breeding birds also make this Conservation Site a conservation unit for state and regional biological diversity.

The Walnut Creek Conservation Site supports the Preble's meadow jumping mouse which is well documented within its borders. This Conservation Site consists of the Walnut Creek stream channel and a 1/4 mile buffer zone on each side. Human impacts to the area and the unnatural surface water flow regime make it a less representative feature of regional, state, and national biodiversity.

Furthermore, these two Conservation Sites are part of a larger Rocky Flats Macrosite. Macrosites are intended to provide boundaries for large, landscape level conservation planning and management efforts. This Macrosite stretches from the Tracy Collins parcel of Boulder County Open Space in the north, to the intersection of Highways 93 and 72 in the south, to the Quarter Circle area in the west, to Indiana Street in the east. The Rocky Flats Macrosite is mostly undeveloped except for the RFETS industrial area and surface mining operations. It includes a large tract of land that could potentially support xeric tallgrass prairie but is as yet unstudied.

The Colorado Natural Heritage Program feels that the Rocky Flats Conservation Site is gravely imperiled. Expansion of area surface mines and possible annexation and development by local municipalites could irreparably fragment or even eliminate the rare natural heritage resources bound by the Conservation Site. The Colorado Natural Heritage Program recommends that the U.S. Department of Energy, the State of Colorado, and Jefferson County act to protect the Rocky Flats Conservation Site within one year or risk damaging the associated rare or imperiled natural values. The Walnut Creek Conservation Site is less imperiled because regulatory restraints

INTRODUCTION

Purpose of Study:
In July, 1994, the Colorado Natural Heritage Program (CNHP) was contracted by the U.S. Department of Energy's Rocky Flats Field Office to inventory and rank the natural heritage resources at its Rocky Flats Environmental Technology Site (RFETS) (Purchase Order Number DE-AP34-94RF00900). The project was conducted in two phases: one to study the Rock Creek drainage and the second to study the rest of the facility's open space belt, or Buffer Zone. The project is intended to provide an independent assessment of the ecological values on plant site for consideration in future land-use planning and compliance documents under numerous environmental statutes. Specifically, DOE requested CNHP to aggregate existing biological data into its Conservation Data Center, and apply an established and scientifically sound methodology to prioritize state-wide and globally significant species, populations and functional ecological communities associated with RFETS.

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imply continued Department of Energy ownership and management for some decades. The Rocky Flats Macrosite is moderately imperiled.

Some changes in the management regimes in the Rocky Flats Conservation Site and Walnut Creek Conservation Site are suggested. Weed control, fire management, water management, and road closures should be reviewed for their impacts on area ecology. The Colorado Natural Heritage Program would like to offer its services to the U.S. Department of Energy in developing natural resource management strategies for the facility and the area. Furthermore, we recommend the Department of Energy, 1) establish a roundtable of area landowners and managers to discuss scientific parameters of natural resource management issues; 2) continue to work with local landowners regarding routine management activities; 3) develop an integrated natural resource strategy; 4) continue to monitor ecological processes at RFETS, and; 5) designate RFETS as a National Environmental Research Park under the guidelines of this farsighted Department of Energy program.

Flora: The vegetative component of RFETS is representative of the High Plains bioregion, with extensive grasslands bisected by riparian shrublands and occasional wet meadows (Vestal 1919; Mutel and Emerick 1992). However, because of RFETS' unique location in the transition, or ecotone, between mountains and plains, many species indicative of montane ecosystems are also found in the study site. These montane representatives are mostly woody species, but herbaceous species typical of higher elevations are also present. The cessation of livestock production at RFETS has probably contributed heavily to the vegetative species mixture and total biomass present today. Furthermore, many exotic species are present, some completely dominating some areas.

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Geology: Surficial geology at RFETS is characterized by the Rocky Flats Alluvium, a remnant of fluvial Quaternary debris flows. These deposits consist of coarse gravel, coarse sand, and gravelly clay, with impermeable clay lenses distributed throughout. The alluvium is up to 100 ft. thick in places (particularly just east of the hogback that runs beneath the west side of the Buffer Zone) although it averages 30 ft. throughout most of the study area (U.S. Department of Energy 1992). Valley fill colluvium dominates the lower areas. The clay lenses in the colluvium are responsible for frequent slumping and sloughing along terrace sides.

Bedrock geology is dominated by Cretaceous sandstones, the Arapahoe, Laramie, and Fox Hills Formations, in descending order. It is believed that the contact point between the upper alluvium, and the lower, less permeable sandstones is at least partially responsible for the numerous seeps and springs in the study area (U.S. Department of Energy 1992).

Hydrology: The hydrographic profile of RFETS is very important in determining the potential natural elements that exist there. Groundwater consists mostly of an upper aquifer in the Rocky Flats Alluvium, and occurs in unconfined conditions. Groundwater flow tends to begin in the west and move towards lower elevations in the east (Hurr 1976). Recharge comes during winter and spring precipitation. While most precipitation occurs during the spring and summer, these events are usually too large and too brief to be properly absorbed by surficial material and contribute instead to surface water flow. Deeper aquifers are confined to bedrock formations, probably recharged from outcropped areas to the west, and do not significantly contribute to RFETS' ecology (EG&G Rocky Flats 1993a).

Most surface water flow is anthropogenically managed for water transfer to downstream users and for facility operations. Only Rock Creek, the northern drainage, and the upper reaches of Woman Creek maintain a natural flow regime. Walnut and Woman Creeks contain 12 surface water management ponds designed for containment of non-point runoff, wastewater treatment plant effluent, and emergency spill containment. Flows are unnaturally managed (i.e. monthly pulses instead of annual pulses) which may be impacting stream ecological processes. The quality of RFETS surface water is well documented and an unlikely factor in determining RFETS' ecological significance (U.S. Department of Energy 1994d).

METHODS

Due to previous CNHP projects in Boulder County and Jefferson County, much of the information required for solid conservation planning is already available. This allowed CNHP staff to conduct the RFETS survey on a more discrete level and more efficiently. The methods for this project are outlined below.

Identify Significant Natural Elements:
The CNHP tracks rare and imperiled natural elements across the state and ranks them based on viability, size, and rarity (Colorado Natural Heritage Program 1995). An element can be a plant, animal, or natural community. The elements that potentially occur in the study area are listed in Table 1. Information explaining the Heritage ranking system is provided in Appendix A. This

list of potential elements was derived by consulting local museums, herbaria, literature, technical experts, and the CNHP's Biological Conservation Database.

Some of the highest priority elements CNHP was interested in identifying were the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), Ottoe skipper (*Hesperia ottoe*), regal fritillary (*Speyeria idalia*), Ute's ladies' tresses (*Spiranthes diluvialis*), Colorado butterfly weed (*Gaura neomexicana ssp. coloradensis*), and the natural communities of great plains mixed grass prairies (*Stipa comata*- east) and xeric tallgrass prairies (*Andropogon gerardii-Schizachyrium scoparium*).

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DOLICHONYX ORYZIVORUS	BOBOLINK	G5	S3B, SZN		
Fish					
none					

Mammals

ZAPUS HUDSONIUS PREBLEI	PREBLE'S MEADOW JUMPING MOUSE	G5T2	S2	C2	SC
MYOTIS CALIFORNICUS	CALIFORNIA MYOTIS	G5	S2		
SOREX MERRIAMI	MERRIAM'S SHREW	G5	S3		

Reptiles

TROPIDOCLONION LINEATUM	LINED SNAKE	G5	S3	U	

Insects

SPEYERIA IDALIA	REGAL FRITILLARY	G3	S1	C2	
HESPERIA OTTOE	OTTOE SKIPPER	G3?	S2		
CELASTRINA NEGLECTAMAJOR	APPALACHIAN BLUE	G4	S1?		
ATRYTONE AROGOS	AROGOS SKIPPER	G4	S2		
ERYNNIS MARTIALIS	MOTTLED DUSKY WING	G4	S2S3		
INCISALIA MOSSI	MOSS'S ELFIN	G4	S3		
DOA AMPLA	A MOTH	G?	S1		
GRAMMIA SP. 1	A MOTH	G?	S?		
AESHNA EREMITA	LAKE DARNER	G5	S1?		
AESHNA VERTICALIS	GREEN-STRIPED DARNER	G5	S?		
CORDULIA SHURTLEFFI	AMERICAN EMERALD	G5	S1?		
CALOPTERYX AEQUABILIS	RIVER JEWELWING	G5	SH		
ARGIA SEDULA	BLUE-RINGED DANCER	G5	S2		
ARCHILESTES GRANDIS	GREAT SPREADWING	G5	S3		

Mollusks

PROMENETUS EXACUOUS	SHARP SPRITE	G?	S2		
PROMENETUS UMBILICATELLUS	UMBILICATE SPRITE	G?	S3		

Vascular plants

SPIRANTHES DILUVIALIS	UTE LADIES' TRESSES	G2	S1	LT	1
GAURA NEOMEXICANA SSP COLORADENSIS	COLORADO BUTTERFLY WEED	G5T1	S1	C1	1
CAREX OREOCHARIS	MONTANE SEDGE	G3	S1?		
MALAXIS BRACHYPODA	WHITE ADDER'S-MOUTH	G4	S1	C2	2
CAREX TORREYI	TORREY SEDGE	G4	S?	3	
RIBES AMERICANUM	AMERICAN CURRANT	G5	S1	2	
CRATAEGUS CHRYSOCARPA	YELLOW HAWTHORN	G5?	S1S2	2	
VIOLA PEDATIFIDA	PRAIRIE VIOLET	G5	S2	3	
EUSTOMA RUSSELLIANUM	SHOWY PRAIRIE GENTIAN	G5	S3	C2	2
ROTALA RAMOSIOR	TOOTHCUP	G5	S?	3	
ARISTIDA BASIRAMEA	FORKTIP THREE-AWN	G5	S?	3	

Natural communities

STIPA COMATA - EAST	GREAT PLAINS MIXED GRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII-SCHIZACHYRIUM SCOPARIUM	XERIC TALLGRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII -SORGHASTRUM NUTANS	WET PRAIRIES	G3	S1
CAREX NEBRASCENSIS WETLAND	GREAT PLAINS WET MEADOWS	G4	S?
POPULUS DELTOIDES-SALIX AMYGDELOIDES/SALIX EXIGUA	GREAT PLAINS RIPARIAN	G2	S2

1 Abbreviations are as follows:
C2 = Category 2 Candidate
LE = Listed Endangered
LT = Listed Threatened

2 Abbreviations are as follows:
1 = federal threatened or endangered that are rare throughout their range
2 = plant species which are rare in Colorado but relatively common elsewhere within their range
3 = species which appear to be rare but for which conclusive information is lacking;

Conduct Field Surveys:
DOE and its prime contractor Kaiser-Hill have ecological surveys and monitoring programs in place that record the presence, absence, and viability of potential natural elements at the RFETS. These include a detailed research program on the Preble's meadow jumping mouse (by Dr. F.A. Harrington) and three years of surveys for the Ute's ladies tresses (by Dr. D. Buckner) (EG&G Rocky Flats, Inc. 1993b). Also, the *Biological Characterization of the Rocky Flats Plant* (U.S. Department of Energy 1992), the Ecological Monitoring Program, and the Natural Resource Protection and Compliance Program have or continue to catalogue and monitor the Site's biota. This work helped focus CNHP field efforts. CNHP agreed to avoid duplicating ongoing or recent research at RFETS by not pursuing these areas. DOE has provided CNHP with all the pertinent data from said research for integration into this report. The high quality research efforts of EG&G Rocky Flats *cum* Kaiser-Hill and its sub-contractors were critical to an accurate assessment of the conservation priorities of the study area.

CNHP conducted field surveys for potential natural elements during the 1994 and 1995 field seasons. The surveys considered the Rock Creek drainage first, generating the Phase I report on the area (see Appendix C). Phase II field work covered the remainder of RFETS, particularly the Buffer Zone where Heritage Program scientists pursued the confirmation of rare and imperiled butterflies and significant natural communities. This work completed the ecological picture needed to develop accurate conservation priorities.

Site Boundary Determination:
Conservation Sites are developed through a rigorous screening process that considers not only the occurrence and viability of a rare ecological element(s), but also the management and protection urgencies associated with the area and the element occurrence(s). They are based on leading principles of conservation biology and the latest scientific understanding of the elements' life-cycle requirements.

Conservation Sites are intended to provide planning units to protect and properly manage the suite of valuable natural elements that occur within the study area. **They are not legal designations of any sort but should be considered in future decision-making regarding land use and management.** The Conservation Sites are described in a standard site report. The sections of this report are outlined and explained below.

SIZE: The approximate acreage included within the conservation planning boundary for the Conservation Site.

BIODIVERSITY RANK: The overall significance of the Conservation Site in terms of rarity of the natural heritage resources and the quality and condition (health, abundance, etc.) of their occurrences. As discussed in Appendix A, these ranks range from B1 (Outstanding Significance) to B5 (General Biodiversity Significance).

PROTECTION URGENCY RANK: The time frame in which conservation protection must occur. In most cases, this rank refers to the need for a major change of protective status (e.g.

agency special area designations or ownership). The ranks range from P1 (immediate urgency; within a one-year time frame) to P5 (no known urgency).

MANAGEMENT URGENCY RANK: The time frame in which a change in management of the element or Conservation Site must occur. Using best scientific estimates, this rank refers to the need for management in contrast to protection (e.g. increased fire frequency, decreased herbivory, weed control, etc.). The ranks range from M1 (immediate urgency; within one year) to M5 (no known urgency).

LOCATION: The USGS 7.5' (1:24,000) topographic quadrangles that include the Conservation Site. The Natural Heritage Program code for the quadrangle is noted in parentheses.

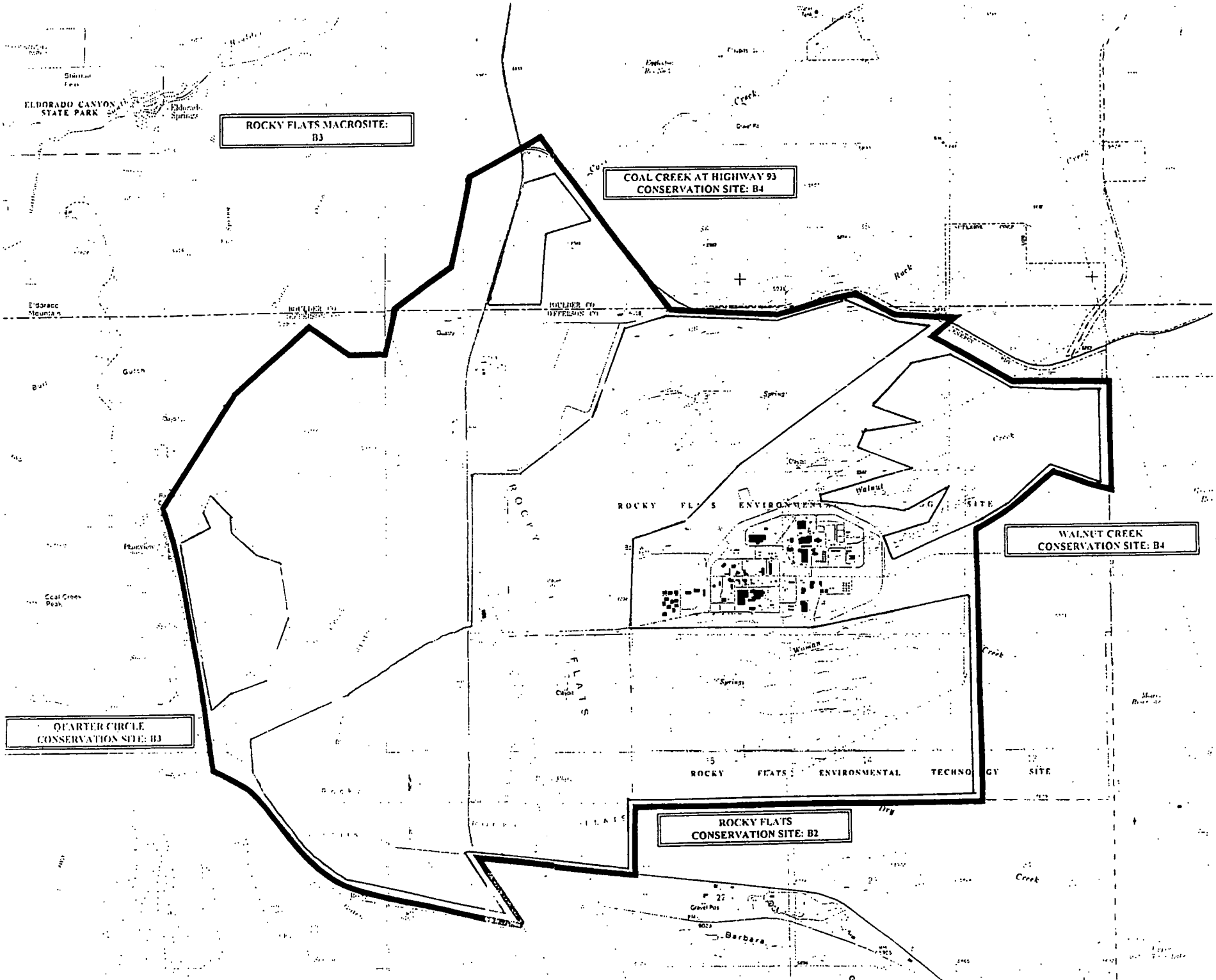
GENERAL DESCRIPTION: A brief narrative picture of the topography, vegetation, and current use of the Conservation Site. Common names are used along with the scientific names.

NATURAL HERITAGE RESOURCE SIGNIFICANCE: A synopsis of the rare species and significant natural communities that occur on the Conservation Site.

CURRENT STATUS: A summary of the ownership, degree of protection currently afforded the Conservation Site, and threats to the site or natural heritage resources as determined to date.

BOUNDARY JUSTIFICATION: The preliminary conservation planning boundary delineated in this report includes all known occurrences of natural heritage resources and the adjacent lands required for their protection.

PROTECTION AND MANAGEMENT CONSIDERATIONS: A summary of the major issues and factors that are known or likely to affect the protection and management of the Conservation Site.


ELDORADO CANYON STATE PARK
ROCKY FLATS MACROSITE: B3
COAL CREEK AT HIGHWAY 93 CONSERVATION SITE: B4
WALNUT CREEK CONSERVATION SITE: B4
QUARTER CIRCLE CONSERVATION SITE: B3
ROCKY FLATS CONSERVATION SITE: B2
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
Walnut
Barbara

ROCKY FLATS CONSERVATION SITE

SIZE: approx. 4000 acres

BIODIVERSITY RANK: B2
PROTECTION URGENCY: P1
MANAGEMENT URGENCY: M2

LOCATION: Louisville Quadrangle (3910582)
Eldorado Springs Quadrangle (3910583)
Golden Quadrangle (3910572)
Ralston Buttes Quadrangle (3910573)
T2S, R70W, Sections 2,3,4,9,10,14,15,16,17,20,21

GENERAL DESCRIPTION: The Rocky Flats Conservation Site occurs on the south and west portions of the Rocky Flats alluvial fan and, to some extent, down into the colluvial valleys that dissect it. Most of the Conservation Site is located on the Rocky Flats Environmental Technology Site (RFETS), a former nuclear weapons manufacturing facility overseen by the U.S. Department of Energy. RFETS is listed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The flora is similar to other alluvial fans in the region, although many of these natural communities are increasingly threatened by urban development. The fauna of the Conservation Site has been more highly impacted by regional extirpations of some high trophic level mammals, but still retains many common animals and some rarer ones.

The Rocky Flats Conservation Site is bounded by Highway 128 on the north, Coal Creek to the west, and the RFETS boundary to the south. The eastern boundary follows a rough line that follows the eastern extent of the Rock Creek watershed, curves around to the west of the facility's industrial area, and runs southeast to include the wetland complexes of upper Woman Creek. Much of this Conservation Site includes a previous Site, "Rock Creek," identified in Phase I, but includes new element occurrences identified in Phase II, warranting a revision of the previous Site boundary.

Additionally, this Conservation Site is part of the larger Rocky Flats Macrosite, a landscape level boundary that includes a reach of Coal Creek below Coal Creek Canyon, the Quarter Circle area below Coal Creek Peak, the previous Rock Creek boundary, and the Walnut Creek site. This information is based on previous surveys conducted by CNHP (Pague et al. 1993).

NATURAL HERITAGE RESOURCE SIGNIFICANCE: This Conservation Site has retained much of its native character due to the general exclusion of the public that occurred during the Cold War. Although RFETS operations and activities have impacted some of the targeted natural elements, particularly on the facility's eastern half, much of the study area remains in relatively natural condition and only moderately fragmented. These areas are included in the Conservation Site.

As with the Rock Creek Conservation Site, the predominant element occurrences are xeric tallgrass prairie, Great Plains riparian community, the Preble's meadow jumping mouse, and unusual shrubland communities. However, CNHP field work this year also discovered the occurences of two rare and imperiled butterflies, Arogos skipper and hops blue.

The dominant upland vegetative type in this Conservation Site is xeric tallgrass prairie. It is likely this association is a Pleistocene relict community that was once connected to tallgrass prairie hundreds of miles to the east (Livingston 1952). Due to climate change, it was restricted to the length of the Colorado Piedmont when European settlement arrived.

Xeric tallgrass prairie is dominated by big bluestem and little bluestem (*Andropogon gerardii-Schizachyrium scoparium*). Additional species found in this occurrence were Canada bluegrass (*Poa compressa*), a low-aggression alien species, needle-and-thread grass (*Stipa comata*), and mountain muhly (*Muhlenbergia montanum*) a native species typical of montane environments, but found here at the lower part of its range (U.S. Department of Energy 1994b; U.S. Department of Energy 1995a). The soils are Flatirons very sandy cobbly loam, 0-3 percent slope (U.S. Department of Agriculture 1980).

In the last one hundred years, xeric tallgrass prairie has been highly impacted throughout its range by urban and rural development. Furthermore, aggressive alien species, such as cheat grass (*Bromus tectorum*), Japanese brome (*Bromus japonicus*), and diffuse knapweed (*Centaurea diffusea*) have invaded and degraded the viability of many examples of this community throughout the west. CNHP believes it exists in less than 20 places globally, therefore it is imperiled globally and in the state and ranked G2/S2 (Bourgeron and Engelking 1994). (See Appendix I for detailed explanation of Natural Heritage ranks.)

The original occurrence boundary discussed in Phase I has been revised. Field surveys and monitoring data indicate that the xeric tallgrass prairie community exists on the mesa tops in the southwest corner (section 15) of the RFETS Buffer Zone and is included in the occurrence. The remainder of section 16 not previously included in the occurrence boundary is also now included. Similar grasslands appear to extend beyond the study area, west of Highway 93, indicating that this community occurrence is part of a larger, even more viable system (Western Aggregates 1994). Therefore, CNHP has included this extended occurrence in the Conservation Site. With the use of a Series 30 Lasico planimeter, CNHP has determined that, with these additions to the previous occurrence, the community is at least 2500 acres.

Discussions with other Natural Heritage Programs throughout the western states indicate that no similarly large occurrence of this community occurs outside Colorado (Cooper pers. comm. 1995). CNHP believes this is **the largest example of a xeric tallgrass prairie remaining in Colorado, and perhaps in North America**. Considering that most occurrences of this community range from 5-100 acres, adequate steps to protect and manage this community are critically important. Further study of this occurrence is warranted and should be afforded a very high priority.

It should be noted that detailed studies have indicated slight differences in species composition between sections 3 and 4, section 15, and section 16 (U.S. Department of Energy 1994a; U.S. Department of Energy 1995a; Western Aggregates Inc. 1994). In particular, big bluestem seems to be best represented on section 16, while sections 3 and 4 have retained a better distribution of forbs, such as blazing star (*Liatris punctata*), Porter's aster (*Aster porteri*), and golden aster (*Chrysopsis villosa*). This difference is probably due to the grazing regimen on section 16 and the complete absence of grazing in sections 3 and 4. More interesting is the dominance of needle-and-thread grass in parts of section 15. CNHP feels that the species composition in section 15 still warrants its classification as xeric tallgrass prairie, but it may be going through successional changes due to historical impacts unknown to CNHP, or growing in different unknown environmental conditions.

The greatest current impact to this occurrence appears to be fragmentation by roads, utility lines, ditches, and gravel pits. It is unclear what impact this has had on genetic viability of the occurrence but models exist to examine the possible effects of community fragmentation and should be considered (Usher 1987). Also, the exotic species mentioned above have impacted the margins of the community, particularly in conjunction with fragmentation and disturbance sites.

The Great Plains riparian community occurs in the Conservation Site. It is characterized by a diverse mixture of plains cottonwood, peach-leaved willow, and coyote willow (*Populus deltoides/Salix amygdaloides-Salix exigua*) with an understory of various low shrubs such as leadplant (*Amorpha fruticosa*) and snowberry (*Symphoricarpos occidentalis*). This community is rare and declining in its native conditions throughout the high plains of Colorado, Nebraska, and Kansas. Threats to this community type are primarily water development, use and management, but exotic species such as leafy spurge (*Euphoribia esula*) and purple loosestrife (*Lythrum elata*) are also problems. Due to these threats it is ranked G2G3/S2S3, indicating that it exists in only 20-50 sites across its historically large range (Bourgeron and Engelking 1994). It is similarly very rare to rare in Colorado. Although some examples of this community are becoming more common along the South Platte river, this may be due to human induced water management and the elimination of the natural flood cycle, not natural processes (Knopf and Scott 1993).

The only significant occurrence of Great Plains riparian community in the Conservation Site is in the Rock Creek drainage. This is probably due to the relatively natural surface water flow regime in the creek (Knopf et al. 1988). This occurrence is considered poor, however, because of the high number of exotic species in the understory. Phase II surveys of Rock Creek riparian vegetation indicate that the intrusion of exotics witnessed during Phase I has not qualitatively declined. Primary invaders are Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutaans*), smooth brome (*Bromopsis inermis*), and Kentucky bluegrass (*Poa pratensis*) (U.S. Department of Energy 1995).

In Walnut Creek, it is unclear how water management affects the plant communities found there, but the flood control systems in this drainage are major human modifications to the natural cycle. Below the Mower Ditch diversion in Woman Creek, for example, the occurrence is severely

impacted. This community could be restored simply by returning natural flows to the lower portions of the creek. Most of the riparian community in Walnut Creek has been fragmented by roads and is dominated in the understory by exotic species.

Despite the generally xeric nature of the Conservation Site several wetlands occur, mostly in the upper Woman Creek drainage but also on north aspect slopes in Rock Creek. The most prominent wetland plant communities present in these wetlands are narrow-leaved cattail (*Typha latifolia*) plant association, Baltic rush (*Juncus balticus*) plant association, and Nebraska sedge (*Carex nebrascensis*) plant association (U.S. Army Corps of Engineers 1995). These communities are all ranked G5/S4 by CNHP. A watercress (*Nasturtium officinale*) community, a small but highly productive association, grows at seep discharge sites with copious surface water flow. This association, however, is unranked by CNHP because watercress is considered an introduced species from Europe (Weber pers. comm. 1995).

The low rarity ranks of these plant associations (and the exotic nature of the *Nasturtium* association) indicate that they are demonstrably secure on a global scale and apparently secure in Colorado. These wetland occurrences are also not among the best examples of common associations in the state due to their relatively restricted size. They don't rank as high priorities for their Natural Heritage values with respect to plant associations. This view is bolstered by recognition that the seep sites in upper Woman Creek may be enhanced by anthropogenic water impoundments (e.g. Rocky Flats Lake) to the west (U.S. Army Corps of Engineers 1995).

The wetlands in the Conservation Site do, however, potentially serve other important functions and values, as do wetlands everywhere. Perhaps most importantly, we do not yet understand how wetland mosaics present in the Conservation Site support local populations of Preble's meadow jumping mouse. These wetlands may also retain nutrients, sediment, and metals in the water, provide food chain support both within the basin and downstream, and provide forage, cover, and nesting habitat for wildlife (Mitch and Gosselink 1994).

As discussed in Phase I, the hillside seeps in Rock Creek support a unique tall shrubland complex (Kettler et al. 1994). Dominated by hawthorn (*Crataegus erythropoda*), chokecherry (*Prunus virginiana*), and some western snowberry (*Symphoricarpos occidentalis*), CNHP has tentatively classified it as hawthorn-chokecherry-snowberry plant association, ranked GU/SU to indicate its poorly known status. The association is known in the vicinity of the study area. primarily where the Laramie/Fox Hills formation outcrops from the Rocky Flats Alluvium as a hogback, but these occurrences are limited in size and number. Historical records have identified the community type along the mountain front in Boulder County, but fire suppression and succession may have led to its decline (McHenry 1929; Roach 1948). Although a similar community exists in Montana, its dominant species is succulent hawthorn (*Crataegus succulenta*) likely making it a different community type (Hansen et al. 1991). Further study of this community is warranted.

