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# SITE-WIDE CHARACTERIZATION REPORT
# VOLUME 4 OF 5 APPENDICES A-M
# AUGUST 1992

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REPORT

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# SITE-WIDE CHARACTERIZATION REPORT

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 4 of 5
APPENDICES
A - M

AUGUST 1992

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
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**APPENDICES**
**A - M**

**AUGUST 1992**

**U.S. DEPARTMENT OF ENERGY**

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**DRAFT**

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AUG 4 1992

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# APPENDIX A

# PLANT AND ANIMAL SPECIES RECORDED AT THE FEMP

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## TABLE A.1
## PLANT SPECIES OBSERVED ON THE FEMP[a]

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Equisetaceae | | | |
| Equisetum arvense | Common horsetail | R | Sp-Su[e]/R |
| Pinaceae | | | |
| Picea excelsa | Norway Spruce | P | Y/R* |
| Pinus nigra | Austrian pine | P | Y/A* |
| Pinus strobus | White pine | P | Y/A* |
| Cupressaceae | | | |
| Juniperus virginiana | Eastern red cedar | W | Y/R |
| Poaceae | | | |
| Bromus ciliatus | Fringed brome | W | Sp/R |
| Bromus inermis | Smooth brome | P | Sp/R* |
| Bromus commutatus | Hairy borme | R | Sp/R* |
| Bromus sp. | Brome grass | IG,F,P,R | Sp/A |
| Festuca rubra | Red fescue | IG,F,P,W,R | Su/A* |
| Festuca elatior | Meadow fescue | IG,P,W,R | Su,Sp[f]/A* |
| Festuca obtusa | Nodding fescue | P,W,R | Sp/O |
| Festuca sp. | Fescue | IG,F,P,R | Sp/A |
| Poa annua | Annual bluegrass | W | Sp/R* |
| Poa compressa | Canada bluegrass | W,R | Sp/O* |
| Poa pratensis | Kentucky bluegrass | IG,F,P,W,R | Sp,Su/A* |
| Poa sp. | Bluegrass | IG,F,P,W,R | Su,Sp/C |
| Dactylis glomerata | Orchard grass | IG,P | Sp/C* |
| Agropyron sp. | Wheatgrass | W | Sp/O |
| Elymus virginicus | Virginia wild-rye | R | Sp/R |
| Elymus villosus | Hairy wild-rye | R | Sp/R |
| Hystrix patula | Bottlebrush | P,R | Sp/R |
| Agrostis alba | Redtop | IG,P,W | Su/R |
| Agrostis stoloniferous var. major | Redtop | IG,P,W | Su/O* |
| Phleum pratense | Timothy-grass | IG,F,P | Su/O* |
| Digitaria filiformis | Slender crabgrass | R | Su/R |
| Digitaria sp. | Crabgrass | IG | Sp/O |
| Enchinochloa crusgalli | Barnyard grass | W,R | Su/R* |
| Setaria sp. | Bristly foxtail | R | Su/R |
| Unknown grasses | | IG,P,R | Sp/O |
| Cyperaceae | | | |
| Carex conjuncta | Sedge | R | Sp/R |
| Carex scoparia | Broom sedge | P | Sp/R |
| Carex amphibola | Narrowleaf sedge | P | Sp/R |
| Carex blanda | Woodland sedge | W | Sp/O |
| Carex sp. | Sedge | IG,F,P,W,R | Sp,Su/O |

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**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Commelinaceae | | | |
| Commelina communis | Dayflower | R | Su/R* |
| Juncaceae | | | |
| Juncus tenuis | Slender rush | IG,W | Su/R |
| Liliaceae | | | |
| Hemerocallis fulva | Day lily | W | Sp/R* |
| Allium canadense | Wild onion | IG,P,W,R | Sp,Su/R |
| Smilacina racemosa | False Solomon's seal | W,R | Sp/R |
| Trillium sessile | Sessile trillium | W,R | Sp/R |
| Smilax glauca | Cat briar | R | Su/O |
| Smilax sp. | Green briar/Cat briar | R | Sp-Su/R |
| Salicaceae | | | |
| Populus deltoides | Eastern cottonwood | F,W,R | Y/A |
| Salix nigra | Black willow | R | Y/R |
| Salix sp. | Willow | R | Y/R |
| Juglandaceae | | | |
| Juglans nigra | Black wlanut | W,R | Y/C |
| Carya cordiformis | Bitternut hickory | W,R | Y/R |
| C. laciniosa | Shellbark hickory | W | Y/C |
| C. tomentosa | Mockernut hickory | W | Y/R |
| C. ovata | Shagbark hickory | R | Y/R |
| Betulaceae | | | |
| Betula sp. | Birch | R | Y/R |
| Fagaceae | | | |
| Quercus bicolor | Swamp white oak | R | Y/R |
| Q. prinus | Chestnut oak | W | Y/O |
| Q. prinoides | Chinquapin oak | R | Y/R |
| Q. imbricaria | Shingle oak | W,R | Y/C |
| Q. borealis | Northern red oak | W | Y/C |
| Ulmaceae | | | |
| Ulmus americana | American elm | F,W,R | Y/A |
| U. rubra | Slippery elm | W,R | Y/O |
| Celtis occidentalis | Hackberry | W,R | Y/C |
| Moraceae | | | |
| Maclura pomifera | Osage-orange (Hedge-apple tree) | R | Y/O |

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TABLE A.1
(Continued)

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Urticaceae | | | |
| Urtica dioica | Nettle | R | Sp-Su/O* |
| U. procera | Nettle | R | Su/O |
| Bohemeria cylindrica | False nettle | F,R | Sp/R |
| Pilea pumila | Clearwood | P,W,R | Su/C |
| Aristolochiaceae | | | |
| Asarum canadense | Wild ginger | W,R | Sp,Su/R |
| Polygonaceae | | | |
| Rumex crispus | Curly dock | R | Sp/R* |
| Rumex obtusifolius | Bitter dock | W | Su/R* |
| Rumex sp. | Dock | W,R | Sp,Su/R |
| Polygonum persicaria | Lady-thumb | W,R | Su/R* |
| Polygonum hydropiperoides | Mild water-pepper, Smartweed | W,R | Su/R |
| Polygonum virginiana | Jumpseed | W | Su/R |
| (Tovara virginiana) | Tovara/Jumpseed | | |
| Polygonum cilinode | Climbing buckwheat, Bindweed | P,R | Su/R |
| Polygonum sp. | Smartweed | R | Su/R |
| Chenopodiaceae | | | |
| Chenopodium album | Lamb's quarters | R | Sp/R* |
| Portulacaceae | | | |
| Clytonia virginiana | Spring beauty | W,R | Sp/R |
| Caryophyllaceae | | | |
| Stellaria media | Common chickweed | IG,F,P,W,R | Sp/C* |
| Cerastium vulgatum | Mouse-ear chickweed | IG | Sp/R* |
| Saponaria officinalis | Bouncing bet/soapwort | R | Sp-Su/R* |
| Ranunculaceae | | | |
| Ranunculus abortivus | Kidney leaf buttercup | W,R | Sp/R |
| Ranunculus sp. | Buttercup | IG,F,P,W,R | Sp/O |
| Berbridaceae | | | |
| Podophyllum peltatum | May apple | W,R | Sp/R |
| Papaveraceae | | | |
| Sanguinaria canadensis | Bloodroot | W,R | Sp/R |
| Fumariaceae | | | |
| Corydalis flavula | Golden corydalis | W,R | Sp/R |

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**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Brassicaceae | | | |
| Thlaspi sp. | Pennycress | P | Sp/R* |
| Capsella bursa-pastoris | Shepherd's purse | IG,F,R | Sp/R* |
| Draba verna | Whitlow-grass | F,R | Sp/R* |
| Dentaria laciniata | Cut-leaved toothwort | W,R | Sp/R |
| Arabis laevigata | Smooth rock cress | R | Sp/R |
| Arabis sp. | Rock cress | R | Sp/R |
| Barbarea vulgaris | Winter cress | IG,F,P,W,R | Sp/C* |
| Alliaria officinalis | Garlic mustard | P,W,R | Sp/C* |
| Unknown mustard | | W | Su/R |
| Saxifragaceae | | | |
| Heuchera americana | Alum-root | W,R | Su/O |
| Plantanaceae | | | |
| Platanus occidentalis | American sycamore | W,R | Y/C |
| Rosaceae | | | |
| Potentilla simplex | Common cinquefoil | W | Sp/R |
| Potentilla canadensis | Dwarf cinquefoil | W | Sp/R |
| Geum vernum | Spring avens | W | Sp/O |
| G. canadense | Geum | F,P,W,R | Su/O |
| Geum sp. | Avens | W,R | Sp/O |
| Rubus allegheniensis | Blackberry | F,P,W,R | Su/O |
| R. occidentalis | Black raspberry | P,R | Sp/R |
| Rubus sp. | Bramble/dewberry/Blackberry | P,W | Sp/O |
| Agrimonia parviflora | Small flowered agrimony | W | Su/O |
| Rosa setigera | Prairie rose | F | Su/R |
| R. multiflora | Multiflora rose | IG,P,W,R | Sp-Su/O* |
| Prunus serotina | Wild cherry | W,R | Y/R |
| P. hortulana | Goose plum | W | Y/R |
| Prunus sp. | Cherry | P | Y/R |
| Crataegus sp. | Hawthorn | R | Y/R |
| Caesalpiniaceae | | | |
| Cercis canadensis | Redbud | F,R | Y/R |
| Gleditsia triacanthos | Honey-locust | W,R | Y/O |
| Gymnocladus dioica | Kentucky coffee-tree | W | Y/R |

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**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Fabaceae (Leguminosae) | | | |
| Trifolium pratense | Red clover | IG,P,W | Sp-Su/O* |
| T. repens | White clover | IG,P,W,R | Sp,Su/C* |
| Melilotus alba | White sweet clover | F | Su/R* |
| M. officinalis | Yellow sweet clover | P,R | Sp-Su/R* |
| Medicago lupulina | Black medick | IG,F,P,W,R | Sp-Su/O* |
| Robinia pseudoacacia | Black locust | P,W,R | Y/R |
| Apios americana | Ground-nut | P,R | Su/R |
| Oxalidaceae | | | |
| Oxalis europea | Wood sorrel | P | Sp/O |
| O. stricta | Yellow wood sorrel | IG,P,W,R | Sp,Su/C* |
| Oxalis sp. | Wood sorrel | P,W,R | Su,Sp/R |
| Rutaceae | | | |
| Dictamnus albus | Burning bush | F,R | Y/O* (cultivar) |
| Euphorbiaceae | | | |
| Acalypha rhomboidea | Copper leaf | IG,P,W | Su/O |
| Anacardiaceae | | | |
| Rhus radicans | Poison-ivy | F,P,W,R | Sp-Su/O |
| Celastraceae | | | |
| Celastrus scandens | Bittersweet | R | Sp/R |
| Aceraceae | | | |
| Acer saccharum | Sugar maple | W,R | Y/C |
| A. nigrum | Black maple | R | Y/R |
| A. rubrum | Red maple | W | Y/R |
| A. saccharinum | Silver maple | W,R | Y/O |
| A. negundo | Box elder | F,W,R | Y/C |
| Hippocastanaceae | | | |
| Aesculus glabra | Ohio-buckeye | W,R | Y/O |
| Balsaminaceae | | | |
| Impatiens sp. | Touch-me-not/jewelweed | P,W,R | Sp-Su/O |
| Vitaceae | | | |
| Vitis riparia | Riverbank grape | R | Sp-Su/R |
| Vitis sp. | Grape | F,P,W,R | Sp-Su/O |
| Parthenocissus quinquefolia | Virginia creeper | F,P,W,R | Sp-Su/C |

**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Hypericaceae | | | |
| Hypericum sp. | St.Johnswort | P | Su/R |
| Violaceae | | | |
| Viola sp. | Violet | IG,P,W,R | Su,Sp/O |
| Onagraceae | | | |
| Ephilobium sp. | Willow-herb | R | Sp/R |
| Oenothera biennis | Evening primose | R | Sp/R |
| Umbelliferae | | | |
| Sanicula canadensis | Black snakeroot | W | Su/O |
| Sanicula sp. | Black snakeroot | W,R | Su,Sp/O |
| Osmorhiza claytoni | Sweet cicely | P,W,R | Sp/O |
| Daucus carota | Wild carrot | IG,F,P,W,R | Sp-Su/O* |
| Chaerophllum procumbens | Wild chervil | W,R | Sp/R |
| Carum carvi | Caraway | W | Su/R* |
| Conium maculatum | Poison hemlock | IG,F,R | Sp/O* |
| Pastinaca sativa | Wild parsnip | P,F | Sp,Su/O* |
| Cornaceae | | | |
| Cornus drummondii | Roughleaf dogwood | W,R | Y/C |
| C. racemosa | Red-panicled dogwood | W | Y/R |
| Cornus sp. | Dogwood | P | Y/R |
| Primulaceae | | | |
| Lysimachia nummularia | Moneywort | W,R | Sp-Su/R* |
| Lysimachia sp. | Loosestrife | R | Sp/R |
| Ebenaceae | | | |
| Diospyros virginiana | Persimmon | W | Y/R |
| Oleaceae | | | |
| Fraxinus americana | White ash | P,W,R | Y/C |
| Fraxinus sp. | Ash | W | Y/R |
| Apocynaceae | | | |
| Apocynum sp. | Dogbane | P | Sp/O |
| Ascelepiadaceae | | | |
| Asclepias syriaca | Common milkweed | IG,W | Sp/R |
| Asclepias sp. | Milkweed | F,P,W,R | Su,Sp/O |

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**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Convolvulaceae | | | |
| Ipomea pandurata | Wild potato-vine | P | Su/O |
| Ipomea sp. | Morning glory | R | Su/R |
| Convolvulus arvensis | Field bindweed | IG,P,W | Su/O* |
| C. sepium | Hedge-bindweed | P,R | Su/R* |
| Convolvulus sp. | Bindweed | P,R | Su,Sp/C |
| Polemoniaceae | | | |
| Phlox divaricata | Blue phlox | R | Sp/R |
| Hydrophyllaceae | | | |
| Phacelia purshii | Miami mist | W,R | Sp/O |
| Boraginaceae | | | |
| Mertensia virginiana | Bluebells | R | Sp/R |
| Verbenaceae | | | |
| Verbena urticifolia | White verain | P,W,R | Su/O |
| Labiatae | | | |
| Glechoma hederacea | Ground-ivy | IG,P,R,W | Su,Sp/O* |
| Prunella vulgaris | Heal-all | P | Su/R* |
| Lamium amplexicaule | Henbit | R | Sp/R* |
| L. purpureum | Purple dead-nettle | IG,P,F,W,R | Sp/O* |
| Leonurus cardiaca | Common motherwort | P | Su/R* |
| Unknown mint | | P | Sp/R |
| Solanaceae | | | |
| Physalis heterophylla | Ground cherry | IG,P,W,R | Su/O |
| Solanum carolinense | Horse-nettle | IG,P,W | Su/O |
| Datura stramonium | Jimsonweed | F,P | Su/R |
| Scrophylariaceae | | | |
| Verbascum blattaria | Moth-mullein | IG | Su/R* |
| Veronica peregrina | Purslane speedwell | IG | Sp/R |
| Veronica sp. | Speedwell | P,R | Sp/R |
| Bignoniceae | | | |
| Campsis radicans | Trumpet creeper | F,P | Su,Sp/O |
| Plantaginaceae | | | |
| Plantago major | Common plantain | IG,W | Sp,Su/R* |
| P. lanceolata | English plantain | IG,P,W | Su,Sp/O* |
| Plantago sp. | Plantain | IG,P | Su/R |

**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Rubiaceae | | | |
| Galium aparine | Cleavers | F,P,W,R | Sp,Su/C |
| Galium sp. | Bedstraw | W,R | Sp/R |
| Caprifoliaceae | | | |
| Sambucus canadensis | Common elder-berry | P,W | Su,Sp/R |
| Lonicera iaponica | Japanese honeysuckle | F,W,R | Sp-Su/O* |
| Lonicera sp. | Honeysuckle | F,P,W,R | Su,Sp/O |
| Valerianaceae | | | |
| Valerianella radiata | Corn salad | W | Sp/R |
| Valerianella sp. | Corn salad | F,W,R | Sp/R |
| Dipsacaceae | | | |
| Dipsacus sylvestris | Teasel | F,P | Su/R* |
| Campanulaceae | | | |
| Campanula americana | Tall bellflower | R | Su/R |
| Compositae | | | |
| Helianthus tuberosus | Sunflower | R | Su/O |
| Actinimeris alternifolia | (Verbesina) Crown-beard | R | Su/O |
| Bidens vulgata | Beggar-ticks | P,R | Su,Sp/O |
| Polymnia sp. | Leafcup | R | Su/R |
| Silphium trifoliolatum | Rosinweed | R | Su/O |
| Ambrosia trifida | Great ragweed | F,P,R | Su/O |
| A. artemisiifolia | Common ragweed | IG,F,P,W,R | Su/C |
| Ambrosia sp. | Ragweed | F,P | Su-Su/R |
| Xanthium strumarium var. canadensis | Cocklebur | R | Su/R |
| X. echinatum | Cocklebur | R | Sp/R |
| Achillea millefolium | Yarrow | IG,P,F,W | Sp-Su/O |
| Senecio sp. | Ragwort | W,R | Sp-Su/R |
| Solidago sp. | Goldenrod | IG,F,P,W,R | Su,Sp/C |
| Aster sp. | Aster | IG,F,P,W,R | Su,Sp/C |
| Erigeron annuus | Daisy fleabane | W | Su/R |
| Erigeron sp. | Fleabane | IG | Sp/R |
| Eupatorium rugosum | White snakeroot | F,R | Sp/R |
| Eupatorium sp. . | Thoroughwort | P,W,R | Su,Sp/R |
| Vernonia altissima | Tall ironweed | IG,F,P,W,R | Sp-Su/C |
| V. gigantea | Ironweed | IG,P,R | Sp/R |
| Arctium sp. | Burdock | R | Su/R |
| Cirsium altissimum | Tall thistle | P | Su/O |
| C. arvense | Canada thistle | IG | Su/R* |
| Cirsium sp. | Thistle | IG,F,P,W | Su,Sp/C |

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**TABLE A.1**
**(Continued)**

| Scientific Name[b] | Common Name | Habitat[c] | Occurrence/[d] Abundance |
|---|---|---|---|
| Compositae (continued) | | | |
| Taraxacum officinale | Common dandelion | IG,F,P,W,R | Su-Sp/C* |
| Lactuca biennis | Blue lettuce | W | Su/R |
| Cichorium intybus | Chicory | IG | Su/R* |
| Unknown Compositae | | R | Sp/R |

[a] Adapted from Facemire et al. (1990).
Sightings identified to genus only do not necessarily indicate one species.

[b] Nomenclature from Gleason and Cronquist (1963).

[c] IG = Introduced Grassland
F = Inactive Fly Ash Disposal Area
P = Pine Plantations
W = Deciduous Woodlands
R = Riparian Woodlands

R = Rare, very seldom seen or collected
0 = Occasional, seen or collected a few times
C = Common, seen regularly
A = Abundant, very numerous
Terminology is that of Facemire et al. (1990)

[d] * = planted ornamental species or cultivar/non-native introduced or escape species
F = Fall
Sp = Spring
W = Winter
Su = Summer
Y = Yearlong

[e] When separated by a hyphen, this indicates a relatively constant frequency for both seasons.

[f] When separated by a comma, first season indicates season of highest frequency although it may persist throughout more than one.

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## TABLE A.2
## MAMMALS OBSERVED ON THE FEMP[a]

| Scientific Name | Common Name | Habitat[b] | Occurrence/[c] Abundance |
|---|---|---|---|
| Didelphidae | New World Opossums | | |
| Didelphis virginiana | Virginia opossums | P | I |
| Soricidae | Shrews | | |
| Blarina brevicauda | Northern short-tailed shrew | IG,F,R,W | A |
| Talpidae | Moles | | |
| Scalopus aquaticus | Eastern mole | U | I |
| Vespertilionidae[d] | Vespertilionid bats | | |
| Eptesicus fuscus | Big brown bat | R | A |
| Lasionycteris noctivagans | Silver-haired bat | R | R |
| Lasiurus borealis | Red bat | R | C |
| Myotis lucifugus | Little brown myotis | W,R | R |
| Leporidae | Rabbits | | |
| Sylvilagus floridanus | Eastern cottontail | IG,P,R,W | A |
| Sciuridae | Squirrels | | |
| Tamias striatus | Eastern chipmunk | W | O |
| Marmota monax | Woodchuck | IG | I |
| Sciurus niger | Fox squirrel | IG,W,R | O |
| Cricetidae | Cricetids | | |
| Peromyscus leucopus[e] | White-footed mouse | F,R,W | C |
| Microtus pennsylvanicus | Meadow vole | IG,P | O |
| Ondatra zibethicus | Muskrat | R | I |
| Procyonidae | Procyonids | | |
| Procyon lotor | Raccoon | U | I |
| Muridae | Murids | | |
| Mus musculus | House mouse | U | I |
| Zapodidae | Jumping mice | | |
| Zapus hudsonicus | Meadow jumping mouse | W | R |
| Canidae | Canids | | |
| Canis latrans | Coyote | U (all) | I |
| Vulpes vulpes | Red fox | U (all) | I |
| Cervidae | Cervids | | |
| Odocoileus virginianus | White-tailed deer | IG,P,R,W | A |

See footnotes on next page.

**TABLE A.2**
**(Continued)**

[a] Adapted from Facemire et al. (1990) and RI/FS threatened and endangered species surveys.

[b] IG = Introduced Grassland
F = Inactive Fly Ash Disposal Area
P = Pine Plantations
W = Deciduous Woodlands
R = Riparian Woodlands
U = Unknown

[c] R = Rare
O = Occasional
C = Common
A = Abundant
I = Incidental sighting, abundance unknown

[d] The Indiana bat (Myotis sodalis), a federally-listed endangered species, was observed on Banklick Creek near Ross, Ohio, and habitat along Paddys Run on the FEMP is rated from fair to excellent for this species.

[e] The report by Facemire et al. (1990) does not list Peromyscus leucopus in its Catalogue of Species, but does list P. maniculatus, the deer mouse. However, the text of Facemire et al. (1990) states that P. maniculatus was absent from the FEMP, while numbers of P. leucopus were present. This report assumes that the Catalogue of Species, not the text, of Facemire et al. (1990) is in error.

## TABLE A.3
## BIRDS OBSERVED ON THE FEMP[a]

| Scientific Name | Common Name | Habitat[b] | Occurrence/[c] Abundance |
|---|---|---|---|
| Ciconiiformes | | | |
| Ardea herodias | Great blue heron | IG,R | Su/R |
| Butorides striatus | Green-backed heron | R | Su/R |
| Anseriformes | | | |
| Aix sponsa | Wood duck | R | Sp/R |
| Anas platyrhynchos | Mallard | R | Su/R |
| Falconiformes | | | |
| Cathartes aura | Turkey vulture | IG,P,W | Su/R |
| Circus cyaneus | Northern harrier | IG | Su/R |
| Accipiter cooperii | Cooper's hawk | F,P,W,R | Sp,W,Su/O |
| Buteo lineatus | Red-shouldered hawk | W | W/R |
| Buteo jamaicensis | Red-tailed hawk | IG,F,P,W,R | W,Su/C |
| Falco sparverius | American kestrel | IG,F,P,W,R | W,Su/C |
| Galliformes | | | |
| Colinus virginianus | Northern bobwhite | IG,F,P,W,R | Y-C |
| Charadriiformes | | | |
| Charadrius vociferus | Killdeer | IG,F,P,R | W,Su-C |
| Tringa solitaria | Solitary sandpiper | R | Sp,Su-U |
| Actitis macularia | Spotted sandpiper | R | Su-O |
| Scolopax minor | American woodcock | W | Su-R |
| Columbiformes | | | |
| Columba livia | Rock dove | IG | Su-R |
| Zenaida macroura | Mourning dove | IG,F,P,W,R | Y-A |
| Cuculiformes | | | |
| Coccyzus americanus | Yellow-billed cuckoo | F,P,W,R | Su/C |
| Coccyzus erythropthalmus | Black-billed cuckoo | F,P,W,R | Su/O |
| Strigiformes | | | |
| Otus asio | Eastern screech owl | R | Su/O |
| Bubo viginianus | Great horned owl | P,W,R | W,Su/O |
| Apodiformes | | | |
| Chaetura pelagica | Chimney swift | IG,F,P,W,R | Su/C |
| Archilochus colubris | Ruby-throated hummingbird | P,W,R | Su/O |
| Coraciiformes | | | |
| Ceryle alcyon | Belted kingfisher | W,R | W,Su/C |

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**TABLE A.3**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Occurrence/[a] Abundance |
|---|---|---|---|
| Piciformes | | | |
| Melanerpes erythrocephalus | Red-headed woodpecker | IG,R | Su/C |
| Melanerpes carolinus | Red-bellied wordpecker | IG,F,W,R | Su/R |
| Picoides pubescens | Downy woodpecker | IG,F,P,W,R | Su/O |
| Picoides villosus | Hairy woodpecker | IG,F,W,R | Su/O |
| Colaptes auratus | Northern flicker | IG,F,P,W,R | Su/A |
| Dryocopus pileatus | Pileated woodpecker | F,W,R | Su/R |
| Passeriformes | | | |
| Contopus virens | Eastern wood-peewee | F,P,W,R | Su/C |
| Empidonax virescens | Acadian flycatcher | W | Su/R |
| Empidonax traillii | Willow flycatcher | IG,P,W | Su/O |
| Sayornis phoebe | Eastern phoebe | F,W,R | Su/O |
| Myiarchus crinitus | Great crested flycatcher | P,W,R | Su/O |
| Tyrannus tyrannus | Eastern kingbird | IG,F,P,W,R | Su/A |
| Progne subis | Purple martin | P,R | Su/R |
| Stelgidopteryx ruficollis | Northern rough-winged swallow | IG,P,R | Su/R |
| Hirundo rustica | Barn swallow | IG,F,P,W,R | Su/C |
| Cyanocitta cristata | Blue jay | IG,F,P,W,R | W,Su/A |
| Corvus brachyrhynchos | American crow | IG,F,P,W,R | W,Su/C |
| Parus carolinensis | Carolina chickadee | F,P,W,R | W,Su/C |
| Parus bicolor | Tufted titmounse | P,W,R | W,Su/C |
| Sitta carolinensis | White-breasted nuthatch | W,R | W,Su/C |
| Certhia americana | Brown creeper | R | W/O |
| Thryothorus ludovicianus | Carolina wren | W,R | W,Su/C |
| Regulus satrapa | Golden-crowned kinglet | F,P,W,R | W/C |
| Troglodytes aedon | House wren | IG,W,R | Su/C |
| Polioptila caerulea | Blue-gray gnatcatcher | F,P | Su/R |
| Sialia sialis | Eastern bluebird | F,W,R | W,Su/O |
| Hylocichla mustelina | Wood thrush | W,R | Su/C |
| Turdus migratorius | American robin | IG,F,P,W,R | W,Su/A |
| Dumetella carolinesis | Gray catbird | P,W,R | Su/C |
| Mimus polyglottos | Northern mockingbird | IG | W,Su/U |
| Toxostoma rufum | Brown thrasher | F,P,W,R | Su/C |
| Bombycilla cedrorum | Cedar waxwing | F,P,W,R | Su/C |
| Sturnus vulgaris | European starling | IG,F,P,R | W,Su/A |
| Vireo griseus | White-eyed vireo | W | Su/U |
| Vireo gilvus | Warbling vireo | W,R | Su/O |
| Vireo philadelphicus | Philadelphia vireo | W | Su/R |
| Vireo olivaceus | Red-eyed vireo | W,R | Su/R |
| Vireo solitarius | Solitary vireo | W | Sp/R |

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TABLE A.3
(Continued)

| Scientific Name | Common Name | Habitat[b] | Occurrence/[c] Abundance |
|---|---|---|---|
| Passeriformes (continued) | | | |
| Vermivora peregrina | Tennessee warbler | F,R,W | Sp/R |
| Dendroica petechia | Yellow warbler | P,W,R | Su/O |
| Mniotilta varia | Black-and-white warbler | W | Su/R |
| Oporonis philadelphia | Mourning warbler | R | Sp/R |
| Vermivora pinus | Blue-winged warbler | W | Sp/R |
| Dendroica coronata | Yellow-rumped warbler | P,W,R | Sp/R |
| Dendroica virens | Black-throated green warbler | W,R | Sp/R |
| Dendroica striata | Blackpoll warbler | W | Sp/R |
| Seiurus noveboracensis | Northern waterthrush | R | Sp/R |
| Seiurus motacilla | Louisiana waterthrush | R | Su/R |
| Setophaga ruticilla | American redstart | W | Sp/R |
| Geothlypis trichas | Common yellowthroat | IG,F,P,W,R | Su/A |
| Icteria virens | Yellow-breasted chat | W | Su/R |
| Piranga rubra | Summer tanager | W,R | Su/R |
| Piranga olivacea | Scarlet tanager | W,R | Su/O |
| Cardinalis cardinalis | Northern cardinal | IG,F,P,W,R | W,Su/A |
| Pheucticus ludovicianus | Rose-breasted grosbeak | W,R | Sp/R |
| Passerina cyanea | Indigo bunting | IG,F,P,W,R | Sp/C |
| Pipilo eyrthropthalmus | Rufous-siding towhee | F,P,W,R | W,Su/C |
| Spizella arborea | American tree sparrow | IG,P,W | W/O |
| Melospiza georgiana | Swamp sparrow | W | Sp/R |
| Spizella passerina | Chipping sparrow | P,W | Su/O |
| Spizella pusilla | Field sparrow | IG,F,P,W,R | Su/A |
| Passerculus sandwichensis | Savannah sparrow | IG | Su/O |
| Ammodramus savannarum | Grasshopper sparrow | IG,F | Su/O |
| Melospiza melodia | Song sparrow | IG,F,P,W,R | W,Su/A |
| Zonotrichia albicollis | White-throated sparrow | W | W/R |
| Junco hyemalis | Dark-eyed junco | IG,P,W,R | W/C |
| Agelaius phoeniceus | Red-winged blackbird | IG,F,P,W,R | W,Su/A |
| Sturnella magna | Eastern meadowlard | IG,F,P,R | W,Su/C |
| Quiscalus quiscula | Common grackle | IG,F,P,W,R | Su/C |
| Molothrus ater | Brown-headed cowbird | F,P,W,R | Su/C |
| Icterus galbula | Northern oriole | F,W,R | Su/C |
| Carduelis tristis | American goldfinch | IG,F,P,W,R | W,Su/A |
| Passer domesticus | House sparrow | IG,R | W,Su/O |
| Carpodacus mexicanus | House finch | P,R | Sp,Su/R |

See footnotes on next page.