An additional unusual shrub community occurs within Rock Creek, and to some extent in Woman Creek. It is dominated by leadplant (*Amorpha fruticosa*) and is also classified as

GU/SU. It occurs in floodplains of the stream channels, adjacent to the Great Plains riparian community. Like the Great Plains riparian community, it is believed that this shrubland has been highly impacted by water management and exotic species intrusion, but historical records and trends are lacking, leading to the "unknown" ranking by CNHP.

An historic record exists from 1973 of the rare sedge, *Carex oreocharis*, near the mesic community study site (TR02) in the northwest corner of the Conservation Site (U.S. Department of Energy 1995a; Nelson pers. comm. 1995). Regionally, this plant species is found in undisturbed xeric outwashed mesas, from the montane to subalpine biomes (Weber 1990). It is a globally uncommon plant, and its status in Colorado is extremely rare but uncertain, giving it a G3/S1? rank by CNHP. It has been recorded in only three other locations in the state: in Teller, Gilpin, and Conejos counties. CNHP believes that its occurrence in the Conservation Site is further indication of the rare and sensitive nature of undisturbed areas. Also, most occurrences of this species have been on granitic soil, so it is of additional interest that this occurrence is found on Cretaceous derived material. Further study of this species' distribution and ecology in the Conservation Site is critical to a better understanding of the its status in Colorado.

The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is well documented in the Conservation Site (EG&G Rocky Flats 1992; Compton and Hugie 1993; U.S. Department of Energy 1993; U.S. Department of Energy 1994a; U.S. Department of Interior 1994; U.S. Department of Energy 1995a). It was previously ranked extremely rare by CNHP, or G5T1?/S1?, because of its relatively unstudied nature and the perception that it occurred in less than 5 populations, globally. However CNHP has re-ranked the sub-species as G5T2/S2 based on field surveys conducted range-wide during 1995 that indicate that it is now found in over 5 populations along the Colorado Piedmont.

The Rock Creek population was previously thought to be the last within the subspecies' range containing sufficient numbers and in adequate habitat to be considered a viable population (Kettler et al. 1994). But additional surveys, particularly in City of Boulder of Open Space and at the U.S. Air Force Academy, have identified other viable populations (Miller pers. comm. 1995; Corn et al. 1995). Because of the natural flow regime and relatively unfragmented habitat, the Preble's meadow jumping mouse occurrence in Rock Creek is still considered very good by CNHP. It is noteworthy that the Rock Creek population may represent an extreme habitat in the range of variability exhibited by the subspecies. The Woman Creek occurrence is considered average to poor due to its smaller population.

Although CNHP did not conduct live trapping for small mammals, Merriam's shrew (*Sorex merriami*) is recorded from previous RFETS studies (U.S. Department of Energy 1992). This insectivore prefers sandy, shaly, broken cover particularly in uplands. Its habitat is often typified by rabbitbrush (*Chrysothamnus nauseosus*) and sagebrush (*Artemisia tridentata*) (Fitzgerald et al. 1995). It is considered rare in Colorado, justifying a G5/S3 rank by CNHP. Information provided to CNHP claims that the capture of Merriam's shrew occurred within the Rocky Flats Conservation Site (Harrington pers. comm. 1995).

Avian species within the Rocky Flats Conservation Site are mainly typical of the high plains biome with a large number of migratory occurrences. Most breeding birds within the Conservation Site, such as song sparrow (*Melospiza melodia*) and red winged blackbird (*Agelaius phoeniceus*) are generally common and not tracked by the CNHP ranking system. Exceptions to this are loggerhead shrike (*Lanius ludovicianus*) and grasshopper sparrow (*Ammodramus savannarum*).

The loggerhead shrike is ranked G4/S3B by CNHP. It is widespread globally, but rarely breeds in Colorado. Breeding status in the Conservation Site for loggerhead shrike is considered probable, as four to six individuals have been observed in the area throughout the year (Murdock pers. comm. 1994). They have been recorded in riparian, shrubland, and grassland habitats (U.S. Department of Energy 1994a). This population is suspected to breed in the tall shrubland complex of Rock Creek (Murdock pers. comm. 1995).

Because CNHP believes breeding grasshopper sparrows occur in just over 100 locations state-wide, the species is ranked G5/S3BS4B. It is known to breed in the xeric tallgrass prairie occurrence in the Conservation Site. EG&G estimated breeding population density for grasshopper sparrows in the prairie community (as it occurs on RFETS) to be 0.65 birds/hectare, or roughly 120 birds (U.S. Department of Energy 1995c). This species' occurrence is a further indicator of the special nature not only of the Conservation Site in general, but the xeric tallgrass prairie in particular.

CNHP documented the presence of two rare or imperiled butterflies during field surveys. These are the Arogos skipper (*Atrytone arogos*) and hops blue (*Celestrina sp.*). Both are considered rare in the state. Also, the Ottoe skipper (*Hesperia ottoe*) has been documented just south of RFETS in historic records. This species may exist in this area but was not documented through this survey.

The Arogos skipper is ranked G3G4/S2 because it is relatively common globally but found in less than twenty places in Colorado and is associated with xeric tallgrass habitats which are themselves threatened. This rarity is probably due to its reliance on certain grassland plant species as hosts, most of which have been impacted throughout their range. It was found in the xeric tallgrass prairie in section 15, in the upper reaches of the Smart Ditch drainage, south of Woman Creek. The specimen was observed resting on a milkweed plant (*Asclepias speciosa*), although many ruderals, such as Canada thistle and Dalmatian toadflax (*Linaria dalmatica*), were present. This observance helps confirm the overall quality of the xeric tallgrass prairie occurrence and indicates that significant components of this community exist.

Hops blue is currently G2Q/S2 because while it is believed to be very rare globally, taxonomic questions exist regarding the species. CNHP field staff captured 2 individuals and observed several others in the upper Rock Creek drainage. The species' host plant, common hops (*Humulus lupulus*), grows in the understory of the seep shrubland community. Although common hops is abundant in upper Rock Creek, it is apparently not widespread in the Conservation Site and may be restricted to this community association. Like the Arogos skipper,

CNHP believes the hops blue occurrence provides further evidence of the biodiversity qualities of the Conservation Site in general, but also of Rock Creek in particular.

Table 2: Known Natural Elements in the Rocky Flats Conservation Site

ELEMENT	COMMON NAME	OCCUR RANK	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
ZAPUS HUDSONIUS PREBLEI	PREBLE'S MEADOW JUMPING MOUSE	B	G5T2	S2	C2	
SOREX MERRIAMI	MERRIAM'S SHREW	?	G5	S3		
LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	?	G4	S3B	C2	
AMMODRAMMUS SAVANNARUM	GRASSHOPPER SPARROW	?	G5	S3B/S4B		
CELESTRINA SP.1	HOPS BLUE	C	G2Q	S2		
ATRYTONE AROGOS	AROGOS SKIPPER	C	G4	S2		
CAREX OREOCHARIS	MONTANE SEDGE	?	G3	S1		
ANDROPOGON GERARDII-SCHIZACHYRIUM SCOPARIUM	XERIC TALLGRASS PRAIRIE	B/C	G2	S2		
POPULUS DELTOIDES-SALIX AMYGDELOIDES/ SALIX EXIGUA	PLAINS COTTONWOOD RIPARIAN WOODLAND	D	G2G3	S2S3		
AMORPHA FRUTICOSA	RIPARIAN SHRUBLAND	?	GU	SU		
CRATAEGUS ERYTHROPODA - PRUNUS VIRGINIANA-SYMPHORICARPOS OCCIDENTALIS	SEEP SHRUBLAND	?	GU	SU		

OTHER BIODIVERSITY VALUES: The Colorado Bird Observatory (CBO), in conjunction with Partners in Flight, has developed a bird prioritization system that considers species status on wintering grounds as well as breeding grounds. Emphasis is also placed on trend data (Colorado Bird Observatory 1995). The CBO ranking scheme recognizes several high priority species that use the Conservation Site. These species include lark bunting (*Calamospiza melanocorys*),

ferruginous hawk (*Buteo regalis*), MacGillivray's warbler (*Oporornis tolmiei*), Brewer's sparrow (*Spizella breweri*), and several others (U.S. Department of Energy 1995a). Although many observations of these species at the Conservation Site appear to be casual, it should not be overlooked that the area could provide essential migratory stopover habitat for these and more common species.

Furthermore, as part of a larger, landscape-level, open space contingent, it is likely that the Conservation Site is an important contributor to healthy predator-prey relationships. The size and relatively high quality of the area supports potentially viable populations of numerous species that are typical of the natural communities at RFETS. This supports biodiversity at the landscape level by preventing biogeographic (or island) effects prevalent in many natural areas (Macarthur and Wilson 1967). This is likely to be important to some common species, but particularly so for more motile and rare species.

CURRENT STATUS: Approximately 1/2 of the Rocky Flats Conservation Site occurs on the Rocky Flats Environmental Technology Site. The western 1/2 lies on private property and State Land Board property. As stated in the Phase I report, **no protection exists for this Conservation Site** (Kettler et al. 1994). Although CNHP recommended immediate (within one year) actions to ensure the area's preservation due to its natural heritage, neither DOE nor any other agency has stepped forward to do so (although DOE's newly established policies to protect the Preble's meadow jumping mouse and to minimize personnel in Rock Creek have demonstrated initiative). CNHP understands that a proposal to formally designate RFETS as a National Environmental Research Park (NERP) was developed, but apparently no further action has taken place (Johnston pers. comm. 1995).

The remainder of the Conservation Site on DOE property has an unsure future. The Future Site Use Working Group (FSUWG) is a stakeholder involvement group convened by DOE to provide input on future use options. The FSUWG has submitted a Site-Wide recommendation to DOE that includes the Conservation Site.(Future Site Use Working Group 1995). Most of the area was identified as Open Space and Environmental Reasearch, but remediation activities in upper Woman Creek are possible, and private gravel mining is recommended. Also, the FSUWG was split on the concept of a regional transportation corridor through the Rock Creek area. Overall, the recommendation is not binding and it is not clear to what extent, if any, DOE will implement the recommendation.

The Jefferson County Planning Commission has conditionally permitted the expansion of a sand and gravel mining operation into the northwest portion of the Conservation Site, in sections 3 and 4 (Jefferson County Planning Commission 1995a). Although the conditional permit requires intensive monitoring of impacts to groundwater, and its contribution to the unique shrublands and riparian area in Rock Creek, there is no discussion of the protection or rehabilitation of the xeric tallgrass prairie found within the permit area.

In section 16, in the south central portion of the Conservation Site, the Jefferson County Planning Commission has conditionally permitted, sand and gravel mining (Jefferson County Planning

Commission 1995b). Unlike the section 3 and 4 permit, however, the county has indicated that the xeric tallgrass found there is worthy of protection and has limited the spatial scope of the requested operating area. The area is also grazed by livestock.

Private land on the western portion of the Conservation Site continues as rangeland for cattle. The county is considering the area as a possible open space parcel but proposals also exist to annex and develop the west side of Highway 93. Some of the land between RFETS and the highway is zoned and for sale for industrial use (Hellner pers. comm. 1995).

Threats from invasion of non-native plant species was mentioned earlier in the report. CNHP considers this continuing pressure on the xeric and riparian vegetation communities to be quite serious, especially considering their rarity. Also, fragmentation of habitats by access and fire break roads, utility poles, ditches, and general Site management activities is generating additional threats to the viability of native plant communities. Due to these increasing or impending threats, CNHP believes the Rocky Flats Conservation Site to be seriously imperiled.

SITE BOUNDARY JUSTIFICATION: The Conservation Site boundaries for the Rocky Flats Conservation Site include the documented boundaries of xeric tallgrass prairie, the Great Plains riparian community in Rock Creek, the Preble's meadow jumping mouse occurrences in Rock Creek and upper Woman Creek, and the invertebrate occurrences.

The potential extent of xeric tallgrass prairie is documented by Western Aggregates, Inc. (1995) and, while fragmented by roads and gravel pits, is considered one occurrence by CNHP. It stretches from the northwest corner of the Conservation Site south through section 16 and west for an uncertain distance across Highway 93. Although it is unclear what size of prairie constitutes a viable community, CNHP feels that the boundary, particularly to the west, accurately captures the known area of the occurrence.

The boundary is also considered a "buffer area" for the rare invertebrates recorded in the study area. It is difficult to monitor the range of these animals but this "buffer area" should sufficiently protect their perceived needs by including adequate habitat size.

It should be noted that the Rock Creek and Woman Creek watersheds are joined into one Conservation Site. This is an atypical boundary determination by CNHP and is due to two factors. First, the xeric tallgrass prairie occurrence equally covers both watersheds. Second, hydrologic inputs to Woman Creek are probably from shallow groundwater recharge in the pediments of sections 16 and 15, east of the sandstone hogback that runs north-south through the area (U.S. Department of Energy 1992; U.S. Department of Energy 1994d). Although the Woman Creek channel has been historically used for water conveyance to downstream users, and thereby contributing to flow patterns and possibly augmenting Preble's meadow jumping mouse habitat, this practice will not continue due to construction of the Kinnear Pipeline (Hill pers. comm. 1995). It is critical that, in order to ensure natural surface water flow and continued viability of the Preble's meadow jumping mouse occurrence in Woman Creek, the groundwater recharge area be included and recognized within the Conservation Site.

PROTECTION RECOMMENDATIONS: The Conservation Site, as noted earlier, is afforded no level of protection, aside from exclusion of the general public. Due to the Conservation Site's ecological significance, and the numerous threats to its viability, CNHP has reissued its Rock Creek Protection Urgency Rank of P1 to this larger, Rocky Flats Conservation Site (Kettler et al. 1994). This indicates that management agency(ies) involved should take steps to ensure its protection within one year or risk losing this valuable natural heritage. This will involve coordination between the U.S. Department of Energy, U.S. Department of Interior, U.S. Environmental Protection Agency, Colorado Department of Natural Resources, Colorado Department of Health and the Environment, Jefferson County, and private landowners, including surface rights owners, mineral rights owners, and water rights holders. Private land trust organizations might be helpful in securing the protection of some or all of this Conservation Site.

Designating RFETS (and subsequently the Conservation Site) as a NERP should be a primary protection objective for the Department of Energy. When compared to other NERPs around the country, such as those at the Savannah River Site and the Hanford Site, the Rocky Flats Conservation Site surely ranks as an area of equal ecological interest, especially considering its unique physiogeographic attributes. This site would provide many beneficial opportunities for research and education, as required by NERP guidelines (U.S. Department of Energy 1994e).

Furthermore, it is unclear what the final actions under CERCLA (or Superfund) might be. Operable Unit 11 (the West Spray Field) lies in the central part of the Conservation Site but there will be no further action in that area. However, there are some Individual Hazardous Substance Sites within Operable Unit 5 (Woman Creek), in the eastern portion of the Conservation Site, that are still under study. CNHP believes that remediation actions will be done with care, but because they are unresolved at this point they are of some concern.

MANAGEMENT RECOMMENDATIONS: The Rocky Flats Conservation Site needs an improved management regime. CNHP feels that this should occur within five years or risk serious degradation of biodiversity attributes. Therefore, the Conservation Site is ranked M2. The reasons for this rank include weed infestation, fragmentation by roads, and unnatural fire and water management. Specific recommendations are outlined below.

Xeric tallgrass prairie management recommendations: This occurrence has utmost management import. The fragmentation of the xeric tallgrass prairie must be addressed soon by the appropriate management agencies. Further stresses of this nature may be irreparable (Kindscher 1995). Most of the fragmentation has come from roads and sand, gravel, and clay mining.

The *Watershed Management Plan* outlines a plan for road closures that CNHP endorses (U.S. Department of Energy 1993). By closing and restoring 0.5-1.0 miles of Buffer Zone roads annually, much of the current fragmentation trend could be reversed. The remaining fragmentation, however, is more difficult to remedy. Previous and current sand, clay, and gravel operations are often deleterious impacts upon the natural community due to their size and

propensity for generating exotic vegetation (Kettler personal observation). They will continue to operate and grow for some time, making management difficult.

As discussed earlier, specific areas of the Buffer Zone have been severely impacted by aggressive, alien vegetation. CNHP feels that these species present a very grave threat to the viability of the Site's native plant communities, particularly the xeric tallgrass prairie. The exotic species threatening the occurrence include diffuse knapweed, cheatgrass, Japanese brome, musk thistle, Dalmatian toadflax, and alyssum (*Alyssum minus*). Of these species, musk thistle, toadflax, alyssum, and knapweed present the greatest threat of increasing invasion of the grassland. Cheatgrass and Japanese brome have formed dense mats in disturbed areas but do not seem to spread aggressively beyond that.

The Site *Watershed Management Plan* (U.S. Department of Energy 1993) outlines a specific program intended to develop effective weed management protocols for the Buffer Zone. After two field seasons of surveys, however, CNHP believes adhering to this Plan may no longer be enough. With each passing year the ability to effectively manage invasive weeds may be compromised. Due to the rapid increase of non-natives since the inception of the *Plan*, it is timely to reconsider new, more accelerated approaches to containing the spread of these serious threats. These tools include not only traditional methods, such as herbicide application and mowing, but also the use of fire.

Fires are an integral part of grassland community evolution and it is believed that, under natural conditions, wild grassland fires occurred every 10-15 years (Brewer 1992). Fire has been well documented to not only to help control the spread of exotic species, but also increase overall species diversity (both floral and faunal) within the burned area, especially if conducted in conjunction with a managed grazing regime (Anderson 1982; Collins 1985; Hatch 1990; Hosten 1992). CNHP urges the Department of Energy to conduct a controlled fire feasibility study immediately and to research the effects of fire on exotic vegetation.

Preble's Meadow Jumping Mouse Recommendations: Because this Conservation Site contains one of the best known occurrences of the Preble's meadow jumping mouse, management for its continued population health is highly critical for the subspecies' range-wide success. Should further study indicate the Preble's meadow jumping mouse is averse to exotic vegetation, weed control should be accelerated in the riparian zone. This will require labor intensive efforts (such as hand pulling and cutting) because herbicide application is not recommended for riparian areas.

Great Plains Riparian Community Recommendations: In places, exotic species heavily dominate the understory in the mosaic of plant associations that make up this community and have degraded the occurrence in Rock Creek. It is suspected that heavy dominance of exotic species in the understory can result in drastic reduction in diversity of some animal groups (Bock and Bock 1988). As mentioned earlier, the most common and problematic species include Canada thistle, Kentucky bluegrass, and smooth brome. Early season grazing, burning or mowing may be effective management tools to control these exotic plants. Biological control

already implemented in the Buffer Zone appears to be only somewhat effective in controlling Canada thistle but quantitative data is lacking. Total elimination of exotic species is impossible but reducing the vigor and dominance of these species may allow native species to increase.

CNHP encourages RFETS to simulate a more natural surface water flow regime in lower Woman Creek. This may help restore the vegetation in the area to more closely resemble a native community. Although CNHP understands that there are several factors determining water management in the watershed, including downstream demands and CERCLA related activities, RFETS should consult with those dictating water use and educate them on the need for natural, cyclic events.

Seep Community Management Recommendations: These communities include both the shrubland and wet meadows complexes. The tall shrubland community has been invaded by non-native vegetation in the understory. Smooth brome and Kentucky bluegrass are the most apparent. As with the riparian areas, an early season grazing regime should be considered to control these aggressive propagators from expanding further. An experimental burning program might also be of merit.

***Carex Oreocharis* Management Recommendations:** The undocumented nature of this species in Colorado suggests to CNHP that its occurrence in the Conservation Site should be protected and studied further. A wider search designed to confirm or deny other occurrences throughout its range may be in order. It may be desirable to enlist the aid of a masters or doctorate student at one of the local universities to assist in this endeavor.

Invertebrate Management Recommendations: Studies have shown that the Colorado Piedmont is one of the country's four most important ecoregions for the conservation of the diversity of butterflies (Opler 1994). Butterflies can be easily monitored and may be good indicators of environmental changes. This is especially true for imperiled species or those associated with rare habitats. To this end, CNHP encourages the Department of Energy to conduct additional studies of the species identified in this report and for other rare species known from the general area that were not confirmed in the Conservation Site. These unconfirmed elements include the rare Ottoe skipper, a G3/S2 species recorded in xeric tallgrass prairie 3 miles southwest of the study area. CNHP also suggests restricting any broad-leaf herbicide application in the vicinity of the known occurrences in order to ensure the protection of the host plants these species require for their survival. We cannot overemphasize that the continued presence of these species is intimately related to the presence and condition of the natural communities identified in this report.

WALNUT CREEK CONSERVATION SITE

SIZE: approx. 500 acres

BIODIVERSITY RANK: B4
PROTECTION URGENCY: P4
MANAGEMENT URGENCY: M3

LOCATION: Louisville Quadrangle (3910582)
T2S, R70W, Sects: 1,2,11,12

GENERAL DESCRIPTION: The Walnut Creek Conservation Site lies on the eastern side of the U.S. Department of Energy's Rocky Flats Environmental Technology Site (RFETS). The topography slopes from west to east, with moderately steep drainages cut into Quaternary formed alluvial mesas. The Conservation Site ranges in elevation from 5300' to 5900'. The upland flora has been degraded by impacts from routine RFETS operations. Some native riparian vegetation remains. Most of the native fauna have been extirpated from the area except for small mammals, generalist avian species, and some native ungulates.

The Walnut Creek Site is bounded by the RFETS Industrial Area to the west, the mesa tops to the north and south, and Indiana Street to the east. Numerous roads, surface water management ponds, ditches, utility poles, fences, and borrow pits are in or adjacent to the Conservation Site. Much of the Conservation Site is regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

NATURAL HERITAGE RESOURCE SIGNIFICANCE: The Conservation Site contains a sizable population of Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (U.S. Department of Energy 1994d; Harrington pers. comm. 1995). A Pleistocene relict animal, its historical range extended along the Colorado piedmont from roughly El Paso county into central Wyoming (Whittaker 1972). The genus generally prefers mesic to hydric environments typical of riparian systems (Quimby 1951; Krutzsch 1954). Although the subspecies has probably never been common, it has been severely restricted throughout its historical range due to water development, livestock grazing, and urban development (Compton and Hugie 1993). Because there are less than 20 populations of this small mammal and its habitat is highly threatened, CNHP ranks it G5T2/S2.

In the Conservation Site, the subspecies has been captured throughout the length of the stream reach. It has been trapped in and around the surface water management ponds, specifically by Ponds A-1, A-2, and B-3. It has been found below the terminal pond, A-4, in the stream channel. Coyote willow (*Salix exigua*), plains cottonwood (*Populus deltoides*), and snowberry (*Symphoricarpos occidentalis*) make up most of the vegetative cover in the capture areas, although it has also been found in the grassy margins of these areas. Exotic vegetation is prevalent in much of the capture areas. These are mostly Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromopsis inermis*), and Canada thistle (*Cirsium arvense*). It is unclear if these exotics impact the subspecies' population.

Because it is downgradient of the RFETS Industrial Area, surface water flow in the capture areas is anthropogenically managed and highly complex. Although the quality of the water is probably adequate to support the population, it is unclear what impacts water quantity in the system is having on the population (Advanced Sciences Inc. 1990; U.S. Department of Energy 1994d). Total output under current conditions is over 100 million gallons per year. Roughly 50% of this flow (57 million gallons) is wastewater treatment plant effluent, while 25% is stormwater runoff from the Industrial Area. Only ten percent is considered natural, or baseflow (U.S. Department of Energy 1994d). The timing of these flows is highly unnatural, consisting of monthly releases due to RFETS' batch discharge regime, and floods are strictly controlled due to health and safety reasons.

Table 3. Known Natural Elements in the Walnut Creek Conservation Site.

ELEMENT	COMMON NAME	OCCUR RANK	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
ZAPUS HUDSONIUS PREBLEI	PREBLE'S MEADOW JUMPING MOUSE	C	G5T2	S2	C2	

OTHER BIODIVERSITY VALUES: This Conservation Site helps support the RFETS population of mule deer (*Odocoilius heminoides*) and coyotes (*Canis latrans*).

CURRENT STATUS: The Walnut Creek Conservation Site is part of Operable Unit 6, under CERCLA (U.S. Department of Energy 1994b). As such, there are several Individual Hazardous Substance Sites (IHSS) in the Conservation Site that may require remediation activity. Many of these IHSS' are pond sediments but some (including IHSS 142.3 and 142.8) include stream channels that appear to contain some Preble's meadow jumping mouse habitat.

BOUNDARY JUSTIFICATION: The Walnut Creek Conservation Site includes the known captures of the Preble's meadow jumping mouse and a "buffer area" of 1/4 mile on each side of the stream channel. CNHP believes this area captures the known habitat requirements of the population.

PROTECTION RECOMMENDATIONS: CNHP believes that there is no known threat to the element occurrence in the Conservation Site. Because the area is regulated by CERCLA, the Department of Energy will retain ownership responsibilities for many years. While remediation activities may take place in the Conservation Site, and CNHP has some concern over their unresolved nature, CNHP trusts that they will be taken with care not to impact the Preble's meadow jumping mouse occurrence. Also, the Future Site Use Working Group's recommendation for the area is to preserve it as open space. Therefore, CNHP ranks the Conservation Site as P4, indicating no threat for the foreseeable future.

MANAGEMENT RECOMMENDATIONS: The intrusion of non-native plant species and the unnatural hydrologic regime in the Conservation Site are of some concern to CNHP. Although

CNHP does not believe that the existence of the occurrence is threatened, the quality of the occurrence may be at risk. Because of the rarity of the Preble's meadow jumping mouse, CNHP believes that implementation of alternative natural resource management strategies within 5 years may be necessary to protect the quality of the occurrence. CNHP ranks the management urgency of this Conservation Site as M3.

Should further studies indicate that Preble's meadow jumping mice have an aversion to exotic vegetation, an accelerated weed control program in the riparian area should be considered. Use of herbicides is discouraged because of the hydric nature of the application zone. An aggressive mechanical campaign, emphasizing manual labor, and a controlled burn program are approaches worthy of consideration.

Returning a natural flow regime to the Conservation Site should be the Department of Energy's first objective in reconsidering water management in the drainage. Management requirements imposed by regulatory agencies dictate how and when water is released from the terminal ponds. Cooperation from all parties will be critical to moving away from the current "batch discharge" system towards a "flow through" system, as recommended in the *Pond Water Management Interim Measures/Interim Remedial Action Decision Document* (U.S. Department of Energy 1994d). This may support a more natural belt of acceptable habitat for the Preble's meadow jumping mouse in the riparian zone.

Further studies on the Preble's meadow jumping mouse, as currently under way in the watershed and throughout RFETS, are critical to understanding the needs of the subspecies and how best to manage for it. CNHP considers these efforts the most critical step in retaining the quality of the occurrence in the Conservation Site.

ROCKY FLATS MACROSITE

SIZE: approx. 10,000 acres

BIODIVERSITY RANK: B3
PROTECTION URGENCY: P2
MANAGEMENT URGENCY: M3

LOCATION: Louisville Quadrangle (3910582)
Eldorado Springs Quadrangle (3910583)
Golden Quadrangle (3910572)
Ralston Buttes Quadrangle (3910573)
T2S, R70W, Sects: 1-20

GENERAL DESCRIPTION: The Rocky Flats Macrosite encompasses most of the Rocky Flats alluvial area, adjacent to the foothills of the Rocky Mountains. It contains four identified Conservation Sites: Quarter Circle, Coal Creek, Rocky Flats, and Walnut Creek. It ranges from 7000' in the west to 5700' at the eastern boundary. Most of it lies upon fluvial outwash (Rocky Flats Alluvium) but it also includes quaternary stream channels that have incised deeply into the highlands. The Macrosite typifies ecotonal areas along the mountain front, with flora and fauna ordinarily found only in the mountains or the plains existing sympatrically. The Macrosite is dissected by a busy two lane highway (Colorado Highway 93), dirt roads, ditches, gravel pits, some structures, utility lines, and a pipeline.

Property ownership in the Macrosite is diverse. Much of it is owned by the U.S. Department of Energy, managed both by the Rocky Flats Environmental Technology Site (RFETS) and the National Renewable Energy Lab's Wind Test Site. The State of Colorado owns section 16 as School Land Board property. The Coal Creek Conservation Site is owned by Boulder County Open Space. The western half of the Macrosite is privately owned.

NATURAL HERITAGE RESOURCE SIGNIFICANCE: The Rocky Flats Macrosite contains several high priority heritage resources. The xeric tallgrass prairie occurrence is believed to be one of less than 20 globally and is the largest and best quality occurrence known. It has been qualitatively documented both on the west side of RFETS and section 16 (Western Aggregates 1994; U.S. Department of Energy 1994c; U.S. Department of Energy 1995a). Quantitative information indicates that this occurrence may extend beyond the current boundary into private land west of Highway 93 (Pague et al. 1993; Western Aggregates 1994). This element is ranked G2/S2 by CNHP.

The mixed prairie community (*Schizacyrium scoparium-Sporobolis heterolepsis*) was recorded by CNHP at the Quarter Circle Conservation Site (Pague et al. 1993). This is an excellent example of a possibly rare community, which is ranked GU/SU due to its uncertain status.

The rare Preble's meadow jumping mouse is known to exist in all four creek drainages in the Macrosite: Coal Creek, Rock Creek, Walnut Creek, and Woman Creek (EG&G Rocky Flats 1992; U.S. Department of Energy 1994c; U.S. Department of Energy 1995a; Miller pers. comm.

1995; Harrington pers. comm. 1995). This subspecies has been extensively impacted across its historical range by urban development, water diversion, and impacts from livestock (Compton and Hugie 1993) and is ranked G5T2/S2 by CNHP. The Rock Creek drainage (in the Rocky Flats Conservation Site), with its natural surface water regime and relatively unfragmented habitat, is considered the best occurrence in the Macrosite, and one of the best throughout the subspecies' range.

Rock Creek also contains an occurrence of Great Plains riparian community (*Populus angustifolia- Salix amygdaloides/Salix exigua*), a declining element throughout its historical range. This community is found in less than twenty places globally and is ranked G2G3/S2S3 by CNHP.

The rare sedge, *Carex oreocharis*, is documented from the Rocky Flats Conservation Site (U.S. Department of Energy 1995a). This species is more typical of montane environments but is found on outwashed areas, perhaps explaining its occurrence on the colluvial material below the Rocky Flats Alluvium. Because it has been documented in only three other locations in Colorado, it is ranked G3/S1 by CNHP.

In addition to Preble's meadow jumping mouse, faunal occurrences in the Macrosite include rare invertebrates such as Arogos skipper (*Atrytone arogos*) and hops blue (*Celestrina sp.*), found in the xeric tallgrass prairie community and seep shrubland community, respectively. The Arogos skipper is somewhat common globally but rare in Colorado, and hops blue is believed to be very rare globally but taxonomic questions remain about the species. They are ranked G3G4/S2 and G2Q/S2, respectively.

Loggerhead shrike is ranked G4/S3B and is probably breeding in tall shrublands in the Rocky Flats Conservation Site (U.S. Department of Energy 1995a). Merriam's shrew (*Sorex merriami*), known from both the Rocky Flats Conservation Site and the Walnut Creek Conservation Site, is ranked G4/S3 (U.S. Department of Energy 1992).

OTHER BIODIVERSITY VALUES: The area supports a wide array of avian species, particularly during their migration and wintering periods (U.S. Department of Energy 1994a).

CURRENT STATUS: There is no protection afforded any parcel of this Macrosite, save for the Coal Creek Conservation Site which is owned and managed by Boulder County Open Space. Grazing is moderate to heavy throughout the western half of the Macrosite. Special use designations are pending for sand and gravel mining in sections 3, 4, and 16 (Jefferson County 1995a; Jefferson County 1995b). Some of the Macrosite, as it occurs on RFETS property, is currently regulated under the Comprehensive Environmental Response, Compensation, and Liability Act.

BOUNDARY JUSTIFICATION: The Macrosite boundary was developed to capture the significant natural elements found within the associated Conservation Sites and aggregate them

on a landscape level. Buffer zones and migration corridors have been integrated. This Macrosite effectively captures the area's abiotic parameters as well.

PROTECTION AND MANAGEMENT RECOMMENDATIONS: Because the Macrosite has not been afforded any formal protection designation, and because CNHP believes it may be threatened by anthropogenic impacts within five years, CNHP ranks this Macrosite P2. The threats may come in the form of urban development or aggregate mining.

CNHP feels that, within 5 years, new management actions may be necessary to maintain the current quality of listed element occurrences. Therefore, the management rank for the Macrosite is M3. Weed control, reclamation, water management, and fire control should be reevaluated in order to ensure the continuing biodiversity significance of the Macrosite.

REPORT RECOMMENDATIONS:

1. Establish a Rocky Flats Natural Resource Management Roundtable.

Because of the demands on the future use of the Rocky Flats area and the documented natural heritage values associated with it, CNHP suggests that the U.S. Department of Energy initiate a roundtable forum to discuss natural resource scientific and management issues. Of paramount import is an understanding of the rarity and restoration potential of the xeric tallgrass prairie. This forum should include noted experts in the field of grassland ecology, weed management, and mine reclamation. Managers affiliated with all pertinent landowners should also be in attendance. CNHP offers its services to convene and chair this forum. Other future issues could include water management or protection strategies.

2. Cooperate with Local Landowners Regarding Routine Management Activities.

Per the Secretary of Energy's Ecosystem Management Initiative, CNHP recommends that RFETS work more closely with local landowners in managing its natural resources (U.S. Department of Energy 1995b). Information indicates that a cooperative weed control effort was organized for the 1994 and 1995 field seasons. CNHP lauds this approach. Several other landowners in the area, together with RFETS, comprise a larger, landscape-level, system that should be managed in concert. Because RFETS is the largest, most central part of this landscape, it behooves the Department of Energy to coordinate activities such as controlled fire and weed management in order to ensure it achieves its natural resource management objectives.

3. Develop an Integrated Natural Resource Management Strategy.

It is critical that U.S. Department of Energy document its goals and objectives regarding its natural resource management responsibilities. CNHP feels that natural resources are being managed at RFETS without a common objective. This strategy should integrate the information included in this report, as well as data generated by Kaiser-Hill and its subcontractors. Cooperative agreements with other natural resource management agencies and university faculty would help produce a more widely reviewed and effective document.

4. Continue to Monitor Ecological Processes and Elements at RFETS.

It is of utmost import that RFETS continue to monitor Site ecology. CNHP is very concerned about the prospect that the Ecological Monitoring Program and the Natural Resources Protection and Compliance Program might be eliminated in the coming Fiscal Year. These programs are vital to understanding the nature of biological processes along mountain front environments. No other federal facility is as well placed to continue the excellent work started by EG&G Rocky Flats and continued by Kaiser-Hill's ecology staff. CNHP would like to offer its services in any way needed to study ways to retain an effective monitoring program.

5. Designate the Site as a National Environmental Research Park.

The National Environmental Research Park (NERP) program is designed to protect natural areas in order to study them and the effects man's activities have on them. CNHP feels that RFETS is an excellent candidate for NERP designation due to the rare natural elements found there and the level of stresses placed upon them by man. This would not only highlight the significance of RFETS natural areas but demonstrate the U.S. Department of Energy's commitment to proper stewardship of its natural resources. It would also afford local students an opportunity to study their natural heritage in a controlled environment. CNHP encourages the U.S. Department of Energy to vigorously pursue NERP designation for RFETS.

Figure 2: Xeric Tallgrass Prairie (*Andropogon gerardii-Schizachyrium scoparium*), G2/S2
Photo by R. Rondeau

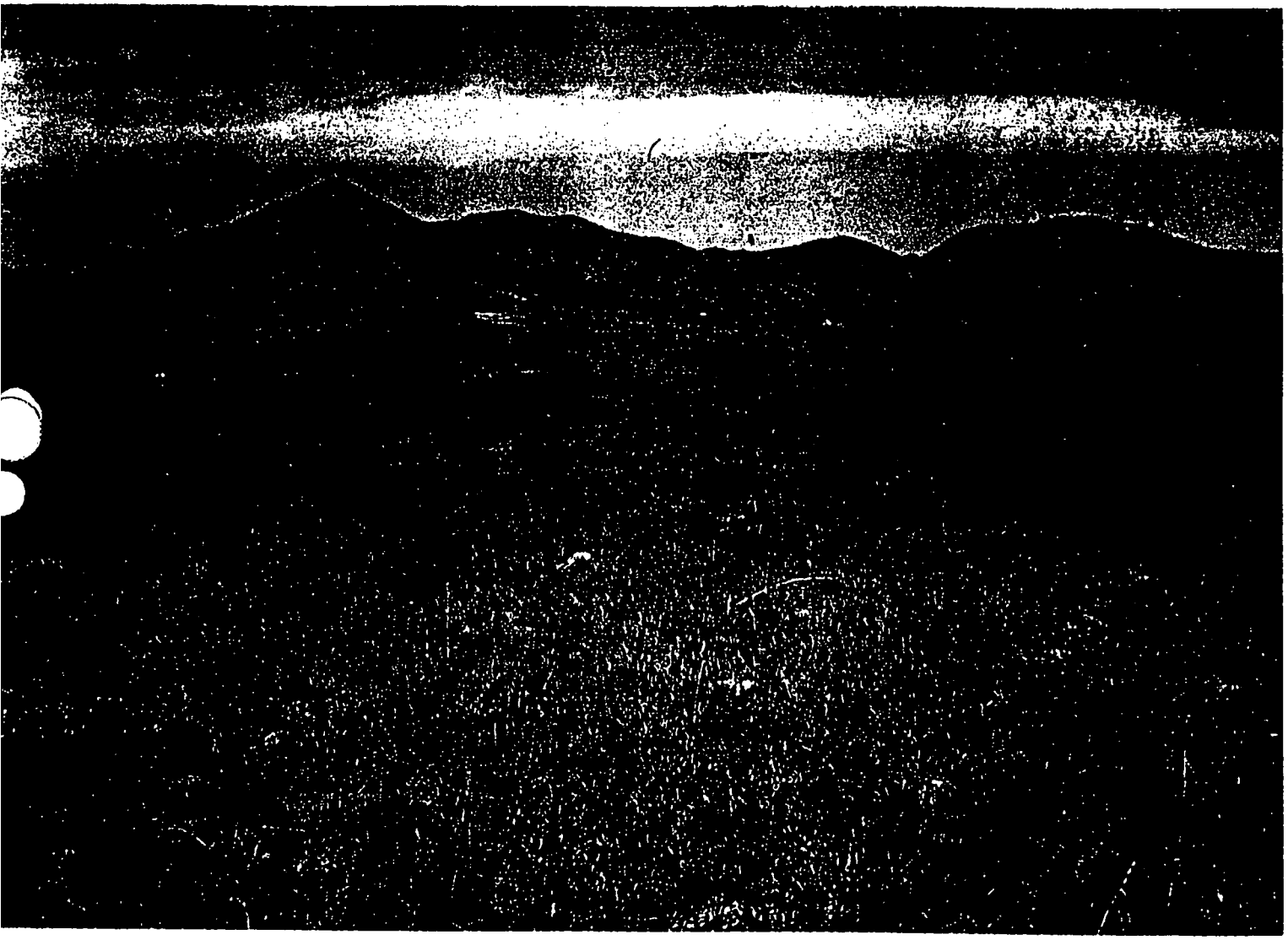


Figure 3: Ottoe Skipper (*Hesperia ottoe*), G3/S2
Photo by Dr. P. Opler

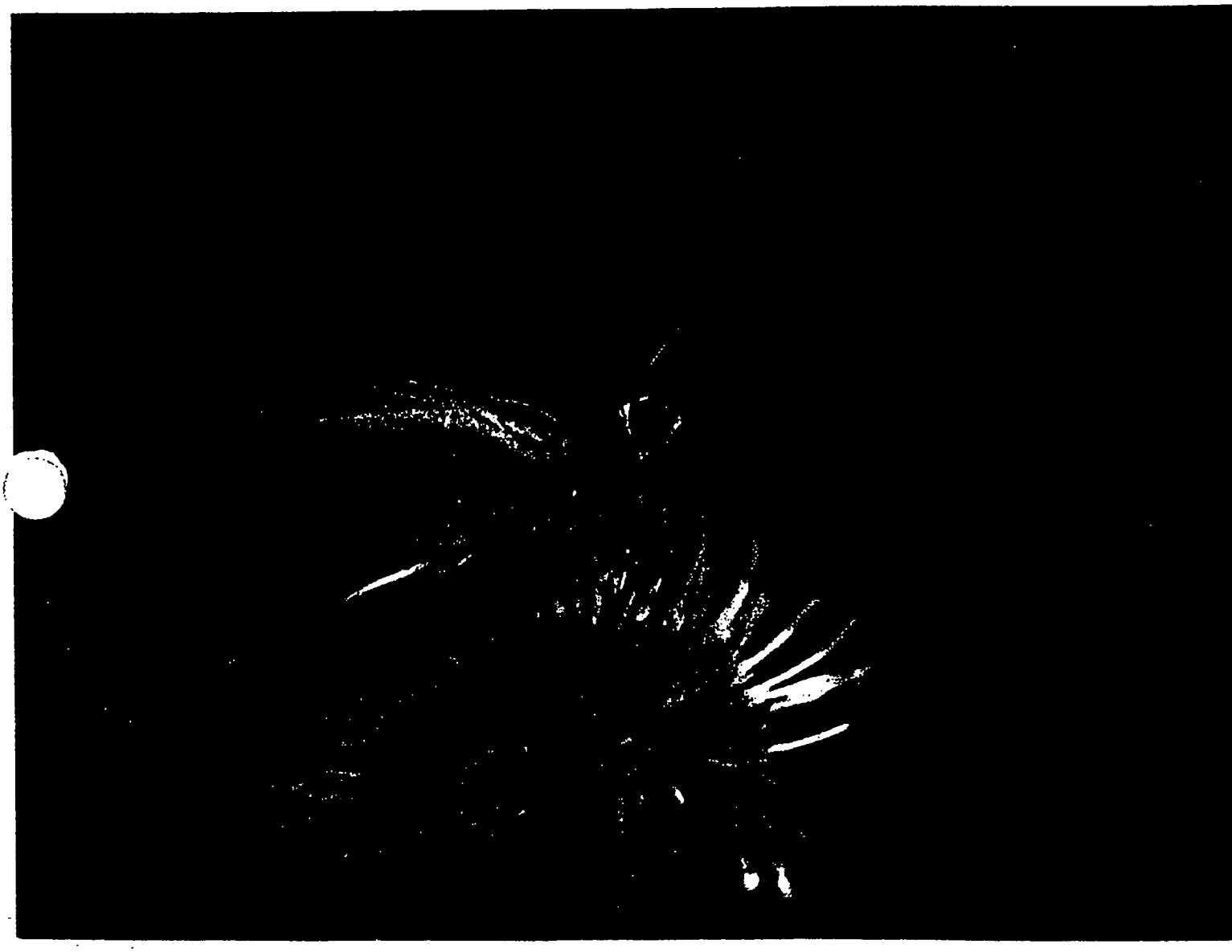


Figure 4: Hops blue (*Celestrina sp.1*), G2Q/S2
Photo by Dr. P. Opler

Figure 5: Arogos skipper (*Atrytone arogos*), G4/S2
Photo by Dr. P. Opler

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APPENDIX A: The Colorado Natural Heritage Program

To place this report in context it is useful to understand the history and functions of the Colorado Natural Heritage Program (CNHP). CNHP has been extant in Colorado for 16 years. CNHP was relocated from the Division of Parks and Outdoor Recreation to the University of Colorado Museum in the spring of 1992, and more recently to the College of Natural Resources at Colorado State University. This multi-disciplinary team of scientists and information managers gather information and incorporate it into a continually updated database. CNHP is part of an international network of conservation data centers that use the Biological and Conservation Database (BCD) developed by The Nature Conservancy. In addition, CNHP has effective relationships with the Colorado Natural Areas Program, the Colorado Division of Wildlife, and pertinent federal agencies.

Table 4. Definition of Natural Heritage State Rarity Ranks.
Global rarity ranks refer to a species' rarity throughout it range. State and Global ranks are denoted, respectively, with an "S" or a "G" followed by a character. These ranks should not be interpreted as legal designations.

S1	Extremely rare: usually 5 or fewer occurrences in the state; or may be a few remaining individuals; often especially vulnerable to extirpation.
S2	Very rare; usually between 5 and 20 occurrences; or with many individuals in fewer occurrences; often susceptible to becoming endangered.
S3	Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
S4	Common; usually > 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.
S5	Very common; demonstrably secure under present conditions.
SA	Accidental in the state.
SH	Historically known from the state, but not verified for an extended period, usually > 15 years; this rank is used primarily when inventory has been attempted recently.
SU	Status uncertain, often because of low search effort or cryptic nature of the element.
SX	Apparently extirpated from the state.
S#B	Same rank as the numbered S-series, but refers to the breeding season rarity of migrants.
S#N	Same rank as the numbered S-series, but refers to the non-breeding season rarity of migrants; where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
S#T#	Same rank as the numbered S-series, but refers to the rarity of an associated sub-species.
S#Q	Same rank as the numbered S-series, but indicates taxonomic uncertainty about the species.

CNHP gathers information on rare species and natural communities, or **elements**. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare/imperiled; 5 = abundant/secure; Table 4). The primary criterion for ranking elements is the number of **element occurrences**, i.e. the number of known distinct localities or populations of the species or natural community. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations

include the condition of the occurrences, the number of protected occurrences, population trends. and threats. However, the emphasis remains on the number of occurrences so that the ranks remain an index of known biological rarity. These ranks are assigned both in terms of the element's rarity within Colorado (its State or S-rank) and the element's rarity over its entire range (its Global or G-rank). Taken together, these two ranks give an instant picture of the rarity of the element. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species are listed as Endangered or Threatened. **Natural Heritage rarity ranks should not be interpreted as legal designations.**

In addition to ranking each element in terms of rarity, Natural Heritage staff scientists rank each element occurrence so that protection efforts can be aimed not only at the rarest elements, but at the best examples of each. Element occurrences are ranked in terms of the **quality** (size, vigor, etc.) of the population or community, the **condition** or naturalness of the habitat, the long-term **viability** of the population or community, and the **defensibility** (ease or difficulty of protecting) of the occurrence. Given the intimate relationship between a natural community and its environment, community occurrences are largely ranked in terms of their quality and condition.

One of the most significant ways that the Colorado Natural Heritage Program uses these element and element occurrence ranks is to design **conservation sites** which include one or many element occurrences and the ecological processes necessary for the elements' continued existence. Based on these ranks, CNHP assesses each site with a **biodiversity** (or B-) **rank** (see Table 5). Furthermore, CNHP ranks the **protection** and **management urgency** of each site on a scale of 1 to 5 based on threats or trends.

Table 5. Definition of Biodiversity Ranks.

B1 Outstanding Significance: only site known for an element or an excellent occurrence of a G1 species.

B2 Very High Significance: one of the best examples of a community type, good occurrence of a G1 species, or excellent occurrence of a G2 or G3 species.

B3 High Significance: excellent example of any community type, good occurrence of a G3 species, or a large concentration of good occurrences of state rare species.

B4 Moderate Significance: good example of a community type, excellent or good occurrence of state-rare species.

B5 General Biodiversity Significance: good or marginal occurrence of a community type, S1, or S2 species.

APPENDIX B: What is Biological Diversity?

Biological diversity has recently become an important management issue for many natural resource professionals. In the most simple terms, biological diversity, or simply biodiversity, is the full variety of plant and animal life in an area **AND** the ecological processes of which they

are a part. This concept includes all living organisms from bacteria and fungi, invertebrate animals, mosses and lichens, and the "higher life forms" of plants and animals.

The biological diversity of an area can be described at four levels:

1. Genetic Diversity -- the genetic variation within a population and among populations of a plant or animal species. The genetic makeup of a species is variable between populations of a species within its geographic range. Loss of a species' population results in a loss of genetic diversity for that species and a reduction of total biological diversity for the region.

2. Species Diversity -- the total number and abundance of plant and animal species in an area.

3. Community Diversity -- the variety of natural communities or ecosystems within that area. These communities may be diagnostic or even endemic to an area. It is within these ecosystems that all life dwells.

4. Landscape Diversity -- the type, condition, pattern, and connectedness of natural communities or ecosystems within a landscape. Fragmentation of forested landscapes, loss of connections and migratory corridors, and loss of natural communities all result in a loss of biological diversity for a region. Humans and the results of their activities are integral parts of most landscapes.

Relating this Report to Managing Biological Diversity at the Landscape Level.

The management of Biological Diversity must consider more than species specific management criteria and consider the elements of human-use in the area. The conservation sites typically identified in this type of study may be considered as core areas for the protection of the full range of biological diversity. Some of these areas are best considered as candidates for special area designations, others as sites within a landscape that should be managed to include the maintenance of the site's integrity.

A basic premise in the landscape management approach starts with the delineation of core protected areas that can be represented by special designations. Where possible, these should be connected through corridors and appropriately buffered. Buffer areas should include the ecological processes supporting the diversity of the core area. Such is the basis of the development of preliminary conservation planning boundaries.

APPENDIX III: PHASE I REPORT

NATURAL HERITAGE RESOURCES OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE AND THEIR CONSERVATION

PHASE I: ROCK CREEK

FINAL REPORT

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December 9, 1994

EXECUTIVE SUMMARY

In 1993, The Colorado Natural Heritage Program (CNHP) was contracted by the Department of Energy to assess the ecological values of the Rock Creek drainage at the Rocky Flats Environmental Technology Site (RFETS). The goal of the project was to accumulate and examine existing biological data from the site, incorporate appropriate portions into the CNHP's Biological Conservation Database, and with appropriate field verification, identify significant natural heritage resources. We were also asked to make recommendations on actions that would be necessary to protect these resources.

The Natural Heritage Inventory was conducted in four steps:

1. Accumulate existing information concerning significant elements of biological diversity from existing data at the Rocky Flats Environmental Technology Site.

2. Perform ground surveys to rank occurrences of elements in terms of quality, condition, viability, and defensibility, and to identify conservation boundaries for each element.

3. Assign natural heritage Biodiversity Ranks (B-ranks) to determine significance of each occurrence.

4. Assess conservation data relative to the conservation priorities of the International Network of Natural Heritage Programs and present in a final report.

The Rock Creek drainage was determined to contain significant natural heritage resources (those species or communities determined by CNHP to be rare, threatened or endangered or of high significance) and was denoted as a "natural heritage conservation site." The Natural Heritage Program developed a preliminary conservation planning boundary for the Rock Creek drainage. In developing this boundary, a number of factors were considered including: habitat for rare species, protection of water quality, buffers from potentially detrimental land uses, and the maintenance of ecological processes necessary for the perpetuation of the significant elements in the area.

The delineation of a conservation planning boundary in this report does not confer any regulatory protection on recommended areas. These boundaries are intended to be used to support wise planning and decision-making for the conservation of these significant areas. The Colorado Natural Heritage Program encourages the Department of Energy (DOE) to take actions that will protect this site, particularly since in the Heritage Program methodology it ranks as a site of

INTRODUCTION

In 1993, The Colorado Natural Heritage Program (CNHP) was contracted by the Department of Energy (DOE), Rocky Flats Field Office to assess the ecological values of the Rock Creek drainage at the Rocky Flats Environmental Technology Site (RFETS). The goal of the project was to accumulate existing data from the site and with some field verification, identify natural heritage resources and actions to protect these resources. Natural heritage resources are defined as rare, threatened, endangered, or sensitive species and significant natural communities that are monitored by the Colorado Natural Heritage Program. In short, we were to identify those sites supporting unique or exemplary natural communities, rare plants and rare animals, and other significant natural features.

Phase I, the evaluation of the Rock Creek drainage portion of the Rocky Flats Environmental Technology Site, has been completed and the results of it are presented herein. A brief overview of the natural condition of the study area is presented first. This is followed by an outline of the mission and methodology of the Colorado Natural Heritage Program. The results of the inventory are briefly discussed. Finally, the area of national biodiversity significance identified during this study is described and future actions, including protection options, are introduced.

Overview of the Study Area

The Rocky Flats Environmental Technology Site is located in northern Jefferson County, Colorado. The entire plant site, including the buffer zone, consists of about 6550 acres. The Rock Creek drainage comprises about 1500 acres roughly located at the northwest end of the site. Elevations range from approximately 5760' to over 6160' within the drainage. Vegetation communities are characterized by grasslands, shrublands and scattered coniferous and deciduous trees and are typical of lower foothills, mesas, and western Great Plains ecosystems (Weber 1976, Mutel and Emerick 1992, Gregg 1963). The Rock Creek drainage was at one time part of a livestock ranch. Extant fauna is dominated by a Great Plains component and enhanced by a foothills element due to the proximity of these two biogeographical units. Animal communities are generally characterized by species of the Great Plains (Mutel and Emerick 1992, Armstrong 1972, Andrews and Righter 1992, Hammerson, 1982).

The relatively recent and extensive use of the area in and around the area now occupied by the Rocky Flats Environmental Technology Site has greatly impacted the flora and fauna. Extirpations have been largely restricted to large mammals. Grizzly bears and gray wolves once roamed throughout the state and

black-footed ferret were not uncommon in large prairie dog towns (Armstrong 1972). All are no longer resident within the state. Although extinctions of bird species are not recorded, the plains sharp-tailed grouse has been extirpated from the vicinity (Braun et al. 1992). Fortunately, most species have not suffered so extensively, but many have been reduced in numbers -- some significantly. Many plant species not native to this area have become established and in some cases dominant, especially in areas that historically or currently are to some degree disturbed by human activity (including livestock grazing, alteration of natural processes such as fire or flooding, gravel mining, agricultural activity, road building or other development). It is within the purpose of this effort to identify the conservation sites which will protect the most sensitive element of natural diversity.

Climate. The climate of the area is strongly influenced by the mountains and is continental in character. Sudden and extreme changes in atmospheric conditions may occur from hour to hour and day to day at any season of the year. The average wind velocity is moderate, although strong gusts (occasionally over 80 mph) are not infrequent (U. S. Dept. of Energy 1980). Winters are generally cool and dry and summers warm. The mean first date of frost is October 4 and the mean last day of frost is May 9. Average yearly precipitation for the period from 1953-1976 is approximately 15 inches (U. S. Dept. of Energy 1992). Approximately 70% of the moisture falls during the growing season, mostly in late spring and early summer (U. S. Dept. of Energy 1992, U. S. Dept. of Agriculture 1980).

Soils. Soils are of two major types. Soils on terraces or piedmonts are a stony or skeletal type developed on glacial outwash (Rocky Flats Alluvium). Fine textured soils developed from shales and mudstones are common in the small drainages associated with Rock Creek (U. S. Dept. of Agriculture 1980).

Geology. Geology is discussed in detail in several papers or reports from the area (U. S. Dept. of Energy 1992, Branson et al. 1965, Vestal 1919) and is an important factor influencing the distribution of plant communities.

Colorado's Natural Heritage Program

To place this report in context it is useful to understand the history and functions of the Colorado Natural Heritage Program (CNHP). CNHP has been extant in Colorado for 16 years. CNHP was relocated from the Division of Parks and Outdoor Recreation into the University of Colorado Museum in the spring of 1992, and more recently to the College of Natural Resources at Colorado State University. With an increased staff, the Program is revitalized and updating comprehensive information on the rare, threatened, and endangered species and significant natural communities in Colorado. The multi-disciplinary team of scientists and information managers gather information and incorporate it into

continually updated databases. CNHP is part of an international network of conservation data centers that use the Biological and Conservation Databases (developed by The Nature Conservancy). In addition, CNHP has effective relationships with the Colorado Natural Areas Program, Colorado Department of Natural Resources, the Colorado Division of Wildlife, and the numerous federal agencies. Concentrating on site-specific data for each element of natural diversity, the accurate status of each element becomes known. The data presented here illustrate a site that is important to the conservation of Colorado's, and indeed the nation's natural biological diversity. By using the element ranks and the quality of each occurrence, priorities can be established for the protection of the most sensitive or imperilled sites. It is by having an updated locational database and priority-setting system that CNHP can provide its most effective, proactive land-planning tools.

Information is gathered by CNHP on species, natural communities, and ecosystems. Each of these significant natural features (species and community types) is an **element of natural diversity**, or simply an **element**. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare/imperilled; 5 = abundant/secure; **Table 1**).

The primary criterion for ranking elements is the number of occurrences, i.e. the number of known distinct localities or populations. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations include the condition of the occurrences, the number of protected occurrences, population trends, and threats. However, the emphasis remains on the number of occurrences, such that ranks are an index of known biological rarity. These ranks are assigned both in terms of the element's rarity within Colorado (its State or S-rank) and the element's rarity over its entire range (its Global or G-rank). Taken together, these two ranks give an instant picture of the rarity of the element. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species are listed as Endangered or Threatened and **Natural Heritage rarity ranks should not be interpreted as legal designations.**

Table 1. Definition of Natural Heritage state rarity ranks. Global rarity ranks are similar, but refer to a species' rarity throughout its range. State and Global ranks are denoted, respectively, with an "S" or a "G" followed by a character. Note that GA and G#N are not used and GX means extinct. These ranks should not be interpreted as legal designations.