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**TABLE A.3**
**(Continued)**

[a] Adapted from Facemire et al. (1990).

[b] IG = Introduced Grassland
F = Inactive Fly Ash Disposal Area
P = Pine Plantations
W = Deciduous Woodlands
R = Riparian Woodlands

[c]

| | |
|---|---|
| F = Fall | R = Rare, very seldom seen or collected |
| Sp = Spring | O = Occasional, seen or collected a few times |
| W = Winter | C = Common, seen regularly |
| Su = Summer | A = Abundant, very numerous |
| Y = Yearlong | |

Terminology is that of Facemire et al. (1990).

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## TABLE A.4
## AMPHIBIANS AND REPTILES OBSERVED ON THE FEMP[a]

| Scientific Name | Common Name | Habitat[b] |
|---|---|---|
| Bufonidae | Bufonids and Toads | |
| Bufo americanus | American toad | IG,P |
| Bufo woodhousei fowleri | Fowler's toad | IG,P |
| Ranidae | Ranids | |
| Rana catesbiana | Bull frog | R |
| Rana clamitans | Green frog | R |
| Hylidae | Hylids and Treefrogs | |
| Hyla crucifer | Spring peeper | R |
| Acris crepitans | Northern cricket frog | R |
| Colubrida | Colubrids | |
| Regina septemvittata | Queen snake | R |
| Nerodia sipedon | Northern watersnake | R |
| Thamnophis butleri | Butler's garter snake | P |
| Elaphe osoleta | Black rat snake | W |
| Emydidae | Emydid Turtles | |
| Terrapene carolina | Box turtle | P,R |
| Chelydridae | Chelydrid Turtles | |
| Chelydra serpentina | Common snapping turtle | R |
| Trionychidae | Trionychid Turtles | |
| Trionyx muticus | Smooth softshell turtle | R |

[a] Source: Facemire et al. (1990). Presence only was recorded.

[b] IG = Introduced Grassland
P = Plantation Pine
W = Deciduous Woodlands
R = Riparian Woodlands

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## TABLE A.5
## INSECTS, SPIDERS, MITES, TICKS, AND MOLLUSCS COLLECTED AT THE FEMP[a]

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Collembola | Springtails | | |
| Entomobryidae | Elongate springtails | IG,P,W | A |
| Poduridae | Elongate springtails | P | R |
| Sminthuridae | Globular springtails | IG,F,P,W | |
| Odonata | Dragonfiles and Damselflies | | |
| Coenagrionidae | Narrow-winged damselflies | R | R |
| Libellulidae | Common skimmers | F,R | R |
| Orthoptera | Grasshoppers, Katydids, Crickets, Cockroaches, Mantids, and Walkingsticks | | |
| Acrididae | Short-horned grasshoppers | IG,F,P,W,R | A |
| Gryllidae | Crickets | IG,F,P,W,R | C |
| Mantidae | Mantids | F,W,R | O |
| Phasmidae | Walking sticks | F,R | O |
| Tetrigidae | Pygmy grasshoppers | R | R |
| Tettigoniidae | Long-horned grasshoppers and katydids | IG,F,P,W,R | C |
| Psocoptera | Psocids | F,W,R | C |
| Thysanoptera | Thrips | IG,F,P,W,R | C |
| Hemiptera | Bugs | | |
| Anthocoridae | Flower bugs; Minute pirate bugs | IG,P,R | O |
| Aradidae | Flat bugs; Fungus bugs | F | O |
| Berytidae | Stilt bugs | IG,F,P,W | O |
| Coreidae | Leaf-footed bugs | R | R |
| Corimelaenidae | Negro bugs | IG,P,R | O |
| Lygaeidae | Chinch bugs; Milkweed bugs, etc. | IG,P,W,R | O |
| Miridae | Leaf bugs; Plant bugs | IG,F,P,W,R | C |
| Nabidae | Damsel bugs | IG,P,W,R | O |
| Pentatomidae | Stink bugs | IG,F,P,W,R | O |
| Phymatidae | Ambush bugs | IG,R | R |
| Reduviidae | Assassin bugs | IG,F,P,W,R | C |
| Rhopalidae | Unknown | IG | R |
| Saldidae | Shore bugs | R | R |
| Scutelleridae | Shield bugs; Shield-backed bugs | W | R |
| Tingididae | Lace bugs | F,W,R | C |

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**TABLE A.5**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Homoptera | Cicadas, Hoppers, Whitefiles, Aphids, and Scale Insects | | |
| Acanaloniidae | Acanoloniid planthoppers | F,P,W,R | C |
| Actiopheridae | Unknown | P | R |
| Aleyrodidae | Whiteflies | R | O |
| Aphididae | Aphids; Plant lice | IG,F,P,W,R | C |
| Cercopidae | Froghoppers; Spittlebugs | IG,F,P,W,R | C |
| Cicadellidae | Leafhoppers | IG,F,P,W,R | A |
| Cicadidae | Cicadas | R | R |
| Cixiidae | Cixiid planthoppers | R | O |
| Coccidae | Scales | P | R |
| Delphacidae | Delphacid planthoppers | IG,P,R | O |
| Dictyopharidae | Dictyopharid planthoppers | IG,P,W | O |
| Flatidae | Flatid planthoppers | F,W,R | C |
| Fulgoridae | Fulgorid planthoppers | IG | R |
| Issidae | Issid planthoppers | R | R |
| Membracidae | Treehoppers | IG,F,P,W,R | O |
| Psylliidae | Jumping plant lice | R | O |
| Neurpotera | Nerve-winged Insects | | |
| Chrysopidae | Green lacewings, Common lacewings | F | O |
| Homerodbiidae | Brown lacewings | R | R |
| Coleptera | Beetles | | |
| Anthribidae | Fungus weevils | P,R | R |
| Cerambycidae | Long-horned Wood-boring beetles | IG,W | R |
| Chrysomelidae | Leaf beetles | IG,F,P,W,R | A |
| Cicindelidae | Tiger beetles | F,R | O |
| Coccinellidae | Ladybugs | IG,P,R | O |
| Cucujidae | Flat bark beetles | P | R |
| Curculionidae | Snout beetles | IG,F,P,W,R | C |
| Elateridae | Click beetles | F | R |
| Histeridae | Hister beetles | R | R |
| Lampyridae | Lightning bugs | IG,P,R | O |
| Lycidae | Net-winged beetles | W | R |
| Meloidae | Blister beetles; Oil beetles | IG,P | O |
| Mordellidae | Tumbling flower beetles | IG,F,P,W,R | O |
| Nitidulidae | Sap beetles | IG,W,R | O |

TABLE A-5
(Continued)

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Scarabaeidae | Scarab beetles | IG,W,R | O |
| Staphylinidae | Rove beetles | IG,P,W | O |
| Mecoptera | Scorpionflies | | |
| Panorphidae | Common scorpionflies | W,R | O |
| Lepidoptera | Butterflies and moths | | |
| Ctenuchidae | Unknown | F | R |
| Danaidae | Milkweek butterflies | F,W,R | R |
| Lycaenidae | Gossamer-winged butterflies | F | R |
| Noctuidae | Noctuid moths | F,P | R |
| Nymphalidae | Brush-footed butterflies | F,W,R | O |
| Pieridae | White, Sulfur and Orange-tip butterflies | IG | R |
| Diptera | Flies | | |
| Agromyzidae | Leaf-miner flies | IG,W,R | O |
| Anthomyzidae | anthomyzid flies | IG,P | R |
| Asilidae | Robber flies | IG,F,P,W,R | O |
| Calliphoridae | Blow flies | IG,F,P,W,R | O |
| Cecidomyiidae | Gall gnats | IG,P,W,R | O |
| Chamaemyiidae | Aphid flies | P | O |
| Chironomidae | Midges | R | O |
| Chloropidae | Fruit flies | IG,F,P,W,R | A |
| Culicidae | Mosquitoes | IG,P,W,R | O |
| Curtonotidae | Curtonotid flies | IG | R |
| Dolichopodidae | Long-legged flies | IG,P,W,R | C |
| Drosophilidae | Small fruit flies | IG,P,W,R | C |
| Emphididae | Dance flies | P,R | R |
| Ephydridae | Shore flies | R | O |
| Heleomyzidae | Heleomyzid flies | IG,P | R |
| Lauxaniidae | Lauxaniid flies | W,R | O |
| Lonchopteridae | Spear-winged flies | IG | R |
| Micropezidae | Stilt-legged flies | IG | R |
| Muscidae | Muscid flies | IG,F,P,W,R | C |

**TABLE A.5**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Mycetophilidae | Fungus gnats | IG,W,R | O |
| Otitdae | Picture-winged flies | R | R |
| Phoridae | Humpbacked flies | IG,W,R | O |
| Piophilidae | Skipper flies | W,R | O |
| Pipunculidae | Big-headed flies | IG,F,P,W,R | O |
| Platystomatidae | Picture-winged flies | IG,W | O |
| Psychodidae | Moth flies | R | R |
| Rhagionidae | Snipe flies | IG,R | R |
| Sarcophagidae | Flesh flies | IG,F,P,R | O |
| Sciaridae | Dark-winged fungus gnats | IG,P,W,R | C |
| Sciomyzidae | Marsh flies | IG,F,P,R | O |
| Sepsidae | Black scavenger flies | IG,P,W,R | O |
| Stratiomyidae | Soldier flies | IG | R |
| Syrphidae | Syrphid flies | IG,F,P,W,R | C |
| Tabanidae | Horse flies, Deer flies, Greenheads | IG,P,W | O |
| Tachinidae | Tachinid flies | IG,P,W | O |
| Tephritidae | Fruit flies | IG,F,P,W,R | C |
| Therevidae | Stiletto flies | IG,P | O |
| Tipulidae | Crane flies | W,R | O |
| Hymenoptera | Ants, Wasps, Bees, Chalcids, Ichneumons, Sawflies | | |
| Apidae | Bumblebees; Honey bees | IG,F,W,R | O |
| Bethylidae | Bethylids | IG,R | R |
| Braconidae | Braconids | IG,F,P,W,R | C |
| Cephidae | Stem sawflies | P | R |
| Chalcidoidea | Chalcids | IG,F,P,W,R | C |
| Colletidae | Plasterer and Yellow-faced bees | IG,P | R |
| Cynipidae | Gall wasps | IG,P,W,R | O |
| Diapriidae | Diapriids | P,R | O |
| Diprionidae | Conifer sawflies | P | R |

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**TABLE A.5**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Formicidae | Ants | IG,F,P,W,R | C |
| Halictidae | Mining bees | IG,F,P,W,R | C |
| Ichneumonidae | Ichneumons | IG,P,W,R | O |
| Megachilidae | Leafcutting bees | R | R |
| Platygasteridae | Platygasterids | IG,F,P,W,R | O |
| Pompilidae | Spider wasps | R | R |
| Proctotrupidae | Parasitic wasps | P,W | R |
| Scelionidae | Scelionids | IG,W,R | O |
| Siricidae | Horntails | W | R |
| Sphecidae | Sphecid wasps | IG,F,P,W,R | O |
| Tenthrediniae | Sawflies | P | R |
| Vespidae | Paper wasps | IG,F,P,W,R | C |
| Coleoptera Larvae | Beetles | IG,P | C |
| Lepidoptera Larvae | Butterflies and Moths | IG,P | O |
| Trichoptera Larvae | Caddisflies | R | R |
| Non-Insect Spiders, Mites, Ticks, and Molluscs | | | |
| Acarina | Mites and Ticks | IG,F,P,W,R | C |
| Araneida | Spiders | IG,F,P,W,R | A |
| Phalangida | Harvestmen | P,W | R |
| Gastropoda | Snails | W,R | C |

See footnotes on next page.

**TABLE A.5**
**(Continued)**

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[a] Adapted from Facemire et al. (1990).

[b] IG = Introduced Grassland
F = Inactive Fly Ash Disposal Area
P = Pine Plantations
W = Deciduous Woodlands
R = Riparian Woodlands

[c] R = Rare, very seldom seen or collected
O = Occasional, seen or collected a few times
C = Common, seen regularly
A = Abundant, very numerous

Terminology is that of Facemire et al. (1990).

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## TABLE A.6
## FISH OBSERVED ON THE FEMP[a]

| Scientific Name | Common Name | Proportion of Catch (%)[b] | Tolerance Index[c] |
|---|---|---|---|
| Cyprinidae | Minnows, Shiners, Daces, Chubs | | |
| Campostoma anomalum | Stoneroller minnow | 18 | - |
| Carpus carpio | Carp | < 1 | T |
| Ericymba buccata | Silverjaw minnow | 3 | - |
| Notropis ardens | Rosefin shiner | 6 | M |
| Notropis atherinoides | Emerald shiner | < 1 | - |
| Notropis chrysocephalus | Striped shiner | 1 | - |
| Notropis spilopterus | Spotfin shiner | 7 | - |
| Notropis stramineus | Sand shiner | < 1 | M |
| Notropis whipplei | Steelcolor shiner | < 1 | P |
| Phenacobius mirabilis | Suckermouth minnow | < 1 | - |
| Phoxinus erythrogaster | Redbelly dace | < 1 | - |
| Pimephales notatus | Bluntnose minnow | 27 | T |
| Rhinichthys atratulus | Blacknose dace | 2 | T |
| Semotilus atromaculatus | Creek chub | 13 | T |
| Catastomidae | Suckers | | |
| Catastomus commersoni | White sucker | 1 | T |
| Centrarchidae | Sunfish, bass | | |
| Lepomis humilus | Orangespotted sunfish | < 1 | - |
| Lepomis macrochirus | Bluegill | < 1 | P |
| Lepomis spp. | Sunfish hybrid | < 1 | - |
| Micropterus salmoides | Largemouth bass | < 1 | - |
| Percidae | Darters | | |
| Etheostona caeruleum | Rainbow darter | < 1 | M |

## FISH OBSERVED ON THE FEMP
(Continued)



| | | | |
|---|---|---|---|
| Etheostona flabellare | Fantail darter | 6 | - |
| Etheostona nigrum | Johnny darter | 8 | - |
| Etheostona spectabile | Orangethroat darter | 10 | - |

[a] Adapted from Facemire et al. (1990).

[b] Total catch for all sampling periods equals 6668 individual fish.

[c] Terminology of OEPA (1989b)
R - Rare intolerant
S - Special intolerant
I - Common intolerant
M - Moderately intolerant
T - Highly tolerant
P - Moderately tolerant

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## TABLE A.7

## FISH COLLECTED FROM THE LOWER MAINSTEM OF THE GREAT MIAMI RIVER AND FIVE TRIBUTARIES[a]

| Scientific Name | Common Name | Tolerance[b] Index |
|---|---|---|
| Amiidae | | |
| Amia calva[c] | Bowfin | - |
| Atherinidae | | |
| Labidesthes sicculus[d] | Brook silverside | M |
| Catastomidae | | |
| Carpiodes carpio | River carpsucker | - |
| Carpiodes cyprinus | Quillback carpsucker | - |
| Carpiodes velifer | Highfin carpsucker | - |
| Catastomus commersoni | White sucker | T |
| Hypentelium nigricans | Northern hog sucker | M |
| Ictiobus bubalis | Smallmouth buffalo | - |
| Ictiobus cyprinellus[d] | Bigmouth buffalo | - |
| Ictiobus niger[c] | Black buffalo | - |
| Minytrema melanops | Spotted sucker | - |
| Moxostoma anisurum | Silver redhorse | M |
| Moxostoma carinatur | River redhorse | I |
| Moxostoma duquesnei | Black redhorse | I |
| Moxostoma erythrurum | Golden redhorse | M |
| Moxostoma macrolepidotum | Shorthead redhorse | M |
| Centrarchidae | | |
| Ambloplites rupestris | Rock bass | - |
| Lepomis cyanellus | Green sunfish | T |
| Lepomis gibbosus | Pumpkinseed sunfish | P |
| Lepomis gulosus[c] | Warmouth sunfish | - |
| Lepomis humilis | Orangespotted sunfish | - |
| Lepomis macrochirus | Bluegill | P |
| Lepomis megalotis | Longear sunfish | M |
| Lepomis spp.[e] | Hybrid sunfish | - |
| Micropterus dolomieui | Smallmouth bass | M |
| Micropterus salmoides | Largemouth bass | - |
| Micropterus salmoides | Spotted bass | - |
| Pomoxis annularis | White crappie | - |
| Pomoxis nigromaculatus | Black crappie | - |

**TABLE A.7**

**(Continued)**

| Scientific Name | Common Name | Tolerance[b] Index |
|---|---|---|
| Cyprinidae | | |
| Campostoma anomalum | Stoneroller minnow | - |
| Carassius auratus | Goldfish | T |
| Cyprinus carpio | Common carp | T |
| Cyprinus X Carassius | Hybrid | T |
| Hybopsis storeriana | Silver chub | - |
| Hybopsis x-punctata[d] | Gravel chub | M |
| Nocomis biguttatus[c] | Hornyhead chub | I |
| Nocomis micropogon | Riverchub | I |
| Notemigonus chrysoleucas | Golden shiner | - |
| Notropis ardens[c] | Rosefin shiner | M |
| Notropis atherinoides | Emerald shiner | - |
| Notropis chrysocephalus | Striped shiner | M |
| Notropis photogenis | Silver shiner | I |
| Notropis rubellus | Rosyface shiner | I |
| Notropis spilopterus | Spotfin shiner | - |
| Notropis stramineus | Sand shiner | M |
| Notropis volucellus | Mimic shiner | I |
| Notropis whipplei[d] | Steelcolor shine | P |
| Phenacobius mirabilis | Suckermouth minnow | - |
| Pimephales notatus | Bluntnose minnow | T |
| Pimephales promelas | Fathead minnow | T |
| Pimephales vigilax[c] | Bullhead minnow | - |
| Semotilus atromaculatus | Creek chub | T |
| Clupeidae | | |
| Alosa chrusochloris | Skipjack herring | - |
| Dorosoma cepedianum | Gizzard shad | - |
| Esocidae | | |
| Esox americanus | Grass pickerel | P |
| Esox lucius | Northern pike | - |
| Hiodontidae | | |
| Hiodon tergisus | Mooneye | R |

**TABLE A.7**

**(Continued)**

| Scientific Name | Common Name | Tolerance[b] Index |
|---|---|---|
| Ictaluridae | | |
| Ictalurus melas | Black bullhead | P |
| Ictalurus natalis | Yellow bullhead | T |
| Ictalurus nebulosus | Brown bullhead | T |
| Ictalurus punctatus | Channel catfish | - |
| Noturus flavus | Stonecat madtom | I |
| Noturus gyrinus | Tadpole madtom | - |
| Pylodictus olivaris | Flathead catfish | - |
| Lepisosteidae | | |
| Lepisosteus osseus | Longnose gar | - |
| Percichthyidae | | |
| Morone chrysops | White bass | - |
| Percidae | | |
| Etheostoma blennioides | Greenside darter | M |
| Etheostoma zonale[d] | Banded darter | I |
| Perca flavescens | Yellow perch | - |
| Percina caprodes | Logperch | M |
| Percina phoxocephala[c] | Slenderhead darter | R |
| Percina shumardi[d] | River darter | - |
| Stizostedion canadense | Sauger | - |
| Stizostedion vitreum | Walleye | - |
| Stizostedion sp.[d] | Sauger x Walley | - |
| Sciaenidae | | |
| Aplodinotus grunniens | Freshwater drum | P |

See footnotes on next page.

**TABLE A.7**

**(Continued)**

[a] Adapted from OEPA (1982, 1989a)

[b] Terminology of OEPA (1989b)
R - Rare intolerant
S - Special intolerant
I - Common intolerant
M - Moderately intolerant
T - Highly tolerant
P - Moderately tolerant

[c] Found only in 1980 survey (OEPA 1982)

[d] Found only in 1989 survey (OEPA 1989a)

[e] Different Lepomis hybrids were found in the 1980 and 1989 surveys.

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## TABLE A.8

## BENTHIC MACROINVERTEBRATES IDENTIFIED FROM RIFFLE AND POOL HABITAT OF PADDYS RUN[a]

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Diptera | Flies, Mosquitoes, Midges | | |
| Ceratopogonidae | Biting midges | P | R |
| Chironomidae | Midges | P,Ri | A |
| Simulidae | Black flies | | |
| Simulium sp. | | Ri | C |
| Tipulidae | Crane flies | | |
| Hexatoma sp. | | Ri | O |
| Dicranota sp. | | Ri | R |
| Tipula sp. | | Ri | R |
| Limonia sp. | | Ri | R |
| Unidentified Tipulid | | Ri | R |
| Tabanidae | Horseflies | | |
| Tabanus sp. | | Ri | R |
| Empididae | | | |
| Hemerodromia sp. | | Ri | R |
| Ephydridae | | U | R |
| Coleoptera | Beetles | | |
| Curculionidae | Snout beetles | U | R |
| Hydraenidae | | U | R |
| Psephenidae | Riffle beetles | | |
| Psephenus herricki | | Ri | O |
| Melyridae | | U | R |
| Elmidae | | | |
| Stenelmis sp. | | P,Ri | O |
| Dubiraphia sp. | | Ri | R |

**TABLE A.8**

**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Hymenoptera | Bees, Wasps | | |
| Scelionidae | | U | R |
| Trichoptera | Caddisflies | | |
| Lemnephilidae | | U | R |
| Psychomyiidae | | U | C |
| Agraylea sp. | | | |
| Hydropsychidae | | | |
| Cheumatopsyche sp. | Caddisfly | Ri | A |
| Hydropsyche sp. | Caddisfly | Ri | C |
| Helicopsychidae | | | |
| Helicopsyche sp. | | Ri | I |
| Philopotamidae | | | |
| Chimarra obscura | | Ri | R |
| Rhyacophilidae | | | |
| Rhyacophila sp. | | Ri | O |
| Polycentropodidae | | U | O |
| Ephemeroptera | Mayflies | | |
| Caenidae | | | |
| Caenis sp. | Mayfly | P,Ri | A |
| Ephemeridae | | U | R |
| Siphonuridae | | U | R |
| Heptageniidae | | | |
| Stenonema bipunctatum | Mayfly | P,Ri | C |
| Stenacron sp. | | Ri | R |

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**TABLE A.8**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Baetidae | | | |
| Baetis sp. | | P | R |
| Pseudocleon sp. | | Ri | R |
| Oligoneuriidae | | | |
| Isonychia sp. | | | |
| Hemiptera | True Bugs | | |
| Microvelia sp. | | U | U |
| Plecoptera | Stoneflies | | |
| Capniidae | | | |
| Allocapnia sp. | Stonefly | P,Ri | A |
| Leuctridae | | U | R |
| Nemouridae | Stonefly | Ri | O |
| Perlodidae | | | |
| Isoperla sp. | | Ri | O |
| Chloroperlidae | | | |
| Alloperla sp. | | Ri | R |
| Taeniopterygidae | | | |
| Taeniopteryx sp. | | Ri | R |
| Lepidoptera | Butterflies, Moths | | |
| Lymnaeide | | U | R |
| Amphipoda | Scuds, Sideswimmers | | |
| Talitridae | | | |
| Hyalella azteca | | P,Ri | R |

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**TABLE A.8**
**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Decapoda | Crayfish, Shrimp | | |
| Astacidae | Crayfish | | |
| Orconectes rusticus | | Ri | R |
| O. sloanii | Cincinnati crayfish | P | C |
| Gastropoda | Snails, Limpets | | |
| Physidae | Pouch snails | | |
| Physa sp. | | P,Ri | C |
| Ancylidae | Limpets | | |
| Ferrissia sp. | | P,Ri | R |
| Pelecypoda | Clams, mussels | | |
| Sphaerium sp. | Fingernail clams | U | U |
| Turbellaria | Flatworms | | |
| Planariidae | Planaria | | |
| Dugesia sp. | | Ri | R |
| Oligochaeta | Aquatic earthworms | P,Ri | C |
| Nematoda | Nematodes | U | O |
| Nematomorpha | Horsehair worms | Ri | R |
| Arachnida | | | |
| Hydracarina | | U | R |
| Collembola | Springtails | Ri | R |
| Sminthuridae | | U | R |
| Megaloptera | Alderflies, Dobsonflies, Fishflies | | |
| Sialidae | Alderflies | | |
| Sialis sp. | | Ri | R |

**TABLE A.8**

**(Continued)**

| Scientific Name | Common Name | Habitat[b] | Relative[c] Abundance |
|---|---|---|---|
| Isopoda | Aquatic Sow Bugs | | |
| Asellidae | | | |
| Lirceus fontinalis | Isopod | P,Ri | C |

[a] Adapted from Facemire et al. (1990) and Pomeroy et al. (1977).

[b] P = Pool
Ri = Riffle
U = Unknown

[c] R = Rare, very seldom seen or collected
O = Occasional, seen or collected a few times
C = Common, seen regularly
A = Abundant, very numerous
U = Unknown
I = Incidental sighting

Terminology is that of Facemire et al. (1990)

## TABLE A.9

## BENTHIC MACROINVERTEBRATES COLLECTED ON ARTIFICIAL SUBSTRATE SAMPLERS FROM THE GREAT MIAMI RIVER[a]

| Scientific Name | Common Name | Relative[b] Abundance |
|---|---|---|
| Porifera | Sponges | |
| Spongilla fragilaris | | P |
| Turbellaria | Flatworms | |
| Unidentified | | P |
| Bryozoa | Moss animalcules | |
| Plumatella repens | | R |
| Urnatella gracilis | | R |
| Annelida | Aquatic Earthworms, Leeches, Polychaetes | |
| Oligochaeta | Aquatic earthworms | |
| Helobdella sp. | | P |
| Dina sp. | | P |
| Isopoda | Aquatic Sow Bugs | |
| Lirceus sp. | Isopod | P |
| Ephemeroptera | Mayflies | |
| Stenacron sp. | | O |
| Stenonema pulchellum (A) | | C |
| Stenonema pulchellum (B) | | C |
| Stenonema pulchellum (C) | | A |
| Stenonema femoratum | | P |
| Heptagenia sp. | | P |
| Baetis sp. | | O |
| Tricorythodes sp. | | O |
| Isonychia sp. | | O |
| Odonata | Dragonflies, Damselflies | |
| Argia sp. | | R |
| Agnon sp. | | P |

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**TABLE A.9**

**(Continued)**

| Scientific Name | Common Name | Relative[b] Abundance |
|---|---|---|
| Trichoptera | Caddisflies | |
| Cheumatopsyche sp. | | O |
| Potamyia sp. | | C |
| Symphitopsyche bifida | | P |
| Hydropsyche orris | | A |
| Hydropsyche bidens | | O |
| Hydropsyche valanis | | O |
| Hydropsyche venularis | | P |
| Hydropsyche simulans | | A |
| Ceraclea sp. | | P |
| Chimarra obscura | | P |
| Coleoptera | Beetles | |
| Stenelmis sp. | | R |
| Dubiraphia sp. | | R |
| Psephenus herricki | Riffle beetle | P |
| Dytiscus sp. | Predaceous diving beetles | P |
| Diptera | Flies, Mosquitoes, Midges | |
| Tipula sp. | | P |
| Pentaneura sp. | | C |
| Tendipedinae | Midges | P |
| Polypedilum illinoense | | C |
| Polypedilum fallax | | O |
| Polypedilum scalaenum | | O |
| Glyptotendipes sp. | | P |
| Cryptochironomus sp. (A) | | P |
| Cryptochironomus sp. (B) | | O |
| Xenochironomus sp. | | P |
| Calopsectra rheotanytarsus | | C |
| Corynoneura sp. | | R |
| Ceratopogonidae | Biting Midges | P |
| Empididae | | O |

TABLE A.9

(Continued)

| Scientific Name | Common Name | Relative[b] Abundance |
|---|---|---|
| Gastropoda | Snails, Limpets | |
| Ferrissia sp. | Limpets | R |
| Goniobasis livescens | River snail | P |
| Pelecypoda | Clams, Mussels | |
| Sphaerium sp. | Fingernail clams | P |

[a] Adapted from OEPA (1982) for River Segments 10-11; data collected in 1980.

[b] P = Present Collected in dredge (qualitative) sample only.
R = Rare < 10 individuals on any one artificial substrate sampler.
O= Occasional 10-50 individuals on any one artificial substrate sampler.
C= Common 50-500 individuals on any one artificial substrate sampler.
A= Abundant > 500 individuals on at least one artificial substrate sampler.

Artificial substrate samplers were placed at River Miles 24.8, 22.5, 15.1, 9.5, and 8.2 from July 7, 1980 to September 3, 1980. River Mile 24.8 is 0.7 miles upstream of the FEMP effluent line.

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## REFERENCES

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# APPENDIX B

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# APPENDIX B

# DELINEATION OF JURISDICTIONAL WETLANDS AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

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## LIST OF ACRONYMS

| | |
|---|---|
| ASI | Advanced Sciences, Inc. |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| COE | U.S. Army Corps of Engineers |
| CWA | Clean Water Act |
| EPA | U.S. Environmental Protection Agency |
| FICWD | Federal Interagency Committee for Wetland Delineation |
| FEMP | Fernald Environmental Management Project |
| FWS | U.S. Fish and Wildlife Service |
| IT | International Technology Corporation |
| NEPA | National Environmental Policy Act |
| NWI | National Wetlands Inventory |
| SCS | Soil Conservation Service of the U.S. Department of Agriculture |
| SSOD | Storm Sewer Outfall Ditch |
| USGS | U.S. Geological Survey |
| WEMCO | Westinghouse Environmental Management Company of Ohio |
| WMCO | Westinghouse Materials Company of Ohio |

# EXECUTIVE SUMMARY



The Fernald Environmental Management Project (FEMP) is a contractor-operated federal facility which formerly produced pure uranium metals for the U.S. Department of Energy (DOE). Production was suspended in mid-1989 and permanently ended in 1990. In April 1990, DOE signed a Consent Agreement with the U.S. Environmental Protection Agency (EPA) under Sections 120 and 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) concerning environmental impacts associated with the FEMP. Pursuant to the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS environmental impact statement (RI/FS - EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major federal actions.