S1	Extremely rare: usually 5 or fewer occurrences in the state; or may be a few remaining individuals; often especially vulnerable to extirpation.
S2	Very rare; usually between 5 and 20 occurrences; or with many individuals in fewer occurrences; often susceptible to becoming endangered.
S3	Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
S4	Common; usually > 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.
S5	Very common; demonstrably secure under present conditions.
SA	Accidental in the state.
SH	Historically known from the state, but not verified for an extended period, usually > 15 years; this rank is used primarily when inventory has been attempted recently.
S#B	Same rank as the numbered S-series, but refers to the breeding season rarity of migrants.
S#N	Same rank as the numbered S-series, but refers to the non-breeding season rarity of migrants; where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
SU	Status uncertain, often because of low search effort or cryptic nature of the element.
SX	Apparently extirpated from the state.

The spot on the landscape that supports a particular population of a specific species or a specific stand of a given community type is an **element occurrence.** The Colorado Natural Heritage Program has mapped over 4,000 element occurrences in Colorado. Information on the location and quality of these element occurrences is also entered into the computerized Biological and Conservation Databases (BCD). This computer system, developed by The Nature Conservancy, is utilized by the international network of heritage programs and conservation data centers. All centers utilize the same methodology, allowing a unique, direct comparison of information throughout the area covered.

In addition to ranking each element in terms of rarity, Natural Heritage staff scientists rank each element occurrence so that protection efforts can be aimed not only at the rarest elements, but at the best examples of each. Element occurrences are ranked in terms of the **quality** (size, vigor, etc.) of the population or community, the **condition** or naturalness of the habitat, the long-term **viability** of the population or community, and the **defensibility** (ease or difficulty of protecting) of the occurrence. Given the intimate relationship between a natural community and its environment, community occurrences are largely ranked in terms of their quality and condition.

One of the strongest ways that the Colorado Natural Heritage Program uses these element and element occurrence ranks is to assess the overall significance of a site, which may include one or many element occurrences. Based on these ranks, each site is assigned a **biodiversity** (or B-) **rank**:

B1 Outstanding Significance: only site known for an element or an excellent occurrence of a G1 species.

B2 Very High Significance: one of the best examples of a community type, good occurrence of a G1 species, or excellent occurrence of a G2 or G3 species.

B3 High Significance: excellent example of any community type, good occurrence of a G3 species, or a large concentration of good occurrences of state rare species.

B4 Moderate Significance: good example of a community type, excellent or good occurrence of state-rare species.

B5 General Biodiversity Significance: good or marginal occurrence of a community type, S1, or S2 species.

What is Biological Diversity?

Biological diversity has recently become an important management issue for many natural resource professionals. Biological diversity at it's most basic level

includes the full range of species on Earth, from species such as bacteria, viruses, and protists, through multicellular kingdoms of plants, animals and fungi. At finer levels of organization, biological diversity includes the genetic variation within species, both among geographically separated populations and among individuals within single populations. On a wider scale, biological diversity includes variations in the biological communities in which species live, the ecosystems in which communities exist, and the interactions among these levels. All levels are necessary for the continued survival of species and natural communities, and all are important for the well-being of humans (Temple 1991).

The biological diversity of an area can be described at four levels:

1. Genetic Diversity -- the genetic variation within a population and among populations of a plant or animal species. The genetic makeup of a species is variable between populations of a species within its geographic range. Loss of a population results in a loss of genetic diversity for that species and a reduction of total biological diversity for the region.

2. Species Diversity -- the total number and abundance of plant and animal species in an area.

3. Community Diversity -- the variety of natural communities or ecosystems within that area. These communities may be diagnostic or even endemic to an area. It is within these ecosystems that all life dwells.

4. Landscape Diversity -- the type, condition, pattern, and connectedness of natural communities or ecosystems within a landscape. Fragmentation of forested landscapes, loss of connections and migratory corridors, and loss of natural communities all result in a loss of biological diversity for a region. Humans and the results of their activities are integral parts of most landscapes.

The Rock Creek Site (Site) presented in this report supports important components of the total biological diversity of Site, the region, the State, and the Nation. This site, if protected, will represent protection for genetic, species, community, and landscape diversity.

Relating this Report to Managing Biological Diversity at the Landscape Level

The management of Biological Diversity must consider more than species specific management criteria and consider the elements of human-use in the area. The conservation sites typically identified in this type of study may be considered

Vascular plants

SPIRANTHES DILUVIALIS	UTE LADIES' TRESSES	G2	S1	LT	1
GAURA NEOMEXICANA SSP COLORADENSIS	COLORADO BUTTERFLY WEED	G5T1	S1	C1	1
MALAXIS BRACHYPODA	WHITE ADDER'S-MOUTH	G4	S1	C2	2
CAREX TORREYI	TORREY SEDGE	G4	S?		3
RIBES AMERICANUM	AMERICAN CURRANT	G5	S1		2
CRATAEGUS CHRYSOCARPA	YELLOW HAWTHORN	G5?	S1S2		2
VIOLA PEDATIFIDA	PRAIRIE VIOLET	G5	S2		3
EUSTOMA RUSSELLIANUM	SHOWY PRAIRIE GENTIAN	G5	S3	C2	2
ROTALA RAMOSIOR	TOOTHCUP	G5	S?		3
ARISTIDA BASIRAMEA	FORKTIP THREE-AWN	G5	S?		3

Natural communities

STIPA COMATA - EAST	GREAT PLAINS MIXED GRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII-SCHIZACHYRIUM SCOPARIUM	XERIC TALLGRASS PRAIRIES	G2	S2
ANDROPOGON GERARDII-SORGHASTRUM NUTANS	WET PRAIRIES	G3	S1
CAREX NEBRASCENSIS WETLAND	GREAT PLAINS WET MEADOWS	G4	S?

1 Abbreviations are as follows:
C2 = Category 2 Candidate
LE = Listed Endangered

2 Abbreviations are as follows:
1 = federal threatened or endangered that are rare throughout their range
2 = plant species which are rare in Colorado but relatively common elsewhere within their range
3 = species which appear to be rare but for which conclusive information is lacking;

• Occurrences for bird species are only those with probable or confirmed breeding status, or significant concentration areas (wintering or migrating).

RESULTS

Significant natural heritage resources were already known from the Rocky Flats Environmental Technology Site as a result of information gained through various research programs at the site and in the surrounding area in past years. By incorporating the previously collected information and conducting additional studies, CNHP was able to develop preliminary conservation planning boundaries that are necessary to protect the suite of natural heritage resources at the site. The elements occurring in the Rock Creek area were assessed in terms of their contribution to maintaining natural biological diversity. The following site, Rock Creek, is presented to DOE as a significant conservation site for the protection of the Nation's natural biological diversity.

Conservation Site Profile

The conservation site is described in a standard site report. The sections of this report and the contents are outlined and explained below.

SIZE: The approximate acreage included within the conservation planning boundary for the conservation site.

BIODIVERSITY RANK: The overall significance of the conservation site in terms of rarity of the natural heritage resources and the quality (health, abundance, etc.) of their occurrences. As discussed on page 5, these ranks range from B1 (Outstanding Significance) to B5 (General Biodiversity Significance).

PROTECTION URGENCY RANK: The time frame in which conservation protection must occur. In most cases, this rank refers to the need for a major change of protective status (e.g. agency special area designations or ownership). The ranks range from P1 (immediate urgency; within a one-year time frame) to P5 (no known urgency).

MANAGEMENT URGENCY: The time frame in which a change in management of the element or site must occur. Using best scientific estimates, this rank refers to the need for management in contrast to protection (e.g. increased fire frequency, decreased herbivory, weed control, etc.). The ranks range from M1 (immediate urgency, within one year) to M5 (no known urgency).

LOCATION: The USGS 7.5' quadrangles that include the Conservation Site. The Natural Heritage Program code for the quadrangle is noted in parentheses.

GENERAL DESCRIPTION: A brief narrative picture of the topography, vegetation, and current use of the conservation site. Common names are used along with the scientific names.

NATURAL HERITAGE RESOURCE SIGNIFICANCE: A synopsis of the rare species and significant natural communities that occur on the conservation site.

OTHER BIODIVERSITY VALUES: Other items of general biodiversity interest or concern.

CURRENT STATUS: A summary of the ownership, degree of protection currently afforded the conservation site, and threats to the site or natural heritage resources as determined to date.

BOUNDARY JUSTIFICATION: The preliminary conservation planning boundary delineated in this report includes all known occurrences of natural heritage resources and the adjacent lands required for their protection. A discussion of the major factors that were considered is on pages 10-11.

PROTECTION AND MANAGEMENT CONSIDERATIONS: A summary of the major issues and factors that are known or likely to affect the protection and management of the conservation site.

ROCK CREEK

SIZE: approx. 1500 acres within the RFETS

BIODIVERSITY RANK: B3
PROTECTION URGENCY: P1
MANAGEMENT URGENCY: M2

LOCATION: Louisville Quadrangle (3910582)
T2S, R69W, Sects: 2,3,4,9,10

GENERAL DESCRIPTION: The Rock Creek Site occurs on the northern edge of the Rocky Flats alluvial mesa. Near the line separating Boulder and Jefferson counties, the site is approximately 2-3 miles east of the foothills and on the far western edge of the Great Plains. The flora is the typical natural flora of the surrounding mesas and grasslands. Most of the site was part of a livestock ranch (The Lindsay Ranch) before the property was purchased by DOE in 1974. The fauna is greatly changed from prehistoric periods with the losses or reduced populations of most of the large herbivores (e.g. bison, bighorn sheep, pronghorn and elk) and losses of the major carnivores (wolves) and omnivores (grizzly and black bears).

The Rock Creek Site is bounded on the north by State Road 128, on the west by State Road 93 and on the south and east by other portions of the Rocky Flats Environmental Technology Site. Numerous roads, diversion ditches, and gravel mines are found within or adjacent to the site. Boulder City Open Space adjoins the site to the north of State Road 128.

NATURAL HERITAGE RESOURCE SIGNIFICANCE: When the first pioneers came to the region, grasslands extended eastward from the base of the mountains for hundreds of miles (Mutel and Emerick 1984). Herds of pronghorn and bison were hunted by gray wolves and Indians. Today much of the natural vegetation has been replaced by croplands, cattle pastures, and human developments. Along the Front Range, extensive urbanization has dramatically changed the character of the grasslands. Due to the great loss of grasslands throughout the United States we feel special effort should be made to maintain any remaining significant grasslands. The Rock Creek area was found to have remnants of good quality grasslands. However, signs of disturbance and potential threats abound and the integrity of the area is considered highly threatened.

The Rock Creek Site contains a good example of a xeric tallgrass prairie community with a rich grass flora, a Great Plains riparian ecosystem supporting a population (or subpopulation) of Preble's meadow jumping mouse and several unusual plant communities associated with seeps.

The dominant species on the xeric grassland (xeric tallgrass prairie - Andropogon gerardii-Schizachyrium scoparium [Andropogon scoparius], Bourgeron and Engelking 1994) are big and little bluestem (Andropogon gerardii and A. scoparius), but other

common graminoids include a sedge (Carex eleocharis), Canada bluegrass (Poa compressa), and mountain muhly (Muhlenbergia montana) (U. S. Dept. of Energy 1994a). This plant association is ranked G2/S2 by the Natural Heritage Program network. The rank G2 indicates that good examples of this community are very rare, occurring in fewer than about 20 places worldwide. In Colorado, we rank this plant association as S2, reflecting its very rare nature. We believe this community to be imperilled in Colorado and rare globally. Xeric tallgrass prairies have become extremely rare, due to building, mining, and grazing (Howe 1994). These types of grasslands once occupied expansive areas on the Great Plains but have been reduced to tiny remnants. The Rock Creek xeric tallgrass prairie occupies a large area and is in good condition in places. Exotic plant species are common in patches throughout the community especially along roads or areas of disturbance. We recommend that it be included in a conservation site due to its size, fairly good condition and rarity.

The xeric tallgrass prairie ecosystem is now fractured into remnants. The placement of several to many remnants such that genetic exchange of the associated organisms is facilitated can aid in the long term persistence of the community. This may happen even though all of the individual components are insufficient. In this light, the setting aside of the Rocky Flats Site would fill a major gap between the City of Boulder Open Space prairies (the nearest at the junction of Hwy 128 and 93) and the smaller patches near White Ranch in Jefferson County. The next closest patches are in the vicinity of Ken Caryl Ranch in southern Jefferson County. The true significance of this site is best viewed from the perspective of the remaining patches of this and associated grasslands in Jefferson County and southern Boulder County. Portions of this landscape are reported in Pague et al. (1993). Associated occurrences of the grassland communities are known from the adjacent areas. It should be considered that these fragments are by themselves insufficient conservation units; however, perhaps with restored linkages, we believe that they could provide community persistence.

The Great Plains riparian community is characterized by a diverse mixture of trees, shrubs, graminoids, and forbs. Common species include plains cottonwood (Populus deltoides), coyote willow (Salix exigua), leadplant (Amorpha fruticosa), baltic rush (Juncus balticus), and various sedges (Carex species) and grasses.

The vegetation along Rock Creek is dominated by a mosaic of several plant associations: Two of which are the Populus deltoides-Salix amygdaloides/S. exigua (Plains cottonwood riparian woodland) and the Amorpha fruticosa shrubland. The first is considered of global significance by the Natural Heritage Network, G2G3/S2S3 (Globally very rare to rare and the same status in Colorado). This plant association is range-restricted and heavily impacted. The occurrence in the Rock Creek drainage is impacted, but potentially restorable. The Amorpha fruticosa shrubland is ranked GU/SU by the Natural Heritage Network, indicating its poorly known status. The GU/SU rank indicates that ranking has not been attempted for this plant association and more information is needed to document its status. Taking a conservative

approach, we will assume (because of the scarcity of information) that it is somewhat rare. This will allow us to prioritize information collection regarding this community. We suspect that this, as with other foothills and western Great Plains communities, is highly impacted throughout its range.

Vegetation communities associated with seeps are in some cases similar to other wetlands at the site supporting sedges, rushes, and cattails (U. S. Army Corps of Engineers 1994), and in some cases very different, supporting an unusual mixture of shrubs including hawthorn (Crataegus erythropoda), chokecherry (Prunus virginiana), and snowberry (Symphoricarpos occidentalis). This shrub community is unusual and may be restricted to the local area.

A unique shrubland community associated with the seeps at the Site is tentatively classified as Crataegus erythropoda-Prunus virginiana-Prunus americana seep shrubland. This plant association is ranked GU/SU by the Natural Heritage Network indicating its poorly known status. This plant association is similar to one described in Montana but Crataegus erythropoda is the dominant species in the Colorado community and Crataegus succulenta is the dominant species in the Montana community (Hansen et al. 1991). These small patches of shrublands are scattered throughout the Rock Creek drainage where seeps form at the contact of the relatively permeable Rocky Flats Alluvium and the less permeable Arapahoe Formation. This community is not well documented in the literature. Special effort should be undertaken to protect and to better understand the biodiversity significance of this community.

Other portions of the Rock Creek Site are occupied by the shortgrass prairie plant association, Agropyron smithii-Bouteloua gracilis (U. S. Department of Energy 1994a). This plant association is believed to remain common, but is also highly impacted throughout its range. The season of study for CNHP was not appropriate to assess the ecological status of this plant association. Follow-up work will occur in the field season of 1995.

The Preble's meadow jumping mouse (Zapus hudsonius preblei) occurs only in Colorado and Wyoming. The mouse is known from Colorado on the basis of fewer than 50 specimens from Larimer, Weld, Boulder, Jefferson, Denver, Adams, and Arapahoe counties (Armstrong 1972). Judging from its limited ecological and geographic distribution in Colorado, the mouse probably is a Pleistocene relict, perhaps once widespread in a tallgrass prairie across the eastern plains, but now restricted to scattered localities on the Colorado Piedmont (Fitzgerald et al. in press).

Preble's meadow jumping mouse may be one of North America's rarest mammals. This subspecies is isolated from its nearest relatives and was naturally rare (relatively) due to its restricted habitat. The Preble's meadow jumping mouse habitat appears to be restricted to relatively short distances from the riparian vegetation (Fred Harrington - personal communication; C. A. Pague - personal observation).

The status of extant populations of Preble's meadow jumping mouse is poorly known in Colorado, and unknown in Wyoming. Extant populations are known from the Rocky Flats Environmental Site, the Fort St. Vrain Nuclear Generating Station, the City of Boulder Open Space (Tracy Collins parcel and the Van Vleet parcel) (Compton and Hugie 1993). An intriguing report of the species comes from near Woodburn, El Paso County, Colorado (Jones and Jones 1985), as cited in Compton and Hugie (1993). The exact location of Woodburn is unknown at this time (personal communication with David Armstrong 1994), and no recent live trapping effort has been conducted in this area (Compton and Hugie 1993).

The first Preble's meadow jumping mouse recorded at the Rocky Flats Environmental Technology Site was captured in 1991 (Ebasco Biologists 1992, U. S. Department of Energy 1994c). Intensive trapping efforts have been conducted since 1992 (U. S. Department of Energy 1994c, 1994a, personal communication with Kevin Essington 1994; EG&G 1993a, 1992). The population at RFETS has been under study for several years and is the best known population in the state (and in the world) (Fred Harrington - personal communication; David Armstrong - personal communication). The Rock Creek population (or subpopulation) is the only known site containing sufficient numbers and habitat to be considered potentially viable. For this reason, the Rock Creek Site is considered by CNHP to be of high biodiversity significance.

The Natural Heritage Network ranks this subspecies as G5T1?/S1? indicating that the species (Zapus hudsonius) is globally common. The subspecies, noted by the T1? rank, is extremely rare and imperilled globally. Finally, Preble's meadow jumping mouse is extremely rare in Colorado, indicated by the rank of S1? The "?" after the ranks indicate a certain level of uncertainty due to insufficient surveys over the potential range. In any case, it is the consensus of experts that this subspecies, even if more widespread, will always be considered rare (David Armstrong - personal communication).

Other mammals known from the Rock Creek site are not considered rare, threatened or endangered. The rare Merriam's shrew (Sorex merriami) is known from the Woman Creek drainage, but has not been verified from the Rock Creek drainage.

Although several special concern bird species have been observed at the Rocky Flats Environmental Technology Site, most cannot be considered occurrences of conservation significance. Tracked occurrences for bird species are only those with probable or confirmed breeding status, as per Colorado Bird Atlas guidelines (Kingery 1990), or significant concentration areas (migrating or wintering). Based on existing information, birds of special concern that probably breed within the Rock Creek Site include the loggerhead shrike (Lanius ludovicianus) and the black-crowned night-heron (Nycticorax nycticorax).

Breeding status for loggerhead shrikes is considered probable, as four to six individuals have been observed at the Site throughout the year. Loggerhead shrikes have been observed in all three drainages at the Rocky Flats Environmental Technology Site in all of the major habitat types including grassland, disturbed areas, shrubland, woodland, and marshland. More specifically, they have been recorded in cottonwoods, chokecherry, xeric grassland areas, and habitats with some Ponderosa pine (Pinus ponderosa) (Department of Energy 1994b; Marcia Murdock - personal communication).

The loggerhead shrike is ranked G4/S3 by the Natural Heritage Network. This rank indicates a widespread distribution globally while at the same time, rare in Colorado. The loggerhead shrike is not uncommon in the shrubby portions of Colorado, but is known to be declining seriously in most of the species' range. The species is recognized by the U. S. Fish and Wildlife Service as a Category 2 species, meaning that evidence exists suggesting that the loggerhead shrike may qualify for listing as a threatened or endangered species.

Black-crowned night-herons have been observed frequently during the breeding season at the Lindsay agricultural pond in the Rock Creek Drainage. This rank (G5/S3B) indicates that the species is globally common, but that breeding status in the state is rare to uncommon. Probable breeding is suggested as a pair was observed throughout the breeding season in suitable nesting habitat. Adults have been observed in disturbed habitats, shrubs, marsh, and woodland habitats. Two young were seen at the Lindsay agricultural pond later in the season (Department of Energy 1994b; Marcia Murdock - personal communication).

Table 3. Significant elements known from the Rock Creek Drainage.

Element	Common Name	Occur. Rank	Global Rank	State Rank	Federal Status	State Status
Zapus hudsonius preblei	Preble's meadow jumping mouse	B	G5T1?	S1?	C2	SC
Lanius ludovicianus	loggerhead shrike	C	G4	S3B,SZN	C2	SC
Nycticorax nycticorax	black-crowned night-heron	D	G5	S3B		
Andropogon gerardii-Schizachyrium scoparium	Xeric tallgrass prairie	B,C	G2	S2		
Populus deltoides-Salix amygdaloides/S. exigua	Plains cottonwood riparian woodland	C	G2G3	S2S3		
Amorpha fruticosa	Riparian shrubland	C	GU	SU		
Crataegus erythropoda-Prunus virginiana-P. americana	Seep shrubland	C	GU	SU		
Agropyron smithii-Bouteloua gracilis	Shortgrass prairie	?*	G5	S4		

* Field verification necessary to determine occurrence rank.

OTHER BIODIVERSITY VALUES: Data provided by EG&G, Kevin Essington, David Armstrong, and personal observations by CNHP staff demonstrated that the shrubby habitats along the riparian zone of Rock Creek and on slopes (particularly on seeps) supported numerous and diverse migratory birds. The abundance of cherries, hawthorne and sumac provide food as well as high quality cover for the birds. Birds observed included neotropical migratory birds as well as species that moved shorter distances.

CURRENT STATUS: The Rock Creek Site occurs largely on the Rocky Flats Environmental Technology Site, but also includes some private property at the western edge. Further investigations may indicate the need to expand the site downstream onto other ownerships. **No protective status is currently provided to the site.** In addition, the Department of Energy is considering potential future uses of the site. Designations other than a conservation designation may prove to be a serious threat to the integrity of the natural heritage resources. Gravel mining operations on the private property west, including recent proposals for extensive expansion, may pose serious threats to the hydrology of the Rock Creek Site, including riparian vegetation, seep vegetation, and therefore, the Preble's meadow jumping mouse.

The xeric tallgrass prairie occurs within the buffer zone and on adjacent private land to the west on the Rocky Flats Alluvium on relatively flat pediments. Gravel mining

operations have occurred between the Rocky Flats Environmental Technology Site portion and the occurrence immediately east of highway 93 on private land. The RFETS portion of the xeric tallgrass prairie appears to have been relatively undisturbed since the Department of Energy acquired the land in 1974, except for numerous access and fire break (gravel and two track) roads which are maintained in the buffer zone. Invasion by exotic plant species, especially knapweed (Centaurea spp.), cheatgrass (Bromus tectorum) and Japanese brome (Bromus japonicus), is the greatest threat to the prairie.

A small patch of xeric tallgrass prairie in the southeast quarter of section 4 has a dense mat of lichen (Cladonia sp.) covering the soil between plants (S. Kettler - personal observation). The dense nature of the crustose soil indicates that this may be an area that has had little disturbance for some time. This seems somewhat unusual and deserves further study. This area could be a good baseline monitoring site as some lichens are known to be good indicators of air quality.

The Plains cottonwood riparian woodland plant association (Populus deltoides-Salix amygdaloides/Salix exigua) occurs in small scattered patches along the lower tributaries and the main stem of Rock Creek. The community was probably somewhat disturbed in the past by livestock grazing and other factors. One result of this disturbance is likely the introduction or spreading of exotic plant species such as Kentucky bluegrass (Poa pratensis), smooth brome (Bromus inermis), and Canada thistle (Cirsium arvense), which now dominate the understory of the community (U. S. Army Corps of Engineers 1994). Knapweed has also invaded portions of the riparian habitat but may have done so by means of natural disturbances (spring flooding).

The seep shrubland community has also been somewhat by the introduction of exotic species which are now common in the understory (S. Kettler - personal observation). This community, which is somewhat degraded by the invasion of exotic species, is not well known or described in the literature and may be rare. Additional information is needed to more accurately assess the status of this community. This community should be of special concern when considering protection of biodiversity.

In summary, immediate threats include gravel mining operations, small population size of the Preble's meadow jumping mouse, potential alternate land use, and the invasion by aggressive weeds. We consider the Rock Creek Site to be seriously imperilled.

BOUNDARY JUSTIFICATION: The conservation site boundaries for Rock Creek (attached map) include all examples of xeric tallgrass prairies found on DOE land and adjacent private land, the riparian areas known to support Preble's meadow jumping mouse, and the mosaic of plant communities associated with seeps at the contact of the Rocky Flats Alluvium and the Arapahoe formation. An ecological buffer area is delineated but various human activities have encroached into this area. We also note that the buffer included in this boundary is already invaded by numerous weeds. The

Colorado Natural Heritage Program is highly concerned about the small size of native prairie remnants and considers it of importance to retain (and potentially restore) the existing remnants.

PROTECTION RECOMMENDATIONS: The significance of the site warrants that the Department of Energy immediately designate the Rock Creek Site as a priority ecological site. The Protection Urgency Rank of P1 indicates that the Site may be threatened by forces that could result in the loss of the element(s) within one year. Such a designation should be formal and be included in any site management plans. This protective status should also be such that it continues in effect with any transfer of the pertinent lands to other ownership or management (unless other more current biological information suggests otherwise). We also recommend that this protection status include no additional road development or other means of fragmentation of the existing site. Proposals to conduct mineral excavation should incorporate these same principles. We note that the ecological integrity of much of this site is dependent on a protected hydrological regime. Finally, since this conservation site extends beyond Rocky Flats Environmental Site boundaries, CNHP recommends that the Department of Energy work in partnership with pertinent federal, state, and local agencies as well as private conservation organizations that could assist in the protection and management of the entire conservation site.

MANAGEMENT RECOMMENDATIONS:

Preble's meadow jumping mouse management recommendations: This site contains the largest known and best studied population of Preble's meadow jumping mouse (Fred Harrington - personal communication, U. S. Department of Energy 1994c). Captures at this site have been reported from a variety of habitat types in and adjacent to the riparian zone of Rock Creek. Long term protection will require the maintenance of these habitats in natural condition (natural ecological functions). This includes the maintenance of supportive ecological processes. Fragmentation of the area by roads, and possibly trails, should be avoided. Road closures should be considered (perhaps through re-routing). We do not consider the existing research to be other than a positive management practice. The information thus far gained from EG&G's excellent research program is the best available for the subspecies.

CNHP is greatly concerned about the extent of weedy invasion in the Rock Creek drainage. The effects of many of these species on the Preble's meadow jumping mouse are not precisely known. Ecological theory and observation of CNHP staff suggest that serious degradation of the mouse habitat quality will occur with additional expansion of weeds, particularly knapweed species. **Exotic plants that threaten to change the structure of the habitats of the Rock Creek Site should be kept in check.**

Off-site land use may pose the greatest threat to this occurrence. Habitat destruction and alteration of the surrounding land may isolate this population, decreasing its

viability. Furthermore alteration of hydrologic regimes, possibly due to factors beyond the control of DOE, may lead to associated changes in vegetation throughout the drainage, potentially degrading Preble's meadow jumping mouse habitat on the site. Any proposed activities on this site that would significantly alter the existing hydrology should be considered a serious threat to the survival of Preble's meadow jumping mouse.

Xeric tallgrass prairie management recommendations: The existence of this increasingly rare xeric tallgrass prairie as a natural area could be a valuable education tool while contributing to conservation. The area should be managed as a tallgrass prairie site. The greatest threat to this community on the buffer zone is invasion by exotic plant species. Further increase of exotic species may decrease the biodiversity significance of the site by altering the native floral and faunal species composition (Bock and Bock 1988, West 1993).

Several exotic species occur in the community in various quantities. These species include cheatgrass, Japanese brome, musk thistle (Carduus nutans), Kentucky bluegrass, toadflax (Linaria dalmatica), alyssum (Alyssum minus), and knapweed. Of these species, musk thistle, toadflax, alyssum, and knapweed present the greatest threat of increasing invasion of the grassland. Other species mentioned above appear to be present in small disturbed patches but do not seem to spread into undisturbed areas. Musk thistle, toadflax, and alyssum are common in areas with little recent disturbance. Knapweed is common to dense along gravel access roads throughout the area and has spread from the roads a short distance into the relatively undisturbed prairie (S. Kettler - personal observation). It is not known if this species will spread further into the prairie over the course of time. Knapweed seems to be aggressively expanding in the area around the Front Range of Colorado (CNHP unpublished data). We observed that significant sources for several weeds are on the adjacent mining sites as well as within the Rocky Flats Environmental Technology Site. To adequately protect this ecosystem will require continued partnerships with the adjacent landowners and managers, particularly to manage weeds and restore gravel mining sites and other significant areas. Aggressive management (herbicide application, manual cutting, etc.) may be necessary to control these species. Early season grazing, burning, or mowing may be effective management tools to control many of the cool season exotic plants and favor warm season dominant native plants. Ecological Monitoring Program site TR01 (U. S. Dept. of Energy 1994a) would be considered a good baseline monitoring site because of its location in a relatively pristine part of the xeric tallgrass prairie. More species-specific management techniques are not presented in this report since relevant information already exists in the Weed Control Program described in the Watershed Management Plan for Rocky Flats (U. S. Dept. of Energy 1993).

Great Plains Riparian Woodland and Shrubland Management Recommendations: Exotic species heavily dominate the understory in the mosaic of plant associations that make up this community and have severely degraded the community. It is suspected that

heavy dominance by exotic species can result in drastic reduction in diversity of some animal groups (Bock and Bock 1988). The most common and problematic species include Canada thistle, Kentucky bluegrass, and smooth brome. Early season grazing, burning, or mowing may be effective management tools to control these exotic plants. Biological control already implemented at the site appears to be somewhat effective in controlling Canada thistle. Total elimination of exotic species is impossible but reducing the vigor and dominance of these species may allow native species to increase.

Seep Community Management Recommendations: Exotic plant species are common in the understory within and surrounding the seep shrublands (S. Kettler - personal observation). The problem species are essentially the same species listed above in the Great Plains Riparian Community. Again, these species may be controlled with early season grazing, burning, or mowing.

Shortgrass Prairie Management Recommendations: Due to the late season of our investigations, this occurrence was not ranked or field checked. Quantitative data from site TR02 (U. S. Dept. of Energy 1994a) suggests that at least some part of this occurrence is relatively free of exotic species, suggesting that it may be of some biodiversity significance and be useful as a baseline restoration monitoring site. We intend to further evaluate this site in the 1995 field season.

A Management Urgency Rank of M2 was assigned to the Site. This indicates that new or modified management activities may be needed within the next 5 years to insure the survival of the element(s).

PROTECTION OF SIGNIFICANT BIODIVERSITY AREAS

This site is recommended to DOE as an area in need of special protection. The ranking system used merely ranks sites for protection relative to the rarity and quality of known significant features. Therefore, the site identified herein comprises the highest priority elements, based on known information, for the conservation of the study area's natural diversity.

Once a Conservation Site has been identified, the first step in protecting the sensitive species or communities is to delineate a preliminary conservation planning boundary. In developing these boundaries, Natural Heritage Program staff considered a number of factors. These included, but were not limited to:

- the extent of current and potential habitat for natural heritage resources, considering the ecological processes necessary to maintain or improve existing conditions;

- species movement and migration corridors;

- maintenance of surface water quality within the site and the surrounding watershed;
- maintenance of the hydrologic integrity of the groundwater, e.g. by protecting recharge zones;
- land intended to buffer the site against future changes in the use of surrounding lands;
- exclusion or control of invasive exotic species; and
- land necessary for management or monitoring activities.

As the label "conservation planning" indicates, the boundaries presented here are for planning purposes. They delineate ecologically sensitive areas where land-use practices should be carefully planned and managed to ensure that they are compatible with protection goals for natural heritage resources and sensitive species. All land within the conservation planning boundary should be considered an integral part of a complex economic, social, and ecological landscape that requires wise land-use planning at all levels.

Protection Tools

Intensive land use in Colorado and multiple demands for many areas contribute to the continual degradation of many natural communities, endangered species habitats, and other types of natural areas. Best management practices can help protect critical buffers, but may not be adequate in the protection of sensitive species and sites. The first and most significant and proactive tool for protection is the continued identification of locations of rare species, natural communities, and the ecosystems that support them. Only with this information can informed decision-making occur.

This document provides base-level information to begin a planned protection effort of the significant biodiversity features within the Rock Creek drainage at Rocky Flats Environmental Technology Site. By using careful planning, and a monitoring program, the significant elements of natural diversity identified herein will be adequately conserved.

REPORT RECOMMENDATIONS

1. **Develop an implementation plan for designation of the Rock Creek Site.**

This work has documented the existence of several elements deemed to be significant for the protection of Colorado's natural diversity. These elements have been incorporated into one conservation site for the Rock Creek drainage. This site is ranked B3 by CNHP and is considered of state, regional, and national significance. Designation of the Rocky Flats Environmental Site portion of this site should occur rapidly to respond to the urgency of threats. Designation of the Rock Creek Site as a National Environmental Research Park (NERP) is warranted. We also encourage DOE to recognize the area as a Research Natural Area (RNA). The significance of ongoing research activities combined with known ecological values would be formally recognized for their national importance.

2. **Incorporate the information included in this report in the review of activities in or near areas identified as significant.**

The area identified in this study is known to support unique or exemplary natural communities and rare species. As proposed activities within the RFETS are considered, they may be compared to the map presented herein. Should any proposed project potentially impact the Rock Creek Site, DOE can decide if it is desirable to contact persons, organizations, or agencies with expertise. The Colorado Division of Wildlife, Colorado Natural Areas Program, and Colorado Natural Heritage Program routinely conduct environmental reviews statewide and should be considered available resources.

3. **Increase public awareness of the benefits of protecting areas determined to be significant to Colorado's natural diversity.**

Natural lands are becoming ever more scarce especially in near proximity to densely populated metropolitan areas. Rare species will continue to decline if not given appropriate protective measures. Increasing the public's knowledge of the remaining significant areas will build support for the programmatic initiatives necessary to protect them. Such activities could be done through interpretive facilities, conferences or meetings to stimulate public involvement, and information pamphlets. Finally, it would be desirable for DOE to promote any protective designations to the public and scientific community to build awareness of DOE's commitment to the protection of sites of national ecological significance.

4. **Promote cooperation among pertinent organizations in the protection of natural diversity.**

The long-term protection of natural diversity at the site will be facilitated with the cooperation of many organizations. Personnel at the site have played a

leadership role in attempting to incorporate diverse opinions in the planning process. Efforts to this end should continue, providing stronger ties among federal, state, and local and private interests involved in the protection or management of natural lands.

5. **Properly manage significant elements of natural diversity within the Rock Creek drainage of Rocky Flats Environmental Technology Site.**

The first step in accomplishing this recommendation would be the appropriate designation of the identified conservation site. In doing so, the development of management plans would be a necessary component of the site designation. Several organizations and agencies are available for consultation in the development of Management Plans for significant natural lands (e.g. Colorado Natural Areas Program, Jefferson County Open Space, the City of Boulder, The Nature Conservancy, and the CNHP). We would also encourage the development of partnerships that could research and develop techniques for maintaining or restoring conservation sites to aid in the preservation of rare, threatened, or endangered species or significant natural communities (e.g. Colorado Division of Wildlife, Colorado Native Plant Society, The Nature Conservancy, and various academic institutions). Because some of the most serious threats to the Rock Creek ecosystem are off-site (altered hydrology, residential encroachment, exotic species invasion), these partnerships become essential to the long term protection of the area.

6. **Conduct further inventory efforts to assess other natural heritage resources.**

The seep shrublands need to be quantitatively evaluated. The similarity to other plant communities, the range, distribution, and naturalness of this community need to be evaluated. In addition, the area of xeric tallgrass prairie covered with lichen should be documented in more detail.

Several rare plants may potentially occur in the area. Field surveys for special concern plants should be conducted in the appropriate season (especially those not already searched for during the Baseline Biological Characterization (Department of Energy 1992) and by EG&G contractors (1993b).

There are several butterflies and moths of special concern known from the region with suitable habitat at the Rocky Flats Environmental Technology Site. Preliminary butterfly and diurnal moth surveys were conducted at RFETS during the 1991 field season. Results were included in the 1992 Baseline Biological Characterization Report. Several moths and 54 butterflies were recorded, none of which are known to be rare. In 1994, 190 butterfly species are known from Boulder County, 181 butterfly species are known from Jefferson County, and 103 species are known from Denver County (Stanford 1994). Although these

ACKNOWLEDGEMENTS

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Final Report

Lower Walnut Creek Aquatic Sampling, Spring 1998

November 1998

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Final Report

Lower Walnut Creek Aquatic Sampling, Spring 1998

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QA ID No.: 8600BAM.001 0813 0998 RN68

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ACRONYMS AND ABBREVIATIONS

BDCWG	Big Dry Creek Watershed Group
DOE RFFO	Department of Energy Rocky Flats Field Office
EPT	Ephemeroptera, Plecoptera, and Trichóptera
HBI	Hilsenhoff biotic index
NPDES	National Pollutant Discharge Elimination System
RBP	Rapid Bioassessment Protocols
RFETS	Rocky Flats Environmental Technology Site

INTRODUCTION

As part of the Big Dry Creek Watershed Group (BDCWG), the cities of Westminster, Broomfield, and Northglenn have conducted a combined water quality monitoring program on Big Dry Creek since 1988. Rocky Flats Environmental Technology Site (RFETS) is located west of the area being monitored by the cities, and the Department of Energy Rocky Flats Field Office (DOE RFFO) also participates in the BDCWG. As such, the DOE RFFO has agreed to monitor several upstream locations along Walnut Creek and near the confluence of Walnut Creek and Big Dry Creek. The purpose of the monitoring is to provide biannual assessments of the aquatic habitat, and the condition and abundance of aquatic life. This information is needed by decision makers to protect and preserve the aquatic integrity of the streams.

The questions being addressed by this sampling include:

- What is the quality of the aquatic habitat in Lower Walnut Creek?
- What are the richness and abundance of the benthic macroinvertebrates in Lower Walnut Creek?
- What fish species are present in Lower Walnut Creek?
- What is the condition of the benthic macroinvertebrate and fish populations in Lower Walnut Creek, and how do they compare to downstream areas?

METHODS

Six locations (sites) were selected along Walnut Creek and near the confluence of Walnut Creek and Big Dry Creek for aquatic sampling in spring 1998. They included one site at Rocky Flats Environmental Technology Site (RFETS) and five others located east of RFETS. These sites were sampled in 1994 as part of a study conducted by Wright Water Engineers, Inc. (WWE 1995). Figure 1 shows the location of the six sample sites. The same site names used by WWE were used again for ease of reference: D1, D2, W1, W2, BD1, and BD2. Methodology followed the *Rapid Bioassessment Protocols* (RBPs) *for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (U.S. EPA 1989) as a minimum standard. These protocols require sampling of fish and benthic macroinvertebrates, habitat characterization of sampling locations, water chemistry information, and water flow levels. The benthic macroinvertebrate sampling in spring 1998 used the RBP III for benthic macroinvertebrates (U.S. EPA 1989). Fish sampling used the RBP V (U.S. EPA 1989). Some modifications to these protocols were necessary because of the habitat constraints in the Lower Walnut and Big Dry Creek drainages. These modifications included compositing kicknet samples, combining sweeps from different habitats, and making the decision to seine for fish instead of electroshocking. The activities conducted at each of the six sampling sites are described below:

Habitat was assessed following the RBP (U.S. EPA 1989), with one assessment for each site. Both physical and water quality data were collected at the time of sampling or within a few days thereafter. Water quality data collected included pH, temperature, dissolved oxygen, stream flow, conductivity, and turbidity. The following modifications were made to the habitat assessment to assist in comparing data from samples collected downstream by the cities. The modifications included:

- Length and width were measured at each site.
- The length of each site was divided into 50-ft transects, or cells, and the transects were staked.
- Flow measurements were taken at each transect.
- All deposits were measured and composition noted.
- Banks were measured for percent vegetation/stable, percent vegetation/unstable, percent rock/stable, and percent exposed soils.
- Substrate percentages were determined for each cell via a random count of 100 grabs.
- Percent embeddedness was estimated for each cell.
- Slope of the bank was estimated.

- All instream structures were measured (boulders, vegetative mattes, log jams, etc.)
- The length of each riffle, pool, and run was measured at each site.
- The type of vegetation was measured and noted along the banks.
- The lengths of overhanging vegetation and undercut banks were measured.

These modifications followed the procedures employed by the City of Northglenn staff (see sample habitat completion sheets, Appendix A).

Two types of benthic macroinvertebrate sampling were conducted. The first type used a Hess sampler. Three replicate samples were taken in different riffle sections of the stream at each of the six sites (assuming three riffles were present in sampling area). Each replicate remained an individual sample. In the field, samples were placed into labeled jars containing a 70 percent ethanol solution for preservation, and were delivered to the laboratory for analysis. The maximum mesh size of nets used with samplers was 250 μm.

The second method of collecting benthic macroinvertebrate samples used a Kicknet type of sampler (or equivalent). Four samples were collected from each habitat (bank, riffle, run, pool) at each site, and were composited into one site sample. The composite samples were preserved and shipped as described previously.

Fish were sampled using minnow (fish) seines and traps. Minnow seining was conducted twice (each time on different days) throughout the entire length of the stream in the sample area. Additionally, four minnow traps were placed at each site. (Note: the small stream channel size and low flow conditions at the time of sampling made electroshocking an inappropriate method for this effort. Furthermore, electroshocking would not have been effective if the stream's conductivity were high. Field crews identified and enumerated fish species at the sites, as well as measuring lengths and weights and noting any anomalies on individuals. Any fish that could not be field identified were placed into labeled jars containing a 70 percent ethanol solution for later identification.

Field data sheets and forms used for sampling are presented in Appendix A. Benthic macroinvertebrate samples were sent to a subcontractor (Chadwick and Associates) for identification to the lowest possible taxon, enumeration, and summary by diversity index, taxa richness, and family biotic index (e.g., Hilsenhoff biotic index [HBI], Ephemeroptera, Plecoptera, and Trichoptera [EPT] index, scraper ratios, etc.). The results from these identifications and summaries are presented in Tables 5–7 and Figures 2–5.

ANALYSIS

Analysis of the data collected followed the recommendations provided in the RBP (U.S. EPA 1989). The benthic macroinvertebrate metrics included:

- Species richness
- Modified HBI
- Ratio of scrapers and filtering collectors
- Ratio of EPT and chironomidae abundance
- Percent contribution of dominant taxa
- EPT index
- Community similarity indices.

Fish metrics included species richness.

RESULTS AND DISCUSSION

STUDY AREA

The study area for the Lower Walnut Creek monitoring extends from one site just west of Indiana Avenue on RFETS to the confluence of Walnut Creek and Big Dry Creek, just southwest of Highway 36. The six sites are all within Jefferson County, with four sites along Walnut Creek and two sites in Big Dry Creek. In Big Dry Creek, one site is above and one below the confluence with Walnut Creek (Figure 1, Table 1). These six sites were used for an aquatic biological assessment in 1994 (WWE 1995). Habitat characterization, and fish and benthic macroinvertebrate sampling were conducted at each of the six sites during late March through April 1998. Appendix B contains photographs of each site, which documents the conditions during the 1998 spring sampling.

HABITAT CHARACTERISTICS

Walnut Creek is an intermittent stream with its headwaters originating on the west side of RFETS. From RFETS, Walnut Creek meanders through a suburban setting that includes ranchettes, subdivisions, municipal open space, and pasture land until reaching the confluence with Big Dry Creek. Stream-side vegetation includes grasses, various wetland species, willow, leadplant and chokecherry shrubs, and trees.

All six of the 1998 sampling sites (Table 1) are in the transition zone between the foothills and the plains. Aquatic habitats and, correspondingly, aquatic life in Walnut Creek are limited by water availability and discharge rates, especially at the upstream sites, D1 and D2. Traveling downstream from the first sampling site, D1 (Figure 1), to the confluence with Big Dry Creek, water availability and stream discharge rates increase.

Stream discharge is highly modified by human activities. Many ditches and reservoirs have been in place for decades, altering stream flows from natural conditions. Present flow conditions depend on the management of these man-made additions to the watershed. Two examples of man-altered conditions are:

1. RFETS must maintain water quality standards under a National Pollutant Discharge Elimination System (NPDES) permit, currently relying on batch testing and discharging to meet the standards (RMRS 1996, *Pond Operations Plan*). The batch discharging perpetuates the intermittent flow conditions and limits the aquatic habitat available at the sampling sites immediately east of the Pond Operations Area (i.e., D1 and D2, Figure 1).

2. Between D2 and W1 (Figure 1), real estate development is occurring in the uplands adjacent to both sides of the creek. Excavation and construction remove vegetation and increase the potential for runoff and sedimentation in the creek. Aquatic habitats in sampling sites below these developments are altered, at least temporarily, during this sampling session.

The following habitat characteristics apply, in general, to all six sampling sites. Sampling sites generally contained three macrohabitat types—riffles, runs, and pools—with the exception of site D2, which had no pool habitat. Cobble and gravel substrates in riffle habitats provide some of the most productive conditions for aquatic life. Riffle habitats at all sites contained some portion of cobble and gravel substrates (Table 2), but also revealed some level of sedimentation (Table 3). Pool habitats generally had sand and silt substrates. Stream discharge varied widely during the sampling period, with flows reaching near flood conditions during the week of 13 April, following a weekend snowstorm. Water clarity was slightly turbid to turbid throughout Walnut Creek, and conductivity fluctuated widely during sampling (Table 4).

Habitat characteristics that differentiated some sampling sites from others were 1) the overall habitat scoring, 2) the amount of macrohabitats available, and 3) the proportions of substrate types. The overall habitat scoring is the result of a habitat assessment that incorporates a variety of habitat parameters according to EPA's Rapid Bioassessment Protocols (U.S. EPA 1989). See Appendix A for an example field data sheet that contains a list of the parameters used during habitat assessment. The amount of macrohabitats available and the proportions of substrate types present at each site give additional information as to the site's habitat suitability and potential productivity.

Site D1 had the lowest habitat score (51, Table 2), the lowest proportion of riffle habitat (17.5 percent, Table 2), and the highest proportion of silt substrate (42 percent, Table 3), compared to the other sampling sites. Site D1 is situated immediately downstream from a small impoundment, the Walnut/Indiana Pond. The habitat conditions likely result from the batch discharging regime from upstream containment ponds, and from the high sediment output from the Walnut/Indiana Pond. Additionally, this portion of Walnut Creek is often dry in the late summer and fall months, except when batch discharging is occurring (see Figure 4-2, WWE 1995). The dry periods at D1 severely limit the aquatic habitat at this site.

Site D2 had the largest proportion of riffle habitat (87.5 percent, Table 2) and contained the most cobble substrate (90 percent, Table 3). These conditions contributed to one of the highest habitat scores (93, Table 2). This reach of Walnut Creek now receives water from the Broomfield Diversion Ditch, Woman Creek Reservoir, Dry Creek Valley Ditch, and the toe drain of Great Western Reservoir. Flows from these sources can be quite large at times and apparently are relatively free of sediment. In aggregate, these flows create some high-quality aquatic habitat at this site in Walnut Creek.

Site W1 was noteworthy because of the large proportion of run habitat (60.6 percent, Table 2) and a relatively large proportion of gravel and sand substrate (40 and 30 percent, respectively, Table 3). The gravel substrate provides higher-quality habitat for aquatic production, but the sand and silt (20 percent, Table 3) suggest some siltation as well. These conditions combine with a large proportion of overhanging trees and shrubs to produce an average habitat score (67, Table 2) at sampling site W1.

Site W2 is most comparable to site W1, and had typical habitat conditions (76, Table 2) for Walnut Creek. This site had a large proportion of run habitat (52.8 percent, Table 2) and contained moderate levels of sand and silt (25 and 20 percent, respectively, Table 3). These substrate proportions indicate that some siltation is occurring. The siltation at this sampling site may be explained by its proximity to Highway 36. Winter highway sand and gravel application may add to stream siltation as snowplows push sand and gravel down the embankment into the creek. Additionally, upstream real estate development may also be adding to siltation at this site.

The last two sampling stations, BD1 and BD2 (Figure 1), both received high habitat scores (85 and 94, respectively, Table 2). In fact, BD2 received the highest score of the six sampling sites. These two sites are in Big Dry Creek and contain large, deep pools, as well as riffle habitat and meandering runs (Table 2). Additionally, the sites contained many areas of undercut banks with overhanging vegetation and submerged logs. This was typically not the case in Walnut Creek, with the exception of the high-quality riffle habitat at D2. These Big Dry Creek sites appear to provide good habitat for aquatic life, especially fish. However, the Aquatic Monitoring Program in Big Dry Creek (Aquatic Associates 1998) reported, "In areas upstream from municipal wastewater discharges...extremely low flows may negatively affect the aquatic community...especially during low base flow conditions." Areas upstream from municipal wastewater discharges would include sampling sites BD1 and BD2. Therefore, although habitat conditions at these two sites appeared to be of good quality in March and April 1998, productivity may be limited by water availability during other times of the year.

Compared to sampling efforts in Lower Walnut Creek in 1994, the habitat scores at site D2 in 1998 improved. This may be due to the addition of the Woman Creek Reservoir diversion channel, although discharges from Woman Creek Reservoir are infrequent (i.e., up to three times per year). A more likely explanation is that flooding in the spring of 1995 flushed accumulated sediments from this site with water volumes that reached 25-year flood levels, thus improving riffle habitat.

At the remaining sites, habitat appears to have declined somewhat from 1994 to 1998. With the exception of site BD2, where the habitat scores were essentially the same, habitat scores declined from 1994 (WWE 1995) to 1998, although it is difficult to say specifically how the habitats changed without consulting the original Aquatic Habitat Assessment Field Data Sheets (U.S. EPA 1989). One possible explanation is that real estate development in the Walnut Creek basin has decreased water availability and increased siltation, embedding cobble and gravel beds.

MACROINVERTEBRATES

Sampling for benthic macroinvertebrates was conducted at the six sites during March and April 1998. Samples were collected using two techniques: Hess sampling in riffles using three replicates, and kicknet sweeps combined from four habitat types. Table 5 presents the results of macroinvertebrate sampling as relative abundance of taxa per site, by method. The Hess sampling results are relative abundance derived from combining the three replicates. Unsummarized results provided by Chadwick and Associates are presented in Appendix C. RBP III metrics and other community parameters for Lower Walnut Creek are presented in Table 6 and Figures 2–10.

Benthic macroinvertebrate communities in the six sampling sites were represented by 14 orders, including 63 separate taxa. Hess sample results demonstrated that Diptera (midges and flies) taxa were predominant at all sites, with Ephemeroptera (mayflies) and to a lesser extent, Tricoptera (caddisflies) providing most of the remaining abundance. Kicknet sampling also revealed a predominant Dipteran taxa, with the exception of samples from D2 and W2. Kicknet samples from these sites show an abundance of the Ephemeropteran species, *Baetis tricaudatus* (Table 5). Regardless of sampling method, Dipteran abundance typically resulted from the presence of one Chironomidae species, *Cricotopus tremulus*. One exception to this trend was at D1, where *Diamesa* sp. were most abundant. The D1 site also lacked in abundance of Ephemeroptera and Tricoptera, unlike other sites downstream. Other groups—including hemiptera (true bugs), ologochaeta (free-living worms), hirudinea (leaches), amphipoda (scuds), gastropoda (snails), Turbellaria (flatworms), and Nematoda (roundworms)—were encountered occasionally but were not abundant at any of the six sampling sites. Cambaridae (crayfish) were either captured or observed at all six sampling sites and were likely *Orconectes* sp.

Before this study, there was considerable interest in finding Plecoptera (stoneflies) in Lower Walnut Creek, because these insects need a constant source of cold, well-oxygenated water to survive. In late summer of 1994, stoneflies were found at site D2 (EG&G 1995, Table D-13) in low abundance (K-H 1998b, Ecology Database). Given the habitat scores and flows at D2, it is not surprising that stoneflies have been found at this site; however, none was found at D2 or any of the remaining five sampling sites during the 1998 spring sampling. Additional late-season sampling may yield stoneflies in Lower Walnut Creek.

Seven RBP III metrics and two other metrics were used to further evaluate the macroinvertebrate data. The total number of organisms per square meter and the Shannon-Weaver Diversity Index were used, in addition to the RBP III metrics, to make comparisons among sites. The seven RBP III metrics were 1) number of taxa, 2) a modified Hilsenhoff biotic index (this is a family-based biotic index), 3) ratio of scrapers to filtering collectors, 4) EPT index, 5) ratio of EPT to Chironomidae abundance, 6) percent contribution of dominant taxon, and 7) ratio of shredders to the total benthic community. Community loss index typically is used as an eighth metric with RBP III,

but for the community loss index to be calculated, a reference site must be included. Under the Lower Walnut Creek sampling plan (K-H 1998a), it was not considered appropriate at the time to declare a reference site. One possible reference site for the future would be the Big Dry Creek site 0.5BD, as used under the BDCWG sampling scheme (Aquatic Associates 1998).

The RBP III metrics, Shannon-Weaver Index, and total organisms are presented in Table 6 and Figures 2–5 for Hess sampling only. Table 7 presents total organisms and total taxa for kicknet samples. RBP III metrics were not calculated for kicknet samples. The following paragraphs relate the nine metrics (seven RBP III and two others) resulting from Hess sampling for macroinvertebrates at the six sampling sites.

Based on Hess sampling, the total number of taxa was greatest at the Big Dry Creek sampling site BD2 (25, Table 6; Figure 2), and site D1 had the fewest taxa (12, Table 6, Figure 2). Site D2 also had a relatively greater number of taxa compared to other sites. The trend of these three sites generally follows the habitat conditions (e.g., habitat scores; Table 2, Figure 2). Total taxa at Site W2 was unexpectedly high given the habitat scoring (Table 6, Figure 2).

The modified Hilsenhoff biotic index compares the abundance of disturbance, and pollution-tolerant species to the abundance of all taxa in the community. The higher the index, the more tolerant the macroinvertebrate community is to disturbance or pollution. D1 and BD2 had the highest modified Hilsenhoff biotic index among the six sampling sites, suggesting that more pollution-tolerant communities are present at these sites than at the four other sites (Table 6, Figure 2). Sites W2 and BD1 had fewer pollution-tolerant macroinvertebrate communities. Similar indices were reported in 1994 (WWE 1995). It is interesting to note that sites in Lower Walnut Creek had similar or lower modified Hilsenhoff biotic index values when compared to sites in Big Dry Creek (Appendix C, Aquatics Associates 1998).

Insects in the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) are generally sensitive to water quality and habitat degradation. When the total number of EPT taxa is greater at one site than at another, the first site has better water quality and/or habitat than the second. The total number of EPT taxa (EPT index) was greatest at D2 (8, Table 6; Figure 3). Sites D1 and W1 had the lowest EPT index. It is interesting that these two sites are upstream (D1) and downstream (W1) from D2 (Figure 1). Once again, riffle habitat is the key to supporting EPT insects. D2 has superior riffle habitat to D1 and W1.

The EPT/Chironomidae Ratio compares the EPT, which is generally pollution intolerant, to the Chironomid group, which are pollution tolerant. Surprisingly, D2 had a relatively low EPT/Chironomidae abundance ratio (0.33, Table 6). W2 had the highest ratio (0.92, Table 6), indicating a more balanced macroinvertebrate community. D1 had the lowest ratio (<0.01, Table 6), which is attributed to the lack of EPTs, the poor-quality habitat, and the lack of water at this site during substantial portions of the year. Site BD2 had a low ratio as well (0.07, Table 6), attributed to the abundance of midges (*Cricotopus tremulus*) in one Hess sample (Appendix C).

A healthy macroinvertebrate community should contain a balance of many different taxa. Conversely, stressed communities are dominated continually by one or two taxa. The Percent Contribution of Dominant Taxa metric was highest at site BD2 (72 percent, Table 6, Figure 2), which means that one taxon contributed 72 percent to the overall abundance in the macroinvertebrate community. This is explained by the fact that two Hess samples from this site had midge counts that were an order of magnitude higher than any of the other sample sites. Sites D1 and BD1 also had relatively high percentages (63 and 60 percent, respectively, Table 6, Figure 2). The other sites had lower percentages, with site W1 the lowest (30 percent, Table 6, Figure 2). Therefore, sites D2, W1, and W2 have relatively balanced macroinvertebrate communities.

The ratio of scrapers to filter collectors is designed to detect organic enrichment in aquatic macroinvertebrate communities. However, filter collectors may be intolerant to pollutants, making the metric somewhat misleading. Site D1 had the highest ratio (17.0, Table 6, Figure 2), which is not surprising, given that D1 site conditions alternate from a dry creek bed to moderate flows, which flush algal growth and plant matter downstream. Surprisingly, site D2 had the lowest ratio (0.85, Table 6, Figure 2), indicating some organic enrichment compared to the other sites. BD2 also had a low ratio (0.96, Table 6, Figure 2) when compared to the other sites. Ratios were much lower in Big Dry Creek (Aquatic Associates 1998).

The ratio of shredders to total number of individuals collected regardless of feeding group was greatest at sites BD2 and BD1 (0.78 and 0.60, respectively, Table 6, Figure 4). The lowest ratios came from sites D1 and W1 (0.24 and 0.30, respectively, Table 6, Figure 4).