Section 121 of CERCLA requires that remedial actions at hazardous waste sites meet the substantive, but not the administrative or permitting requirements of other federal and state environmental laws, including the Clean Water Act (CWA). Section 404 of CWA prohibits discharge of dredge or fill material into any waters of the United States, including wetlands, without a permit from the U.S. Army Corp of Engineers. Additionally, Executive Order (E.O.) 11990, Protection of Wetlands, requires federal agencies to

> avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative...

Where no practicable alternative exists, proposed actions must include "all practicable measures to minimize harm to wetlands which may result from such use." 10 CFR 1022 also requires DOE to formally assess impacts of any actions which may affect wetlands or floodplains. In order for remedial activities at the FEMP to meet the substantive requirements of these regulations, it was necessary to identify and delineate the jurisdictional wetlands at the FEMP, as defined by the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (FICWD 1989).

Jurisdictional wetlands are identified by the presence of hydric soils, hydrophytic vegetation, and wetlands hydrology. Hydric soils have the seasonal high water table within six inches of the surface for at least one week during the growing season, and typically become depleted of oxygen as a result. Hydrophytic plants can grow in water or in soils at least periodically depleted of oxygen due to water saturation, and may be restricted to wetlands (obligate) or able to grow in both wetlands and uplands (facultative). Wetland hydrology is defined as permanent or periodic inundation or soil saturation for a week or more during the growing season. All three criteria must be met for an area to be classified as a jurisdictional wetland.

Wetlands within FEMP boundaries were identified and delineated using the "off-site" method described by FICWD (1989), supplemented by an on-site field reconnaissance. "Off site," as used by FICWD (1989) and in this report, refers to activities conducted at a location physically removed from the FEMP, as distinct from the CERCLA definition meaning outside the contaminated area. Similarly, "on site" as used here refers to activities conducted in the field, within FEMP boundaries. Areas adjacent to the FEMP meeting the CERCLA definition of "on site," but lying outside FEMP boundaries, were excluded from the scope of the present wetlands identification and delineation. The off-site delineation method provides approximate wetland boundaries (FICWD 1989) and was considered appropriate for the FEMP due to its large size (approximately 1050 acres) and to the availability of site-specific vegetation and soils information.

The off-site delineation included review of U.S. Geological Survey topographical information, Soil Conservation Service (SCS) soils maps, aerial photographs, the vegetation and habitat descriptions of the FEMP compiled by Facemire et al. (1990), and RI/FS soil boring logs. Results of the off-site procedure were used to target areas with potential wetlands for a limited on-site field reconnaissance. This reconnaissance was conducted in April 1990 to verify the presence or absence of wetlands in specific areas and to establish the approximate wetland/upland boundary. At their lower boundary, wetlands often border "other waters of the United States," which are also regulated by CWB. When this occurs, the two are not typically delineated separately. Other waters of the United States within FEMP boundaries were identified separately only in the case of unvegetated streams not bordered by wetland.

Results of the off-site delineation indicated that the field reconnaissance should focus on two areas, the wooded area north of the Production Area, which contains a deciduous woodlot and a pine plantation, and the riparian corridor associated with Paddys Run. According to the SCS soil surveys and hydric soils lists, one hydric soil series was present on the FEMP, to the north of the Production Area in portions of the deciduous woodlot and pine plantation areas. In addition, the dominant vegetation in one transect in the eastern portion of the deciduous woodlot was only marginally non-hydrophytic, and obligate wetland vegetation was present, although not dominant. As a result, this area was considered to have relatively high potential for the presence of wetlands. Although hydric soils were also mapped in the adjacent pine plantation, this area showed only limited wetlands potential. There were no hydrophytic species among the dominant plants in the transects, and nondominant obligate wetland vegetation was absent.

Although the soils in the riparian corridor along Paddys Run were mapped by the SCS as moderately well drained and well-drained upland soils, the two transects along Paddys Run characterized by Facemire et al. (1990) had hydrophytic dominant vegetation. Additionally, nondominant obligate wetland vegetation was present. These observations indicated that the field investigation should focus

on the riparian corridor along Paddys Run as well as the deciduous woodlot area.

In addition to these two areas, the field investigation included tributaries and drainage ditches emptying into Paddys Run, as well as portions of the Inactive Fly Ash Disposal Area (mapped as somewhat poorly drained soil with a marginally nonhydrophytic vegetation determination) and areas of somewhat poorly drained soils that showed only limited wetlands potential.

Results of the on-site field reconnaissance indicated that wetlands at the FEMP are limited to a small forested wetland of approximately 50 acres in the northern portion of the facility and emergent wetlands associated with tributaries and drainage ditches that feed into Paddys Run. Remedial actions affecting these areas would be subject to the substantive requirements of laws, regulations, and orders concerned with wetlands protection, including E.O. 11990. Paddys Run and the remainder of its tributaries, including the Storm Sewer Outfall Ditch, are characterized by unvegetated stream channels incised into surrounding uplands. These unvegetated stream channels do not meet the wetland criteria and would be classified as "other waters of the United States." As such, they would not be protected by E.O. 11990 or other wetlands regulations, but remedial actions affecting them would still be subject to the substantive requirements of the Clean Water Act.

# B.1.0 INTRODUCTION

## B.1.1 SITE DESCRIPTION AND HISTORY

An investigation was conducted in April 1990 to determine the extent and approximate boundaries of jurisdictional wetlands (defined in Chapter 2.0 below) within the boundaries of the Fernald Environmental Management Project (FEMP). The FEMP is a government-owned facility which formerly produced pure uranium metals. The facility is operated by Westinghouse Environmental Management Company of Ohio (WEMCO) for the U.S. Department of Energy (DOE). The FEMP is located on a 1050-acre site in a rural agricultural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler counties (Figure B.1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the Production Area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In April 1990, DOE signed a Consent Agreement with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sections 120 and 106(a), concerning environmental impacts associated with the FEMP. Pursuant to the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS environmental impact statement (RI/FS-EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major Federal actions.

## B.1.2 REQUIREMENTS FOR WETLANDS PROTECTION DURING REMEDIATION

Section 121 of CERCLA requires that remedial actions at hazardous waste sites meet the substantive, but not the administrative or permitting, requirements of other federal and state environmental laws, including the Clean Water Act of 1977 (CWA). Section 404 of CWA prohibits discharge of dredge or fill material into any waters of the United States, including wetlands, without a permit from the U.S. Army Corp of Engineers (COE). Additionally, Executive Order (E.O.) 11990, Protection of Wetlands, which was promulgated in 1977 in furtherance of NEPA, requires federal agencies to

> avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative...

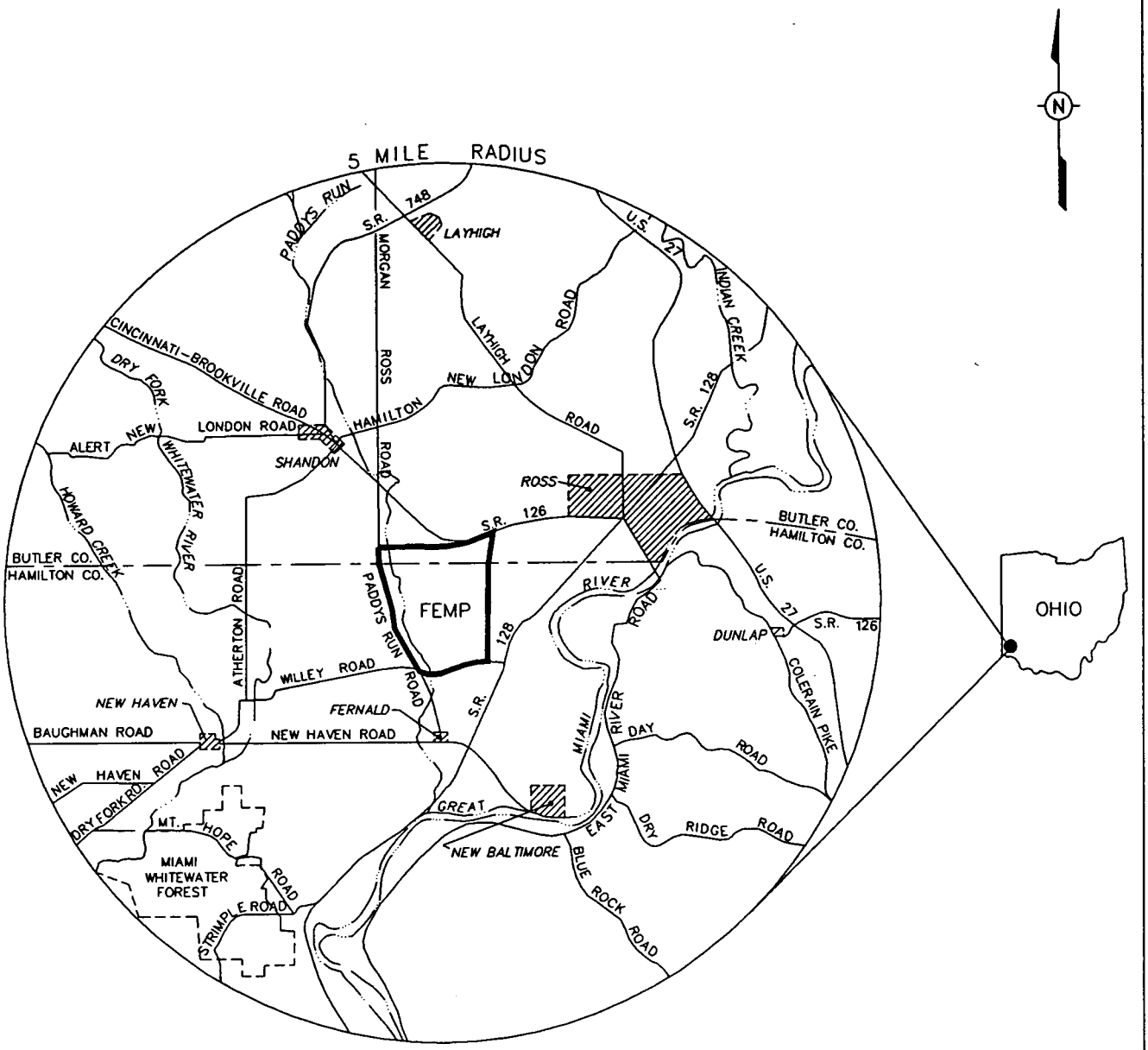


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FIGURE B.1-1. FIVE-MILE RADIUS MAP, FEMP

Where no practicable alternative exists, proposed actions must include "all practicable measures to minimize harm to wetlands which may result from such use." 10 CFR 1022 also requires DOE to formally assess impacts of any actions which may affect wetlands or floodplains. In order for remedial activities at the FEMP to meet the substantive requirements of these regulations, it was necessary to identify and delineate the jurisdictional wetlands at the FEMP. As specific remedial activities are defined in the future, this completed identification and delineation will provide a basis for determining whether wetlands exist and could be impacted by actions in proposed project areas.

### B.1.3 DEFINITION OF JURISDICTIONAL WETLANDS

#### B.1.3.1 COE and EPA Definitions

As stated above, Section 404 of CWA regulates the discharge of dredged or fill materials into any "waters of the United States," including wetlands. Although the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (FICWD 1989) does not completely define the term "waters of the United States," a definition is provided in the "Corps of Engineers Wetlands Delineation Manual" (Environmental Laboratory 1987), as follows:

> The term "waters of the United States" has broad meaning and incorporates both deep-water aquatic habitats and special aquatic sites, including wetlands (Federal Register 1982), as follows:
>
> a. The territorial seas with respect to the discharge of fill material.
>
> b. Coastal and inland waters, lakes, rivers, and streams that are navigable waters of the United States, including their adjacent wetlands.
>
> c. Tributaries to navigable waters of the United States, including adjacent wetlands.
>
> d. Interstate waters and their tributaries, including adjacent wetlands.
>
> e. All other waters of the United States not identified above, such as isolated wetlands and lakes, intermittent streams, prairie potholes, and other waters that are not a part of a tributary system to interstate waters or navigable waters of the United States, the degradation or destruction of which could affect interstate commerce.
>
> ....The U. S. Environmental Protection Agency (EPA) identifies six categories of special aquatic sites in their Section 404 b.(1) guidelines (Federal Register 1980), including:
>
> a. Sanctuaries and refuges
> b. Wetlands
> c. Mudflats
> d. Vegetated shallows
> e. Coral reefs
> f. Riffle and pool complexes

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Although Section 404 thus regulates a broad range of habitats under the term "waters of the United States," much recent attention has been focused on wetlands, which form a transitional area between terrestrial and aquatic ecosystems. For the purpose of administering the Section 404 permit program, COE and EPA define the term "wetlands" as follows (FICWD 1989):

> Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, bogs, marshes, and similar areas (EPA, 40 CFR 230.3 and COE, 33 CFR 328.3).

For an area to be defined as a wetland, the area must exhibit all of the following characteristics under normal circumstances:

1. The land supports predominantly hydrophytes;
2. The substrate is predominantly undrained hydric soil; and
3. The substrate is saturated with water or covered with shallow water for a prolonged period during the growing season, resulting in a wetlands hydrologic regime.

B.1.3.2 Hydrophytic Vegetation

A hydrophyte is any plant with the ability to grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content and depleted soil oxygen levels. A national list of wetland plants has been prepared by the U. S. Fish and Wildlife Service (FWS) (Reed 1988).

B.1.3.3 Hydric Soils

Hydric soils are very poorly drained, poorly drained, or somewhat poorly drained soils with the seasonal high water table within six inches of the surface for a significant period during the growing season (FICWD 1989). Prolonged saturation and anaerobic soil conditions during the growing season lead to the development of a variety of characteristic field indicators. These indicators include the presence of organic soils such as peats and mucks, soils emitting an odor of hydrogen sulfide, and gleyed, low chroma, or low chroma mottled soils immediately below the B-horizon, the surface layer of soil characterized by an accumulation of organic material (FICWD 1989). Gleying is recognized by characteristic bluish, greenish, or grayish soil colors. Chroma, one of the three variables of color, is a measure of the relative purity or saturation of a color. For hydric mineral soils, the horizon immediately below the B-horizon is usually characterized by a matrix chroma of 2 or less in mottled soils, or a matrix chroma of 1 or less in unmottled soils. The Soil Conservation Service (SCS), in

cooperation with the National Technical Committee for Hydric Soils, has prepared a national list of hydric soils (SCS 1987). In some cases state and county hydric soil lists are also available.

B.1.3.4 Wetlands Hydrology

A wetland hydrologic regime is defined as a permanent or periodic inundation or soil saturation for a significant period, usually a week or more, during the growing season. Field indicators include: inundation, soil saturation, water marks, drift lines, surface scouring, oxidized channels associated with living roots and rhizomes, water-stained leaves, morphological plant adaptations such as buttressed tree trunks and shallow root systems, and hydric soil characteristics such as mottling (FICWD 1989).

B.1.3.5 Disturbed and Problem Areas

Disturbed and problem areas present two cases in which an area may be classified as a wetland without meeting all three criteria (FICWD 1989). In disturbed areas, one or more of the criteria may not be met as the result of recent change resulting from human activities or catastrophic natural events. In problem areas, field indicators of one or more of the criteria may be lacking for all or part of the year due to normal environmental conditions, for example, highly variable seasonal wetlands that lack hydrophytic vegetation during the drier portion of the growing season.

# B.2.0 METHODOLOGY

Wetlands within FEMP boundaries were identified using the off-site determination method described by FICWD (1989), supplemented by an on-site field reconnaissance. "Off site," as used by FICWD (1989) and in this report, refers to activities conducted at a location away from the FEMP, as distinct from the CERCLA definition meaning outside the contaminated area. Similarly, "on site" as used here refers to activities conducted in the field, within FEMP boundaries. Areas adjacent to the FEMP meeting the CERCLA definition of "on site," but lying outside FEMP boundaries, were excluded from the scope of the present wetlands identification and delineation.

The off-site wetlands identification method is based on the review of U.S. Geological Survey (USGS) topographical information, National Wetland Inventory (NWI) maps (if they exist), SCS soil surveys, aerial photographs, and site-specific vegetation, soils, and/or hydrological information. The method provides approximate wetland boundaries based on available information, and was an appropriate method to use in the present study because of the large size of the FEMP (approximately 1050 acres) and the availability of site-specific vegetation and soils information. Compilation of available FEMP-specific data and preparation of an approximate wetland boundary map were especially important since an NWI map has not been completed for the area surrounding the FEMP.

The off-site method was also used to provide a focus for a limited on-site field reconnaissance of wetlands at the FEMP. This field investigation was used to verify the presence or absence of wetlands in specific areas and to locate an approximate upland/wetland boundary. The boundary between wetlands and neighboring other waters of the United States, which would be the lower wetland boundary, is not typically delineated separately (FICWD 1989). In the present study, other waters of the United States were identified separately only in the case of unvegetated streams not bordered by wetlands.

## B.2.1 TOPOGRAPHICAL INFORMATION

The Shandon, Ohio Quadrangle of the USGS 7.5 minute series was reviewed for information on the FEMP's hydrology. The presence and location of lakes, streams, ponds, and swamps on the FEMP were noted. Maximum and minimum site elevations were obtained from the 1987 Environmental Monitoring Report (WEMCO 1988).

## B.2.2 SCS SOILS INFORMATION

The SCS soil surveys of Butler and Hamilton counties (SCS 1980, 1982) were reviewed in conjunction with the national (SCS 1987c), state (SCS 1987d), and county (SCS 1987a, b) hydric soils lists. Hydric soils, as well as somewhat poorly drained soils, which may prove hydric in the field, were noted on a CAD base map of the FEMP as areas to be field checked.

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## B.2.3 SITE-SPECIFIC INFORMATION

### B.2.3.1 Vegetation

Site-specific vegetation data were collected at the FEMP by Facemire et al. (1990) during the summer of 1986 and the spring of 1987. This sampling was part of a larger study designed to provide a quantitative analysis of community structure in the major ecological habitats at the FEMP. For the present study, these data were reviewed and analyzed in a wetlands context, as described below.

During 1986 and 1987, Facemire et al. (1990) collected vegetation data along eleven 600-meter transects distributed among six habitat types -- riparian, deciduous woodlots, pine plantations, reclaimed fly ash pile, and grazed and ungrazed pastures. The "reclaimed fly ash pile" is referred to in RI/FS reports as the Inactive Fly Ash Disposal Area, and this usage is substituted for that of Facemire et al. (1990) below. The number of transects within each habitat was allocated in proportion to the area of each habitat type, estimated from an aerial photograph. A stratified random procedure was used to establish the beginning of each transect to assure adequate coverage of each area. Transects were laid out by compass and transit, flagged, and mapped.

Herbaceous vegetation was sampled during the summer of 1986 and the spring of 1987 using a focal-point sampling procedure supplemented by foot surveys. With the focal-point sampling procedure a sighting scope was used to pick out individual plants (or non-living ground cover) visible at one-meter intervals along each transect. Relative cover and herbaceous community structure indices were then calculated from these data.

Woody vegetation was sampled during the summer of 1986 (Facemire et al. 1990). The deciduous habitats (riparian, deciduous woodlots, and Inactive Fly Ash Disposal Area) were sampled using 0.04-hectare tree plots and 0.004-hectare shrub plots, centered within the tree plots. Frequency, density, and dominance (diameter at breast height) data were collected for both trees and shrubs. Relative frequency, density, and dominance were used to calculate importance values for the trees, and frequency and density data were used to calculate community indices for the shrubs. For the pine plantations, seven stratified random, 0.25-hectare rectangular plots were laid out on an aerial photograph to determine tree frequency, density and dominance. Species of individual trees were identified on the basis of color. Selected trees on the photograph were ground-truthed to confirm species identification. The shrub community was not sampled in the pine plantations because of high tree density and inaccessibility. Woody vegetation in the pastures was extremely sparse and was not sampled. The tables reporting the tree and shrub data in Facemire et al. (1990) stated common names only. For the wetland study, the scientific names of woody plants were assigned by checking both the catalogue of species provided at the end of the Facemire report and common field guides (Little 1980, Petrides 1972). Additional details of the methods used by Facemire et al. may be obtained by referring to the 1990 report (Facemire et al. 1990).

Although the vegetation data reported by Facemire et al. (1990) were not collected for the purpose of making wetland determinations, they do provide site-specific information relevant to wetlands identification. These data were used for wetlands identification in two ways: to determine the dominant plant species (or taxa) for each transect (as defined by FICWD (1989), and to identify any additional non-dominant obligate wetland plant species recorded on the FEMP. The dominant plant species were used to determine whether the hydrophytic vegetation criterion was met for each transect.

To determine the dominant taxa, a dominance measure was established for each vegetation layer sampled, that is, the tree, shrub, and herbaceous layers. The "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (FICWD 1989) suggests establishment of dominance measures based on relative basal area, areal cover, or stem density. In the present case, the dominance measure varied among the layers, since different types of information were provided by Facemire et al. (1990) for different layers. For the tree layer, importance percentages given in Facemire et al. (1990) were used as the dominance measure. These importance percentages were based on relative frequency, relative density, and relative dominance (Facemire et al. 1990). For the shrub layer, density data were used to calculate the dominance measure as follows:

$$\frac{\text{Density of shrub species in transect}}{\text{Total density of all shrub species in transect}} \times 100.$$

The dominance measure for the herbaceous layer (ground cover) was calculated using the relative percent cover data as follows:

$$\frac{\text{Relative percent cover of ground cover species in transect}}{\text{Total percent cover of all ground cover species in transect}} \times 100.$$

The calculations performed on the shrub and ground cover data were designed to show the percentage of the vegetation within each stratum contributed by each species. Within each stratum, the sum of the dominance measures for all taxa equals 100 percent.

The methods described in FICWD (1989) were used to determine the dominant species or taxa for each stratum of each transect, based on the above dominance measures. Within each stratum of each transect, taxa were ranked by dominance measure in descending order. Dominant taxa were taken as those taxa for which the cumulative total dominance immediately exceeded 50 percent of the total dominance measure for the stratum, plus any additional species comprising 20 percent or more of the total dominance measure.

To determine whether the hydrophytic vegetation criterion was met for each transect, the wetland indicator status was recorded for each dominant species using the "National List of Plant Species that

Occur in Wetlands: National Summary" (Reed 1988). This list is described by the FICWD (1989) as follows:

> The list separates vascular plants into four basic groups, commonly called "wetland indicator status," based on a plant species' frequency of occurrence in wetlands: (1) obligate wetland plants (OBL) that occur almost always (estimated probability >99%) in wetlands under natural conditions; (2) facultative wetland plants (FACW) that usually occur in wetlands (estimated probability 67-99%), but occasionally are found in non-wetlands; (3) facultative plants (FAC) that are equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%); and (4) facultative upland plants (FACU) that usually occur in non-wetlands (estimated probability 67-99%), but occasionally are found in wetlands (estimated probability 1-33%). If a species occurs almost always (estimated probability >99%) in non-wetlands under natural conditions, it is considered an obligate upland plant (UPL). These latter plants do not usually appear on the wetland plant list; they are listed only when found in wetlands with a higher probability in one region of the country. If a species is not on the list, it is presumed to be an obligate upland plant. The "National List of Plant Species That Occur in Wetlands" has been subdivided into regional and state lists.

A positive (+) sign is used with the facultative indicator categories to indicate a tendency towards the wetter end of the category, and a negative (-) sign is used to indicate a tendency towards the drier end of the category (Reed 1988). For the purposes of making hydrophytic vegetation determinations, however, FICWD (1989) does not recognize all of these subcategories -- FACW+ and FACW- are grouped with FACW, and FAC+ is grouped with FAC.

In the terminology of Reed (1988), the FEMP is located in the Northeast Region (Region 1); each indicator status used in this study was that for Region 1. Not all plants in the Facemire data (Facemire et al. 1990) were identified to species. Where plants were identified only to genus, Reed (1988) was consulted. If the genus did not appear on the list, it was assumed that the genus consists only of obligate upland plants (UPL); if the genus appeared on the list and the indicator status varied with species, assigning an indicator status at the genus level was considered inappropriate.

The hydrophytic vegetation determination for each transect was made by calculating the percentage of dominant species (from all layers combined) with an indicator status of FAC or wetter. A determination of hydrophytic was made for those transects in which the proportion of dominant species FAC or wetter exceeded 50 percent; a determination of non-hydrophytic was made for those transects in which the proportion of dominant species FAC or wetter was 50 percent or less (FICWD 1989). Since ground cover data were collected twice, in the summer of 1986 and in the spring of 1987, vegetation determinations were calculated twice for each transect, once using the spring ground cover data, and once using the summer ground cover data. Although the hydrophytic vegetation

determination is based on the dominant taxa, the indicator status was also determined for each non-dominant species, and obligate wetland species (OBL) were noted.

Results of the site-specific vegetation information review were used in conjunction with other existing information, such as SCS soils maps and the USGS topographic map, to determine areas to be targeted for the field investigation. Extra care was taken during the field investigation of areas where existing vegetation and soils data were contradictory, for example hydric soils and nonhydrophytic vegetation, and where transect data recorded obligate wetland species.

B.2.3.2 Soils

Site-specific soil profile data recorded from soil borings taken during the RI/FS were reviewed to establish whether these data contained soil chroma and saturation information relevant to an off-site wetlands determination. Soils and hydrology information provided by chroma and saturation data, if relevant, would be used in conjunction with SCS soils maps and site-specific vegetation data, to focus the field investigation.

B.2.3.3 Hydrology

During the off-site investigation, site-specific aerial photographs (Sitton 1988) and the USGS topographic maps were reviewed to obtain information regarding hydrology at the FEMP. The presence and location of lakes, streams, ponds, and swamps on the FEMP were noted as described above in Chapter 2.1. Aerial photographs, as received, were marked with the location and direction of flow of water bodies and water courses, and were reviewed for the presence of impoundments, flooded pastures, and changes in water courses, ditches, and ponds over the period covered by the photographs (1950 to 1988).

B.2.3.4 Aerial Photographs

As described above, a set of eight aerial photographs interpreted by the EPA's Environmental Photographic Interpretation Center (Sitton 1988) was reviewed during the wetlands investigation. The date and scale of each photograph appears in Table B.2-1. The photographs, collected from a variety of agencies, were reviewed and analyzed by Sitton (1988) for waste pits, sludge ponds, drums, fill areas, disturbed areas, tanks, impoundments, staining, and trenches in order to determine past disposal practices and locations. For the purposes of wetlands identification, the photographs were reviewed to establish whether they provide useful information on hydrophytic vegetation, flooded pasture, and stressed crops, an indicator of soil saturation. Locations and directions of flow of water bodies and water courses, as well as changes in water courses, ditches, and ponds during the period covered by the photographs, were noted as described above.

**TABLE B.2-1**
**AERIAL PHOTOGRAPHS**
**FEED MATERIALS PRODUCTION CENTER**

| Title | Date | Approximate Scale | Original Scale |
|---|---|---|---|
| Figure 2, FMPC | October 13, 1950 | 1:9,000 | 1:20,000 |
| Figure 4, DOE Feed Materials | March 21, 1957 | 1:4,200 | 1:26,000 |
| Figure 6, DOE Feed Materials | April 15, 1964 | 1:5,700 | 1:24,000 |
| Figure 7, FMPC | September 12, 1968 | 1:6,500 | 1:20,000 |
| Figure 8, FMPC | May 20, 1976 | 1:5,600 | 1:38,000 |
| Figure 9, FMPC | May 10, 1983 | 1:7,200 | 1:40,000 |
| Figure 10, DOE Feed Materials | April 20, 1988 | 1:6,800 | Not Stated |
| Figure 11, FMPC, Production Area | April 20, 1988 | 1:2,600 | 1:6,000 |

SOURCE: Sitton, M.D., September 1988, "Site Analysis, Feed Materials Production Center, Fernald, Ohio, Interim Report," TS-PIC-88088, The Bionetics Corp., Warrenton, VA., prepared for the U.S. Environmental Protection Agency, Environmental Photographic Interpretation Center, Warrenton, VA.

B.2.4 ON-SITE FIELD RECONNAISSANCE

The purpose of the field reconnaissance was to confirm the presence of wetlands and to determine approximate wetland boundaries, based on the three wetlands criteria described above and in FICWD (1989). This limited field investigation, conducted during April 1990, focussed on those areas where soils, vegetation, and/or hydrological data (derived from the topographical maps and aerial photographs) indicated a potential for the presence of wetlands. The specific areas investigated were a hydric soil area in the deciduous woodlots and pine plantation north of the Production Area, the riparian areas along Paddys Run, and the Inactive Fly Ash Disposal Area. Areas with somewhat poorly drained soils were also examined.

Dominant plants in each area investigated were estimated visually, and a hydrophytic vegetation determination was made where the proportion of dominants FAC or wetter exceeded 50 percent. Soil borings were taken by hand auger and the profiles were reviewed using a Munsell chart to determine the colors of matrix and mottles. A hydric soil determination was made on the basis of soil colors and other field indicators. A wetland hydrology determination was made based on field indicators such as surface scouring and drift lines. If all three criteria were satisfied, the area was mapped as wetland on

the most recent aerial photograph (April 1988), which was also used for orientation and as a base map during the field investigation. Upland/wetland boundaries were determined on the basis of changes in the vegetation, soils, or hydrologic indicators, and their approximate locations were sketched onto the aerial photograph in the field. Photographs taken during the field investigation to illustrate wetlands and uplands at the FEMP are reproduced in Attachment B-I.

# B.3.0 RESULTS

## B.3.1 REVIEW OF TOPOGRAPHICAL INFORMATION

The FEMP site is situated on a relatively level plain, about 580 feet above mean sea level (MSL) (Figure B.3-1). The land rises to 698 feet MSL at the northern boundary and slopes downward to 551 feet MSL at Paddys Run along the western boundary (WMCO 1988). Paddys Run and its tributaries are well incised into the landscape and show signs of severe erosion. Paddys Run flows towards the south and drains into the Great Miami River. The Great Miami River, which also flows in a southerly direction, is located 0.6 mile east and south of the FEMP. There are numerous drainage ditches throughout the FEMP reservation, with the majority of them eventually flowing into Paddys Run. Drainage ditches and other water courses and water bodies are shown on the FEMP map which appears in Figures B.3-3, B.3-5, and B.3-6. Drainages and water bodies by definition exhibit wetlands hydrology and were therefore potential wetlands or other waters of the United States based on this criterion.