Healthy aquatic communities exhibit a balance of many different macroinvertebrate taxa. Diversity stems from high taxa richness without any one or two groups dominating in abundance. The Shannon-Weaver index (H') is used to determine the evenness of community diversity. A higher H' value indicates more even diversity. Sites with the greatest diversity, as calculated using the Shannon-Weaver index, were D2 and W1 (Table 6, Figure 4). These sites had a more even distribution of taxa abundance within the macroinvertebrate communities. Alternatively, sites with a large number of total organisms, such as BD2 (Table 6, Figure 5), but with great numbers from only a few groups (e.g., *Cricotopus tremulus* from BD2, Appendix C) had low H'. D1 also had a low H', as a result of two dominant species within the 12 taxa found there (Table 6, Appendix C). These results follow trends in habitat conditions when considered with Percent Contribution of Dominant Taxa. For example, BD2 had a high habitat score but also a high contribution from one taxon and thus a low H'. Conversely, D2 had a high habitat score and a more even contribution from many taxa. Therefore, D2 had a high H'. D2 has many more abundant taxa than BD2 and therefore is more diverse. When considering all the macroinvertebrate metrics taken at the six sampling sites, sites W1 and D2 (Table 1, Figure 1) have the most robust and diverse macroinvertebrate communities, because they have a relatively even distribution of taxa, high EPT index, and low contribution from dominant taxa.

Based on macroinvertebrate metrics, the water at sites D2 and W1 is of good quality and apparently devoid of pollutants, and the habitat is adequate and shows no signs of physical disturbance. However, the habitat score for site W1 would not indicate one of the highest macroinvertebrate communities in Lower Walnut Creek, although it is difficult to make strong conclusions on the health of the macroinvertebrate and fish communities on the basis of a single sampling event.

Metrics from site D1 indicate the presence of environmental stress. Site D1 appears to have an impoverished macroinvertebrate community, based on low taxa richness, low EPT index, high percent contribution from dominant taxa, and an overall low number of organisms. This is most likely due to a lack of adequate habitat and, fundamentally, a lack of water. As indicated in the Habitat Results, this site sustains major desiccation for relatively long periods of time as a result of the batch discharging from RFETS. On the other hand, based on this sampling session, the ratio of scrapers to filter collectors does not indicate problems with pollutants. Therefore, it appears that the lack of a robust macroinvertebrate community and the presence of only a transient fish community are due simply to a lack of water at site D1. Again, this discussion is based only on a single sampling event, and site conditions may improve in later years or different seasons.

Although direct comparisons of macroinvertebrate communities from 1994 (WWE 1995) to 1998 are not possible because of differences in sampling methods, general trends are evident in the two resulting data sets. Taxa richness was highest at sites D2 and W2 during both years, and the modified HBI was nearly the same or had slightly declined over time (with the exception of D1, where the modified HBI was higher in 1998 than in 1994). The contribution of dominant taxa was highest at D1, BD1, and BD2 during both years.

Comparing the macroinvertebrate communities of Lower Walnut Creek in spring 1998 to those of Big Dry Creek in spring 1997 (Aquatic Associates 1998), many differences in the RBP metrics are apparent. The number of taxa in Big Dry Creek during spring 1997 was always higher (1 to 16 more taxa per site) than at Lower Walnut Creek sites during 1998. The modified HBI values were generally higher in Big Dry Creek than in Lower Walnut Creek one year later. The percent contribution of dominant taxa was generally higher at the downstream sites of Big Dry Creek (i.e., below the confluence with Walnut Creek) in 1997 than at upstream sites in 1998. The EPT index and the ratios of EPT to Chironomidae, and scrapers to filter collectors, were typically higher in upstream sites in 1998 than in Big Dry Creek downstream sites in 1997. The shredder/total-abundance ratio and the total number of organisms per square meter were always higher in downstream sites in 1997. These metrics seem to indicate better water quality in upstream sites in Lower Walnut Creek and the Big Dry Creek site above the confluence with Walnut Creek. However, these sampling events likely took place under different conditions, because the sampling events in Big Dry Creek were conducted one year earlier than those in Lower Walnut Creek. Thus, it is possible that most of the differences in RBP metrics result from year-to-year variations in the macroinvertebrate communities.

FISH SURVEYS

Fish surveys were conducted at all six sampling sites in late March and April 1998. Although backpack electroshocking was considered as a survey method, it was thought that conductivities in Lower Walnut Creek and Big Dry Creek may be too high for the electroshocker to work properly. The suspected high conductivity levels were based on studies in Big Dry Creek (Cline 1998, pers. comm.). Instead of electroshocking, fish surveys were done using a minnow seine. Although this method is semi-quantitative, it still allowed biologists to assess the fish communities in Lower Walnut Creek. Surveys were conducted during runoff conditions in April. As a result, the high water may have affected the number of fish captured.

Table 8 presents presence/absence information for fish at the six sampling sites. This table shows a general trend of increasing diversity and abundance going downstream, with the most abundance in Big Dry Creek. This trend is most likely due to recurrent dry periods at upstream sites in Lower Walnut Creek, especially site D1.

All species found are native to Colorado. The longnose dace, creek chub, and white sucker are cool headwater fishes, whereas the fathead minnows are ubiquitous, silt-tolerant fish. The green sunfish is a warm-water species that is typically found in still waters in rivers or ponds.

According to Walnut Creek study reports prior to 1998 (WWE 1995, EG&G 1992), no fish species other than fathead minnows had ever been observed in the stream reach below the RFETS ponds (i.e., the Walnut Creek Stream reach from the RFETS A-4 Pond to Simms Street). These fathead minnows likely exist in Lower Walnut Creek as a result of pond water discharge practices at RFETS. When discharging occurs, fish are carried downstream from the RFETS A-4 and the Indiana Street ponds. During the 1998 sampling, however, creek chubs were discovered at site D2 (Figure 1, Table 8). With the many sources of water from different creeks converging on this site (i.e., D2), many opportunities exist for fish introduction or re-introduction. A plausible explanation for the recent occurrence of creek chubs at this site is that they entered the site from one of the many diversion ditches or emigrated upstream from Big Dry Creek.

Furthermore, Wright Water Engineers (WWE 1995) reported that fish sampling was conducted in Big Dry Creek by the Colorado Division of Wildlife in 1992 above and below the confluence of Walnut Creek. These locations approximate sites BD1 and BD2. During the Division of Wildlife surveys, the same five species of fish were found as in 1998 below the confluence with Walnut Creek. Above the Walnut Creek confluence, however, the Division of Wildlife found a total of eight species, whereas in 1998, only three were found. The species missing above the confluence of Walnut Creek are the Johnny darter, longnosed sucker, white sucker, green sunfish, and small mouth bass. The most likely cause of the difference is the different sampling methods used. The Division of Wildlife used electroshocking, and this study used seining. However, these results

may also show that upstream sites in Big Dry Creek are replenished by fish populations from downstream or from tributaries (Sites W2 and BD1 vs. BD2, Table 8).

Compared to surveys of Big Dry Creek in 1997 (Aquatic Associates) upstream of the two confluence sites, similar species diversity was observed. Five fish species were collected both at a site 0.5 miles below Standley Lake (Site BDC-0.5; Aquatic Associates 1998) in spring 1997 and in Big Dry Creek in spring 1998. However, the species compositions of the two sampling events were different. No green sunfish were captured in spring 1997, but Johnny darters and longnose suckers were captured. Johnny darters and longnose suckers were not observed in 1998, but green sunfish and fathead minnows were observed. However, it is difficult to draw any strong conclusions from only one sampling event in a single season.

CONCLUSIONS AND RECOMMENDATIONS

Aquatic life in Walnut Creek is limited by stream flow, which has been greatly modified from natural flow conditions. However, this assessment presents findings of good habitat and a relatively healthy macroinvertebrate community, which equates to relatively good water quality. Current real estate development may be affecting water quality somewhat by creating increased siltation. However, as construction is completed and the developed areas are revegetated, this disturbance may disappear. Water quality is good in Walnut Creek, and no indications were found that pollution is limiting aquatic life. However, only a single sampling event has been conducted recently, and further sampling is needed to fully document conditions.

More than any other factor, the lack of water due to batch discharges limits aquatic life in Lower Walnut Creek, especially at site D1. The lack of distinguishable habitats and a riparian zone immediately below the RFETS ponds further limits the aquatic communities at D1 (WWE 1995). A change to a limited continuous flow regime at RFETS would do much to enhance aquatic communities (fish and macroinvertebrates) within the downstream stretch from the A-4 Pond to the Broomfield diversion ditch.

Based on habitat scores (U.S. EPA 1989), habitat at site D2 appears to have improved since 1994, most likely as a result of recent flood events. Habitat at site BD2 in Big Dry Creek has stayed unchanged, as determined by habitat scoring. At sites D1, W1, W2, and BD1, habitat quality appears to have declined. Possible explanations for the decline include increased real estate development in upland areas, and at site D1, the continued batch discharging has likely continued to add silt and sand to substrates. Overall, man-made changes in and upgradient of Walnut Creek have enhanced some stretches (e.g., site D2), but may have degraded others (e.g., site W2).

Past sampling events have found Plecoptera (stoneflies) in Lower Walnut Creek (K-H Ecology Database 1998b), but none was found during spring 1998 sampling. Lower Walnut Creek does produce other important aquatic insects in the EPT group, in the orders Ephemeroptera (mayflies) and Trichoptera (caddisflies), and the presence of stoneflies may have been overstated in the past, particularly given their low abundance in Lower Walnut Creek in 1994. It is likely that Lower Walnut Creek is a replenishing source of EPT to Big Dry Creek, but is not a source of fish.

Fish diversity in Lower Walnut Creek is much lower than in Big Dry Creek. Fish species are limited to those that can survive the intermittent flows in this tributary. Diversity does increase with an increasing proximity to Big Dry Creek (e.g., site W2, Table 8, Figure 1), indicating a likely influx from Big Dry Creek.

Differences in RBP metrics for macroinvertebrate communities were noted in a comparison of the Lower Walnut Creek site to Big Dry Creek sites sampled by Aquatic

Associates in 1997. Although the differences in metrics that were noted indicated better water quality in upstream sites in both Walnut Creek and Big Dry Creek, simple year-to-year variation cannot be ruled out as an explanation. Therefore, future comparisons should be made during the same season of the same year when possible.

We have the following recommendations:

- Present these findings to the BDCWG
- Continue monitoring habitat and aquatic life at the six sampling sites, especially in the fall of 1998
- Consider using electroshocking methods, and compare the options for bank and backpack shocking methods versus seining
- Incorporate City of Broomfield and City of Westminster surface-water information (if available) into future aquatic monitoring reports.
- Continue to coordinate with the BDCWG to ensure compatibility of sampling programs.
- Compare macroinvertebrate communities in Big Dry Creek with those in Lower Walnut Creek using data from the same season of the same year.

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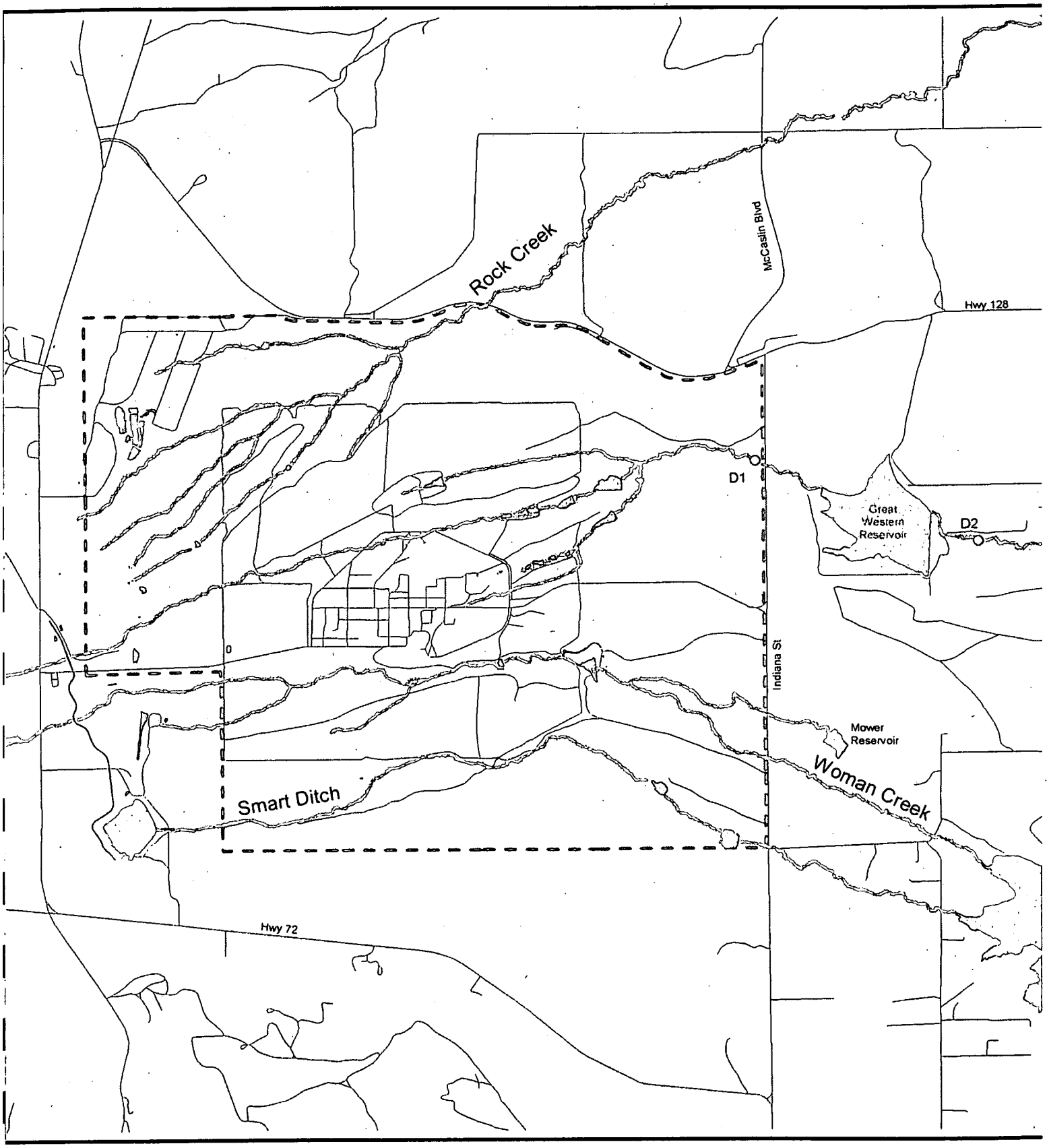
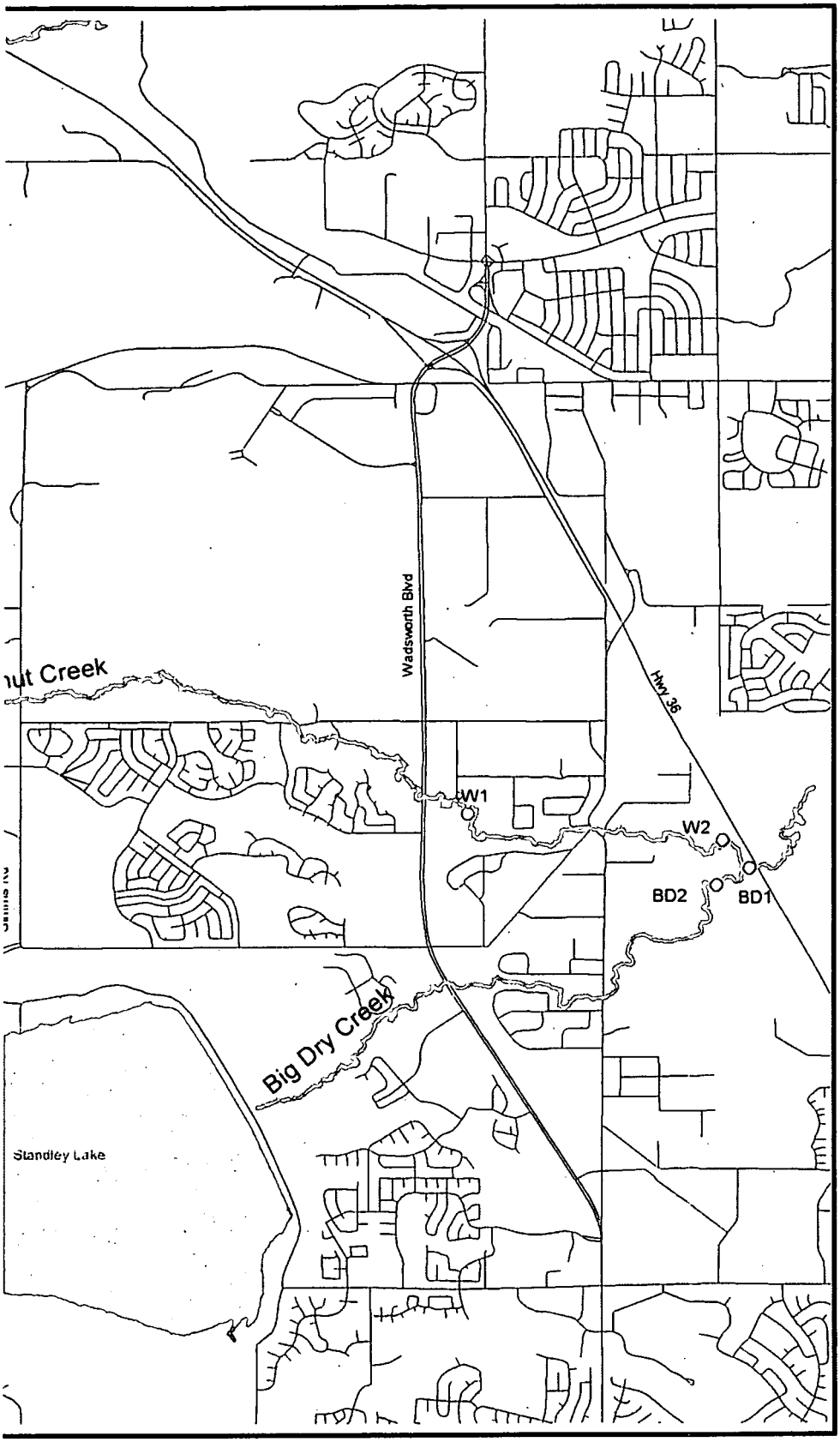
WWE. 1995. Biological assessment and analysis of physical characteristics of Walnut Creek and Woman Creek. Prepared by Wright Water Engineers, Inc., for EG&G, Rocky Flats Environmental Technology Site, Golden, CO.

Figures


Rock Creek
McCaslin Blvd
Hwy 128
D1
Great Western Reservoir
D2
Indiana St
Mower Reservoir
Woman Creek
Smart Ditch
Hwy 72



Lower Walnut Creek
1998 Aquatic Sampling Sites

Figure 1.

LEGEND

- Aquatic Sites
- Lakes
- Streams
- Roads
- Rocky Flats Boundary

Data Sources:
RFETS boundary provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991, Hydrology and roads provided by USGS - (date unknown)

N

1:46249

0 0.5 1 Miles

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

Exponent tm

M. Fink aquatics.apr 9/08/98

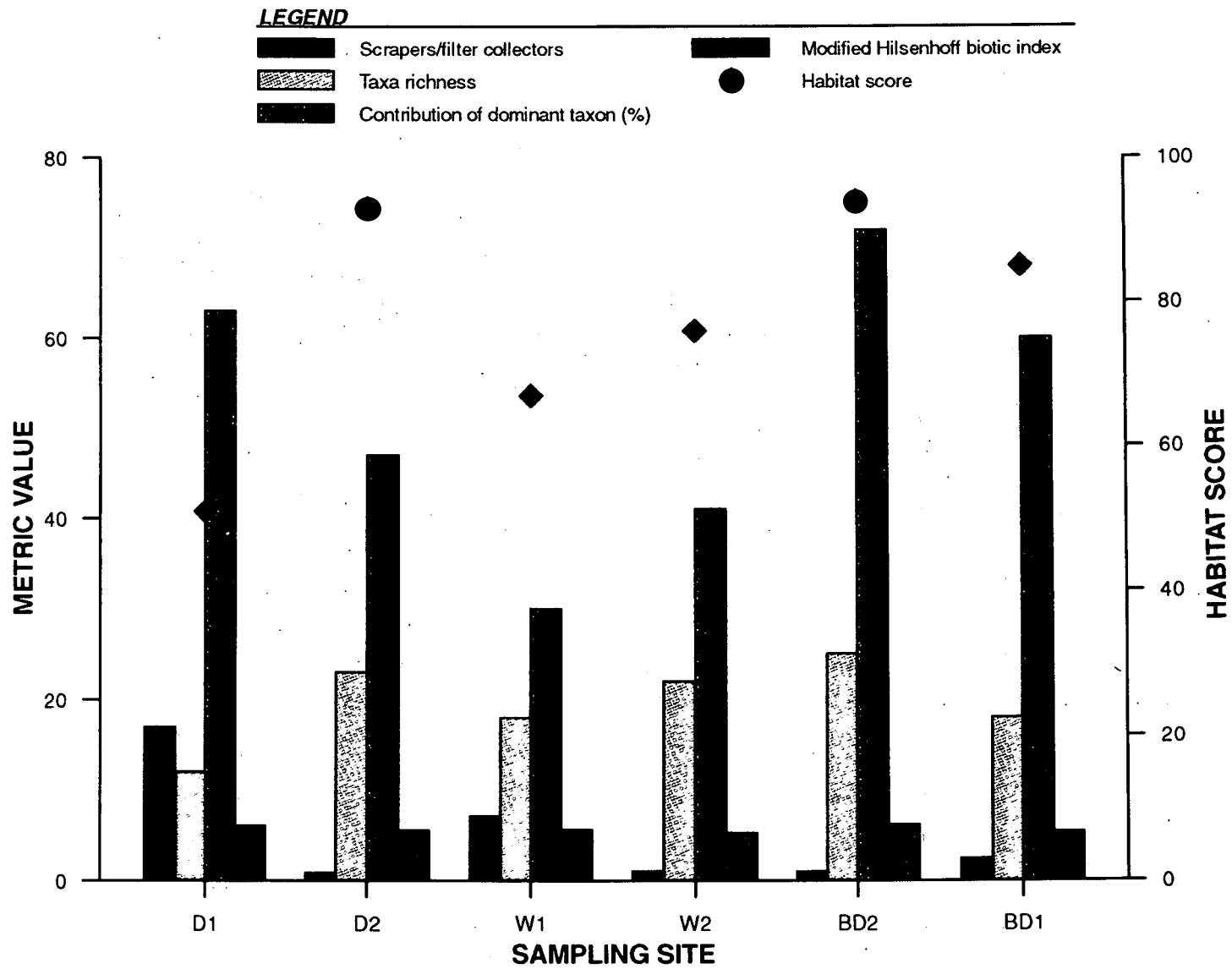


Figure 2. Values of scrapers/filter collectors, taxa richness, percent contribution of dominant taxon, modified Hilsenhoff biotic index, and habitat scores, Lower Walnut Creek, March/April 1998.

i:\datamgmt\cbam\98_aquatic\WCsp98_c.pre 090498

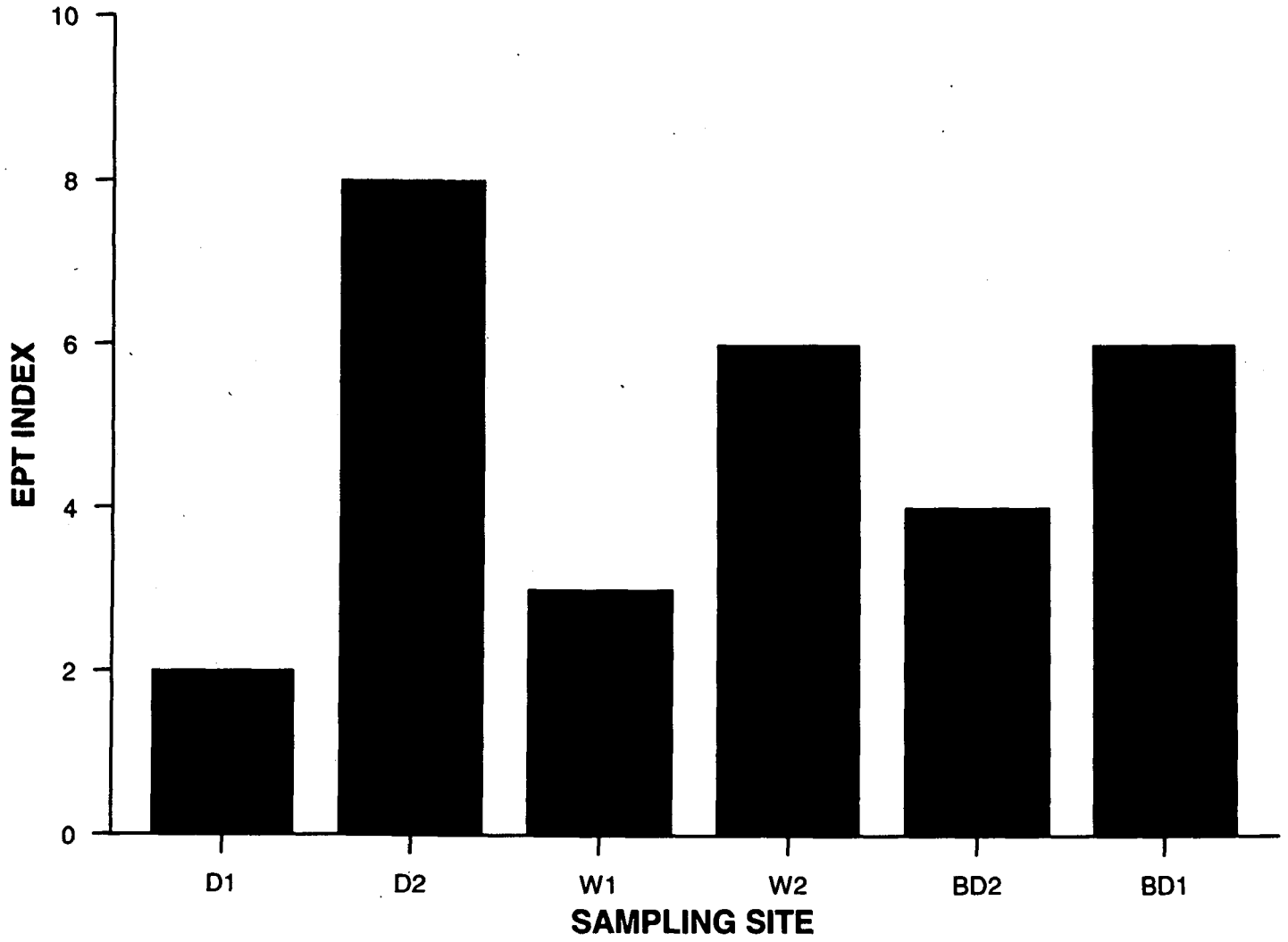


Figure 3. EPT index for spring 1998 aquatic sampling.