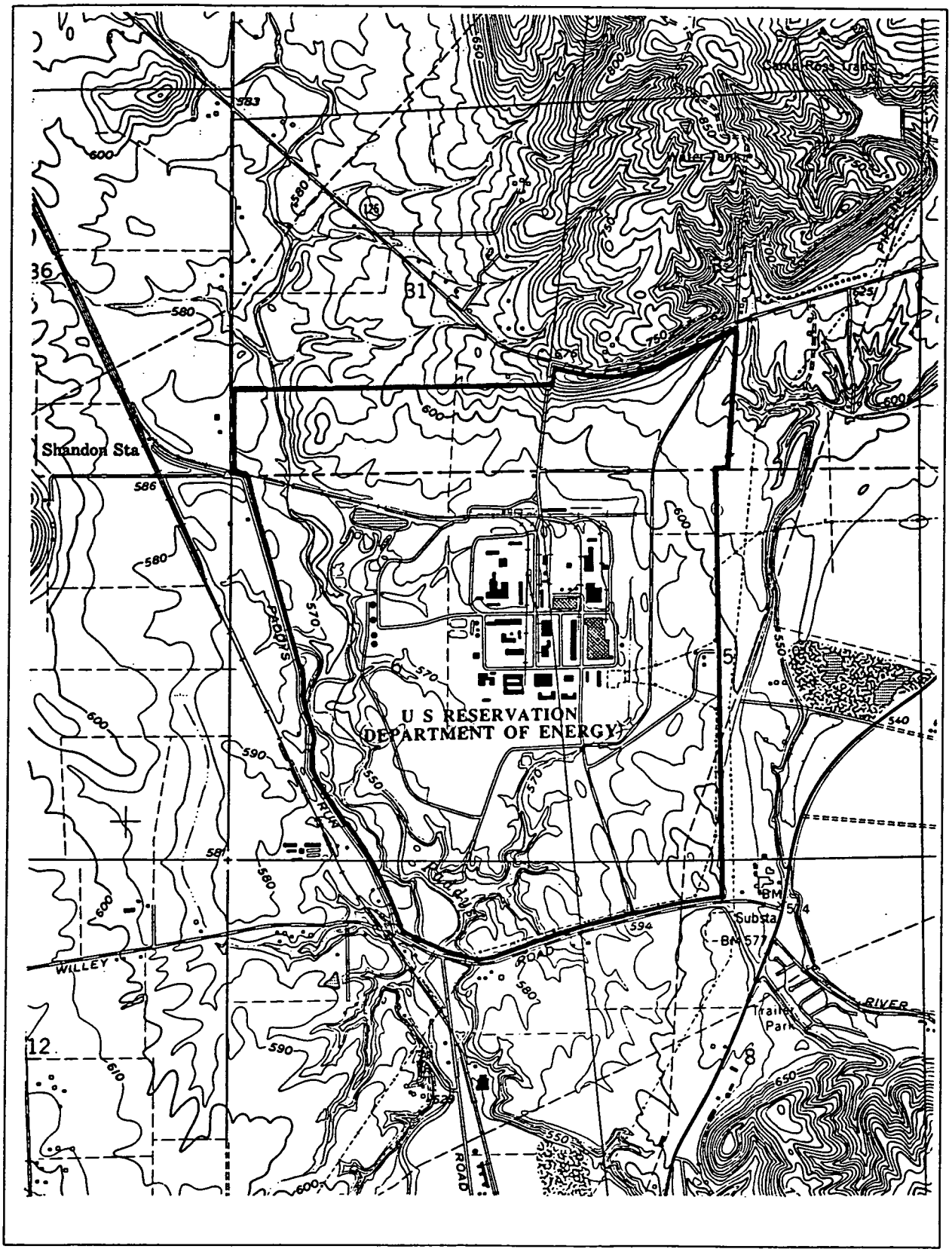
## B.3.2 REVIEW OF SCS SOILS INFORMATION

The Butler County and Hamilton County soil surveys have fifteen soil series mapped on site (Figure B.3-2). They are: Dana, Eden, Fincastle, Fox, Genesee, Hennepin, Henshaw, Markland, Martinsville, Miamian, Ragsdale, Raub, Russell, Uniontown, and Xenia. Table B.3-1 lists the symbol, name, slope, and drainage classification for each map unit that appears within the FEMP boundaries.

### B.3.2.1 Very Poorly Drained Soils

Of the fifteen soil series mapped within FEMP boundaries, only one appears on the national (SCS 1987c), state (SCS 1987d) or county (SCS 1987a and b) hydric soil lists. This very poorly drained soil, Ragsdale silty clay loam, is one of the two soils appearing on the hydric soil list for Butler County. The other soil, Patton silty clay loam, is not mapped for the site. The Hamilton County hydric soil list consists of two soils: Patton silty clay loam and Wakeland silt loam, occasionally flooded. Neither is mapped for the site.

Ragsdale silty clay loam is mapped for approximately 53 acres in the northern portion of the FEMP (Figures B.3-2, B.3-3). The Ragsdale soil series is nearly level, deep, and very poorly drained. It is usually located in long, narrow depressions or in shallow basins. This series has a slow permeation rate and a high available water capacity. The seasonal high water table is near the surface from December through May. These soils are associated with the drainage fingers and basin in the northern end of the FEMP. This area was targeted for inclusion in the field reconnaissance.



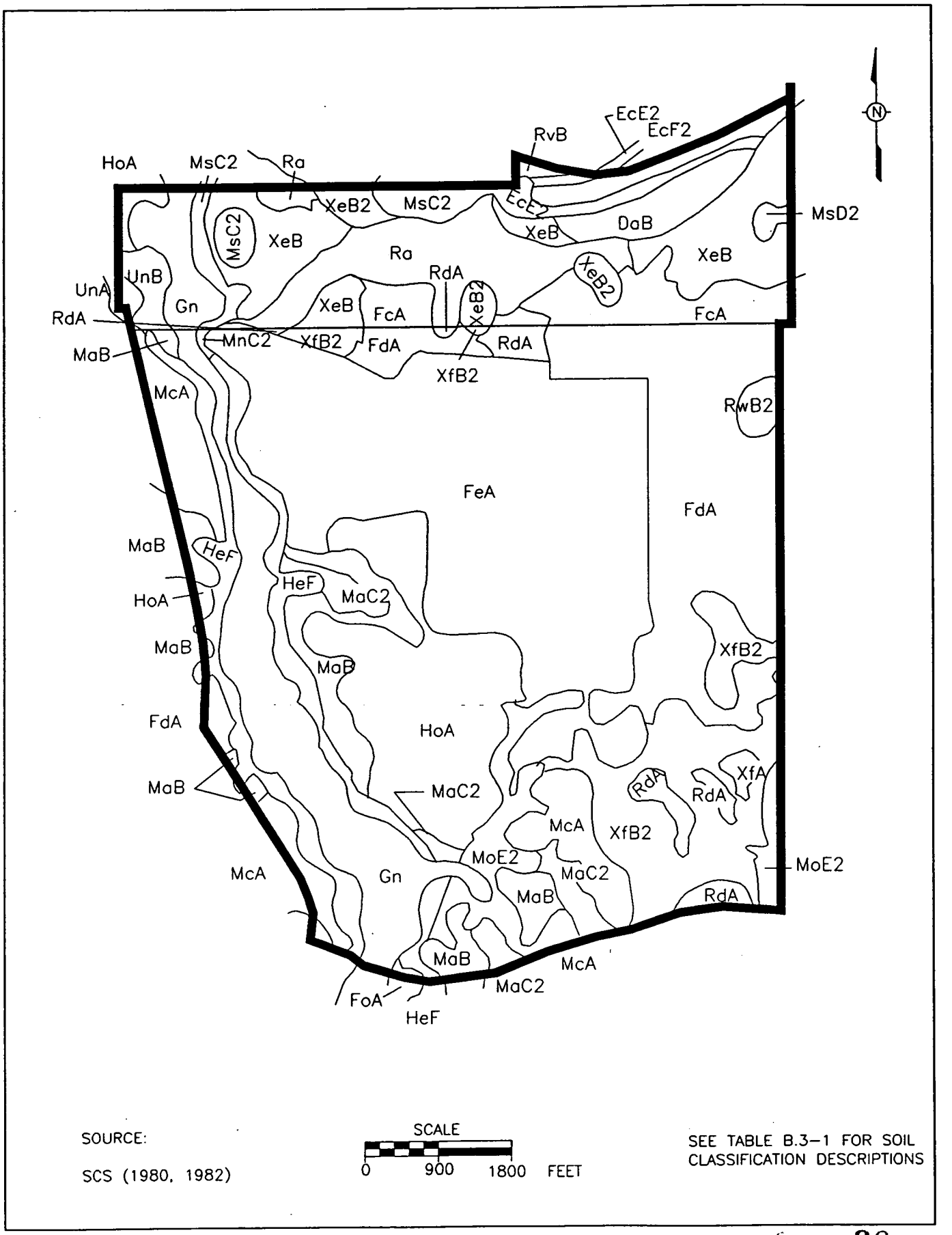

SOURCE:
USGS (1981)
SHANDON, OHIO
QUADRANGLE

SCALE
1:24,000



FIGURE B.3-1. TOPOGRAPHIC MAP OF THE FEMP

602.A_TOPO_EIS_FND




SOURCE:

SCS (1980, 1982)

SCALE

0 900 1800 FEET

SEE TABLE B.3-1 FOR SOIL CLASSIFICATION DESCRIPTIONS

313327.A_WTLNSOIL_SCR_CIN

FIGURE B.3-2. FEMP SOILS MAP

**TABLE B.3-1**
**SCS SOILS DRAINAGE CLASSIFICATIONS**
**FEED MATERIALS PRODUCTION CENTER**

| Symbol | Name | Slopes (%) | Drainage Classification |
|---|---|---|---|
| DaB | Dana silt loam | 2-6 | Moderately well drained |
| EcE2 | Eden silty clay loam | 15-25 | Well drained |
| EcF2 | Eden silty clay loam | 25-50 | Well drained |
| FcA and FdA | Fincastle silt loam | 0-2 | Somewhat poorly drained |
| FeA | Fincastle-Urban land complex | 0-2 | Somewhat poorly drained |
| FoA | Fox loam | 0-2 | Well drained |
| Gn | Genesee loam | 0-2 | Well drained |
| HeF | Hennepin silt loam | 35-60 | Well drained |
| HoA | Henshaw silt loam | 0-2 | Somewhat poorly drained |
| MaB | Markland silty clay loam | 2-6 | Moderately well drained |
| MaC2 | Markland silty clay loam | 6-12 | Moderately well drained |
| McA | Martinsville silt loam | 0-2 | Well drained |
| MnC2 | Miamian silt loam | 8-15, eroded | Well drained |
| MoE2 | Miamian-Hennepin silt loams | 25-35, eroded | Well drained |
| MsC2 | Miamian-Russell silt loams | 2-6 | Well drained |
| MsD2 | Miamian-Russell silt loams | 12-18, moderately eroded | Well drained |
| Ra | Ragsdale silty clay loam | level | Very poorly drained |
| RdA | Raub silt loam | 0-2 | Somewhat poorly drained |
| RvB | Russell-Miamian silt loams | 2-6 | Well drained |
| RwB2 | Russell silt loam | 3-8, eroded | Well drained |
| UnA | Uniontown silt loam | 0-2 | Well drained |
| UnB | Uniontown silt loam | 2-6 | Well drained |
| XeB | Xenia silt loam | 2-6 | Moderately well drained |
| XeB2 | Xenia silt loam | 2-6 | Moderately well drained |
| XfA | Xenia silt loam | 0-2 | Moderately well drained |
| XfB2 | Xenia silt loam | 0-2, eroded | Moderately well drained |

SOURCE: SCS (1980, 1982)

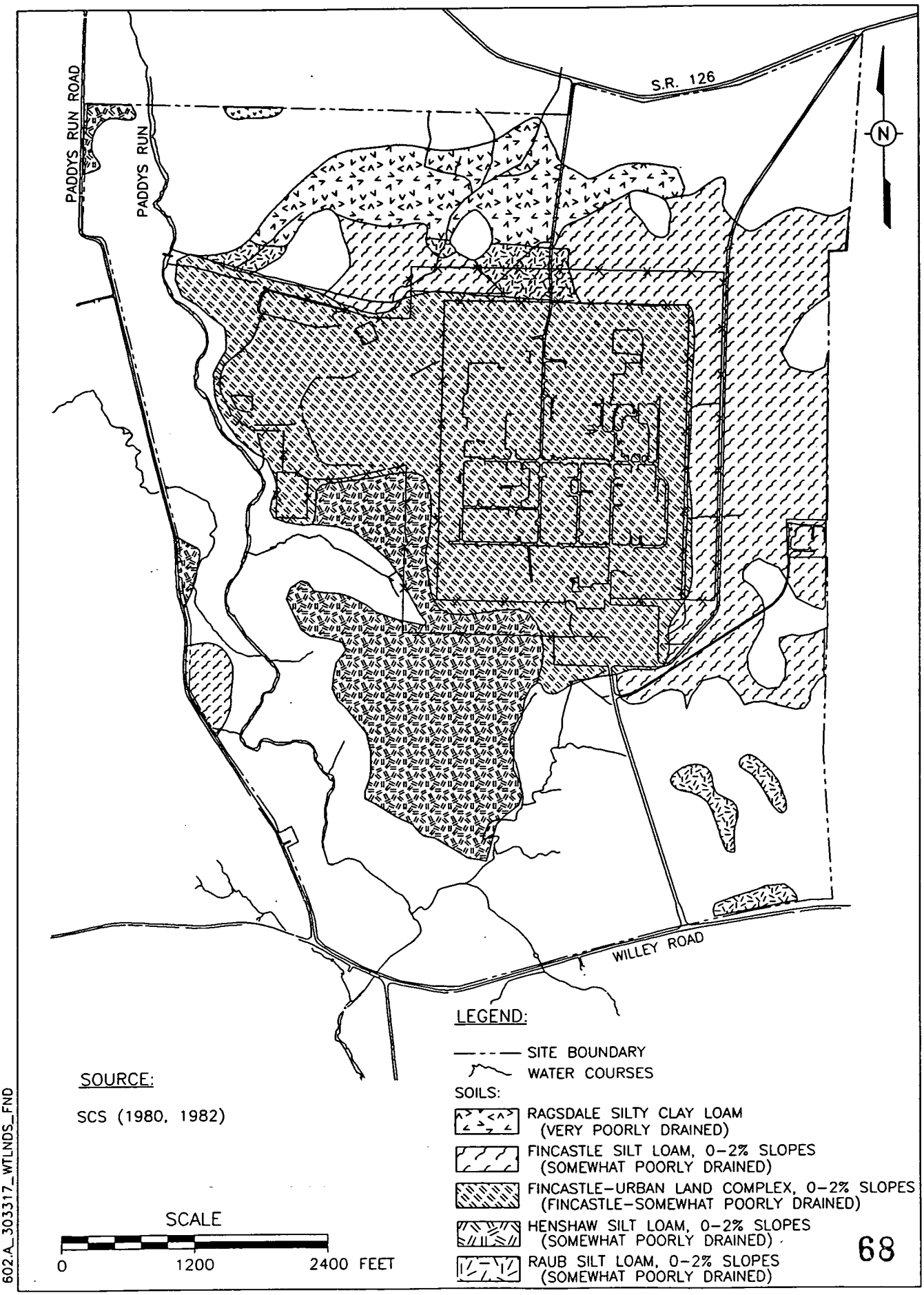



FIGURE B.3-3. POTENTIALLY HYDRIC SOILS AT THE FEMP

B.3.2.2 Somewhat Poorly Drained Soils

Three of the fifteen soil series, represented by four map units, are classified as somewhat poorly drained soils. These include the Fincastle series (Fincastle silt loam and Fincastle-Urban land complex map units), the Henshaw series (Henshaw silt loam map unit), and the Raub series (Raub silt loam map unit). They are shown along with the hydric soil in Figure B.3-3. Somewhat poorly drained soils, which may or may not be hydric, occupy approximately 364 acres at the FEMP (excluding the highly developed portions of the Fincastle-Urban land complex). Portions of the area mapped as somewhat poorly drained soils were investigated during the field reconnaissance, especially where information such as site-specific vegetation data also suggested the potential for wetlands.

The Fincastle series consists of deep, nearly level, somewhat poorly drained soils on broad flats. The permeability of this soil is slow and the available water capacity is high. The seasonal high water table is commonly found between one and three feet below the ground surface from January through April. These soils are associated with the Production Area and the pastures to the east and west.

Henshaw soils are deep, nearly level, somewhat poorly drained soils on flats and low stream terraces and in basins. Permeability is moderately slow, available water capacity is high, and runoff is slow. The seasonal high water table is usually within two feet of the ground surface between November and March. A small area of these soils exists along the western property line adjacent to Paddys Run Road, and south of the Production Area.

Raub soils are deep, nearly level, somewhat poorly drained, dark soils located on glacial till plains. These soils have slow permeation rates and high available water capacity. The seasonal high water table is between one and three feet during January through April. These soils are located on upland terraces in the southeast portion of the site and immediately north of the Production Area.

B.3.2.3 Moderately Well Drained and Well Drained Soils

The remaining eleven soil series mapped on site are moderately well-drained and well-drained upland soils (Table B.3-1 and Figure B.3-2). Portions of this area were included in the field investigation based on the wetlands potential as indicated by other available information.

The Dana series consists of deep, gently sloping, moderately well drained soils on slopes, or in gently sloping basins on till plains and moraines. This series has moderate permeability, and the available water capacity is high. The water table is usually perched at a depth of three to six feet between March and April. These soils are located within the northern pine plantation.

The Eden series is moderately deep, steep, well-drained soil on valley walls and hillsides. This series has a slow permeability and the available water capacity is low. The water table is usually found at a depth of greater than six feet. This series is located on the side slopes of the pine plantation.

Fox soils are deep, gently sloping, well-drained soils on slight rises and stream terraces. Erosion has removed the majority of the original surface layer. Permeability is moderate in the upper horizons, and very rapid in the lower horizons. The seasonal high water table is normally greater than six feet in depth. A small area of Fox soils exists along the southern property line on the upland terrace immediately east of Paddys Run.

Genesee soils are deep, nearly level, well drained soils located on terraces adjacent to floodplains. The areas that they occupy are subject to occasional brief flooding. The permeability is moderate, and the available water capacity is very high. Normally, the seasonal high water table is deeper than six feet. This series is associated with the corridor containing Paddys Run and part of the Storm Sewer Outfall Ditch (SSOD).

The Hennepin Series is a deep, very steep, well-drained soil along streams in dissected parts of the level plain. The permeability is moderately slow to slow. The available water capacity is moderate and runoff is very rapid. The seasonal high water table is usually greater than six feet in depth. These soils are associated with the steep banks along Paddys Run and its tributaries.

The Markland series consists of deep, gently sloping, moderately well-drained soils. Permeability of this soil is slow; the available water capacity is moderate, and the runoff hazard is medium. The seasonal high water table is usually perched between three and six feet between the months of March and April. These soils are located on the top portions of the side slopes of Paddys Run.

Martinsville soils are deep, nearly level, well-drained soils on stream terraces and outwash plains. The permeability is moderate, and the available water capacity is high. The runoff hazard is low. The seasonal high water table is greater than six feet in depth. Martinsville soils are found on a level terrace in the southern end of the FEMP adjacent to a tributary to Paddys Run.

Miamian soils are deep, strongly sloping, well-drained soils located on dissected plains. Erosion has removed portions of the original surface layer and the subsoil has been filled into the existing surface layer. Permeability is moderately slow, and the available water capacity is moderate. The seasonal high water table is usually greater than six feet in depth. Miamian soils exist along the northern property line of the FEMP between the wetland fingers.

Russell silt loams are gently sloping, deep, well-drained soils on slight rises and knolls of till plains. Russell soils have moderate permeability in the lower horizons. Surface runoff is medium. The seasonal high water table is perched and commonly found between 3 and six feet between March and April. Russell soils are mapped east of the Production Area and support pastures.

Uniontown soils are deep, gently sloping, well-drained soils formed in deposits on stream terraces. These soils have moderate permeability with a very high available water capacity. The seasonal high water table is between 2.5 to six feet between November and May. Uniontown soils are mapped in the northwest corner of the FEMP on a terrace above Paddys Run.

The Xenia soil series is a deep, nearly level, moderately well-drained soil located on till plains. Xenia soils have moderately slow permeability and a high available water capacity. The runoff hazard is low. The seasonal high water table is usually encountered between two and six feet between the months of March and April. These soils are located within the northern pine plantation and the pastures to the east of this area.

### B.3.3 REVIEW OF SITE-SPECIFIC INFORMATION

#### B.3.3.1 Vegetation

##### B.3.3.1.1 Hydrophytic Vegetation Determinations

Facemire et al. (1990) categorized the site as comprising six habitat types: riparian, deciduous woodlots, pine plantations, Inactive Fly Ash Disposal Area (reclaimed fly ash pile), and grazed and ungrazed pastures. Figure B.3-4 shows the location of habitat types at the FEMP. For this map, the "grazed pasture" and "ungrazed pasture" categories used by Facemire et al. (1990) have been combined as "introduced grassland," as cattle are not always grazed in the same pastures on the FEMP. Locations of Facemire's 11 permanent transects are shown in Figure B.3-5. Dominant plant taxa for the 11 permanent transects are listed in Tables B.3-2 through B.3-12.

Grazed and Ungrazed Pastures

The grazed and ungrazed pasture transects (Tables B.3-2 through B.3-4) were dominated by upland grasses. Two species, red fescue (*Festuca rubra*, FACU) and Kentucky bluegrass (*Poa pratensis*, FACU), were dominants at all three pasture transects using both spring and summer data. Orchard grass (*Dactylis glomerata*, FACU) was a codominant at the ungrazed pasture transect during the spring sampling. The proportion of dominants FAC or wetter was zero percent for each pasture transect. Spring and summer vegetation determinations for all three pasture transects are non-hydrophytic. On the basis of this nonhydrophytic vegetation determination and soils mapped as somewhat poorly drained, moderately well-drained, or well-drained, the pasture areas were examined only briefly during the field investigation, rather than acting as a focus for it.

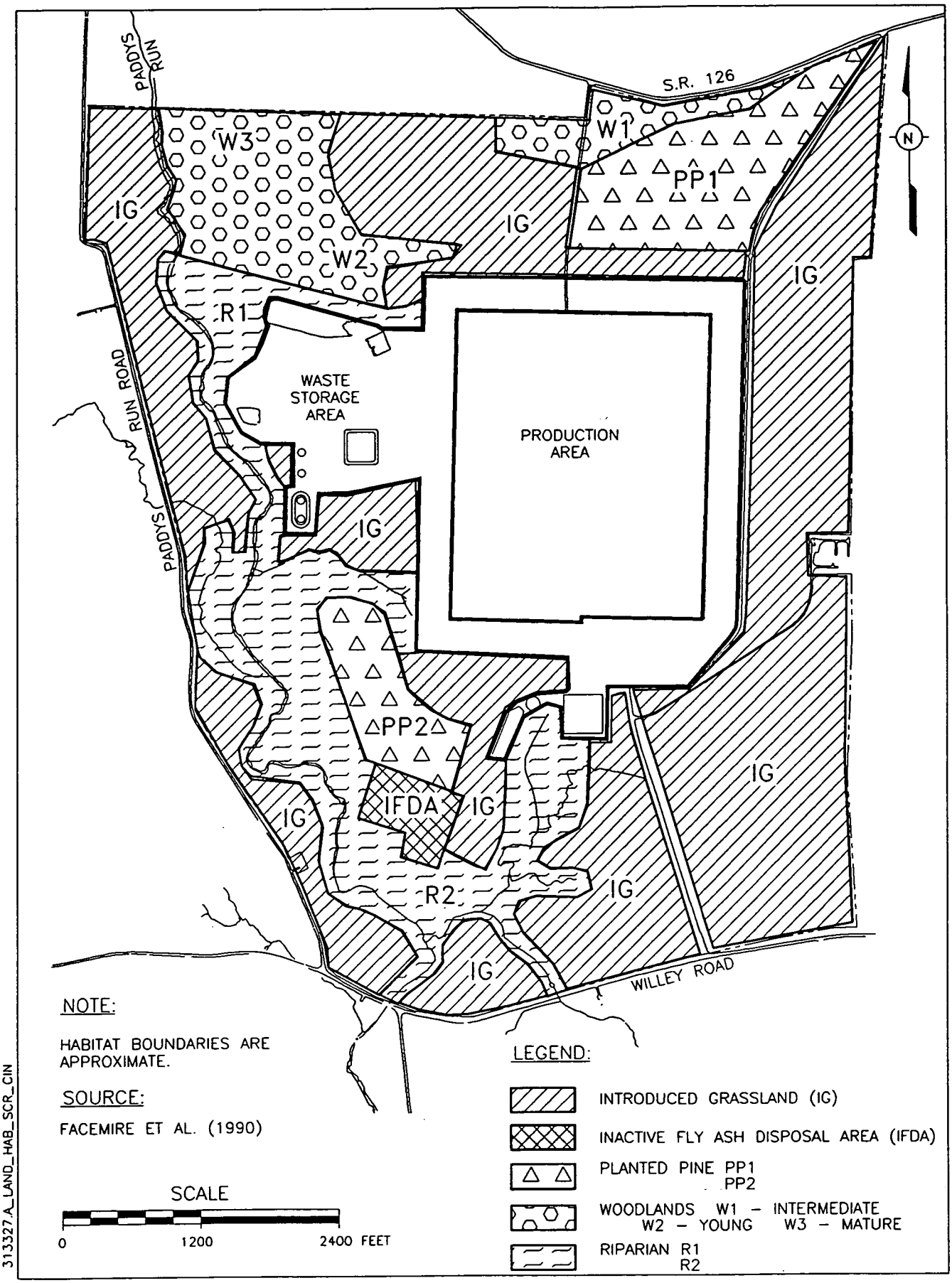



FIGURE B.3-4. HABITAT TYPES PRESENT ON THE FEMP

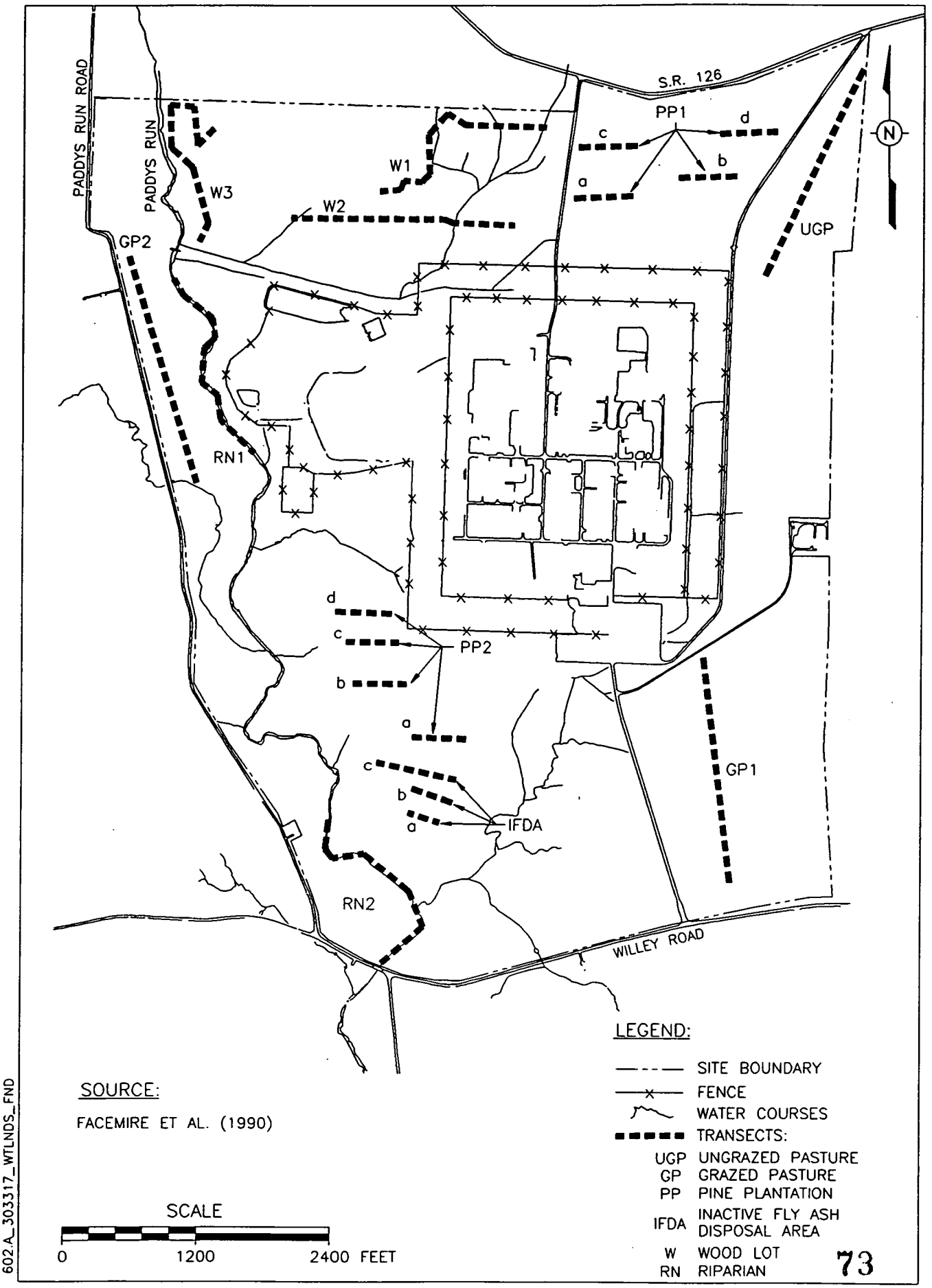



FIGURE B.3-5. LOCATION OF PERMANENT TRANSECTS AT THE FEMP

**TABLE B.3-2**
**DOMINANT VEGETATION**
**UNGRAZED PASTURE TRANSECT**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| No tree layer recorded. | | | |
| Shrub layer: | | | |
| No shrub layer recorded. | | | |
| Spring ground cover: | | | |
| Festuca sp. | fescue | b | 52.6 |
| Poa pratensis | Kentucky bluegrass | FACU | 23.3 |
| Dactylis glomerata | orchard grass | FACU | 22.5 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 68.8 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 0/2 = 0%
Vegetation Determination for UGP: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 0/1 = 0%
Vegetation Determination for UGP: Nonhydrophytic

[a] Dominance measures were calculated for all species. Within each stratum, the sum of the dominance measures for all species is 100 percent; only the dominant species are presented here. See Section 3.3.1 for the method used to determine the dominant species.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on spring ground cover; summer determination based on summer ground cover.