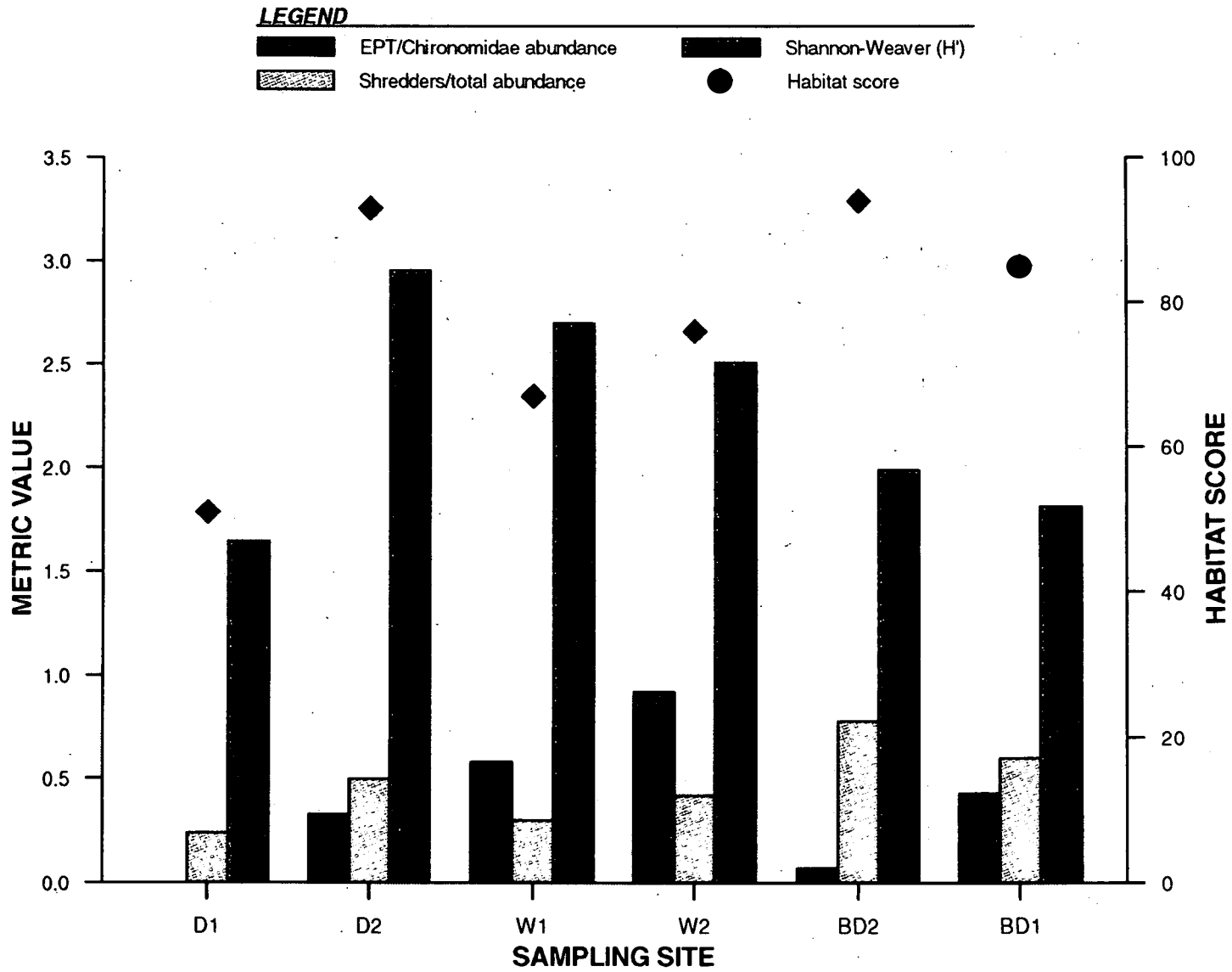


Figure 4. Values of EPT/Chironomidae abundance, shredders/total abundance, Shannon-Weaver (H'), and habitat scores, Lower Walnut Creek, March/April 1998.

i:\datamgmt\cbarn\98_aquatic\WCsp98_c.pre 090498

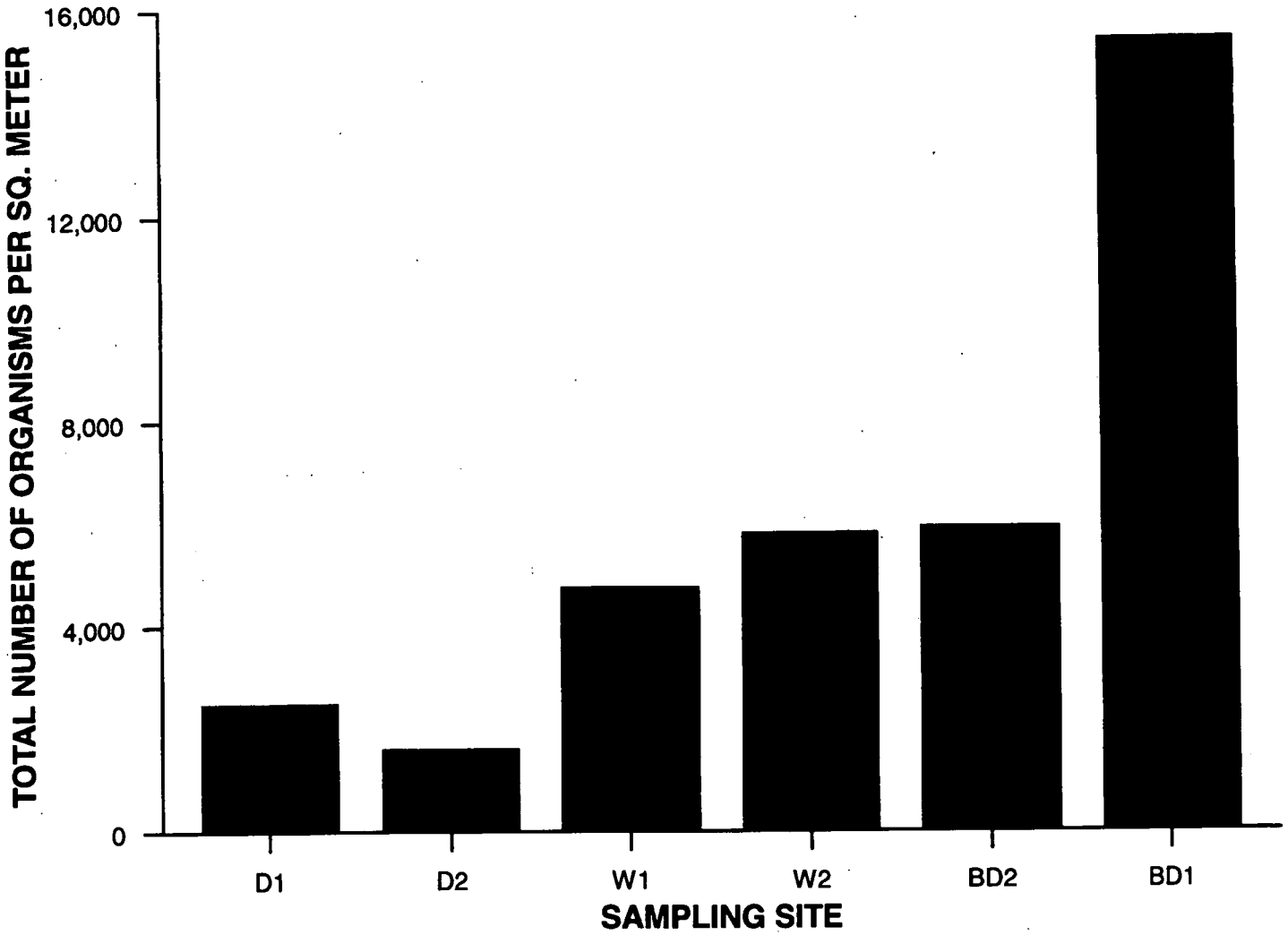


Figure 5. Total number of organisms for spring 1998 aquatic sampling.

TABLE 1. AQUATIC SAMPLING LOCATIONS IN LOWER WALNUT CREEK, SPRING 1998

Sample Site	Location	Stream Type
D1	Rocky Flats Environmental Technology Site, upstream from Indiana Avenue	Transitional foothills-plains
D2	City of Broomfield property, downstream from Great Western Reservoir	Transitional foothills-plains
W1	City of Westminster Walnut Creek Open Space, downstream from Wadsworth Blvd.	Transitional foothills-plains
W2	Hawn Parcel (private), access through City of Westminster Open Space, downstream from rip-rap structure along Highway 36 and east of Church Ranch Blvd.	Transitional foothills-plains
BD2	Hawn Parcel (private), access through City of Westminster Open Space, on Big Dry Creek upstream of confluence with Walnut Creek	Transitional foothills-plains
BD1	Hawn Parcel (private), access through City of Westminster Open Space, on Big Dry Creek downstream of confluence with Walnut Creek	Transitional foothills-plains

TABLE 2. PROPORTIONS OF AQUATIC MACROHABITATS IN LOWER WALNUT CREEK, 1998

Site	Riffle (%)	Run (%)	Pool (%)	Habitat Score
D1	17.5	31.3	51.2	51
D2	87.5	12.5	0.0	93
W1	22.4	60.6	17.0	67
W2	31.5	52.8	15.7	76
BD2	51.6	21.1	27.3	94
BD1[a]	28.7	39.0	32.3	85

[a] BD1 only has four cells, compared to six cells at all other sample sites.

Note: Habitat scores are derived from the quality of three principal categories:

1. substrate, flow, & cover
2. channel morphology
3. channel alteration, including scouring and deposition.

TABLE 3. PROPORTIONS OF SUBSTRATES AT AQUATIC SAMPLING SITES, 1998

Site	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
D1	0	0.5	24.5	12.3	18.7	42	2
D2	0	0	90	1	8	1	0
W1	5	0	0	40	30	20	5
W2	0	0	40	10	25	20	5
BD2	0	0	70	5	20	5	0
BD1[a]	0	1	40	10	25	20	4

[a] BD1 only has four cells, compared to six cells at all other sample sites.

TABLE 4. PHYSICAL WATER CHEMISTRY MEASURES IN LOWER WALNUT CREEK, 1998

Site	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (s.u.)	Conductivity (μS/L)
BD2	4/6/98	6.5	12.8	7.83	1,534
BD2	4/20/98	13.3	16	9.20	1,009
BD1	4/22/98	14.0	9.7	--	280
BD1	4/24/98	8.9	15	--	402
BD1[a]	4/14/98	11.3	10.8	8.39	1,130
D1	3/25/98	9.6	11.09	7.39	400
D1	3/27/98	9.4	--	7.72	500
D2	3/26/98	11.5	8.5	7.50	477
D2	3/27/98	12.8	--	7.86	497
D2	4/1/98	11.6	12.3	7.98	539
D2	4/6/98	11.5	8.5	7.50	477
W1	4/1/98	11.3	12.6	7.85	424
W1	4/23/98	6.4	11.9	8.43	796
W2	4/14/98	9.1	9.6	8.38	1,015
W2	4/22/98	13.6	9.3	--	344
W2	4/24/98	9.4	14.9	--	327

-- = no reading taken

[a] BD1 only has four cells, compared to six cells at all other sample sites.

TABLE 5. RELATIVE ABUNDANCE OF LOWER WALNUT CREEK MACROINVERTEBRATES BASED ON HESS AND KICKNET SAMPLES, SPRING 1998

			Sample Sites											
			D1		D2		W1		W2		BD2		BD1	
Division	Order	Species	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet
ANNELIDA	Hirudinea	Mooreobdella microstoma	0.93			0.96		0.64						
ANNELIDA	Oligoheata	Aulodrilus americanus			0.19									
ANNELIDA	Oligoheata	Eiseniella tetraedra									0.18		0.22	
ANNELIDA	Oligoheata	Homochaeta naidina		1.18										
ANNELIDA	Oligoheata	Lumbriculus sp.	0.93											
ANNELIDA	Oligoheata	Unid. Immature Tubificidae w/ Capilliform Chaetae			1.45				0.34		0.13		0.79	
ANNELIDA	Oligoheata	Unid. Immature Tubificidae w/o Capilliform Chaetae		3.54	1.26		0.99		2.06	0.33	0.05		0.34	
		Total: [a]	0.93	1.18	0.19	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.22	0.00
CRUSTACEA	Amphipoda	Crangonyx sp.									1.25	2.54		
CRUSTACEA	Amphipoda	Hyalella azteca			1.70	0.32	2.10	3.82	0.46				0.29	0.86
		Total:	0.00	0.00	1.70	0.32	2.10	3.82	0.46	0.00	1.25	2.54	0.29	0.86
GASTROPODA	NA	Fossaria sp.												0.43
GASTROPODA	NA	Physa sp.	3.12	1.97							0.08			
		Total:	3.12	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.43
HYDRACARINA	NA	Sperchon/Sperchonopsis			1.07	0.32	0.27		0.46	0.17	2.46	1.41	8.80	0.86
INSECTA	Coleoptera	Dubiraphia quadrinotata					0.06		0.34					
INSECTA	Coleoptera	Helophorus sp.						1.27						
INSECTA	Coleoptera	Microcylloepus pusillus												0.43
INSECTA	Coleoptera	Tropisternus sp.				0.32								
		Total:	0.00	0.00	0.00	0.32	0.06	1.27	0.34	0.00	0.00	0.00	0.00	0.43
INSECTA	Diptera	Brillia sp.						1.91		0.83				
INSECTA	Diptera	Ceratopogon sp.							0.12		0.05			
INSECTA	Diptera	Chelifera sp.			0.19			1.27	0.34	0.66			0.67	
INSECTA	Diptera	Chironomus sp.		2.76	3.33								0.56	2.05
INSECTA	Diptera	Corynoneura sp.					0.57							
INSECTA	Diptera	Cricotopus tremulus	23.77	14.57	46.98	19.11	29.25	16.56	40.95	20.00	71.62	61.97	59.81	53.56
INSECTA	Diptera	Demicryptochironomus sp.										2.89	0.12	
INSECTA	Diptera	Diamesa sp.	62.47	43.31	2.08	3.82	2.80		0.57					
INSECTA	Diptera	Dicrotendipes sp.		2.76										
INSECTA	Diptera	Empididae							0.34					
INSECTA	Diptera	Hemerodromia sp.			1.07	1.27	0.42		0.69	0.66	0.05		0.89	
INSECTA	Diptera	Heterotrissocladius sp.	6.07	8.66	4.21	1.27	17.89	20.38	0.40		2.59	2.89		
INSECTA	Diptera	Limonia sp.		0.39										
INSECTA	Diptera	Mallochohelea sp.	0.69	5.91	2.52	1.59		0.64	0.12		0.18	0.28	0.22	
INSECTA	Diptera	Micropsectra sp.			4.21	1.27								
INSECTA	Diptera	Muscidae									0.05			

TABLE 5. (cont.)

			Sample Sites											
			D1		D2		W1		W2		BD2		BD1	
Division	Order	Species	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet	Hess	Kicknet
INSECTA	Diptera	Pagastia sp.	0.69											
INSECTA	Diptera	Polypedilum sp.		5.91							5.66	2.89		
INSECTA	Diptera	Rheotanytarsus sp.					0.69							
INSECTA	Diptera	Simulium sp.				1.27	2.67	3.18	12.59	7.27	0.05		0.67	
INSECTA	Diptera	Thienemanniella sp.					6.17	1.91			1.30			
INSECTA	Diptera	Tipula sp.				0.96	0.27		0.57	0.66	1.12		0.45	0.43
INSECTA	Diptera	Zavrelimyia sp.			6.29	6.37	1.05	3.82			6.07	5.70		
	Total:		93.68	84.25	70.88	36.94	61.78	49.68	56.68	30.08	88.72	76.62	63.40	56.03
INSECTA	Ephemeroptera	Baetis magnus		0.39	0.63	8.92								
INSECTA	Ephemeroptera	Baetis tricaudatus			7.74	36.62	30.09	43.31	22.90	66.78	0.21	1.13	17.68	34.05
INSECTA	Ephemeroptera	Caenis amica		0.39	0.44	0.32								
INSECTA	Ephemeroptera	Heptagenia sp.									0.05	0.28		
INSECTA	Ephemeroptera	Tricorythodes minutus			1.89	4.14	0.27		0.22		2.81	15.49	1.63	3.02
	Total:		0.00	0.79	10.69	50.00	30.37	43.31	23.13	66.78	3.07	16.90	19.31	37.07
INSECTA	Hemiptera	Corisella sp.										0.56		
INSECTA	Hemiptera	Hesperocorixa sp.	0.12	7.87										
INSECTA	Hemiptera	Notonecta sp.		0.39										
INSECTA	Hemiptera	Trichocorixa sp.										0.28		
	Total:		0.12	8.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00
INSECTA	Odonata	Argia sp.				0.32								
INSECTA	Odonata	Gomphus sp.									0.18			
	Total:		0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00
INSECTA	Trichoptera	Agraylea sp.			0.63	0.32		0.64						0.86
INSECTA	Trichoptera	Ceratopsyche oslari			0.19									
INSECTA	Trichoptera	Cheumatopsyche sp.	0.40		10.69	8.92	3.37	0.64	12.49	1.98	3.07	0.85	5.84	3.02
INSECTA	Trichoptera	Helicopsyche borealis			0.19	0.32								
INSECTA	Trichoptera	Hydropsyche morosa							0.12					
INSECTA	Trichoptera	Hydropsyche occidentalis							0.22		0.26			
INSECTA	Trichoptera	Hydropsyche simulans											0.89	
INSECTA	Trichoptera	Hydroptila sp.							2.53	0.66	0.39	0.85		
INSECTA	Trichoptera	Limnephilus/Philarctus	0.53											
	Total:		0.93	0.00	11.70	9.55	3.37	1.27	15.36	2.64	3.71	1.69	6.73	3.88
NEMATODA	NA	Unid. Nematoda					1.05		1.15		0.18		0.12	0.43
PELECYPODA	NA	Pisidium sp.				0.32								
TURBELLARIA	NA	Dugesia dorotocephala	0.28		1.07	0.96								

NA – not applicable

[a] This total does not include the unidentified immature species.

TABLE 6. SPRING 1998 BDCWG HESS SAMPLER MACROINVERTEBRATE METRICS SUMMARY

Metric	D1	D2	W1	W2	BD2	BD1
Number of taxa	12	23	18	22	25	18
Modified Hilsenhoff biotic index	6.08	5.55	5.60	5.26	6.14	5.35
EPT index	2	8	3	6	6	4
EPT/Chironomidae abundance	0.00	0.33	0.58	0.92	0.07	0.43
Contribution of dominant taxon (%)	63	47	30	41	72	60
Scrapers/filter collectors	17.00	0.85	7.13	1.03	0.96	2.39
Shredders/total abundance	0.24	0.50	0.30	0.42	0.78	0.60
Shannon-Weaver (H')	1.64	2.95	2.70	2.51	1.81	1.99
Total number of organisms per sq. meter	2,470	1,590	4,752	5,820	15,428	5,940

TABLE 7. SPRING 1998 BDCWG KICKNET SAMPLER MACROINVERTEBRATE METRICS SUMMARY

Metric	D1	D2	W1	W2	BD2	BD1
Total number of organisms per sq. meter	254	314	157	605	1,420	928
Number of taxa	15	23	14	11	15	12

TABLE 8. LIST OF FISH SPECIES COLLECTED IN LOWER WALNUT CREEK, 1998

	Sampling Sites					
Species	D1	D2	W1	W2	BD2	BD1
Creek chub		X		X	X	X
Longnose dace			X	X	X	X
White sucker				X		X
Green sunfish				X		X
Fathead minnow	X	X	X	X	X	X

Appendix A

Sample Data Sheets

BIG DRY CREEK SAMPLE COLLECTION FORM

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Reason for Survey _____

Sample ID	Sample Code	Collection Date	Collector(s)	Sample Type	Collection Method	Comments

Form Completed By _____ Date _____
Print Sign

AQUATIC SAMPLE SITE DRAWING FORM

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Reason for Survey _____

Form Completed by _____ Date _____
Print Sign

BIG DRY CREEK AQUATIC SAMPLING CHAIN OF CUSTODY FORMS

Contractor: Exponent Environmental Group
Date:____
Laboratory: Chadwick and Associates

Form #_________
Page____of _____

Sample ID	Sample Present (check-off)	Sample Type

Relinquished By	Received By	Date/Time	Problems:

FISH FIELD COLLECTION DATA SHEET

Station Name (Sampsite)_____ Project ID_____
Observers_____ Date_____
Drainage_____ Field Notebook_____
Start Time_____ Finish Time_____ Sampling Duration_____
Sampling Distance (m)_____ Sampling Area_____
Habitat Complexity/Quality (excellent good fair poor very poor)
Flow (flood bankfull moderate low)
Weather_____
Gear Used_____ Gear/Crew Performance_____
Fish (preserved) Number of Individuals_____ Number of Anomalies_____

	Adults		Juveniles		Anomalies*
Genus/Species	Number	Weight	Number	Weight	Number

Comments:_____

Form Completed by_____ Date_____
Print Sign

(*) Discoloration, deformities, eroded fins, excessive mucus, excessive external parasites, fungus, poor condition, reddening, tumors, and ulcers

MACROBENTHIC IMPAIRMENT ASSESSMENT SHEET

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Reason for Survey _____

1. Detection of impairment: Impairment detected (Complete Items 2-6) No impairment detected (Stop here)

2. Biological impairment indicator:
   - _____Benthic macroinvertebrates
   - _____absence of EPT taxa
   - _____dominance of tolerant species
   - _____low benthic abundance
   - _____low taxa richness
   - _____other
   - _____Other aquatic communities
   - _____periphyton
   - _____filamentous
   - _____other
   - _____macrophytes
   - _____slimes

3. Brief description of problem: _____
   Year and date of previous survey: _____
   Survey data available in: _____

4. Cause (indicate major cause): organic enrichment toxicants flow habitat limitations
   other _____

5. Estimated areal extent of problem (m^2) and length of stream reach affected (m) where applicable: _____

6. Suspected source(s) of problem
   - _____point source
   - _____urban runoff
   - _____agricultural runoff
   - _____silvicultural runoff
   - _____livestock
   - _____landfill
   - _____mine
   - _____dam or diversion
   - _____channelization or snagging
   - _____natural
   - _____other
   - _____unknown

Comments: _____

Form Completed by _____ Date _____
Print Sign

FISH IMPAIRMENT ASSESSMENT SHEET

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Reason for Survey _____

1. Detection of impairment: Impairment detected (Complete Items 2-6) No impairment detected (Stop here)

2. Biological impairment indicator:

Fish
- _____sensitive species reduced/absent
- _____dominance of tolerant species
- _____skewed trophic structure
- _____abundance reduced/unusually high
- _____biomass reduced/unusually high
- _____hybrid or exotic abundance unusually high
- _____poor size class representation
- _____high incidence of anomalies

Other aquatic communities
- _____macroinvertebrates
- _____periphyton
- _____macrophytes

3. Brief description of problem: _____

4. Cause (indicate major cause): organic enrichment toxicants flow sediment temperature poor habitat other _____

5. Estimated areal extent of problem (m^2) and length of stream reach affected (m) where applicable: _____

6. Suspected source(s) of problem
- _____point source
- _____urban runoff
- _____agricultural runoff
- _____silvicultural runoff
- _____livestock
- _____landfill
- _____mine
- _____dam or diversion
- _____channelization or snagging
- _____natural
- _____other
- _____unknown

Comments: _____

Form Completed by _____ Date _____
Print Sign

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Form Completed by _____
Reason for Survey _____

RIPARIAN ZONE/INSTREAM FEATURES:

Predominant Surrounding Land Use:
Forest Field/Pasture Agricultural Residential Commercial Industrial Other _____
Local Watershed Erosion: None Moderate Heavy
Local Watershed NPS Pollution: No evidence Some Potential Sources Obvious Sources
Estimated Stream Width (m): _____ Estimated Stream Depth (m) Riffle _____ Run _____ Pool _____
High Water Mark (m): _____ Velocity: _____ Dam Present: Yes No Channelized: Yes No
Canopy Cover: Open Partly Open Partly Shaded Shaded

SEDIMENT/SUBSTRATE:

Sediment Odors: Normal Sewage Petroleum Chemical Anaerobic None Other _____
Sediment Oils: Absent Slight Moderate Profuse
Sediment Deposits: Sludge Sawdust Paper Fiber Sand Relict Shells Other _____
Are the undersides of stones which are not deeply imbedded black? Yes No

Inorganic Substrate Components			Organic Substrate Components		
Substrate Type	Diameter	Percent Composition in Sampling Area	Substrate Type	Characteristicr	Percent Composition in Sampling Area
Bedrock			Detritus	Sticks, Wood, Coarse Plant Materials (CPON)	
Boulder	>256mm (10")		Muck-Mud	Black, Very Fine Organic (FPOM)	
Cobble	64-256mm (2.5-10")		Marl	Grey, Shell Fragments	
Gravel	2-64mm (0.1-2.5")				
Sand	0.06-2.00mm (gritty)				
Silt	0.004-0.06mm				
Clay	<0.004mm (slick)				

WATER QUALITY:

Temperature [C]_____ Dissolved Oxygen_____ pH_____ Conductivity_____ Other_____

Instrument(s) Used:_____

Stream Type: Coldwater Warmwater

Water Odors: Normal Sewage Petroleum Chemical None Other_____

Water Surface Oils: Slick Sheen Globs Flecks None

Turbidity: Clear Slightly Turbid Turbid Opaque Water Color_____

WEATHER CONDITIONS:

Temperature [C]_____ Clouds(0-8)_____ Precipitation_____ Wind_____

Photograph Numbers (if taken)_____

Comments:_____

_____

_____

_____

Form Completed by_____ Date_____

Print Sign

AQUATIC HABITAT ASSESSMENT FIELD DATA SHEET

Waterbody Name _____ Location _____
Reach/Milepoint _____ Lat/Long _____
County _____ State _____ Aquatic Ecoregion _____
Station Name (Sampsite) _____ Project ID _____
Observers _____ Hydrologic Unit Code _____
Date _____ Agency _____
Start Time _____ Finish Time _____ Field Notebook _____
Reason for Survey _____

Habitat Parameter	Category			
	Excellent	Good	Fair	Poor
1. Bottom substrate/available cover (a)	Greater than 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat 16-20	30-50% rubble, gravel, or other stable habitat. Adequate habitat. 11-15	10-30% rubble, gravel, or other stable habitat. Habitat availability less than adequate. 6-10	Less than 10% rubble, gravel, or other stable habitat. Lack of habitat is obvious. 0-5
2. Embeddedness (b)	Gravel, cobble, and boulder particles are between 0-25% surrounded by fine sediment. 16-20	Gravel, cobble, and boulder particles are between 25-50% surrounded by fine sediment. 11-15	Gravel, cobble, and boulder particles are between 50-75% surrounded by fine sediment. 6-10	Gravel, cobble, and boulder particles are over 75% surrounded by fine sediment. 0-5
3. Less than or equal to 0.15 cms (5 cfs) at rep. low flow (a) or > 0.15 cms (5 cfs) Velocity/depth	Cold >0.05 cms (2cfs) Warm >0.15 cms (5 cfs) 10-20 Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m): fast (>0.3 m/s), deep; fast, shallow habitats all present. 16-20	Cold 0.03-0.05 cms (1-2cfs) Warm 0.05-0.15 cms (2-5 cfs) 11-15 Only 3 of the 4 habitat categories present (missing riffles or runs receive lower score than missing points). 11-15	Cold 0.01-0.03 cms (.5-1cfs) Warm 0.03-0.05 cms (1-2 cfs) 6-10 Only 2 of the 4 habitat categories present (missing riffles/ runs receive lower score). 6-10	Cold <0.01 cms (.5 cfs) Warm <0.03 cms (1 cfs) 0-5 Dominated by one velocity/depth category (usually pool). 0-5
4. Channel alteration (a)	Little or no enlargement of islands or point bars, and/or no channelization. 12-15	Some new increasing in bar formation, mostly from coarse gravel; and/or some channelization present. 8-11	Moderate deposition of new gravel, coarse sand on old and new bars; pools partially filled w/silt; and/or embankments on both banks. 4-7	Heavey deposits of fine material, increased bar development; most pools filled w/silt; and/or extensive channelization. 0-5
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 12-15	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8-11	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools. 4-7	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 0-3

Habitat Parameter	Category: Excellent	Good	Fair	Poor
6. Pool/riffle, run/bend ratio (distance between riffles divided by stream width) (a)	5-7. Variety of habitat. Deep riffles and pools. 12-15	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8-11	15-25. Occassional riffle or bend. Bottom contours provide some habitat. 4-7	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 0-3
7. Bank stability (a)	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 9-10	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 6-8	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme high flow. 3-5	Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends. 0-2
8. Bank vegetative stability (b)	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 9-10	50-79% of the streambank surfaces covered by vegetation, gravel, or larger material. 6-8	25-49% of the streambank surfaces covered by vegetation, gravel, or larger material. 3-5	Less than 25% of the streambank faces covered by vegetation, gravel, or larger material. 0-2
9. Steambank cover (b)	Dominant vegetation is shrub. 9-10	Dominant vegetation is of tree form. 6-8	Dominant vegetation is grass or forbs. 3-5	Over 50% of the stream bank has no vegetation and dominant material is soil, rock bridge materials, culverts, or mine tailings. 0-2
Column totals				
	Score			