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**TABLE B.3-3**
**DOMINANT VEGETATION**
**GRAZED PASTURE TRANSECT GP1**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| No tree layer recorded. | | | |
| Shrub layer: | | | |
| No shrub layer recorded. | | | |
| Spring ground cover: | | | |
| Festuca sp. | fescue | b | 52.6 |
| Poa pratensis | Kentucky bluegrass | FACU | 31.8 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 55.1 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 0/1 = 0%
Vegetation Determination for GP1: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 0/1 = 0%
Vegetation Determination for GP1: Nonhydrophytic

[a] For explanation of Dominance Measures, see Table A.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on spring ground cover; summer determination based on summer ground cover.

## TABLE B.3-4
## DOMINANT VEGETATION
## GRAZED PASTURE TRANSECT GP2

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| No tree layer recorded. | | | |
| Shrub layer: | | | |
| No shrub layer recorded. | | | |
| Spring ground cover: | | | |
| Festuca sp. | fescue | b | 59.6 |
| Poa pratensis | Kentucky bluegrass | FACU | 26.9 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 70.2 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 0/1 = 0%
Vegetation Determination for GP2: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 0/1 = 0%
Vegetation Determination for GP2: Nonhydrophytic

[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on spring ground cover; summer determination based on summer ground cover.

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**TABLE B.3-5**
**DOMINANT VEGETATION**
**INACTIVE FLY ASH DISPOSAL AREA TRANSECT**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| Populus deltoides | eastern cottonwood | FAC | 35.6 |
| Robinia pseudoacacia | black locust | FACU- | 34.0 |
| Shrub layer: | | | |
| Rhus radicans | poison ivy | FAC | 60.0 |
| Lonicera sp. | honeysuckle | b | 25.9 |
| Spring ground cover: | | | |
| Poa pratensis | Kentucky bluegrass | FACU | 35.6 |
| Festuca sp. | fescue | b | 35.1 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 32.9 |
| Solidago sp. | golden rod | b | 16.7 |
| Ambrosia artemisiifolia | ragweed | FACU | 7.3 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 2/4 = 50%
Vegetation Determination for RFAP: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 2/5 = 40%
Vegetation Determination for RFAP: Nonhydrophytic

[a] For explanation of Dominance Measures, See Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-6**
**DOMINANT VEGETATION**
**PINE PLANTATION TRANSECT PP1**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| Pinus strobus | white pine | FACU | 58.9 |
| Pinus nigra | Austrian pine | UPL[b] | 41.1 |
| Shrub layer: | | | |
| None recorded | | | |
| Spring ground cover: | | | |
| Solidago sp. | goldenrod | c | 10.3 |
| Poa pratensis | Kentucky bluegrass | FACU | 9.9 |
| Bromus sp. | bromus | c | 9.7 |
| Festuca sp. | fescue | c | 9.4 |
| Convolvulus sp. | bindweed | UPL[b] | 8.5 |
| Galium aparine | cleavers | FACU | 6.3 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 32.9 |
| Solidago sp. | golden rod | c | 16.7 |
| Ambrosia artemisiifolia | ragweed | FACU | 7.3 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 0/5 = 0%
Vegetation Determination for PP1: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 0/4 = 0%
Vegetation Determination for PP1: Nonhydrophytic

[a] For explanation of Dominance Measures, See Table B.4-2.

[b] Indicator status of UPL assumed, since genus and/or species does not appear in: Reed (1988)

[c] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

## TABLE B.3-7
## DOMINANT VEGETATION
## PINE PLANTATION TRANSECT PP2

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| Pinus strobus | white pine | FACU | 49.9 |
| Pinus nigra | Austrian pine | UPL[b] | 50.1 |
| Shrub layer: | | | |
| None recorded | | | |
| Spring ground cover: | | | |
| Festuca sp. | fescue | c | 12.5 |
| Bromus sp. | brome | c | 11.4 |
| Poa pratensis | Kentucky bluegrass | FACU | 10.8 |
| Rubus sp. | bramble | c | 7.4 |
| Pinus strobus | white pine | FACU | 5.23 |
| Convolvulus sp. | bindweed | UPL[b] | 5.2 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 36.8 |
| Solidago sp. | golden rod | c | 14.0 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 0/5 = 0%
Vegetation Determination for PP2: Nonhydrophytic
Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 0/3 = 0%
Vegetation Determination for PP2: Nonhydrophytic

[a] For explanation of Dominance Measures, See Table B.4-2.

[b] Indicator status of UPL assumed, since genus and/or species does not appear in: Reed (1988)

[c] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-8**
**DOMINANT VEGETATION**
**WOODLOT TRANSECT W1**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| Carya laciniosa | shellbark hickory | FAC | 16.3 |
| Quercus rubra | northern red oak | FACU- | 11.9 |
| Ulmus americana | American elm | FACW- | 10.3 |
| Celtis occidentalis | hackberry | FACU | 9.0 |
| Quercus imbricaria | shingle oak | FAC | 8.5 |
| Shrub layer: | | | |
| Cornus drummondii | roughleaf dogwood | FAC | 48.6 |
| Rosa multiflora | multiflora rose | FACU | 15.8 |
| Spring ground cover: | | | |
| Poa pratensis | Kentucky bluegrass | FACU | 22.5 |
| Festuca elatior | meadow fescue | FACU- | 17.3 |
| Stellaria media | common chickweed | UPL | 10.9 |
| Summer ground cover: | | | |
| Festuca rubra | red fescue | FACU | 17.9 |
| Heuchera americana | rock geranium | FACU- | 11.3 |
| Parthenocissus quinquefolia | Virginia creeper | FACU | 8.5 |
| Solidago sp. | goldenrod | b | 8.2 |
| Lonicera sp. | honeysuckle | b | 7.8 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 4/10 = 40%
Vegetation Determination for W1: Nonhydrophytic

Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 4/10 = 40%
Vegetation Determination for W1: Nonhydrophytic

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[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-9**
**DOMINANT VEGETATION**
**WOODLOT TRANSECT W2**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree layer: | | | |
| Fraxinus americana | white ash | FACU | 31.8 |
| Platanus occidentals | American sycamore | FACW- | 19.2 |
| Shrub layer: | | | |
| Cornus drummondii | roughleaf dogwood | FAC | 27.6 |
| Rubus allegheniensis | blackberry | FACU- | 23.0 |
| Spring ground cover: | | | |
| Solidago sp. | goldenrod | b | 13.3 |
| Stellaria media | common chickweed | UPL | 13.1 |
| Agropyron | sp. wheatgrass | b | 9.9 |
| Geum | sp. avens | b | 7.5 |
| Trifolium pratense | red clover | FACU- | 6.4 |
| Summer ground cover: | | | |
| Solidago sp. | goldenrod | b | 16.0 |
| Festuca rubra | red fescue | FACU | 12.9 |
| Rubus allegheniensis | blackberry | FACU- | 10.3 |
| Poa pratensis | Kentucky bluegrass | FACU | 7.1 |
| Parthenocissus quinquefolia | Virginia creeper | FACU | 6.6 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 2/6 = 33.33%
Vegetation Determination for W2: Nonhydrophytic

Summer Determination[c]:
Proportion of Dominanants FAC or Wetter: 2/8 = 25.0%
Vegetation Determination for W2: Nonhydrophytic

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[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-10**
**DOMINANT VEGETATION**
**WOODLOT TRANSECT W3**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree Layer: | | | |
| Acer negundo | boxelder | FAC | 20.7 |
| Acer Saccharum | sugar maple | FACU- | 19.4 |
| Juglans nigra | black walnut | FACU | 11.2 |
| Shrub layer: | | | |
| Acer saccharum | sugar maple | FACU- | 38.1 |
| Aesculus glabra | Ohio Buckeye | FACU+ | 22.2 |
| Spring ground cover: | | | |
| Stellaria media | common chickweed | UPL | 26.1 |
| Poa pratensis | Kentucky bluegrass | FACU | 23.8 |
| Summer ground cover: | | | |
| Pilea pumila | clearweed | FACW | 17.2 |
| Festuca rubra | red fescue | FACU | 13.2 |
| Glechoma hederacea | ground ivy | FACU | 11.9 |
| Geum canadense | white avens | FACU | 8.7 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 1/7 = 14.3%
Vegetation Determination for W3: Nonhydrophytic

Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 2/9 = 22.2%
Vegetation Determination for W3: Nonhydrophytic

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[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-11**
**DOMINANT VEGETATION**
**RIPARIAN TRANSECT RN1**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree Layer: | | | |
| Populus deltoides | eastern cottonwood | FAC | 20.4 |
| Celtis occidentalis | hackberry | FACU | 16.5 |
| Acer negundo | boxelder | FAC | 9.4 |
| Ulmus americana | American elm | FACW- | 8.2 |
| Shrub layer: | | | |
| Rhus radicans | poison ivy | FAC | 33.7 |
| Acer negundo | box elder | FAC | 18.5 |
| Spring ground cover: | | | |
| Alliaria officinalis | garlic mustard | FACU- | 23.5 |
| Galium arapine | cleavers | FACU | 8.3 |
| Solidago sp. | goldenrod | b | 8.3 |
| Stellaria media | common chickweed | UPL | 7.5 |
| Rhus radicans | poison ivy | FAC | 6.1 |
| Summer ground cover: | | | |
| Solidago sp. | goldenrod | b | 22.3 |
| Festuca rubra | red fescue | FACU | 20.0 |
| Urtica procera | nettle | FACU | 7.2 |
| Parthenocissus quinquefolia | Virginia creeper | FACU | 4.9 |

Spring Determination[c]:
Proportion of Dominants FAC or Wetter: 6/10 = 60%
Vegetation Determination for RN1: Hydrophytic

Summer Determination[c]:
Proportion of Dominants FAC or Wetter: 5/9 = 55.6%
Vegetation Determination for RN1: Hydrophytic

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[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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**TABLE B.3-12**
**DOMINANT VEGETATION**
**RIPARIAN TRANSECT RN2**

| Scientific Name | Common Name | Indicator Status | Dominance Measure[a] (percent) |
|---|---|---|---|
| Tree Layer: | | | |
| Acer negundo | boxelder | FAC | 21.9 |
| Ulmus americana | American elm | FACW- | 16.8 |
| Juglans nigra | black walnut | FACU | 11.3 |
| Shrub layer: | | | |
| Rhus radicans | poison ivy | FAC | 37.3 |
| Acer negundo | box elder | FAC+ | 17.0 |
| Spring ground cover: | | | |
| Bromus sp. | brome | b | 18.4 |
| Stellaria media | common chickweed | UPL | 27.6 |
| Summer ground cover: | | | |
| Solidago sp. | goldenrod | b | 18.4 |
| Festuca rubra | red fescue | FACU | 16.7 |
| Helianthus tuberosus | Jerusalem artichoke | FAC | 7.5 |
| Silphium triofoliatum | rosinweed | UPL[c] | 6.9 |
| Parthenocissus quinquefolia | Virginia creeper | FACU | 4.8 |

Spring Determination[d]:
Proportion of Dominants FAC or Wetter: 4/6 = 66.67%
Vegetation Determination for RN2: Hydrophytic

Summer Determination[d]:
Proportion of dominanats FAC or Wetter: 5/9 = 55.6%
Vegetation Determination for RN2: Nonhydrophytic

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[a] For explanation of Dominance Measures, see Table B.4-2.

[b] Unable to assign indicator status, since not identified to species.

[c] Indicator status of UPL assumed, since genus and/or species does not appear in Reed (1988).

[d] Spring determination based on tree layer, shrub layer, and spring ground cover; summer determination based on tree layer, shrub layer, and summer ground cover.

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Inactive Fly Ash Disposal Area

The Inactive Fly Ash Disposal Area (reclaimed fly ash pile) transect (Table B.3-5) was dominated by a mixture of upland and facultative species characteristic of disturbed areas. The tree layer was dominated by two species, eastern cottonwood (Populus deltoides, FAC) and black locust (Robinia pseudoacacia, FACU-), and the shrub layer was dominated by poison ivy (Rhus radicans, FAC) and honeysuckle (Lonicera sp.). The ground cover was dominated by the upland species, Kentucky bluegrass, red fescue, and ragweed (Ambrosia artemisiifolia, FACU), as well as goldenrod (Solidago sp.). The proportion of FAC or wetter dominants for this transect was 50 percent when the spring ground cover data were used, and 40 percent when the summer ground cover data were used. This produced a vegetation determination of nonhydrophytic in both cases. However, this determination was marginal for the spring flora and there was a somewhat poorly drained soil (Henshaw silt loam) in the area of the transect, suggesting that the Inactive Fly Ash Disposal Area should be included in the field investigation to confirm the absence of wetlands in this area.

Pine Plantations

Two pine plantations are located at the FEMP (Figures B.3-4 and B.3-5). The tree layer of transects in both plantations was dominated by two pine species, white pine (Pinus strobus, FACU) and Austrian pine (Pinus nigra, UPL) (Tables B.3-6 and B.3-7). The shrub layer was not sampled. During the spring sampling, ground cover was characterized in each transect by six or seven codominants. Indicator status for these codominants, where possible to assign, was FACU or UPL. By the time of the summer sampling, the number of dominants had decreased to three taxa: red fescue and goldenrod at both transects, and ragweed at the northern pine plantation. The vegetation determination for each pine plantation transect was nonhydrophytic, based on a proportion of FAC or wetter dominants of zero percent for both the spring and summer determinations. Soils in the southern pine plantation were mapped as somewhat poorly drained (Henshaw silt loam); the northern pine plantation was mapped as upland soils in the north and hydric (Ragsdale silty clay loam) and somewhat poorly drained (Fincastle silt loam) in the south (Figures B.3-2, B.3-3). Although the lack of any FAC or wetter dominants for the northern pine plantation suggests that a mapping of Ragsdale silty clay loam may be incorrect for this area, the northern pine plantation was included in the field investigation.

Woodlots

The northern portion of the FEMP is occupied by deciduous woodlots (Figures B.3-4 and B.3-5) which exhibit a range of disturbance due to grazing and bush-hogging. Some of the woodlots are relatively undisturbed. The tree layer in the three woodlot transects (Tables B.3-8 through B.3-10) showed considerable among-transect variation. The tree layer of woodlot transect W1 (Table B.3-8) was dominated by five tree species varying in indicator status from FACW- (American elm, Ulmus americana) to FACU- (northern red oak, Quercus rubra). The tree layer in woodlot transect W2 (Table B.3-9) was dominated by only two species representing approximately the same range of indicator status, white ash (Fraxinus americana, FACU) and American sycamore (Platanus occidentalis,

FACW-). Woodlot transect W3 (Table B.3-10) had three dominant species in its tree layer, boxelder (Acer negundo, FAC+), sugar maple (Acer saccharum, FACU-), and black walnut (Juglans nigra, FACU).

Dominants in the shrub layer range in indicator status from FAC (roughleaf dogwood, Cornus drummondii, at W1 and W2) to FACU- (blackberry, Rubus allegheniensis, at W2, and sugar maple at W3). Dominants in the ground cover layer range from FACW (clearweed, Pilea pumila, at W3) to UPL (common chickweed, Stellaria media, at W1, W2, and W3). Ground cover dominants found at all three transects included red fescue (FACU) and Kentucky bluegrass (FACU), as well as common chickweed.

Among the woodlot transects, the proportion of dominants FAC or wetter ranged from 14.3 percent for W3 (spring) to 40 percent for W1 (spring and summer). Vegetation determinations for all three transects were nonhydrophytic. Interestingly, when the vegetation data were considered in conjunction with the soils data (Figures B.3-3 and B.3-5), it was seen that W1, which had the greatest proportion of dominants FAC or wetter, was located, at least in part, in soils mapped as hydric. W3, which had the smallest proportion of dominants FAC or wetter, was located in an area mapped as upland soils. W2, which shows intermediate values for the proportion of dominants FAC or wetter, was located on the border among soils mapped as hydric, somewhat poorly drained, and upland (Figure B.3-2). These data suggested that the eastern portion of the woodlot area (W-1 and W2) had a fairly high potential for the presence of wetlands, and should be a focus for the field reconnaissance.

Riparian

Two transects used by Facemire et al. (1990) were located in the relatively undisturbed riparian area adjacent to Paddys Run in the western portion of the FEMP (Figure B.3-5). Riparian transect RN1 was located west of the Production and Waste Storage Areas, and RN2 was located in the southern part of the FEMP. American elm (FACW-) and boxelder (FAC+) were dominants in the tree layer at both transects. Additional dominants included eastern cottonwood (FAC) and hackberry (Celtis occidentalis, FACU) at RN1, and black walnut (FACU) at RN2. The shrub layer at both transects was dominated by poison ivy (FAC) and boxelder (FAC+). The ground cover was characterized by a large number of dominants at each site. Indicator status of these dominants varied from FAC for poison ivy (RN1) and Jerusalem artichoke (Helianthus tuberosus, RN2), to UPL for common chickweed (RN1 and RN2) and rosinweed (Silphium trifoliatum; RN2). Dominants found at both transects included red fescue (FACU), Virginia creeper (Parthenocissus quinquefolia, FACU), and goldenrod, as well as common chickweed.

Vegetation in both RN1 and RN2 met the hydrophytic criterion. The proportion of dominants FAC or wetter for RN1 was 60.0 percent for the spring sampling and 55.6 percent for the summer. For RN2, the proportion was 66.7 percent for the spring sampling and 55.6 percent for the summer. Although a review of the SCS soils information (Figure B.3-2) showed that the soils mapped for the riparian areas are moderately well-drained and well-drained upland soils, the hydrophytic vegetation determinations and the presence of nondominant obligate wetland vegetation (Table B.3-13) suggested that the riparian corridor should be targeted during the field reconnaissance for further clarification.

B.3.3.1.2 Nondominant Obligate Wetland Vegetation

The indicator status of nondominant species, in addition to dominants, was reviewed in order to detect obligate wetland vegetation. The results revealed that only two obligate wetland species (OBL) were recorded at the FEMP by Facemire et al. (1990) -- moneywort (*Lysimachia nummularia*) and mild water-pepper (*Polygonum hydropiperoides*). One or both of these obligate wetland species was recorded for five of the eleven permanent transects -- the three woodlot transects and the two riparian transects. Table B.3-13 indicates the transects where these species were recorded, the sampling season, and the dominance measure, that is, the percentage of total ground cover in the transect contributed by individual species. All of the dominance measures were low, and neither species was a dominant in any of the transects in which it occurred (Tables B.3-8 through B.3-12). Since the dominance measures represent the dominant taxa for the entire transect, however, a transect which lies mostly in upland may cross a wetland. In this case, obligate wetland vegetation could dominate the wetland, but not be a dominant for the transect. The presence of nondominant obligate vegetation in woodlot and riparian transects provided additional support for making these areas the focus of the field reconnaissance.

B.3.3.2 Soils

A review of the RI/FS soil boring logs showed that the scale and level of detail of the soil profiles makes them inadequate for use in wetlands identification and delineation. Data were recorded at 1.5 foot increments, to a depth in many cases of 100 feet or more. The changes of interest for wetlands identification, however, occur on the scale of inches, usually in the upper 10 inches of the profile. Use of the RI/FS soil profile data, therefore, did not proceed beyond a review of the data.

B.3.3.3 Hydrology

A review of the aerial photographs and USGS topographic maps confirmed the location of numerous water bodies and water courses on the FEMP that showed the potential for an association with wetlands. These water bodies and water courses are shown in Figures B.3-1 and B.3-6. Additional

**TABLE B.3-13**
**OBLIGATE WETLAND PLANTS**

| Species | Sampling Season[a] | Dominance Measure[a] (percent) W1 | W2 | W3 | RN1 | RN2 |
|---|---|---|---|---|---|---|
| Lysimachia nummularia | Spring | -- | 1.1 | 1.7 | 0.22 | [b] |
| (moneywort) | Summer | 0.27 | -- | 1.3 | -- | 0.42 |
| Polygonum hydropiperoides | Spring | -- | -- | -- | -- | -- |
| (mild water-pepper) | Summer | 1.6 | -- | -- | -- | 2.1 |

[a] For explanation of Dominance Measures, See Table B.3-2.

[b] Present, but no percent cover provided in data.

descriptions of hydrology for the FEMP appear in the results for topographical information (Section 3.1) and aerial photographs (Section 3.4).

B.3.4 REVIEW OF AERIAL PHOTOGRAPHS

Aerial photographs of the FEMP dating back to 1950 were reviewed (Table B.3-1). Special attention was paid to the most recent photograph, April 1988. This photograph was used as the field map and is a reasonably accurate depiction of existing site conditions, with the main exception being the construction of a new stormwater retention basin immediately south of the Production Area. Because of the new basin, the adjacent ditch has been realigned.

The October 13, 1950, photograph indicates the site's previous use as agricultural. Paddys Run and its tributaries were contained in a tree lined corridor as they are today. In the March 21, 1957, photograph, the Production Area dominates the FEMP, surrounded by fallow agricultural fields. In addition, there appears to be construction activity at numerous areas throughout the FEMP. The September, 1968, photograph indicates that the fallow agricultural fields have gone through a successional change, with shrubs appearing in some areas. The wooded corridor along Paddys Run appears to have expanded slightly. The 1983 photograph indicates that the pine plantations have been planted, and the numerous drainage ditches associated with the Production Area are in place.

The aerial photographs illustrate how the FEMP has changed over time with respect to water course location and farming and silvicultural practices. They are not, however, characterized by features that considered independently, would allow location of wetland boundaries. They were most useful in the field, where the April 1988 photograph was used for orientation and as an initial base map for drawing the approximate wetland boundaries.

B.3.5 FIELD RECONNAISSANCE

During April 16-20, 1990, a field investigation was conducted to establish the approximate wetland boundary. The investigation consisted of a visual reconnaissance of potential wetland areas determined by the off-site investigation, including the area north of the Production Area, the riparian areas along Paddys Run and its tributaries, a portion of the ditches on site, and the Inactive Fly Ash Disposal Area. Wetlands were identified according to the vegetation, soil, and hydrology criteria described above and in FICWD (1989). The approximate wetland boundary derived from the off-site delineation and limited field reconnaissance is shown in Figure B.3-6.

The northern portion of the FEMP contains a mosaic of upland woodlot, old field pasture, and forested wetland, with a pine plantation in the northeast corner. The pine plantation area was dominated by

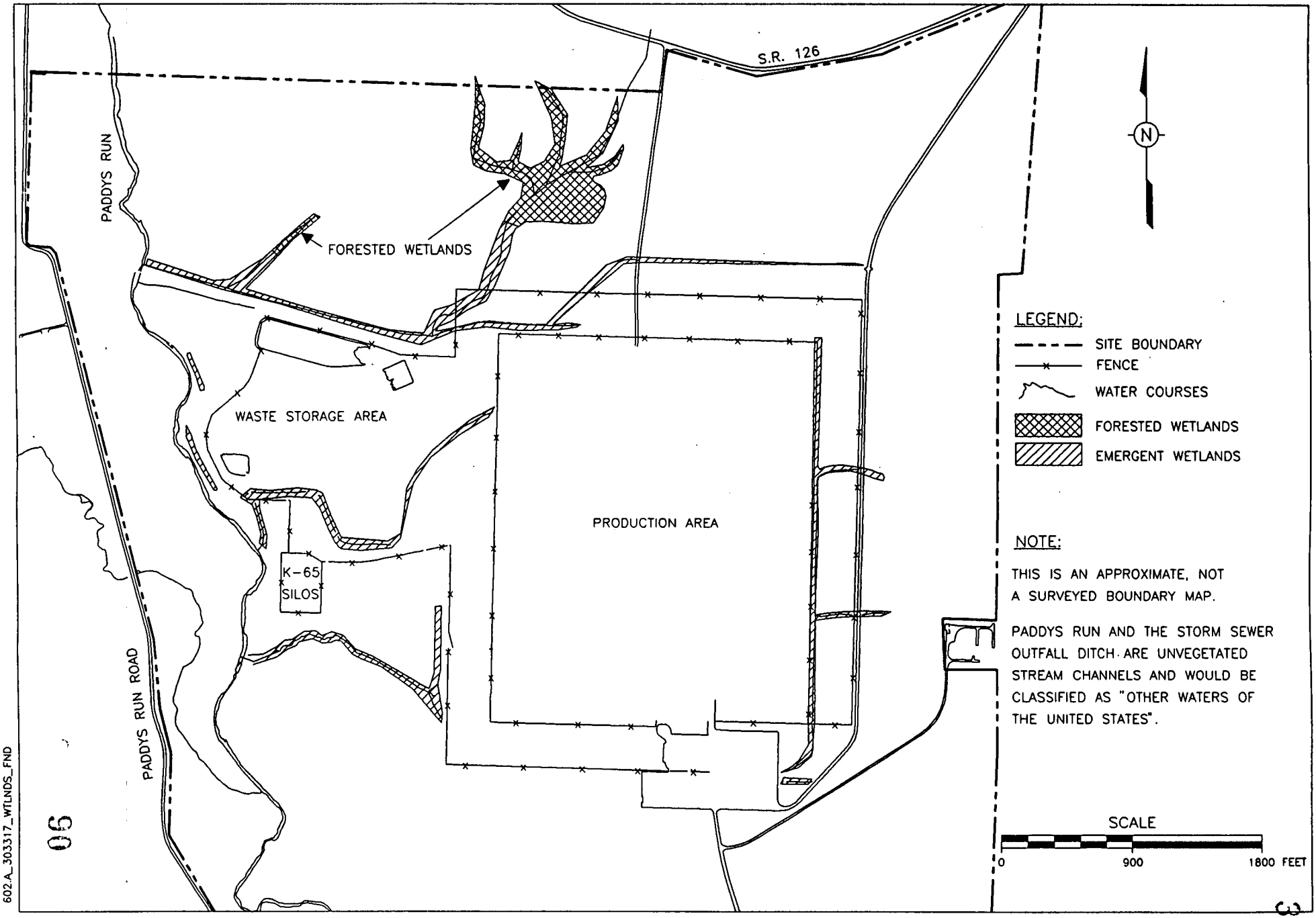


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FIGURE B.3-6. APPROXIMATE BOUNDARIES OF JURISDICTIONAL WETLANDS AT THE FEMP

nonhydrophytic vegetation such as white pine and Austrian Pine, with nonhydric soils. Indicators of seasonal flooding or soil saturation were not encountered in this area. Directly north of the Production Area, a series of five wetland fingers exists. These fingers show erosional patterns characteristic of occasional heavy flow. The dominant species in this forested wetland are American elm (Ulmus americana), American sycamore (Platanus occidentalis), and roughleaf dogwood (Cornus drummondii). These fingers eventually form a single distinct channel that flows into a man-made ditch running parallel to the railroad tracks. This ditch, which drains into Paddys Run, contained cattail (Typha latifolia), boxelder (Acer negundo), and various species of grasses. Standing water was observed in the ditch.

Paddys Run, which flows south along the western boundary of the FEMP, is well incised into the surrounding uplands and separated from them by a distinct topographic change. The steep banks of Paddys Run show signs of scouring due to increased flow during storm events. An upland terrace on either side of Paddys Run, well above the stream bed elevation, contained no evidence of wetland conditions such as hydrophytic vegetation or hydric soils. The terraces support variously an upland woodlot or open pasture. The open pastures are dominated by grasses and forbs. The upland woodlots contain such common canopy species as boxelder, northern red oak (Quercus rubra), Ohio buckeye (Aesculus glabra), shellbark hickory (Carya laciniosa) and sugar maple (Acer saccharum). Common ground cover species include virginia creeper (Parthenocissus quinquefolia), goldenrod (Solidago sp.), chickweed (Stellaria media), and various species of grass.

The major tributary to Paddys Run, the Storm Sewer Outfall Ditch (SSOD), flows into Paddys Run near the southern boundary of the FEMP. The SSOD has a well defined channel similar to that of Paddys Run. The banks contained evidence of scouring, and the stream channel was dry and contained a large amount of debris forming drift lines. The canopy and understory were similar to those adjacent to Paddys Run. The soils on the top of the banks were nonhydric with a chroma greater than two and no mottling present. Drift lines were noted only in the channel.

The Production Area is located in the center of the FEMP. Numerous man-made drainage ditches occur in and adjacent to this area. These ditches contain such emergent vegetation as cattail (Typha latifolia), rushes (Juncus sp), sedges (Carex sp.), and various species of grasses. The majority of the ditches contained flowing water, with soils containing hydric indicators such as a chroma less than two, mottling, and/or iron staining.

In addition to the various ditches at the FEMP, two small swales also contained emergent vegetation (Figure B.3-6). These elongated swales are northwest of the silo area, and appear to collect runoff

from the upland slopes due east. Direct investigation of the soils in this area was not possible because the area was not accessible during this period. There are also two man-made, lined, stormwater retention basins immediately south of the Production Area parking lot. The majority of the FEMP contains upland soils supporting common upland vegetation used as pasture for cattle grazing (Figures 3-2, 3-4). Representative photographs of wetlands, other waters of the United States, and uplands at the FEMP appear in Attachment B-I.

### B.3.6 SUMMARY AND CONCLUSIONS

In March and April 1990, an off-site identification and delineation of jurisdictional wetlands was conducted at the FEMP. Review of the existing soils information indicated that very poorly drained hydric soils had been mapped by the SCS for only a small portion of the FEMP, in the northern woodlot and pine plantation areas. A large portion of the FEMP was mapped as somewhat poorly drained soils, which may be hydric, although they do not appear on the national list of hydric soils (SCS 1980, 1982, 1987c). The remainder of the FEMP, including the riparian zone associated with Paddys Run, was mapped as moderately well-drained or well drained upland soils.

The FEMP-specific vegetation data of Facemire et al. (1990) were reviewed in conjunction with the SCS soils data. Review and analysis of these data led to a determination that nine of the eleven transects sampled by Facemire et al. (1990) did not meet the hydrophytic vegetation criterion (FICWD 1989). The vegetation in the two remaining, riparian, transects was hydrophytic. Although the riparian area along Paddys Run was mapped as upland soils (SCS 1980, 1982), the hydrophytic vegetation determination and, additionally, the presence of nondominant obligate wetland vegetation, indicated sufficient wetlands potential to target this area for inspection during the field reconnaissance. The northern deciduous woodlot area was also included as a focus for the field reconnaissance, on the bases that one of the transects in that area was only marginally nonhydrophytic, there were nondominant obligate wetland plants in all three transects, and the area was mappped as hydric soil.

The vegetation in the Inactive Fly Ash Disposal Area was marginally nonhydrophytic, and was also included in the field investigation, although somewhat poorly drained soils and the absence of nondominant obligate wetland vegetation suggested limited wetlands potential. The northern pine plantation was included in the field investigation because a portion of it was mapped as hydric soil. However, the lack of any FAC or wetter dominants, or any nondominant obligate wetland species, indicated extremely limited wetlands potential. A review of the vegetation data for the grazed and ungrazed pasture transects and the southern pine plantation transect indicated no potential for wetlands in these areas, and they were examined only briefly during the field reconnaissance.

The on-site field reconnaissance was conducted during April 1990. Observations of vegetation, soils, and hydrologic field indicators were used to determine the presence or absence of wetlands and to establish approximate locations for the wetland boundaries. As a result of the field reconnaisance, it was concluded that the majority of the wetlands on the FEMP consist of drainage ditches with well-defined channels containing emergent vegetation. The exception to this pattern occurs in the northern end of the FEMP, where there is a forested wetland of approximately 53 acres. This wetland consists of five distinct drainage fingers leading to a flat basin within a pasture (Figure B.3-6). This flat basin is drained by a distinct channel into the ditches parallel to the railroad tracks, which ultimately drain into Paddys Run. Both the areas characterized as emergent wetlands and as forested wetlands would be protected by federal and state regulations concerning jurisdictional wetlands, including E.O. 11990. Paddys Run and the SSOD are well-incised into the surrounding landscape and are not jursidictional wetlands, but remedial actions affecting these areas would be subject to the substantive requirements of regulations concerning other waters of the United States.

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## REFERENCES

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**ATTACHMENT B-I**

**SITE PHOTOGRAPHS**

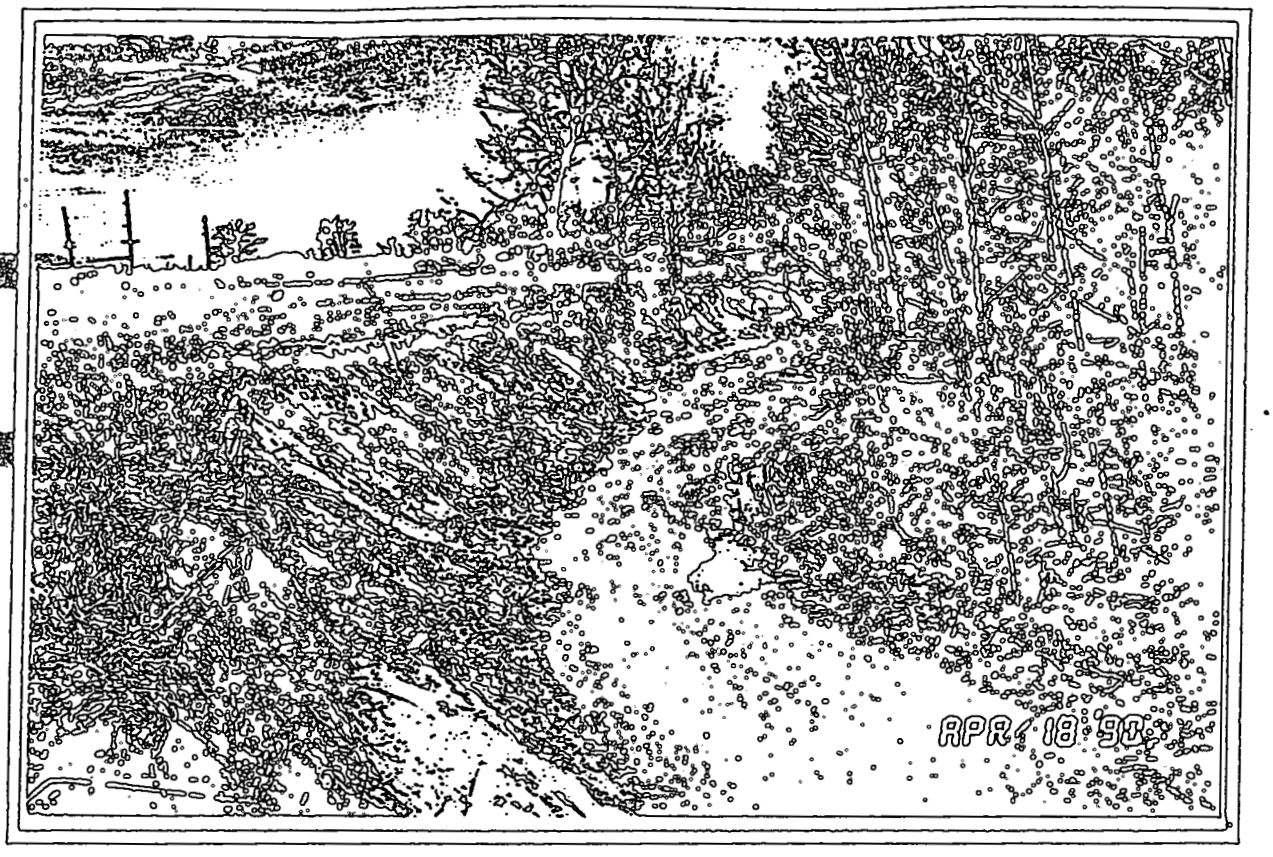


FIGURE BI-1. NORTHERN PORTION OF PADDYS RUN, DEEPLY INCISED INTO SURROUNDING AREA

FIGURE BI-2. PADDYS RUN, SHOWING SIGNS OF BANK EROSION AND SEDIMENT DEPOSITS



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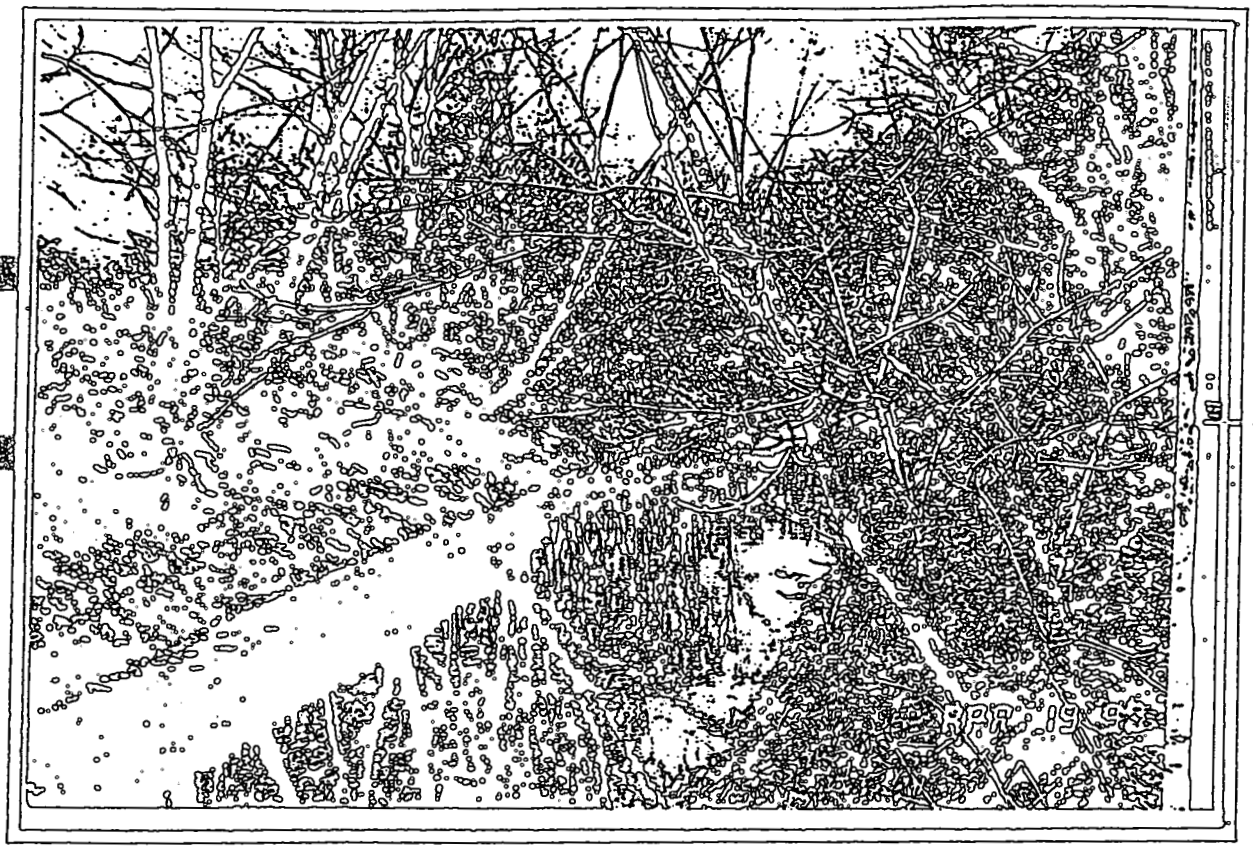

FIGURE BI-3. LOWER SECTION OF PADDYS RUN LINED BY BOXELDER

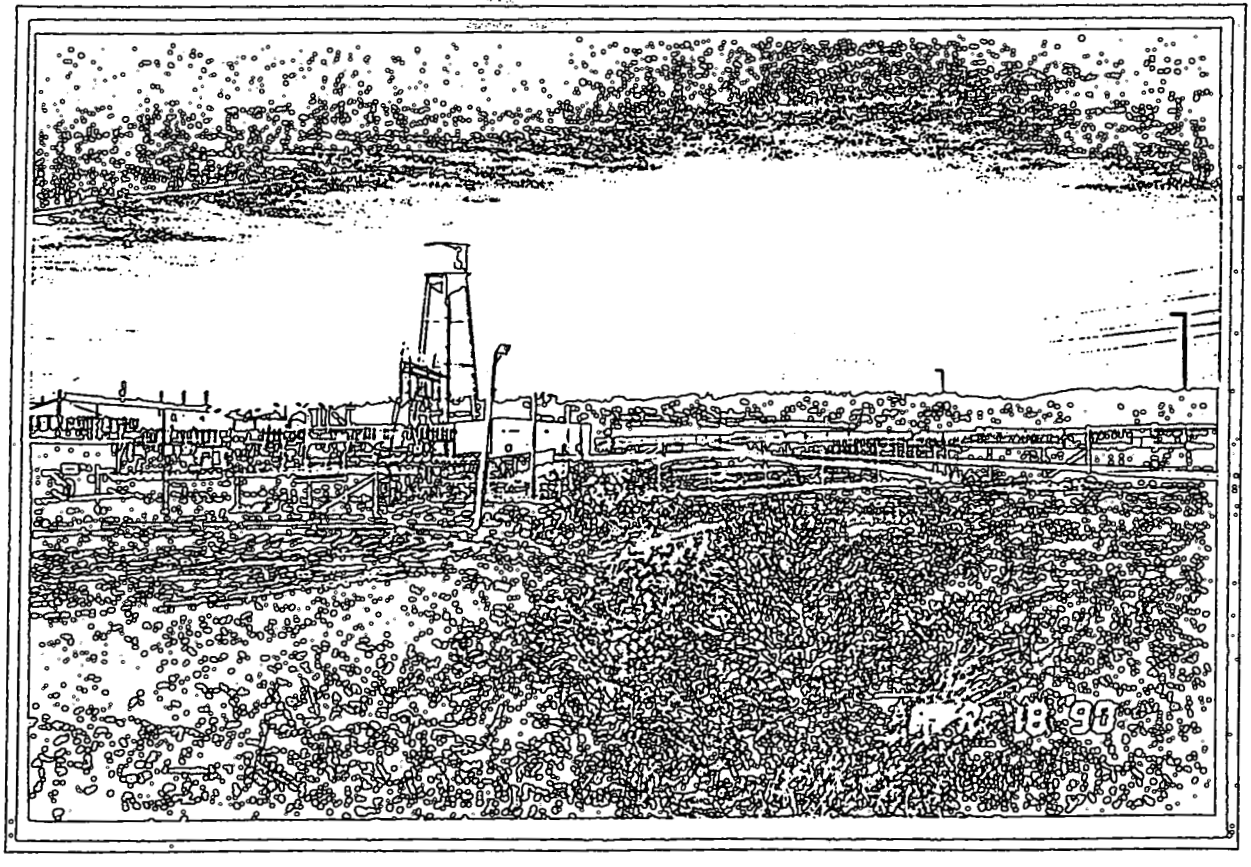

FIGURE BI-4. TYPICAL EMERGENT WETLAND AT THE FMPC, ADJACENT TO SOUTHEAST CORNER OF THE PRODUCTION AREA



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FIGURE BI–5. TYPICAL UPLAND PASTURE AT THE FMPC, EAST OF PRODUCTION AREA

APPENDIX C

# APPENDIX C

## 1990 POPULATION ESTIMATES AND PROJECTED POPULATION DATA

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# LIST OF ACRONYMS

| | |
|---|---|
| ASI | Advanced Sciences, Inc. |
| EIS | environmental impact statement |
| FEMP | Fernald Environmental Management Project |
| IT | International Technology Corporation |
| MSA | metropolitan statistical area |
| OKI | Ohio-Kentucky-Indiana Regional Council of Governments |
| RI/FS | remedial investigation/feasibility study |
| TM | technical memorandum |
| USGS | U.S. Geological Survey |

# C.1.0 POPULATION DATA



## C.1.1 INTRODUCTION

This report presents population data for the area within a five-mile-radius of the Fernald Environmental Management Project (FEMP) located near Fernald, Ohio. Estimates of 1990 population, projections to the year 2010, and a 1990 daytime residential/employment population are presented. The estimates and projections are based on results of the 1990 Decennial Census. These data are for use in the remedial investigation/feasibility study (RI/FS) currently underway at the FEMP.

## C.1.2 LOCAL, STATE, AND NATIONAL POPULATION TRENDS

Total population in the United States has been steadily increasing to over 249 million in 1990, up 10.2 percent from 1980. Compared to this national growth rate, population in the three states comprising the tri-state area (Ohio, Kentucky, and Indiana) has been very slow, as indicated in Table C.1-6. Population in Hamilton County steadily declined until 1984 and has been in a slow but steady upswing since, remaining the third most populous county in the state. Population growth in Butler County, with the eighth highest population of Ohio's counties, was 12.6 percent, above national rates and the fourth fastest-growing county in the state (U.S. Bureau of the Census 1991).

## C.1.3 POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP

Figure C.1-1 depicts the 1990 residential population distribution within a five-mile radius of the FEMP. The distribution is formatted to conform with meteorological data. A representation of 16 compass sectors was combined with a series of concentric circles drawn at one-mile intervals from the center of the FEMP. The resulting circular grid was superimposed on a map of the area for a calculation of the population within each of the 80 segments. Table C.1-2 presents the population figure for each segment and a tabulation of sector totals for the 1990 estimates, showing that the residential population within a five-mile radius of the FEMP is 22,927. The heaviest concentrations of population lie in a corridor extending from the east-northeast to the southeast of the FEMP. Due to the predominantly rural nature of the study area, a rural population density method was used for the primary estimate of population within each segment. For each township, figures for any population centers reported by the Census were subtracted from total township population. This resulting "rural population" was then divided by the land area within the township to generate a rural population density. Each grid segment's land area was then multiplied by the rural density figure for the underlying township to determine the segment's share of population. When applicable, the figures for population centers were added to the segment density totals. Many grid segments consisted of populations from more than one township and densities were calculated using proportions of the land

**TABLE C.1-1**

**LOCAL, REGIONAL, AND NATIONAL POPULATION ESTIMATES AND PROJECTIONS**

| | Population | | | Population change | | |
|---|---|---|---|---|---|---|
| Area | 1980 | 1990 | 2010 | 1970-80 | 1980-90 | 1990-2010 |
| Five-Mile Radius[a] | NA[b] | 22,927 | 27,500 | NA | NA | 19.9% |
| Harrison City | 5,855 | 7,518 | NA | 32.8% | 28.4% | NA |
| Hamilton County | 873,204 | 866,228 | 927,408 | -5.5% | -0.8% | 7.1% |
| Butler County | 258,787 | 291,479 | 291,000 | 14.4% | 12.6% | -0.1% |
| Cincinnati - CMSA[c] | 1,660,257 | 1,728,934 | 1,862,128 | 3.1% | 4.1% | 7.7% |
| Ohio | 10,797,604 | 10,847,115 | 10,398,338 | 1.4% | 0.5% | -4.1% |
| Kentucky | 3,660,777 | 3,685,296 | 4,185,811 | 13.7% | 0.7% | 13.6% |
| Indiana | 5,491,890 | 5,544,159 | 5,718,340 | 5.7% | 1.0% | 3.1% |
| Tri-State Area | 19,950,289 | 20,076,570 | 10,302,489 | 4.6% | 0.6% | 1.1% |
| United States | 226,546,000 | 249,632,692 | 282,055,000 | 11.4% | 10.2% | 13.0% |

[a] The five-mile radius is measured from the center of the FEMP.
[b] Not Available.
[c] The Cincinnati Consolidated Metropolitan Statistical Area (CMSA) includes Hamilton, Butler, Warren and Clermont counties in Ohio; Boone, Kenton, and Campbell counties in Kentucky; and Dearborn County, Indiana.

SOURCES: Ohio Data Users Center, Ohio Dept. of Development, 1991. The Ohio-Kentucky-Indiana Regional Council of Governments, 1988 and 1990. U.S. Dept. of Commerce, Bureau of the Census, 1981 and 1991. Urban Studies Center, College of Urban and Public Affairs, Univ. of Louisville, 1988. Indiana Business Research Center, Indiana Univ., 1988 and 1991.

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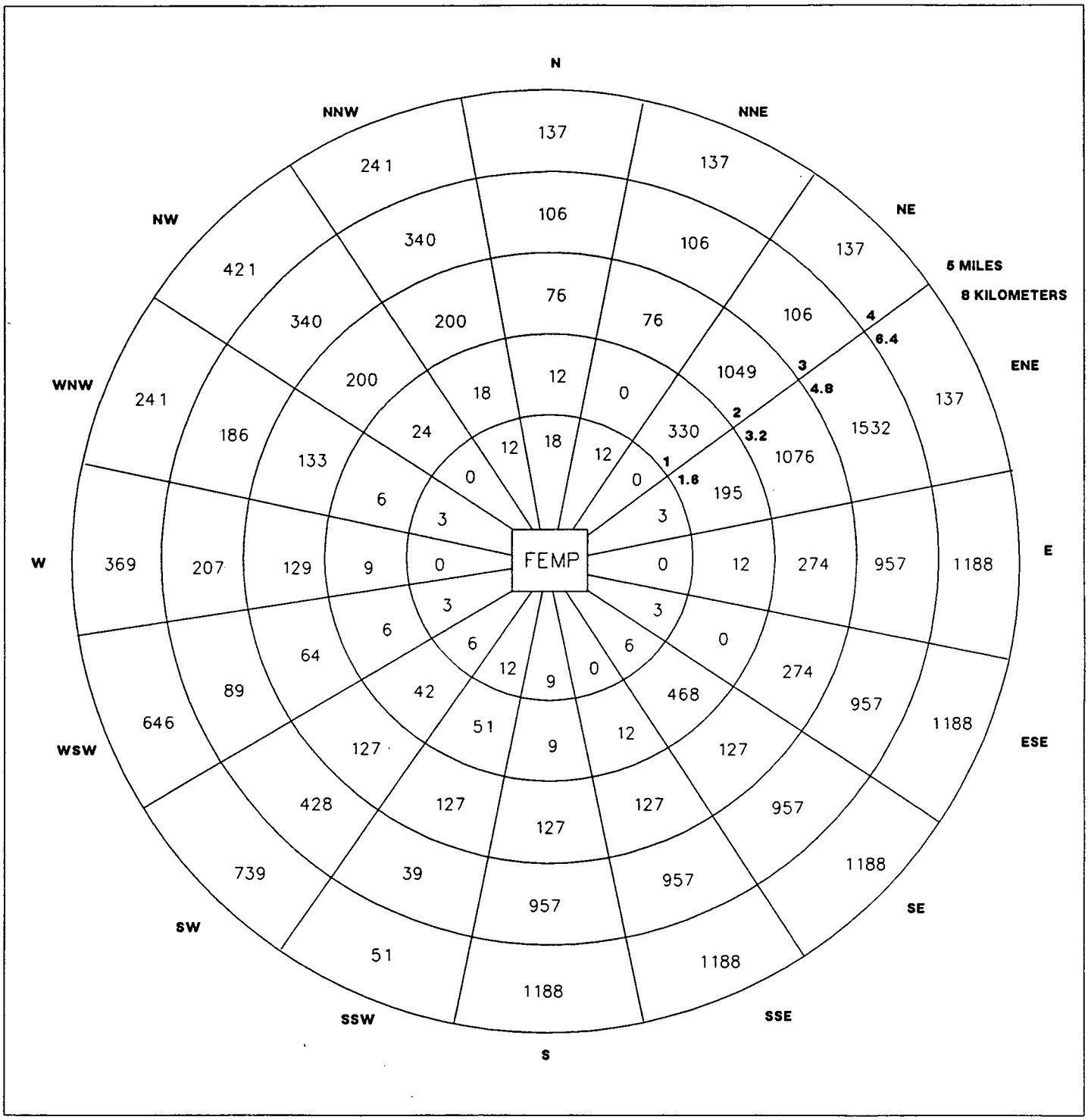


FIGURE C.1-1. RESIDENTIAL POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION, 1990

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## TABLE C.1-2

## RESIDENTIAL POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION, 1990

| | Distance | | | | | |
|---|---|---|---|---|---|---|
| Direction | 0 - 1 Mile | 1 - 2 Miles | 2 - 3 Miles | 3 - 4 Miles | 4 - 5 Miles | Total |
| North | 18 | 12 | 76 | 106 | 137 | 349 |
| North northeast | 12 | 0 | 76 | 106 | 137 | 331 |
| Northeast | 0 | 330 | 1,049 | 106 | 137 | 1,622 |
| East northeast | 3 | 195 | 1,076 | 1,532 | 137 | 2,943 |
| East | 0 | 12 | 274 | 957 | 1,188 | 2,431 |
| East southeast | 3 | 0 | 274 | 957 | 1,188 | 2,422 |
| Southeast | 6 | 468 | 127 | 957 | 1,188 | 2,746 |
| South southeast | 0 | 12 | 127 | 957 | 1,188 | 2,284 |
| South | 9 | 9 | 127 | 957 | 1,188 | 2,290 |
| South southwest | 12 | 51 | 127 | 39 | 51 | 280 |
| Southwest | 6 | 42 | 127 | 428 | 739 | 1,342 |
| West southwest | 3 | 6 | 64 | 89 | 646 | 808 |
| West | 0 | 9 | 129 | 207 | 369 | 714 |
| West northwest | 3 | 6 | 133 | 186 | 241 | 569 |
| Northwest | 0 | 24 | 200 | 340 | 421 | 985 |
| North northwest | 12 | 18 | 200 | 340 | 241 | 811 |
| Total | 87 | 1,194 | 4,186 | 8,264 | 9,196 | 22,927 |
| Cumulative total | 87 | 1,281 | 5,467 | 13,731 | 22,927 | |

SOURCE: Ohio Data Users Center, "Ohio Population by Governmental Unit, 1980-1990," Ohio Dept. of Development, February 1991.

area covered. Population estimates for the six-township area were obtained from Ohio Population by Governmental Unit, 1980-1990, prepared and distributed by Ohio Data Users Center, Department of Development, in conjunction with the U.S. Bureau of the Census.

Further adjustments were made to some population segments to more accurately reflect populations. For example, the presence of a large state park or residential area within a segment would require appropriate population adjustment, such as using only half of a rural density figure in the case of a large park area. Data used for these adjustments were acquired through interviews with local planners and examinations of local maps.

Because the identification of the concentration of population within a two-mile radius is of major importance for the purposes of notification in the event of an accident at the FEMP (the two-mile Notification Zone), a more detailed method of population estimation was used for that area. Windshield surveys were conducted to determine the number of households in the area, using the U. S. Geological Survey (USGS) map of the Shandon Quadrangle. An estimate of three persons per household was then used to calculate residential population. This estimate of three persons per household was derived by averaging persons per household figures for all the incorporated areas and townships in the study area.

### C.1.4 POPULATION PROJECTIONS

Projections to the year 2010 are provided for the study area, Hamilton and Butler Counties, the tri-state area, and the U.S.

#### C.1.4.1 Five-Mile Radius

Projected population distribution within a five-mile radius of the FEMP for the year 2010 is shown on Figure C.1-2. Growth rates used were those published by the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) in 1982. The OKI projections were calculated at a sub-county level (transportation analysis zones) and are used throughout the tri-state area for planning purposes. Many segments (of the 80 total segments) included more than one transportation zone. In these instances, the current population was divided into smaller portions, the corresponding growth rate applied to each portion, and the results totalled for a segment projection. Total population for the study area will be an estimated 27,500 as shown in Table C.1-3.

As indicated in Table C.1-4, the corridor extending from south southwest through west southwest of the FEMP is anticipated to experience strong growth between 1990 and 2010, with certain individual segments demonstrating significant growth trends. The corridor extending from the south-southwest through the west of the FEMP is anticipated to experience strong growth between 1990 and 2010, with certain individual segments demonstrating significant growth trends. The corridor between east-

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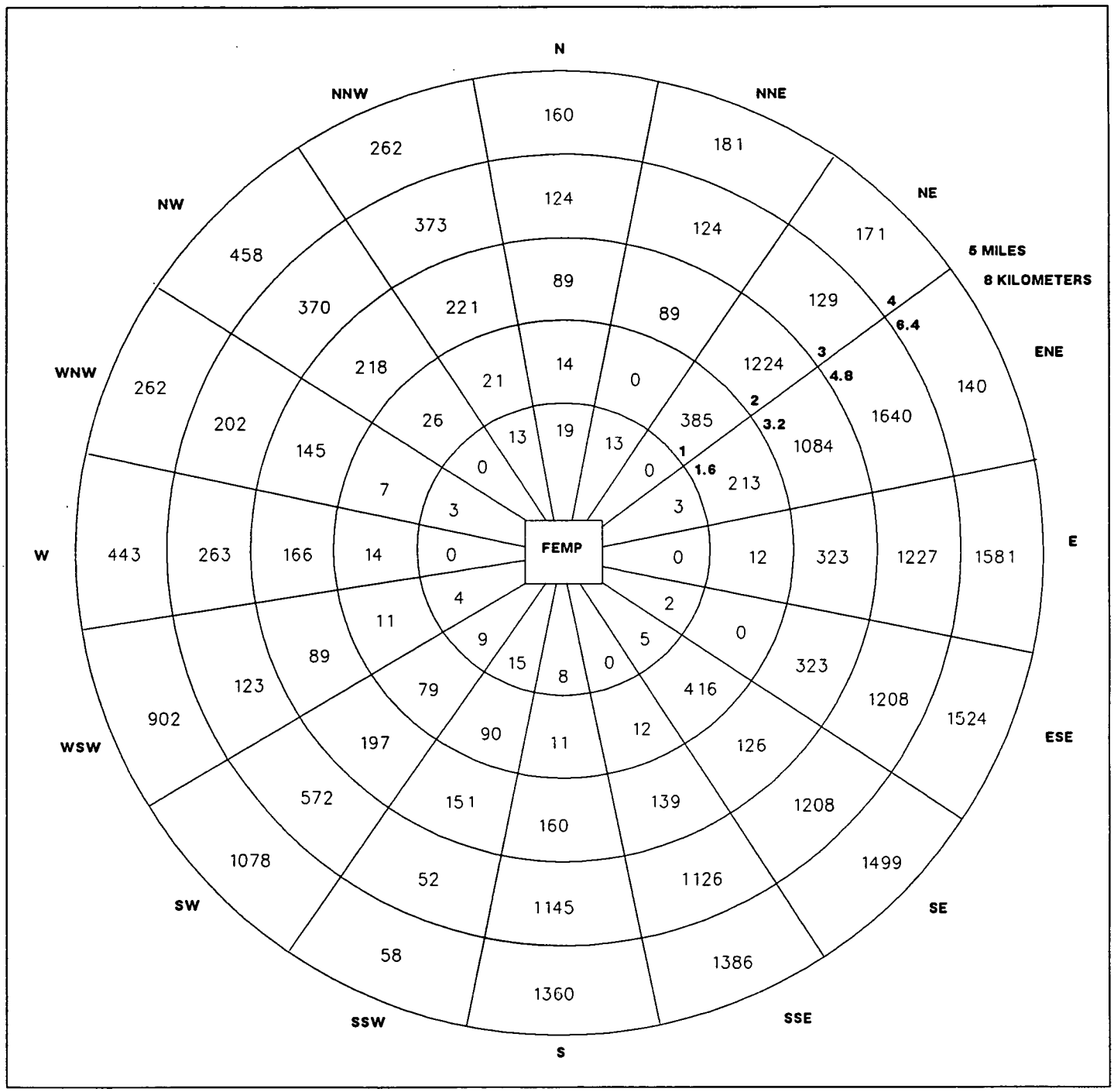


C.1-2. PROJECTED RESIDENTIAL POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION, 2010

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## TABLE C.1-3
## RESIDENTIAL POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION, 2010

| | Distance | | | | | |
|---|---|---|---|---|---|---|
| Direction | 0 - 1 Mile | 1 - 2 Miles | 2 - 3 Miles | 3 - 4 Miles | 4 - 5 Miles | Total |
| North | 19 | 14 | 89 | 124 | 160 | 406 |
| North northeast | 13 | 0 | 89 | 124 | 181 | 407 |
| Northeast | 0 | 385 | 1,224 | 129 | 171 | 1,909 |
| East northeast | 3 | 213 | 1,084 | 1,640 | 140 | 3,080 |
| East | 0 | 12 | 323 | 1,227 | 1,581 | 3,143 |
| East southeast | 2 | 0 | 323 | 1,208 | 1,524 | 3,057 |
| Southeast | 5 | 416 | 126 | 1,208 | 1,499 | 3,254 |
| South southeast | 0 | 12 | 139 | 1,126 | 1,386 | 2,663 |
| South | 8 | 11 | 160 | 1,145 | 1,360 | 2,290 |
| South southwest | 15 | 90 | 151 | 52 | 58 | 280 |
| Southwest | 9 | 79 | 197 | 572 | 1,078 | 1,342 |
| West southwest | 4 | 11 | 89 | 123 | 902 | 808 |
| West | 0 | 14 | 166 | 263 | 443 | 714 |
| West northwest | 3 | 7 | 145 | 202 | 262 | 569 |
| Northwest | 0 | 26 | 218 | 370 | 458 | 985 |
| North northwest | 13 | 21 | 221 | 373 | 262 | 811 |
| Total | 94 | 1,311 | 4,744 | 9,886 | 11,465 | 27,500 |
| Cumulative total | 94 | 1,405 | 6,149 | 16,035 | 27,500 | |

SOURCES: Ohio Data Users Center, "Ohio Population by Governmental Unit, 1980-1990," Ohio Dept. of Development, February 1991.