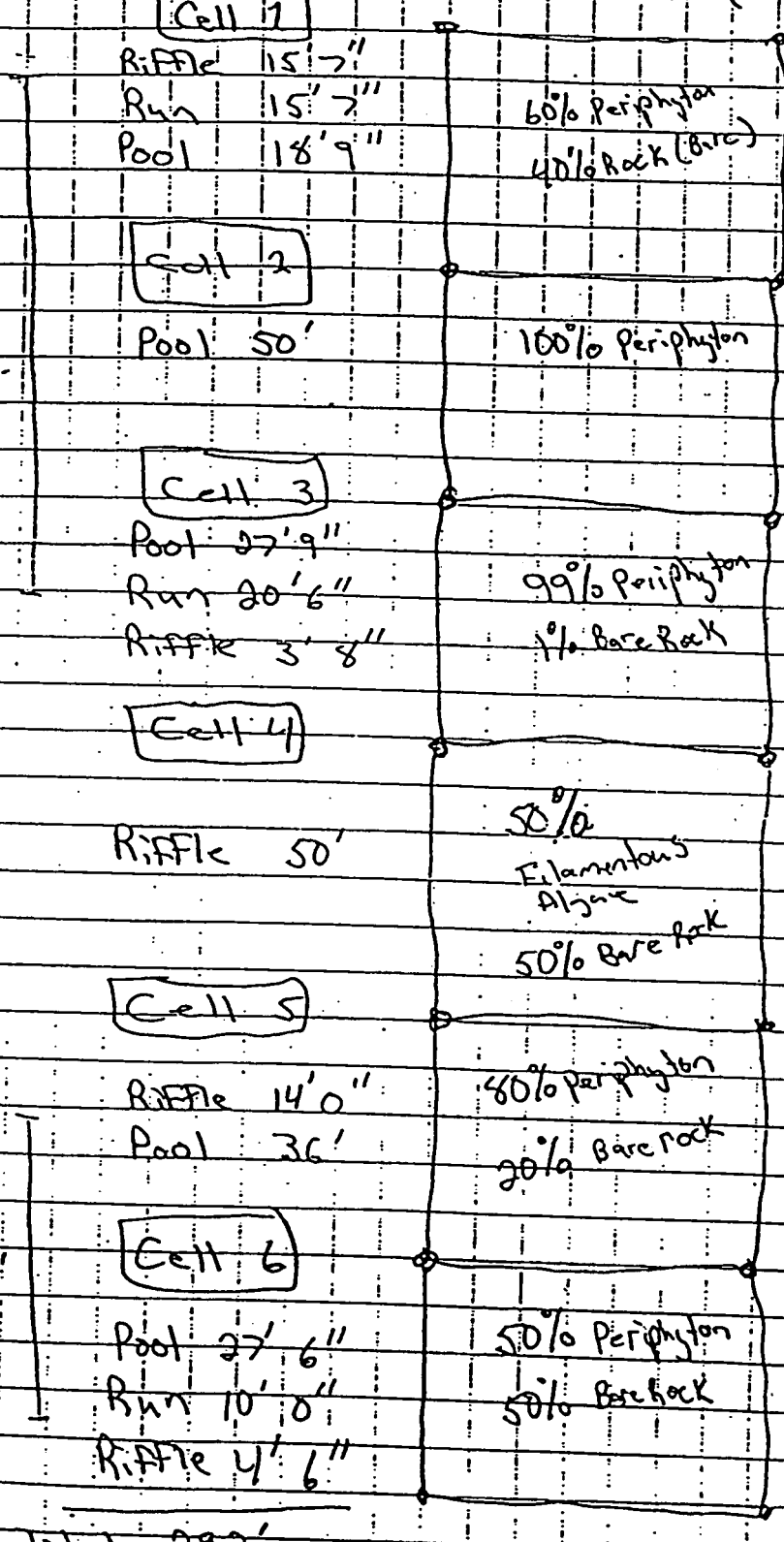
Comments:_____

Form Completed by_____ Date_____

Print Sign

Date 4/3/97

Site 0.5 (Church Ranch)



Total 292'

~DBR = 104'/13.54 = 7.7

Avg. Flow = 0.22 cfs

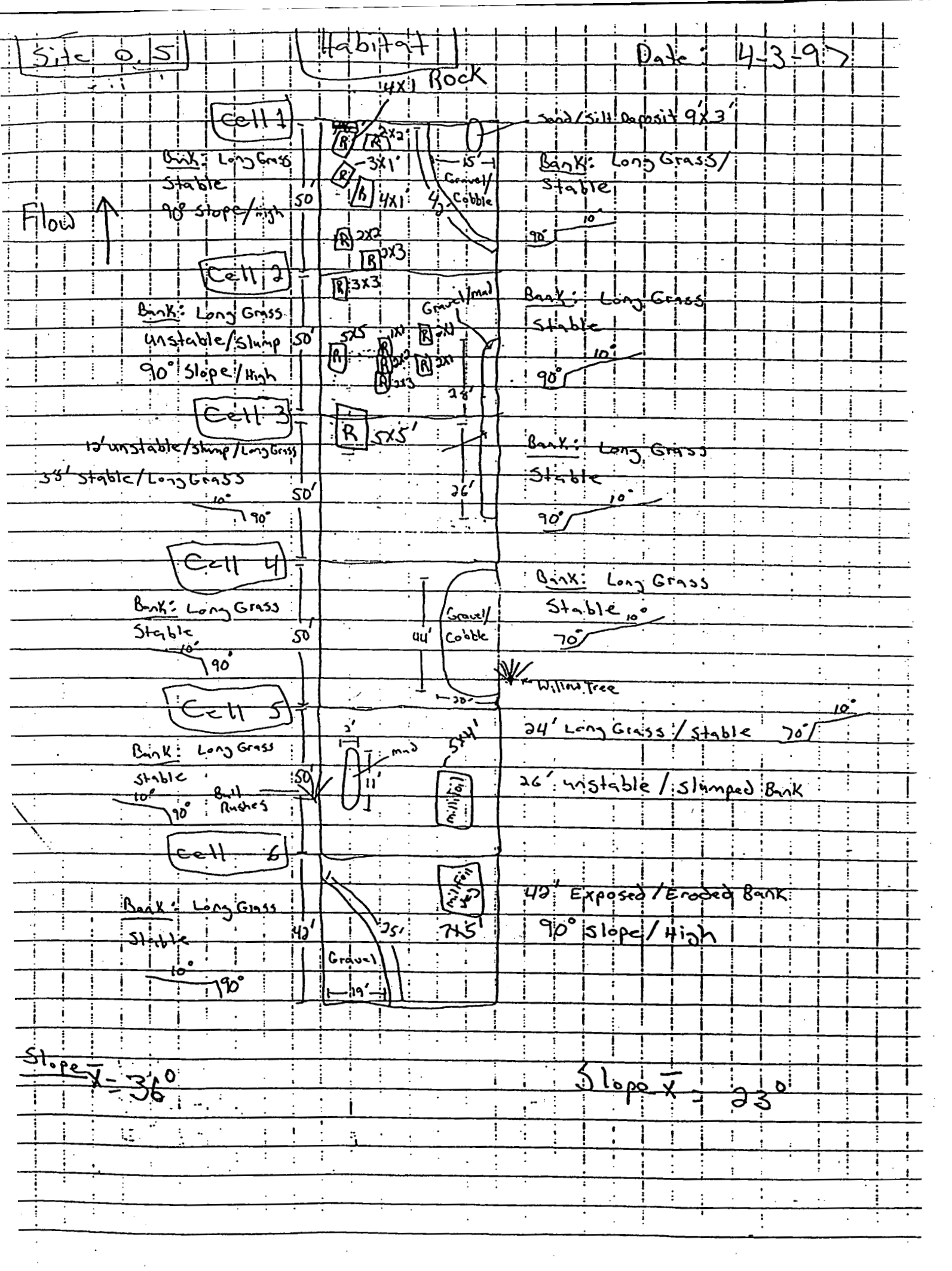
~~RP Ratio = 30% Riffle, 16% Run, 55% Pool~~

~~Riffle = 88' = .30~~

Run = 46' = .16

Pool = 160' = .55

Site 0.5 | Habitat | Date: 4-3-97



Slope $\bar{x}$ = 36°

Slope $\bar{x}$ = 23°

Appendix B

Photographic Documentation

Figure B-1. Aquatic site D-1 on Walnut Creek at Rocky Flats looking westward from Indiana Street.

Figure B-2. Aquatic site D-1 on Walnut Creek at Rocky Flats looking westward from Indiana Street.

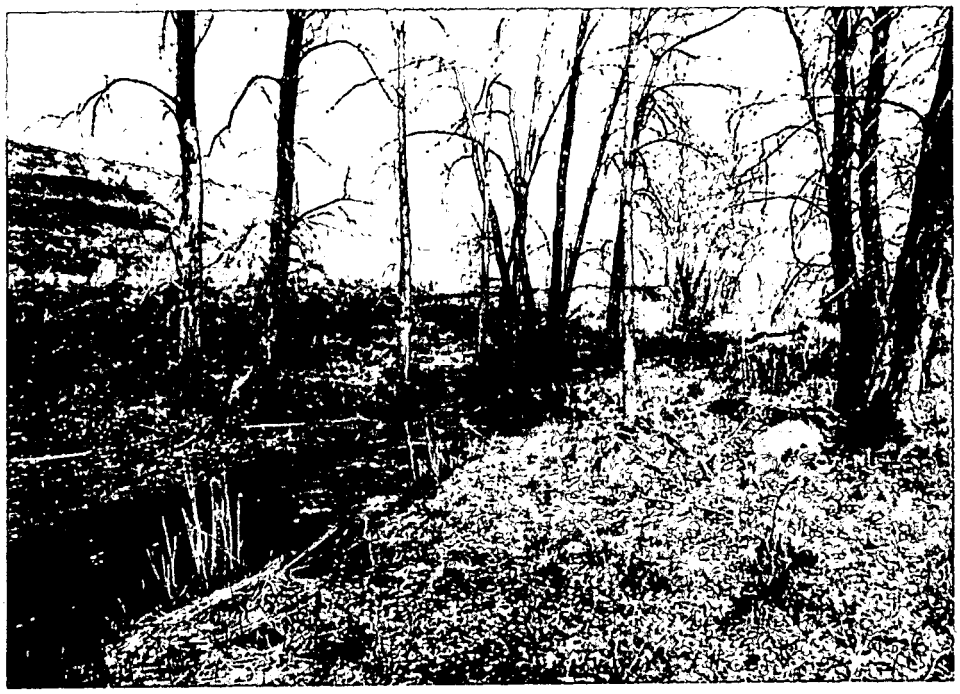


Figure B-3. Aquatic site D-2 on Walnut Creek below Great Western Reservoir looking eastward near the upper end of the study area.

Figure B-4. Aquatic site D-2 on Walnut Creek below Great Western Reservoir looking eastward near the lower end of the study area.

Figure B-5. Aquatic site W-1 on Walnut Creek near Wadsworth Blvd. on Westminster Open Space looking eastward near the upper end of the study area.

Figure B-6. Aquatic site W-1 on Walnut Creek near Wadsworth Blvd. on Westminster Open Space looking northwest from the lower end of the study area.

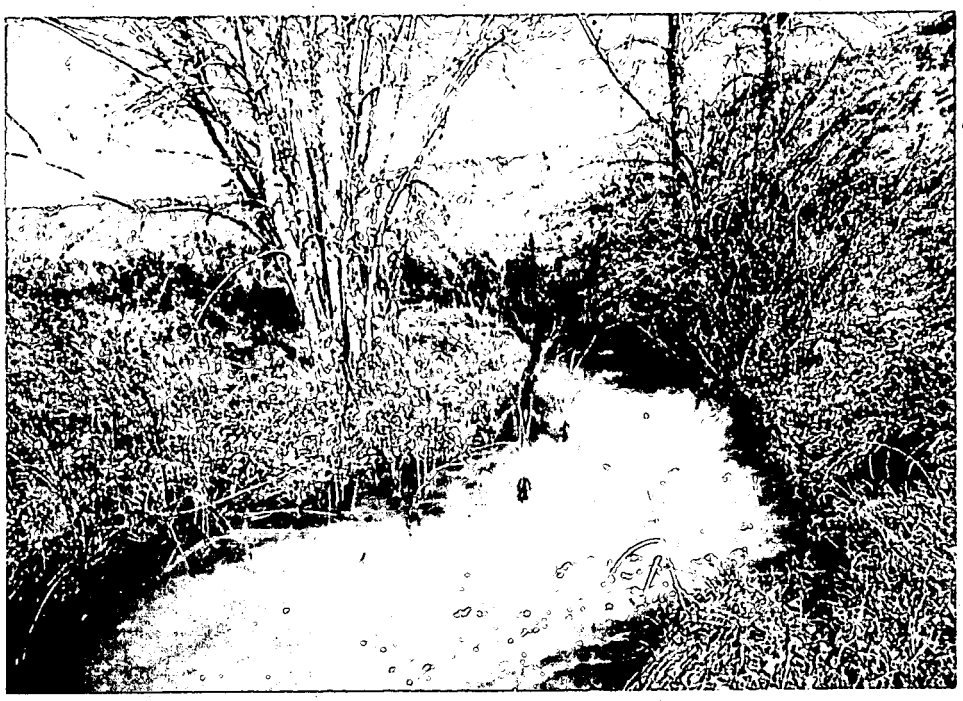


Figure B-7. Aquatic site W-2 on Walnut Creek southwest of the Church Ranch exit on Hwy. 36 looking northwest from the middle of the study area.

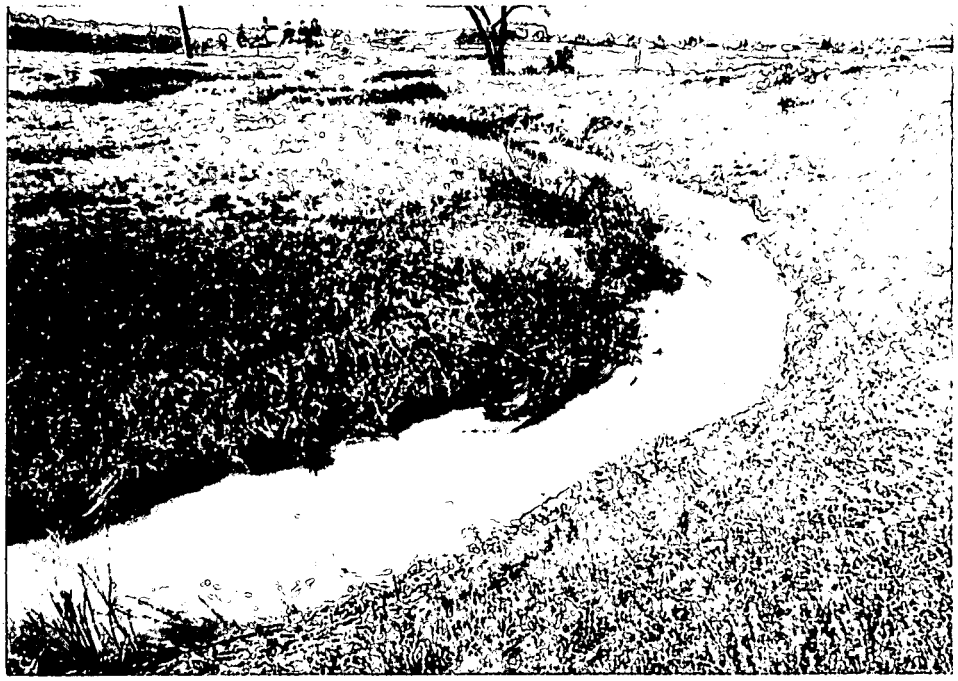


Figure B-8. Aquatic site W-2 on Walnut Creek southwest of the Church Ranch exit on Hwy. 36 looking southwest from the upper end of the study area.

Figure B-9. Aquatic site BD-2 on Big Dry Creek west of Hwy. 36 looking north from the upper end of the study area.

Figure B-10. Aquatic site BD-2 on Big Dry Creek west of Hwy. 36 looking east from near the middle of the study area.

Figure B-11. Aquatic site BD-1 on Big Dry Creek west of Hwy. 36 looking east from the upper end of the study area.

Figure B-12. Aquatic site BD-1 on Big Dry Creek west of Hwy. 36 looking west from the lower end of the study area.

Appendix C

Site Data

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, D1
SAMPLED: 3-25-98

TAXA	HESS 1	HESS 2	HESS 3	COMPOSITE	SWEEP 4
INSECTA					
EPHEMEROPTERA					
Baetis magnus					1
Caenis amica					1
TRICHOPTERA					
Cheumatopsyche sp.	10		20	10	
Limnephilus/Philarctus			40	13	
HEMIPTERA					
Hesperocorixa sp.	10			3	20
Notonecta sp.					1
DIPTERA					
Chironomus sp.					7
Cricotopus tremulus	300	60	1400	587	37
Diamesa sp.	860	1310	2460	1543	110
Dicrotendipes sp.					7
Heterotrissocladius sp.	50		400	150	22
Limonia sp.					1
Mallochohelea sp.	20	10	20	17	15
Pagastia sp.	50			17	
Polypedilum sp.					15
TURBELLARIA					
Dugesia dorotocephala			20	7	
ANNELIDA					
OLIGOCHAETA					
Homochaeta naidina					3
Lumbriculus sp.	20	10	40	23	
Unid. Immature Tubificidae w/o Capilliform Chaetae					9
HIRUDINEA					
Mooreobdella microstoma		10	60	23	
GASTROPODA					
Physa sp.	10		220	77	5

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, D1
SAMPLED: 3-25-98

TOTAL (#/sq. meter)	1330	1400	4680	2470	254
NUMBER OF TAXA	9	5	10	12	15
SHANNON-WEAVER (H')	1.59	0.44	1.82	1.64	
MODIFIED HILSENHOFF BIOTIC INDEX	6.08	6.03	6.14	6.08	
SCRAPERS/FILTER COLLECTORS	10.00	0.00	20.00	17.00	
EPT/CHIRONOMIDAE ABUNDANCE	0.00	0.00	0.00	0.00	
% CONTRIBUTION OF DOMINANT TAXON	65	94	53	63	
EPT INDEX	1	0	2	2	
SHREDDERS/TOTAL DENSITY	0.22	0.04	0.31	0.24	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, D2
SAMPLED: 3-26-98

TAXA	HESS 5	HESS 6	HESS 7	COMPOSITE	SWEEP 8
INSECTA					
EPHEMEROPTERA					
Baetis magnus		10	20	10	28
Baetis tricaudatus	170	170	30	123	115
Caenis amica		10	10	7	1
Tricorythodes minutus	30	50	10	30	13
TRICHOPTERA					
Agraylea sp.			30	10	1
Ceratopsyche oslari		10		3	
Cheumatopsyche sp.	150	190	170	170	28
Helicopsyche borealis	10			3	1
ODONATA					
Argia sp.					1
COLEOPTERA					
Tropisternus sp.					1
DIPTERA					
Chelifera sp.		10		3	
Chironomus sp.	120	40		53	
Cricotopus tremulus	1200	620	420	747	60
Diamesa sp.	60	40		33	12
Hemerodromia sp.	20	20	10	17	4
Heterotrissocladius sp.	120	40	40	67	4
Mallochohelea sp.	50	60	10	40	5
Micropsectra sp.		180	20	67	4
Simulium sp.					4
Tipula sp.					3
Zavrelimyia sp.	60	180	60	100	20
TURBELLARIA					
Dugesia dorotocephala			50	17	3

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, D2
SAMPLED: 3-26-98

TAXA	HESS 5	HESS 6	HESS 7	COMPOSITE	SWEEP 8
ANNELIDA					
OLIGOCHAETA					
Aulodrilus americanus	10			3	
Unid. Immature Tubificidae w/ Capilliform Chaetae	40	30		23	
Unid. Immature Tubificidae w/o Capilliform Chaetae	30	20	10	20	
HIRUDINEA					
Mooreobdella microstoma					3
CRUSTACEA					
AMPHIPODA					
Hyalella azteca	40	40		27	1
HYDRACARINA					
Sperchon/Sperchonopsis		20	30	17	1
PELECYPODA					
Pisidium sp.					1
TOTAL (#/sq. meter)	2110	1740	920	1590	314
NUMBER OF TAXA	15	19	15	23	23
SHANNON-WEAVER (H')	2.45	3.19	2.73	2.95	
MODIFIED HILSENHOFF BIOTIC INDEX	5.91	5.64	5.10	5.55	
SCRAPERS/FILTER COLLECTORS	1.81	0.60	0.52	0.85	
EPT/CHIRONOMIDAE ABUNDANCE	0.23	0.40	0.50	0.33	
% CONTRIBUTION OF DOMINANT TAXON	57	36	46	47	
EPT INDEX	4	6	6	8	
SHREDDERS/TOTAL DENSITY	0.65	0.38	0.46	0.50	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, W1
SAMPLED: 3-30-98

TAXA	HESS 9	HESS 10	HESS 11	COMPOSITE	SWEEP 12
INSECTA					
EPHEMEROPTERA					
Baetis tricaudatus	3840	110	340	1430	68
Tricorythodes minutus	20		20	13	
TRICHOPTERA					
Agraylea sp.					1
Cheumatopsyche sp.	480			160	1
COLEOPTERA					
Dubiraphia quadrinotata		10		3	
Helophorus sp.					2
DIPTERA					
Brillia sp.					3
Chelifera sp.					2
Corynoneura sp.		80		27	
Cricotopus tremulus	480	1410	2280	1390	26
Diamesa sp.	100		300	133	
Hemerodromia sp.	60			20	
Heterotrissocladius sp.	1610	480	460	850	32
Mallochohelea sp.					1
Rheotanytarsus sp.	100			33	
Simulium sp.	380			127	5
Thienemanniella sp.	190	80	610	293	3
Tipula sp.			40	13	
Zavrelimyia sp.			150	50	6
ANNELIDA					
OLIGOCHAETA					
Unid. Immature Tubificidae w/o Capilliform Chaetae			140	47	
HIRUDINEA					
Mooreobdella microstoma					1
NEMATODA					
Unid. Nematoda	120	10	20	50	
CRUSTACEA					
AMPHIPODA					
Hyalella azteca	140	120	40	100	6

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, W1
SAMPLED: 3-30-98

TAXA	HESS 9	HESS 10	HESS 11	COMPOSITE	SWEEP 12
HYDRACARINA					
Sperchon/Sperchonopsis	40			13	
TOTAL (#/sq. meter)	7560	2300	4400	4752	157
NUMBER OF TAXA	13	8	11	18	14
SHANNON-WEAVER (H')	2.31	1.74	2.30	2.70	
MODIFIED HILSENHOFF BIOTIC INDEX	4.86	6.00	5.93	5.60	
SCRAPERS/FILTER COLLECTORS	5.67	0.00	0.00	7.13	
EPT/CHIRONOMIDAE ABUNDANCE	1.75	0.05	0.90	0.58	
% CONTRIBUTION OF DOMINANT TAXON	51	61	52	30	
EPT INDEX	3	1	2	3	
SHREDDERS/TOTAL DENSITY	0.06	0.61	0.53	0.30	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, W2
SAMPLED: 4-13-98

TAXA	HESS 17	HESS 18	HESS 19	COMPOSITE	SWEEP 20
INSECTA					
EPHEMEROPTERA					
Baetis tricaudatus	1340	1040	1620	1333	404
Tricorythodes minutus			40	13	
TRICHOPTERA					
Cheumatopsyche sp.	160	1140	880	727	12
Hydropsyche morosa			20	7	
Hydropsyche occidentalis		40		13	
Hydroptila sp.	40	60	340	147	4
COLEOPTERA					
Dubiraphia quadrinotata			60	20	
DIPTERA					
Brillia sp.					5
Ceratopogon sp.	20			7	
Chelifera sp.	20	40		20	4
Cricotopus tremulus	2520	1850	2780	2383	121
Diamesa sp.	100			33	
Empididae		40	20	20	
Hemerodromia sp.	40	40	40	40	4
Heterotrissocladius sp.		70		23	
Mallochohelea sp.	20			7	
Simulium sp.	200	1140	860	733	44
Tipula sp.	80		20	33	4
ANNELIDA					
OLIGOCHAETA					
Unid. Immature Tubificidae w/ Capilliform Chaetae	60			20	
Unid. Immature Tubificidae w/o Capilliform Chaetae	180		180	120	2
NEMATODA					
Unid. Nematoda	200			67	
CRUSTACEA					
AMPHIPODA					
Hyalella azteca	60		20	27	
HYDRACARINA					
Sperchon/Sperchonopsis	40		40	27	1

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, W2
SAMPLED: 4-13-98

TOTAL (#/sq. meter)	5080	5460	6920	5820	605
NUMBER OF TAXA	16	10	14	22	11
SHANNON-WEAVER (H')	2.32	2.29	2.41	2.51	
MODIFIED HILSENHOFF BIOTIC INDEX	5.44	5.15	5.19	5.26	
SCRAPERS/FILTER COLLECTORS	3.83	0.63	1.15	1.03	
EPT/CHIRONOMIDAE ABUNDANCE	0.59	1.19	1.04	0.92	
% CONTRIBUTION OF DOMINANT TAXON	50	34	40	41	
EPT INDEX	3	4	5	6	
SHREDDERS/TOTAL DENSITY	0.52	0.34	0.40	0.42	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, BD2
SAMPLED: 4-2-98

TAXA	HESS 13	HESS 14	HESS 15	COMPOSITE	SWEEP 16
INSECTA					
EPHEMEROPTERA					
Baetis tricaudatus	60	40		33	16
Heptagenia sp.	20			7	4
Tricorythodes minutus	100	360	840	433	220
TRICHOPTERA					
Cheumatopsyche sp.	260	760	400	473	12
Hydropsyche occidentalis		120		40	
Hydroptila sp.	20	80	80	60	12
ODONATA					
Gomphus sp.		40	40	27	
HEMIPTERA					
Corisella sp.					8
Trichocorixa sp.					4
DIPTERA					
Ceratopogon sp.	20			7	
Cricotopus tremulus	3500	15560	14090	11050	880
Demicryptochironomus sp.					41
Hemerodromia sp.	20			7	
Heterotrissocladius sp.	800	400		400	41
Mallochohelea sp.	40	40		27	4
Muscidae	20			7	
Polypedilum sp.	200	400	2020	873	41
Simulium sp.	20			7	
Thienemanniella sp.	200	400		200	
Tipula sp.	160	280	80	173	
Zavrelimyia sp.	400	1600	810	937	81
ANNELIDA					
OLIGOCHAETA					
Eiseniella tetraedra	80			27	
Unid. Immature Tubificidae w/ Capilliform Chaetae	60			20	
Unid. Immature Tubificidae w/o Capilliform Chaetae	20			7	
NEMATODA					
Unid. Nematoda	40	40		27	
CRUSTACEA					
AMPHIPODA					
Crangonyx sp.	340	80	160	193	36
HYDRACARINA					
Sperchon/Sperchonopsis	260	520	360	380	20
GASTROPODA					
Physa sp.			40	13	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, BD2
SAMPLED: 4-2-98

TOTAL (#/sq. meter)	6640	20720	18920	15428	1420
NUMBER OF TAXA	22	16	11	25	15
SHANNON-WEAVER (H')	2.67	1.59	1.44	1.81	
MODIFIED HILSENHOFF BIOTIC INDEX	5.95	5.81	6.66	6.14	
SCRAPERS/FILTER COLLECTORS	3.21	0.59	0.01	0.96	
EPT/CHIRONOMIDAE ABUNDANCE	0.09	0.07	0.08	0.07	
% CONTRIBUTION OF DOMINANT TAXON	53	75	74	72	
EPT INDEX	5	5	3	6	
SHREDDERS/TOTAL DENSITY	0.58	0.78	0.86	0.78	

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, BD1
SAMPLED: 4-13-98

TAXA	HESS 21	HESS 22	HESS 23	COMPOSITE	SWEEP 24
INSECTA					
EPHEMEROPTERA					
Baetis tricaudatus	2160	360	630	1050	316
Tricorythodes minutus	160	100	30	97	28
TRICHOPTERA					
Agraylea sp.					8
Cheumatopsyche sp.	760	280		347	28
Hydropsyche simulans	160			53	
COLEOPTERA					
Microcylloepus pusillus					4
DIPTERA					
Chelifera sp.	120			40	
Chironomus sp.		100		33	19
Cricotopus tremulus	5440	4800	420	3553	497
Demicryptochironomus sp.			20	7	
Hemerodromia sp.	120	40		53	
Mallochohelea sp.	40			13	
Simulium sp.	80	20	20	40	
Tipula sp.	40	40		27	4
ANNELIDA					
OLIGOCHAETA					
Eiseniella tetraedra	40			13	
Unid. Immature Tubificidae w/ Capilliform Chaetae	70		70	47	
Unid. Immature Tubificidae w/o Capilliform Chaetae	30		30	20	
NEMATODA					
Unid. Nematoda		20		7	4
CRUSTACEA					
AMPHIPODA					
Hyalella azteca	40		10	17	8
HYDRACARINA					
Sperchon/Sperchonopsis	1200	340	30	523	8
GASTROPODA					
Fossaria sp.					4

MACROINVERTEBRATE DENSITY
CLIENT: EXPONENT
SITE: BIG DRY CREEK, BD1
SAMPLED: 4-13-98

TOTAL (#/sq. meter)	10460	6100	1260	5940	928
NUMBER OF TAXA	15	10	9	18	12
SHANNON-WEAVER (H')	2.18	1.29	1.89	1.99	
MODIFIED HILSENHOFF BIOTIC INDEX	5.16	5.68	5.20	5.35	
SCRAPERS/FILTER COLLECTORS	2.16	1.20	32.00	2.39	
EPT/CHIRONOMIDAE ABUNDANCE	0.60	0.15	1.50	0.43	
% CONTRIBUTION OF DOMINANT TAXON	52	79	50	60	
EPT INDEX	4	3	2	4	
SHREDDERS/TOTAL DENSITY	0.52	0.81	0.33	0.60	

3/83