Ohio-Kentucky-Indiana Regional Council of Governments, "Transportation Analysis Zone Projections for the Year 2010," Ohio-Kentucky-Indiana Regional Council of Governments, 1988.

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## TABLE C.1-4

## RESIDENTIAL POPULATION CHANGE, 1990 - 2010 FOR THE AREA WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION

| | Distance | | | | | |
|---|---|---|---|---|---|---|
| Direction | 0 - 1 Mile | 1 - 2 Miles | 2 - 3 Miles | 3 - 4 Miles | 4 - 5 Miles | Total |
| North | 5.6 | 16.7 | 17.1 | 17.0 | 16.8 | 16.3 |
| North northeast | 8.3 | 0.0 | 17.1 | 17.0 | 32.1 | 23.0 |
| Northeast | 0.0 | 16.7 | 16.7 | 21.7 | 24.8 | 17.7 |
| East northeast | 0.0 | 9.2 | 0.7 | 7.0 | 2.2 | 4.7 |
| East | 0.0 | 0.0 | 17.9 | 28.2 | 33.1 | 29.3 |
| East southeast | -33.3 | 0.0 | 17.9 | 26.2 | 28.3 | 26.2 |
| Southeast | -16.7 | -11.1 | -0.8 | 26.2 | 26.2 | 18.5 |
| South southeast | 0.0 | 0.0 | 9.4 | 17.1 | 16.7 | 16.6 |
| South | -11.1 | 22.2 | 26.0 | 19.6 | 14.5 | 17.2 |
| South southwest | 25.0 | 76.5 | 18.9 | 33.3 | 13.7 | 30.7 |
| Southwest | 50.0 | 88.1 | 55.1 | 33.6 | 45.9 | 44.2 |
| West southwest | 33.3 | 83.2 | 39.1 | 38.2 | 39.6 | 39.7 |
| West | 0.0 | 55.6 | 28.7 | 27.1 | 20.1 | 24.1 |
| West northwest | 0.0 | 16.7 | 9.0 | 8.6 | 8.7 | 8.8 |
| Northwest | 0.0 | 8.3 | 9.0 | 8.8 | 8.8 | 8.8 |
| North northwest | 8.3 | 16.7 | 10.5 | 9.7 | 8.7 | 9.7 |
| Total | 8.0 | 9.8 | 13.3 | 19.6 | 24.7 | 19.9 |

SOURCES: Ohio Data Users Center,"Ohio Population by Governmental Unit, 1980-1990," Ohio Dept. of Development, February 1991.

Ohio-Kentucky-Indiana Regional Council of Governments, "Transportation Analysis Zone Projections for the Year 2010," Ohio-Kentucky-Indiana Regional Council of Governments, 1988.

southeast and southeast has been projected to decline during the same period and the area to the east-northeast of the FEMP is expected to exhibit very slow growth. The remaining sectors have moderate population growth forecasted. The areas with significant growth potential have more than offset those other areas with slower or even negative growth projections to result in a very positive anticipated growth rate.

C.1.4.2 Local, State, and National Trends

The population within the five-mile radius of the FEMP has been projected to increase by 19.9 percent between 1990 and 2010, a greater increase than the 7.1 percent predicted for Hamilton County and Butler County's 0.1 percent (see Table C.1-1). The tri-state area is projected to experience very slow growth between 1990 and 2010 (1.1 percent), primarily due to the large losses expected for Ohio (-4.1 percent). National population is expected to increase by 13.0 percent.

C.1.5 DAYTIME RESIDENTIAL/EMPLOYMENT POPULATION

A presentation of daytime residential/employment population within a five-mile radius of the FEMP is summarized in Table C.1-5 with a separate indicator of employment for the FEMP in Figure C.1-3. Daytime residential/employment population is a calculation of the number of residents who remain in an area during the day (children, homemakers, retirees, for example) and the number of those who come to the area to work. Daytime residential/employment population figures for each of the 80 segments were calculated by subtracting the corresponding segment labor force estimates from the residential population to derive the daytime residential population. Employment for each segment was added to the daytime population to get the segment's total daytime residential/employment population, (OKI 1989). Within the two-mile Notification Zone, employment figures were obtained directly from each of the local employers and FEMP representatives.

C.1.6 SEASONAL/TEMPORARY POPULATIONS

Discussions with Migrant Ombudsmen in the Ohio, Kentucky, and Indiana Bureaus of Employment Services indicate that there is no measurable seasonal population within the five-mile study area. (Ohio, Kentucky, Indiana Bureau of Employment Services 1990).

C.1.7 POPULATION DISTRIBUTION WITHIN A FIFTY-MILE RADIUS OF THE FEMP

Residential population within a 50-mile radius of the FEMP exceeded 2.9 million in 1990. This population estimate represents an increase of 3.3 percent over 1980 population figures. While this rate of increase is below the national growth rate of 10.2 percent, it is above estimated growth rates in each of the three states in the study area: Ohio - 0.5 percent, Kentucky - 0.7 percent, and Indiana - 1.0 percent. The population within a 50-mile radius is projected to increase to 3.01 million (1.7 percent) to the year 2010, while the states' projected rates of change vary from a substantial 13.6 percent for Kentucky, a small 3.1 percent expansion in Indiana, and a loss of 4.1 percent in Ohio. The national population is expected to increase by 13.0 percent to reach over 282 million in the year 2010.

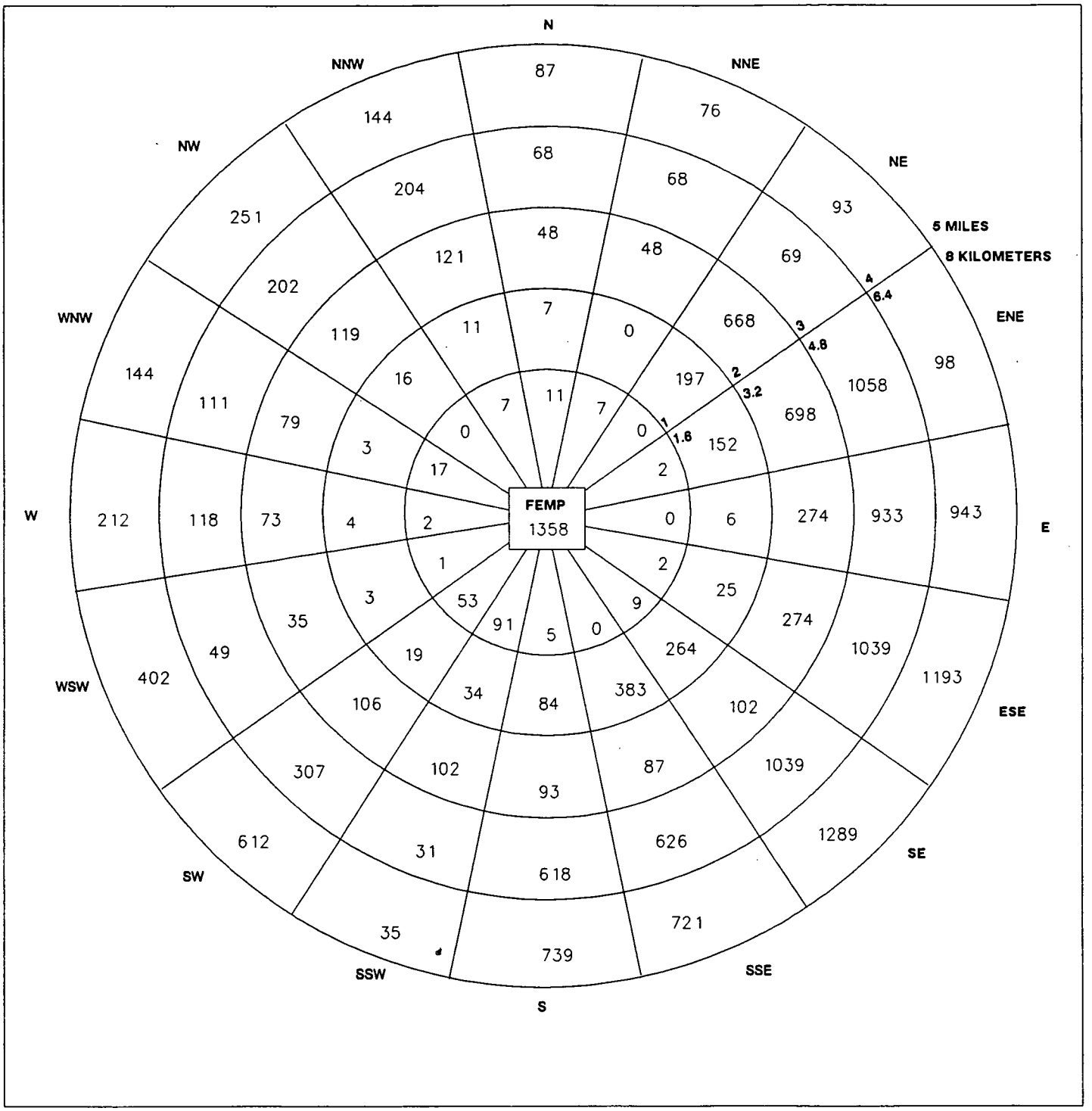


FIGURE C.1-3. DAYTIME RESIDENTIAL/EMPLOYMENT POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION, 1990

## TABLE C.1-5
## DAYTIME RESIDENTIAL/BUSINESS POPULATION DISTRIBUTION WITHIN A FIVE-MILE RADIUS OF THE FEMP, BY DISTANCE AND DIRECTION

| | Distance | | | | | |
|---|---|---|---|---|---|---|
| Direction | 0 - 1 Mile | 1 - 2 Miles | 2 - 3 Miles | 3 - 4 Miles | 4 - 5 Miles | Total |
| North | 11 | 7 | 48 | 68 | 87 | 221 |
| North northeast | 7 | 0 | 48 | 68 | 76 | 199 |
| Northeast | 0 | 197 | 668 | 69 | 93 | 1027 |
| East northeast | 2 | 152 | 698 | 1058 | 98 | 2008 |
| East | 0 | 6 | 274 | 933 | 943 | 2156 |
| East southeast | 2 | 25 | 274 | 1039 | 1193 | 2553 |
| Southeast | 9 | 264 | 102 | 1039 | 1289 | 2703 |
| South southeast | 0 | 383 | 87 | 626 | 721 | 1817 |
| South | 5 | 84 | 93 | 618 | 739 | 1539 |
| South southwest | 91 | 34 | 102 | 31 | 35 | 293 |
| Southwest | 53 | 19 | 106 | 307 | 612 | 1097 |
| West southwest | 1 | 3 | 35 | 49 | 402 | 490 |
| West | 2 | 4 | 73 | 118 | 212 | 409 |
| West northwest | 17 | 3 | 79 | 111 | 144 | 354 |
| Northwest | 0 | 16 | 119 | 202 | 251 | 588 |
| North northwest | 7 | 11 | 121 | 204 | 144 | 487 |
| Total[a] | 206 | 1209 | 2927 | 6540 | 7039 | 17921 |
| Cum. Total | 206 | 1415 | 4342 | 10882 | 17921 | |

[a] School enrollment can be added to the following segments:
SW - 3 miles - 406; NW - 4 miles - 554; ENE - 4 miles - 585;
SE - 5 miles - 387; NE - 5 miles - 1384 (2 schools).
Adjusted daytime residential employment population - 21,237

SOURCES: Ohio Data Users Center, "Ohio Population by Government Unit, 1980-1990," Department of Development, 1991.
Ohio-Kentucky-Indiana Regional Council of Governments, "Transportation Analysis Zone Projections, to the Year 2010," Ohio-Kentucky-Indiana Regional Council of Governments, 1989.

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# ATTACHMENT C.I

# POPULATION PROJECTION METHODOLOGY

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ATTACHMENT 4

# 2000 TRANSPORTATION ANALYSIS ZONE PROJECTIONS - METHODOLOGY FOR POPULATION AND HOUSEHOLDS

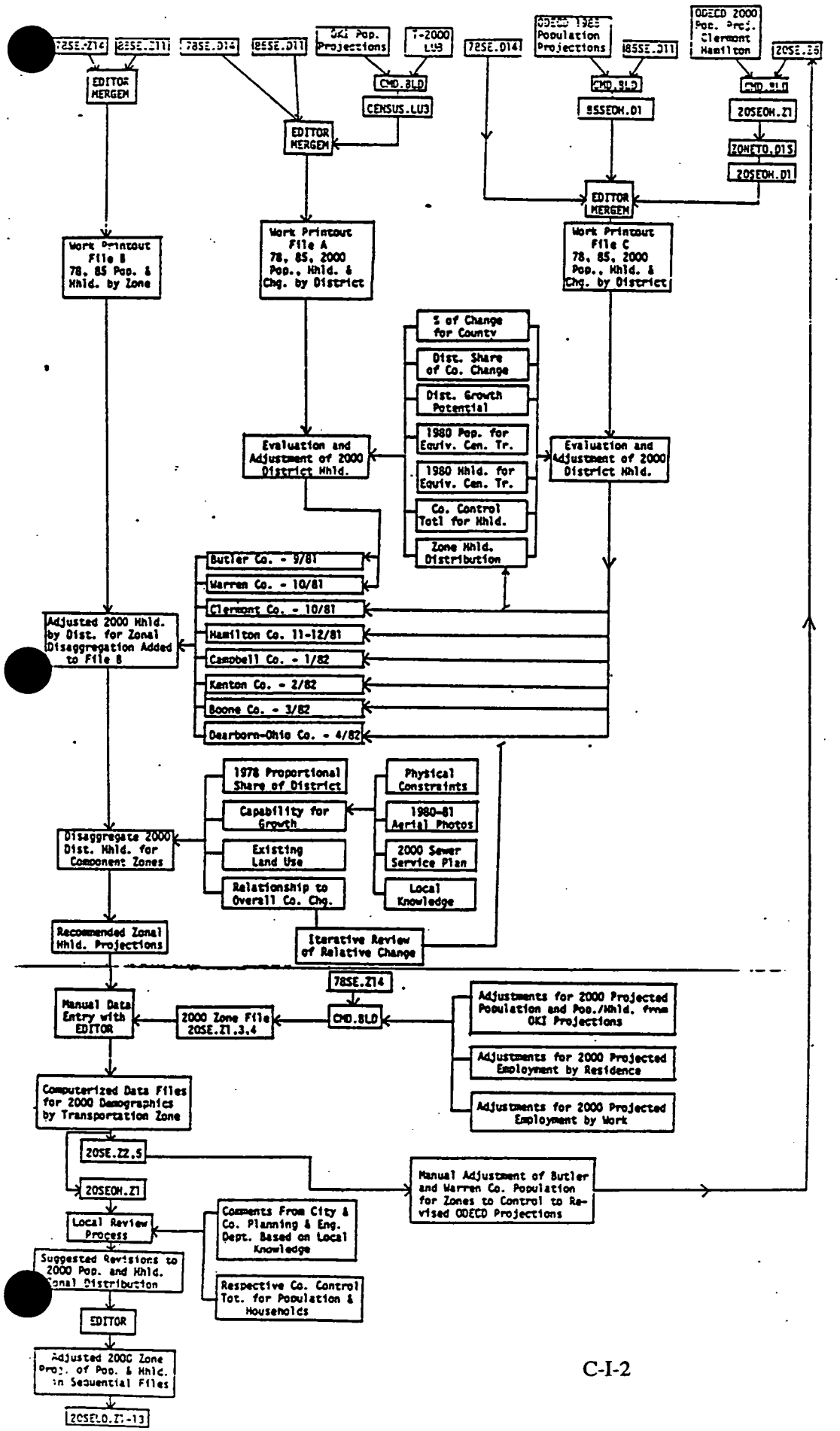
## OVERVIEW

The work described below was undertaken under Part V of the OKI Transportation 2000 study, detailing the Recommended Plan. It follows as an extension of previous work where social and economic variables were projected to 2000 for the region's 248 transportation districts. This phase further disaggregates the information variables to the 909 transportation analysis zones (TAZ). The resultant data file is used as input to the Urban Transportation Planning System traffic simulation models.

The procedure followed included three parts. First, district level population and household projections were developed for the revised year 2000 county population projections. Second, the households for each district were apportioned among its component zones considering land use, public facilities, and natural constraints. The resulting zonal household distribution was evaluated, revised where needed, and entered into a computer file. Third, the OKI staff figures for population, households and employment were sent to the local planning and county engineering departments for review. Meetings were held with local staff and suggestions for redistribution were incorporated into the computer file. Upon completion of all three stages for each of the nine OKI counties, the resulting regional data file was applied to transportation alternative analysis. A flow chart of the zonal disaggregation process is included in this memo.

The zonal projection process was begun in September, 1981 and was completed the following May (1982). Generally, each county was worked through the three-step procedure sequentially. Butler and Warren Counties were projected first in order to provide the necessary demographics for the Hamilton Corridor analysis study. Clermont and Hamilton Counties were done next to similarly provide data for the Eastern Corridor review. Campbell, Kenton, and Boone Counties were then prepared, followed by Dearborn and Ohio Counties.

SCHEMATIC FLOW CHART FOR 2000 ZONE PROJECTIONS



## Previous OKI Work

Previous phases of the Transportation 2000 Plan (T-2000) resulted in a series of demographic data files for transportation model validation and system planning. 1978 base year data was prepared for the 248 districts in Phase I. These figures, with some adjustment in response to preliminary 1980 Census results, were disaggregated to the zone level for Phase III.

Demographic projections were first prepared for districts for the long range target year 2000 in Phase II. These projections were supplemented in Phase III with the preparation of two additional alternative growth projection series, LU-1 and LU-3 added to LU-2. These reflected two different land use assumptions regarding concentration of development and one alternative set of county population projections for districts.

Intermediate year projections for 1985 were prepared as part of Phase III for both the district and zone level.

## Other Resources

During the four year T-2000 planning process from 1978-82, the project staff closely monitored the progress and release of 1980 Census of Population and Housing data. The first figures released were preliminary population counts for local review in July, 1980. Population counts for census tracts were not obtained until the PL 94-171 reapportionment tables were received in August, 1981. Census tract figures for numbers of households and housing units, which are the preferred variable unit for these projections, were not obtained until October, 1981 or after this process was begun. As census data were released, the staff attempted to incorporate the findings into the T-2000 data files to improve accuracy although at the expense of continuity.

Also, county population projections for the target year 2000 have been revised during the planning process. The first projections were developed by OKI. These were revised by the staff upon receipt of the first census data with its indication of unexpectedly lower household size, and also in response to the findings of the OKI regional econometric model in 1981. Subsequently, the forecasts for the four Ohio counties of the region were replaced by the preliminary projections of the Ohio Department of Economic and Community Development at the request of the Ohio Department of Transportation in November, 1981. The Kentucky and Indiana county projections used in the 2000 zonal disaggregations remain those prepared by OKI.

The T-2000 transportation zone projections were derived through a top-down procedure whereby the projected regional population is first allocated to the nine counties, then to the 248 transportation districts, and, finally, to the 909 zones. While much objective information is considered in the process, such as census data; aerial photo land use and housing counts; and available public services, the end results rely heavily on the subjective evaluation of the data by the project staff and knowledge of the community by local planning staffs.

Among the resources used were past geographic data files prepared in preceding T-2000 planning phases and planning resources such as sewage facility plans, topographic and flood plain maps, local land use plans, 1980 aerial photography and available census data. OKI transportation zone maps at 2000 feet per inch scale were used for reference in allocating population because of the greater detail of local streets and the updated development obtained from the 1980 aerial photography.

Three computer programs were developed to manipulate the massive zone files including EDITOR which allows piecemeal editing of any of 20 variables, calculations with the variables, and displays of the data files. The second program, CMD.BAS, permits the mass adjustment of area variables by creating a command file using county-specific factors. The third program, MERGEM, combines sub-files created by EDITOR. These programs are referred to within the operation symbols of the procedural flow chart attached.

Methodology

The household totals for districts used for 2000 zonal disaggregation were modified from those developed in Phases II and III although the previous households were used in the adjustment process. Three printout files were used in the zonal disaggregation process and are represented in the attachments by a sample page illustrating the work done.

Two of these files, A and C are district files. File A is comprised of 1978, 1985, and 2000 population and household figures by district along with the percent change between these years. The 2000 projections in File A represent the revised OKI county projections distributed to the districts the same as the LU-3 land use alternative which is based on no new sewer extensions and considerable urban infill.

File C also includes district population and household data for 1978, 1985, and 2000 along with percent change. However, in File C, the 1985 and 2000 OKI population projections for Butler, Clermont, Hamilton and Warren Counties have been replaced by those prepared by the Ohio Department of Economic and Community Development in February 1981*. These county projections are distributed to the districts in proportion to the 1978 district estimates rather than the LU-3 alternative because of the receipt in November, 1981 of census tract household data. In many areas there is a reasonable match between census tracts and OKI's districts and/or zones. Where this comparison is possible, the 1980 households were added to File C and used as an accurate base for adding the appropriate increment of growth.

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*Additional adjustments to accommodate the revised Ohio population projections released in June, 1982 were carried out in February, 1983.

The need to incorporate the Ohio DECD population projections and the 1980 Census household counts for tracts (File C) occurred after the zonal disaggregation process was carried out for Butler and Warren Counties using File A, but before the local review stage was begun. Therefore, it was necessary to modify the zone and district population projections for these two counties in order to total to the state-prepared projections. This was done by raising zones likely to grow or taking households from zones likely to decline or not grow as much. Since the state's projections are only for population, the number of households remained a function of the OKI projected household size for 2000.

For the Kentucky and Indiana Counties, the 2000 population projections by OKI in File A were carried over in File C.

File B is a zone level printout listing 1978 and 1985 population and households and was used to record the 2000 projected households by zone. The use of File B will be described further in the zonal disaggregation section.

The year 2000 district total for households in Files A and C were reviewed and modified after taking into consideration the following factors:

- Percent Change in Households for the County Between 1978 and 2000. Should the district receive an increment of change greater, less than or the same as the county it is in?

- District Growth Potential. Is this district able or likely to grow or decline between 1978/80 and 2000 considering the land use types and age, amount of open space, and availability of utilities?

- 1980 Population and Households. If the district or a combination of districts and zones is comparable to 1980 census tracts, do the 2000 households seem reasonable when compared to how many are already there in 1980?

- 2000 Household Total for the County. Do the total households for all the districts in the given county still total the county control projection after adjustments have been made?

- 2000 Zonal Level Distribution of Variables. Has the zonal disaggregation of the district households revealed any problems or inconsistencies that would justify further adjustment of the district totals? (See the iterative review loop in the flow chart.)

Once a satisfactory allocation of the county households has been achieved for the districts in a given county, the projected district household count is transferred to File B, the zone file printout. In File B, the zones are listed with their respective districts. The 2000 district household figure is placed to the right of the 1985 households and the next step, zonal disaggregation is begun.

## 2000 ZONAL DISAGGREGATION

A district is comprised of from one to eight zones and the objective of this procedure is to obtain the most likely distribution of population and households for these zones in the year 2000. As previously stated, households is the variable selected to project because they can be equated with housing units, a quantifiable unit of land use. Additionally, the number of people per household varies significantly and has been found to be more effective to let population be a function of the number of households (Population = Households x Persons Per Household).

A district and its zones are a reasonably comprehendable area. Within urbanized areas they are small enough to examine on aerial photography and topographic maps. The zones are also delineated to represent homogeneous land use, some entirely comprised of commercial or industrial activity and likely to remain as such in the future.

The process for disaggregating the district households to its zones is based upon the following steps:

First, the OKI district and zone map was compared with the 1980 census tract map to determine if the district or some combination of zones is comparable to a census tract. Where an equivalent combination was found, the 1980 census tract household total was allocated among the zones using the 1978 zone proportions as follows:

$$\frac{Zone_{78}}{Dist/Zone_{78}} \times Tract_{80} = Zone_{80}$$

The result was considered to be a more accurate reference base for allocation of the 1978 to 2000 increment of household change. If an equivalent combination was not found, a mental note was made as to whether the 1980 households were more or less than the OKI estimates for the general area.

Second, using the 1978 or 1980 household estimates for zones, the previously determined 1978 to 2000 increment of household change for the district was allocated among its component zones and listed on File B. The following items were taken into consideration in determining the year 2000 households:

- Proportional Share of Change Based on 1978 - This is to determine the projected households if each zone changed at the same rate as the district and results in a number on which to base further evaluation.

- Existing Land Use - Using the OKI 1980/81 aerial photo coverage, the zones were studied to see if they were residential or non-residential, full or partially developed, and if the development was new or old. Households were generally added to new, partially developed, residential areas.

- Capability for Growth: Several factors were reviewed and contributed to the determination of how much of the district's increment of growth could be absorbed by a zone. These factors include the following:

- Physical Constraints - This was determined from the OKI Regional Land Use Map 2000 showing areas of flood susceptibility and steep slope. In some areas, the seven and one-half minute U.S.G.S. topographic maps were also used. Generally, the presence of flood plain or steep slope discourages additional development.

- Available Land - The presence of open, farmed, or cleared land as determined from the aerial photographs, was considered as an encouragement for future growth. Availability of land was considered in terms of land use and proximity to urbanized areas. For example, an open tract of land in an industrial area was judged more likely to be used for non-residential purposes and a tract in a remote rural area was assumed to remain rural.

- Available Public Facilities - Where growth was being considered for 2000, the availability of water and sewer services was investigated. Two resources were used including the OKI Inducements and Constraints to Urban Development Map and a work map delineating existing and funded future sewer services which was developed for the alternative land use scenarios of Phase III. It was assumed that sewer service in 2000 would be limited to that area presently served plus those areas included in grant applications assured funding by the Enviornmental Protection Agency. In regard to unsewered rural areas, it was assumed that the lack of sewers, poor soil conditions for individual systems, and countywide land use controls would inhibit significant amounts of development. Households which were allocated to rural zones represent single lot splits along existing roads.

- Local Planning Studies - Local development plans were also consulted to determine anticipated growth characteristics for certain zones. These plans were particularly useful to determine the intended location of residential and non-residential development.

- Local Knowledge - The local knowledge of the region by the OKI staff plus that of local planning and engineering staffs was used to provide a subjective evaluation of "reasonableness" to the amount of change allocated to each zone. During the initial allocation of the district increments of change to the zones, OKI staff considered the likelihood of varying amounts of change given the previously mentioned factors plus local community values and projects planned for the future. At the subsequent local review stage, representatives of the local planning and county engineer offices reviewed the OKI distribution of change in light of likely development projects and service extensions.

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Third, once the previously-described process was completed and a preliminary projection of households was listed in File B for each zone in the subject county, the results were reviewed. The number of projected households and the increment of change were reviewed within the context

of the district and the county as a whole. This review resulted in a second round of household allocations as areas judged to be under-projected were supplemented by households from areas over-projected or likely to decline. This review step sometimes affected the previously projected district allocations and therefore is represented as a loop in the accompanying flow chart of the zonal projection procedure. If the number of zones and districts changed was significant, the review stage was repeated.

Fourth, the household projections by zone resulting from the above procedure were next entered into a computer file. For this purpose, the most recent 1978 zone file, 78SE.Z14, was modified using the CMD.BLD program to adjust the population, population per household, and the employees per population ratios to the year 2000 level. Mathematically this was done as follows:

$$\text{Variable}_{2000\ \text{Zone}} = \frac{\text{Variable}_{1978\ \text{Zone}} \times \text{Variable}_{2000\ \text{County}}}{\text{Variable}_{1978\ \text{County}}}$$

The year 2000 population per household for counties was determined for the OKI county population projections in August, 1981. The OKI household size ratio was used with both the OKI and State of Ohio county population control totals because the state's projections do not include households. The modified file is designated 20SE.Z1. (The first two digits represent the year: 20 = 2000; SE refers to social and economic data; the Z designates a zone file and the final number is the edition of the file.)

The 2000 zone projections for households were data-entered from File B into the computer file using the edit option of the EDITOR program. As this is done for each zone, the population, employment by place of residence and number of vehicles automatically changed to correspond with the household projection.

The usual result of entering the 2000 zonal households is that the total of the zone populations will no longer equal the county control total. This occurs because population is both lost and gained as the household values are revised but the household size variables are not. This is compensated for, and the 2000 county population is regained, by selectively adjusting the household size in certain zones. If the population has fallen below the county control total, the necessary people were added by raising the household size in urbanizing zones likely to be predominantly single family residential in 2000. If the population exceeds the county control total, the excess population was removed by lowering the household size in zones likely to receive large concentrations of high density housing, or mature residential areas where family size is likely to drop in the future. In either case, several zones of the appropriate type were compared and the ones most needing adjustment were changed.

Once both the population and households by zone total to the correct county control totals, the data file was used to prepare a printout for the local review procedure.

It was at this stage of the Butler and Warren County projections using OKI forecasts, that the directive was received to use the Ohio Department of Economic and Community Develoment figures for the four Ohio counties. For Butler and Warren Counties, the OKI-DECD population difference was converted to households using the OKI produced household size projections. In Butler County, the 1520 excess households were primarily taken out of built-up zones where growth would represent infill. In Warren County, the shortage of 290 households was added to zones with the space and services to hold more. These specific OKI to DECD adjustments were recorded on work File B and transferred to computer file 20SE.Z6.

Adjustments to Clermont County (add 2620 households) and Hamilton County (remove 28,838 households) were made using the CMD.BLD program on 20SE.Z6. By using this input file, the above adjustments for Butler and Warren Counties could be retained and previous work on the Kentucky and Indiana zone variables was preserved. The output file was 20SEOH.Z1.

LOCAL REVIEW

The year 2000 demographic projections, disaggregated to transportation analysis zones and, in Ohio, controlled to DECD county projections, were sent to local planning commission staffs and county engineers for review of the distribution of population, households and employment by place of work. The material sent included a computer printout listing 1978 and 2000 population, households and employment by zone in district order (Files 78SE.Z14 and 20SELO.Z). Where a useful level of comparability existed between districts and census tracts, a 1980 census tract map was also provided and marked to delineate geographic areas common to groups of census tracts and districts. For each of these common areas, the 1980 population and households were listed.

A follow-up meeting was then held at the offices of the local planning commissions to review the local comments. A list of these meetings is attached. Adjustments were made to each zone as suggested by the city or county officials where the distribution of households or employment was not considered accurate. Often these trips were combined with field inspection of uncertain areas.

At the OKI office, the local review suggestions were incorporated in the work files for the appropriate characteristic (See notations in blue pencil on File B). Where the result of the local suggestions showed a difference in the county control totals, the differences were resolved by re-adjusting the revised zones and, if not sufficient, by adjusting other zones selected as appropriate to meet the control totals.

Once the local review adjustments were made and the revisions controlled to the correct county totals, the revisions were transferred to the computer files. Local review changes were added to the Ohio DECD adjusted file (20SEOH.Z1) and re-named 20SELO.Z- with sequential suffix numbers as additional counties were reviewed and added (See file listing).

Upon the completion of the local review adjustments for the last county, all county control totals were checked for the variables and the file data was rounded to the nearest 10 using the round option of the EDITOR program. Once the zonal data was rounded, the county control totals were checked again and the zone level adjustments were made, if needed. The resultant 2000 zone file, 20SELO.Z13, was then turned over for use in detailing the long range plan.

APPENDIX D

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# APPENDIX D

## BENTHIC MACROINVERTEBRATE SURVEY
## GREAT MIAMI RIVER AND PADDYS RUN
## FALL 1988 THROUGH SUMMER 1990

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Attachment D.II Water Quality Data for the Great Miami River and Paddys Run

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## LIST OF ACRONYMS

| | |
|---|---|
| ASI | Advanced Sciences, Inc. |
| EE/CA | engineering evaluation/cost analysis |
| EIS | environmental impact statement |
| EPA | U.S. Environmental Protection Agency |
| FEMP | Fernald Environmental Management Project |
| FMPC | Feed Materials Production Center |
| FS | feasibility study |
| ICI | Invertebrate Community Index |
| IT | IT Corporation |
| NEPA | National Environmental Policy Act |
| OEPA | Ohio Environmental Protection Agency |
| RI | remedial investigation |
| RI/FS | remedial investigation/feasibility study |
| RM | river mile |
| SCUBA | Self Contained Underwater Breathing Apparatus |
| WEMCO | Westinghouse Environmental Management Company of Ohio |
| WMCO | Westinghouse Materials Company of Ohio |

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# EXECUTIVE SUMMARY

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The Fernald Environmental Management Project (FEMP) is a government-owned facility which formerly produced pure uranium metals. The facility is operated by Westinghouse Environmental Management Company of Ohio (WEMCO) for the Department of Energy (DOE). The FEMP is located on a 1050-acre site in a rural agricultural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler Counties. In July 1990, DOE signed a Consent Agreement with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sections 120 and 106(a), concerning environmental impacts associated with the FEMP. Pursuant to the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS Environmental Impact Statement (RI/FS - EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major Federal actions.

Potential remedial actions at the FEMP may affect several surface waters on and adjacent to the facility, including the Great Miami River, which is the receiving water for an NPDES-permitted discharge from the FEMP; Paddys Run, which drains the western side of the FEMP; and the storm sewer outfall ditch, a major tributary to Paddys Run which runs southwest from the Production Area to Paddys Run near the southern border of the facility. Potential remedial actions, including no action, may affect water quality in the Great Miami River and Paddys Run by affecting the quantity or quality of FEMP effluent or runoff to Paddys Run. For example, contaminated groundwater in the Great Miami Buried Valley Aquifer and in perched ground water tables on the property may be pumped out, treated to remove radionuclides, and discharged to the Great Miami River via the main effluent line. Another example is the planned Waste Pit Area Storm Water Runoff Control removal action, which will direct runoff currently entering Paddys Run to a treatment plant and then to the Great Miami River.

In order to meet CERCLA and NEPA requirements to evaluate the potential effects of such alterations in effluent or runoff quality on the aquatic community, it was first necessary to determine the existing effects. The composition of the macroinvertebrate community is considered to be a sensitive indicator of environmental effects on aquatic organisms as a whole. The purpose of the present study was to analyze the composition of the macroinvertebrate communities in Paddys Run and the Great Miami River upstream, adjacent to, and downstream of FEMP influence.

Five rounds of sampling were conducted during the following periods:

- October - December, 1988
- May - June, 1989
- November - December, 1989
- March - May, 1990
- June - August, 1990

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In October - December, 1988, data were collected from the Great Miami River only. The other rounds of sampling covered both the Great Miami River and Paddys Run. 3579

Water quality and biological data were collected from Paddys Run at sampling stations located upstream from, adjacent to and downstream from the FEMP property. Sampling stations on the Great Miami River were located upstream from, adjacent to, and downstream from the FEMP wastewater treatment plant outfall. The water quality variables measured included temperature, dissolved oxygen, pH, conductivity, turbidity, and current velocity.

Benthic macroinvertebrates were sampled with Hester-Dendy artificial substrates in both streams. The substrates were placed in the streams and were allowed a colonization period of approximately five weeks. When substrates were retrieved, additional samples were collected from Paddys Run with Surber stream bottom samplers and from the Great Miami River via grab sampling or with an Emery pipe dredge.

The primary tool used to compare samples was the Invertebrate Community Index developed by the Ohio Environmental Protection Agency. Other analyses included ecological diversity, evenness, organism density, total taxa, and tolerance classification of the taxa present. The results indicate that the FEMP does not strongly affect the composition of macroinvertebrate communities in Paddys Run or the Great Miami River. Rather, variables unrelated to the FEMP appear to be the primary factors controlling community composition in both streams. Particularly important is the seasonal intermittent flow of Paddys Run, which leaves much of the stream bed adjacent to the FEMP dry for intervals which may last for months in dry years. Benthic macroinvertebrate communities will return when stream flow resumes but may show reduced diversity and altered species composition. The effects of seasonal drying are exacerbated by periodic scouring from heavy floods when flow is present. In the Great Miami River, high sediment loads, which occur during extended periods of heavy precipitation, cause scouring, with consequent effects on the macroinvertebrate community. Great Miami River data collected during spring flood conditions showed severe reductions in benthic macroinvertebrate populations.

Based on Ohio Environmental Protection Agency criteria for the classification of water quality, Paddys Run and the Great Miami River in the vicinity of the FEMP would be Class III waters, indicating fair water quality. This study did not demonstrate that the current status of these waters is affected by the presence or operations of the FEMP.

# D.1.0 INTRODUCTION



## D.1.1 SITE DESCRIPTION AND HISTORY

The Fernald Environmental Management Project (FEMP) is a government-owned facility which formerly produced pure uranium metals. The facility is operated by Westinghouse Environmental Management Company of Ohio (WEMCO) for the Department of Energy (DOE). The FEMP is located on a 1050-acre site in a rural agricultural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler Counties (Figure D.1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the Production Area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In July 1990, DOE signed a Consent Agreement with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sections 120 and 106(a), concerning environmental impacts associated with the FEMP. Pursuant to the Consent Agreement, DOE is conducting a Remedial Investigation/Feasibility Study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS Environmental Impact Statement (RI/FS - EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major Federal actions. In order to expedite remedial actions at the FEMP, separate RI/FS reports are being prepared for each of five operable units. They are:

- Operable Unit 1 - Waste Pits 1 through 6, Clearwell, and Burn Pit
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Production Area and Suspect Areas
- Operable Unit 4 - Silos 1, 2, 3, and 4
- Operable Unit 5 - All Environmental Media

Detailed descriptions of the operable units are provided in project documents.

## D.1.2 SURFACE WATER HYDROLOGY OF THE FEMP

Remedial actions at the FEMP may affect several surface waters on and adjacent to the facility, including the Great Miami River, which is the receiving water for a National Pollutant Discharge Elimination System (NPDES) permitted discharge from the FEMP; Paddys Run, which drains the western side of the FEMP; and the storm sewer outfall ditch, a major tributary to Paddys Run which

runs southwest from the Production Area to Paddys Run near the southern border of the facility (Figure D.1-2). 3579

D.1.2.1 Great Miami River

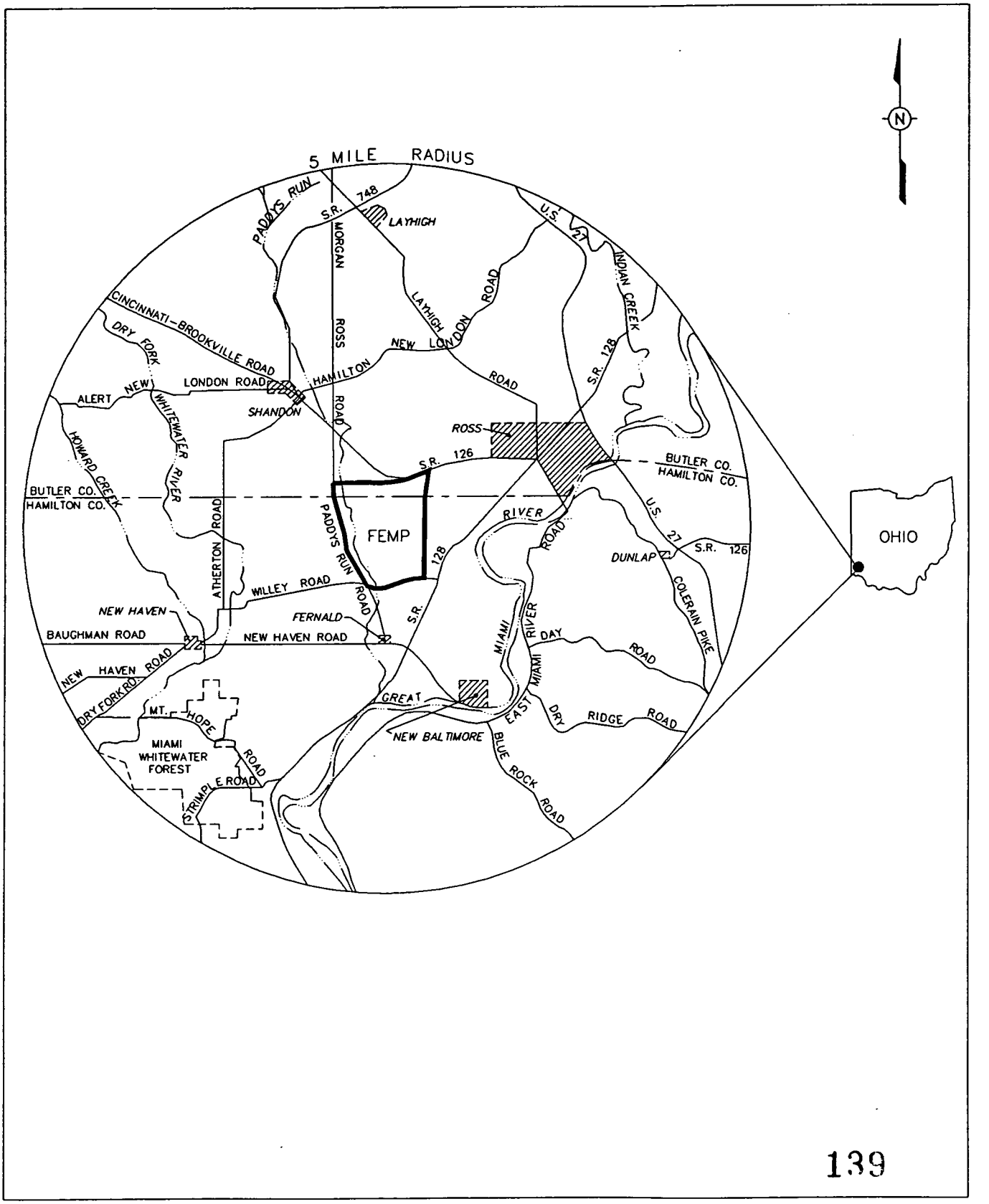
The Great Miami River is the main surface water feature in the vicinity of the FEMP (Figure D.1-2). The river flows generally to the southwest and has a drainage area of approximately 3360 square miles at the Hamilton gage, which is located about 10 miles upstream from the FEMP outfall. Meandering patterns in the river result in sharp directional changes over distances of less than 3000 feet. Directly east of the FEMP and within the RI/FS study area, the river passes through a 180-degree curve known as the "Big Bend" (Figure D.1-2). A 90-degree bend in the river also occurs near New Baltimore, approximately two miles downstream from the FEMP outfall.

The average discharge of the Great Miami River at Hamilton, based on 55 years of records, is 3305 cubic feet/second ($ft^3/s$). The corresponding average flow at the FEMP outfall has been estimated to be 3460 $ft^3/s$. The maximum discharge ever recorded for the Great Miami River at Hamilton occurred on March 26, 1913 and was estimated to be 352,000 $ft^3/s$. The maximum discharge since the construction in 1922 of five retarding basins, located approximately seven miles upstream of Ross, was 108,000 $ft^3/s$ and occurred on January 21, 1959. The ten-year-flood discharge has been calculated to be 81,455 $ft^3/s$ for the reach of the river adjacent to the FEMP. The minimum daily discharge of 155 $ft^3/s$ was recorded on September 27, 1941. This value is approximately half of the seven-day, ten-year low flow of 267 $ft^3/s$, as computed by the U.S. Geological Survey (USGS) for the Hamilton gage. This translates to 280 $ft^3/s$ at the FEMP.

Liquid waste effluent generated from FEMP operations is sent to a general plant sump for treatment and analysis prior to release to the Great Miami River through the main effluent line (Figure D.1-2). The main effluent line is a permitted discharge regulated by a NPDES permit and DOE orders, with compliance monitoring performed at Manhole 175 before the effluent leaves the FEMP boundary. The average effluent flow, radionuclide concentrations, and NPDES data for 1989 are stated in Table D.1-1.

D.1.2.2 Paddys Run

Natural surface drainage from the FEMP is primarily to Paddys Run, which originates north of the facility, drains southward along the western boundary of the FEMP, and enters the Great Miami River approximately 1.5 miles south of the FEMP (Figure D.1-2). Paddys Run is an extremely steep-sided stream, which has cut to depths of 6.1 meters or more through the geological deposits upon which the FEMP is built. This stream loses flow to the underlying aquifer along much of its course due to this highly permeable channel bottom, which is carved into the Great Miami Aquifer.




602.A_3317A146_BP_FND



FIGURE D.1-1. FIVE-MILE RADIUS MAP, FEMP

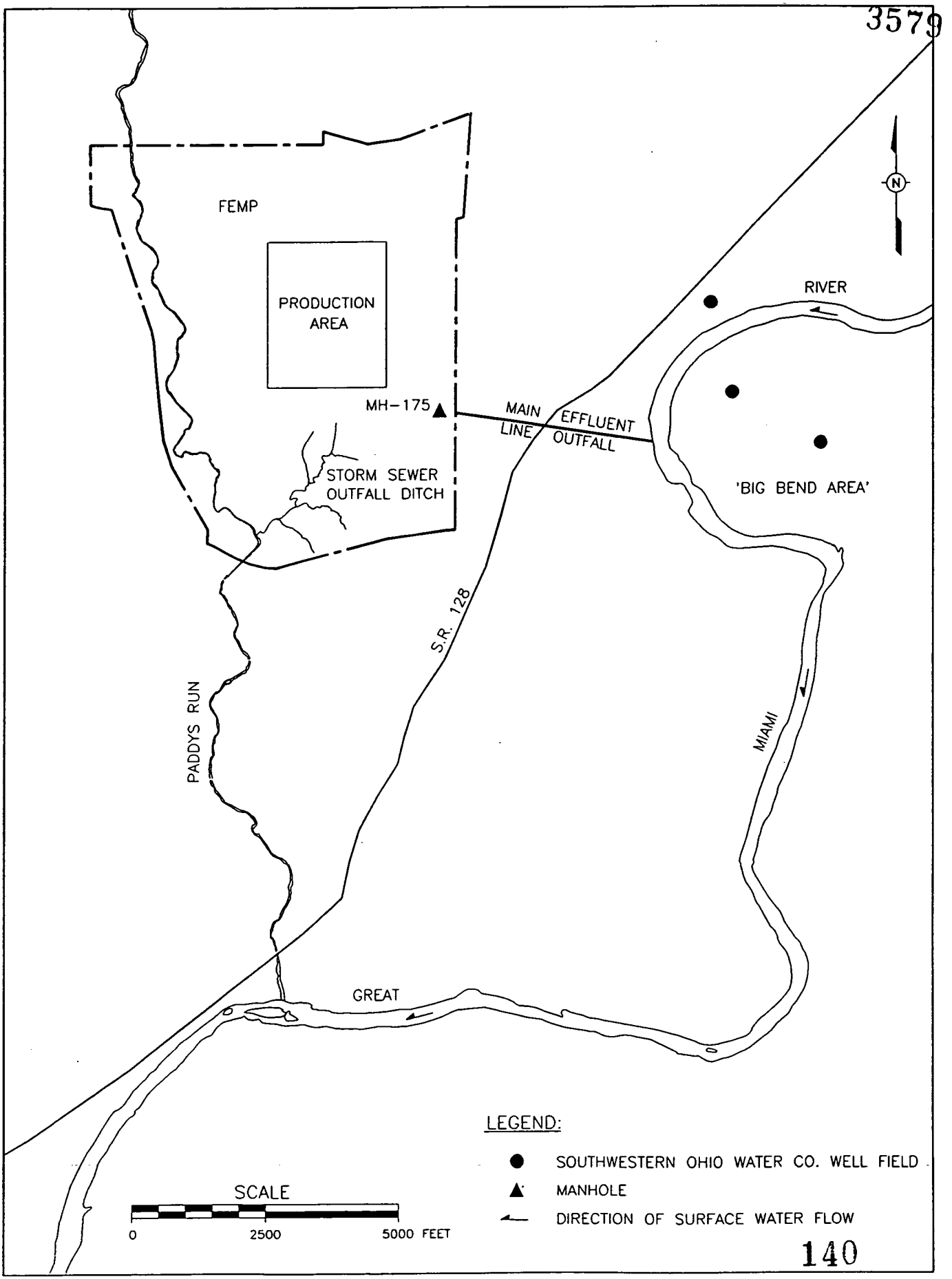





FIGURE D.1-2. SURFACE WATER HYDROLOGY AND MAIN EFFLUENT LINE AT THE FEMP

## TABLE D.1-1
## AVERAGE FLOW, RADIONUCLIDE CONCENTRATIONS, AND NPDES DATA FOR FEMP EFFLUENT, 1989

| Variable | Units | Average[a] |
|---|---|---|
| Flow Rate | MGD[b] | 0.68 |
| Plutonium-239/240[c] | pCi/ℓ | 0.11 |
| Thorium-230 | pCi/ℓ | 0.27 |
| Thorium-232 | pCi/ℓ | 0.78 |
| Thorium-234 | pCi/ℓ | 300 |
| Uranium-234 | pCi/ℓ | 240 |
| Uranium-235 | pCi/ℓ | 12 |
| Uranium-236 | pCi/ℓ | 8.4 |
| Uranium-238 | pCi/ℓ | 300 |
| pH | SU[d] | 7.4 to 9.3 |
| Suspended solids | mg/ℓ | 17 |
| Oil and grease | mg/ℓ | <5.1 |
| Residual chlorine | mg/ℓ | <0.04 |

[a] For details of sampling techniques and average computations, see WMCO (1990a).

[b] MGD, millions of gallons per day

[c] Average concentrations of radionuclides not listed were below detection limits.

[d] SU, standard units, the negative log of the hydrogen ion concentrations. Only the range was reported.

SOURCE: WMCO (1990a)

Paddys Run is an ungaged, intermittent stream which flows primarily between January and May, with an estimated discharge for this period ranging between 0.2 and 4.0 $ft^3/s$. Peak flows have not been measured. Between January and May, flow is generally continuous in the stream throughout its length. Between June and December, flow north of the K-65 silos is reduced to a trickle, and there is typically no flow south of the silos except during and immediately following rainfalls. The course of the stream has been changed twice in recent times (WMCO 1987a); in 1961 and 1962, the stream was directed away from the waste pit area to prevent it from reaching the stored wastes. A stretch south of the K-65 silos was straightened in 1970 to prevent erosion of Paddys Run Road. Review of aerial photographs of the FEMP also indicates that a tributary to Paddys Run similar in length to the storm sewer outfall ditch was buried during construction of the waste pit area (Sitton 1988).

Storm water runoff from the production area is collected in storm water retention basins, located on the south side of the production area, to allow for solids removal prior to being analyzed and released to the Great Miami River through the same effluent line. During extreme rainfalls, if the storm water retention basins overflow, storm water is discharged through the storm sewer outfall ditch to Paddys Run.

### D.1.3 PURPOSE OF STUDY

Potential remedial actions, including no action, at the FEMP, may affect water quality in the Great Miami River and Paddys Run by affecting the quantity or quality of FEMP effluent or runoff to Paddys Run. For example, contaminated groundwater in the Great Miami Buried Valley Aquifer and in perched ground water tables on the property may be pumped out, treated to remove radionuclides, and discharged to the Great Miami River via the main effluent line (DOE 1990a,b). Another example is the planned Waste Pit Area Storm Water Runoff Control removal action (DOE 1990c), which will direct runoff currently entering Paddys Run to a treatment plant and then to the Great Miami River.

In order to meet CERCLA and NEPA requirements to evaluate the potential effects of such alterations in effluent or runoff quality on the aquatic community, it was first necessary to determine the existing effects. The composition of the macroinvertebrate community is considered to be a sensitive indicator of environmental effects on aquatic organisms as a whole (OEPA 1982). Macroinvertebrates are relatively short-lived, typically less than a year, which means their abundances reflect the relatively recent status of the water body. They are also less transient than fish, forming permanent or semi-permanent communities, such that variation in the community can indicate water quality differences over small spatial scales. Finally, they are easier to quantify than microorganisms (e.g. phytoplankton and bacteria) and frequently occur in numbers sufficient to allow statistical comparisons of closely spaced sampling stations.

The purpose of the present study was to analyze the composition of the macroinvertebrate communities in Paddys Run and the Great Miami River upstream, adjacent to, and downstream of FEMP influence.

Samples were collected over a two year period from October 1988 to August 1990. A variety of methods were used in data analysis and evaluation, including indices of diversity and evenness, number of taxa, organism density, and the Invertebrate Community Index (ICI) developed by the Ohio Environmental Protection Agency (OEPA 1988).

# D.2.0 METHODS

Water quality and benthic macroinvertebrate populations were monitored on the Great Miami River and Paddys Run during five sample periods between October 1988 and August 1990. Sampling was conducted on the following dates:

- October 27, 28 - December 1, 2, 1988
- May 9, 10 - June 12, 15, 1989
- November 7, 9 - December 11, 13, 1989
- March 28, 29 - May 1, 2, 1990
- June 26, 27 - August 1, 2, 1990

The first sampling dates of each period represent initial macroinvertebrate sampler deployment and the later dates represent sampler retrieval. Water quality variables were monitored during each visit to sample stations for all five sample periods.

## D.2.1 SAMPLING STATION LOCATIONS

### D.2.1.1 Great Miami River

The seven stations selected for the Great Miami River survey (Figure D.2-1) were identical to those used for previous water and sediment quality sampling for the RI/FS and by WEMCO. Stations designated with a "W" were surface water sampling stations routinely monitored by WEMCO, as described in annual Environmental Monitoring Reports, for example, WMCO (1988). For the purpose of consistency and to eliminate confusion when comparing data, the WEMCO designations were retained. The "GMR" designations were established for those stations not monitored by WEMCO.

Two of the seven sampling stations were located upstream of the FEMP discharge (at River Mile (RM) 24.1), one station was adjacent to the discharge, and four stations were located downstream. The stations were designated and located as follows (Figure D.2-1):

| | |
|---|---|
| W-1 | Approximately 100 feet upstream of the Ross Bridge (RM 25.7) |
| GMR-1 | Approximately 1000 feet upstream of the FEMP discharge (RM 24.3) |
| GMR-2 | Approximately 300 feet downstream of the FEMP discharge (RM 24.0) |
| GMR-3 | Approximately 0.9 miles downstream of the FEMP discharge (RM 23.2) |
| W-3 | Approximately 100 feet upstream of the New Baltimore Bridge (RM 20.8) |
| GMR-4 | Below the confluence of Paddys Run and the Great Miami River (RM 19.6) |
| W-4 | Approximately 100 feet upstream of the Miamitown Bridge (RM 14.9) |

All the sampling stations had comparable flow characteristics and were classified as river runs with depositional zones.

D.2.1.2 Paddys Run

Eight stations were sampled on Paddys Run (Figure D.2-1). These sampling locations are designated and located as follows:

PR-1 Approximately 300 feet south of the northern FEMP boundary (Stream Mile 3.50)

PR-2 Approximately 50 feet south of the railroad bridge traversing Paddys Run, approximately 600 feet south of PR-1. (Stream Mile 3.35)

PR-3 Approximately 300 feet north of the K-65 silos. (Stream Mile 3.08)

PR-4 Approximately 1500 feet south of the K-65 silos. (Stream Mile 2.59)

PR-5 Approximately 600 feet north of the southern FEMP boundary. (Stream Mile 2.17)

PR-6 Approximately 100 feet north of the Willey Road Bridge (Stream Mile 1.92)

PR-7 Approximately 300 feet north of New Bridge on River Road (Stream Mile 0.98)

PR-8 Approximately 1000 feet north of the Rt. 128 bridge (Stream Mile 0.23)

D.2.2 WATER QUALITY

Water quality was monitored coincident with macroinvertebrate sample collection during each of the five sample periods. In situ water quality variables and current velocities were measured at Paddys Run stations in midstream adjacent to artificial substrates, as described below. This was done at the time of substrate deployment and at the time of retrieval. In the Great Miami River, these measurements were taken at each station at sampling points one, three and five (left bank, midstream and right bank when facing downstream) concurrent with collection of benthic macroinvertebrate samples. Single point measurements were taken at each station in the Great Miami at the time of artificial substrate deployment. These measurements were made adjacent to the sampler location. All measurements were made at a depth of 0.5 meters when possible, or at the maximum existing depth. During the first and second sampling events (October - December, 1988 and May - June, 1989), bottom measurements were also made in the Great Miami River when the depth exceeded 1.0 meter. This practice was discontinued because of the difficulty in obtaining bottom measurements in swift currents and because the data showed little variation, indicating that the water column was well mixed.

A Hydrolab Surveyor II water quality analyzer, calibrated according to the manufacturer's instructions, was employed to determine:

- Dissolved oxygen (DO) (mg/ℓ)
- Temperature (°C)
- pH
- Conductivity (μmhos)
- Oxidation reduction potential (ORP) (volts)

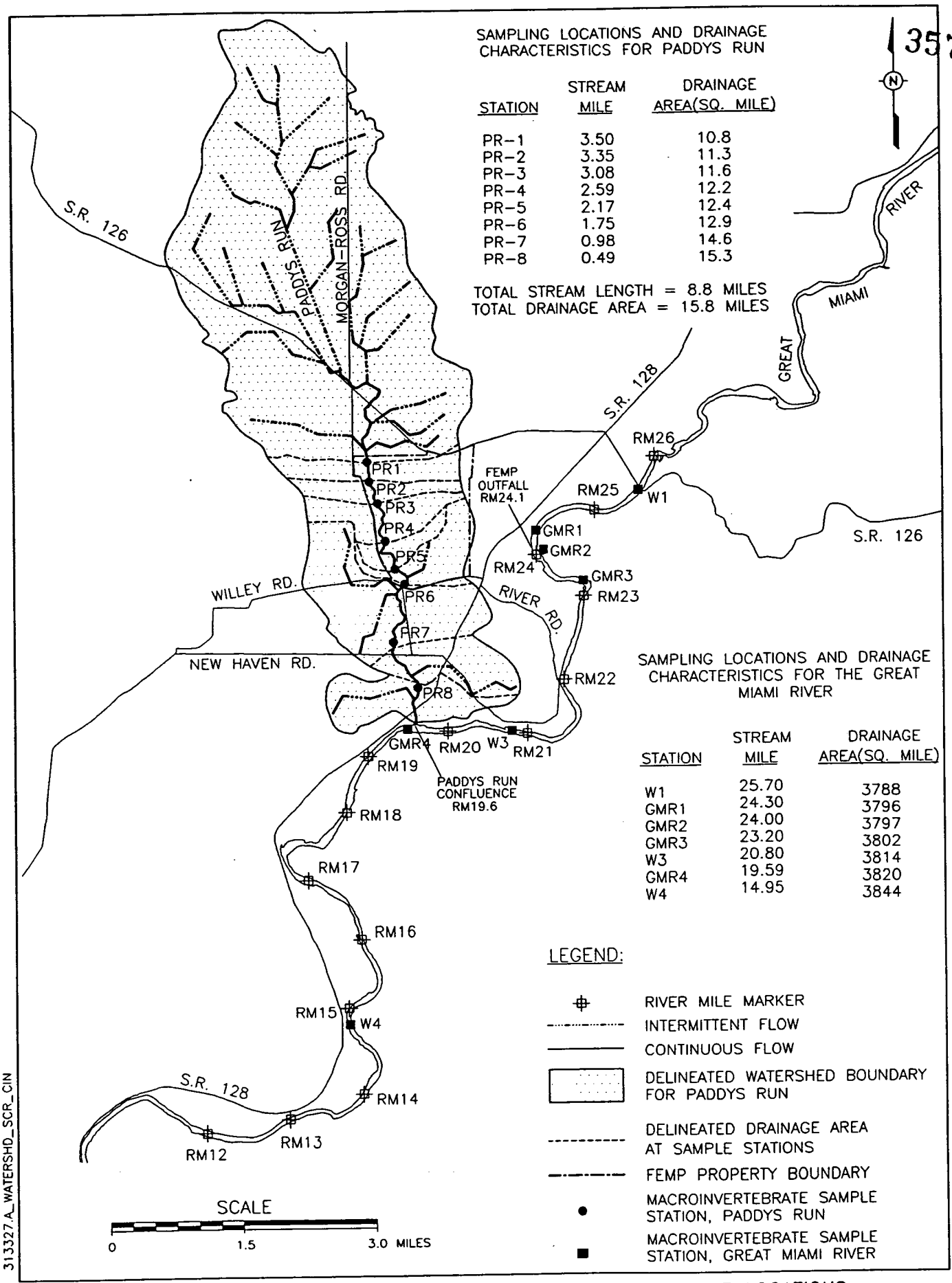



FIGURE D.2-1. RI/FS BENTHIC MACROINVERTEBRATE SAMPLE LOCATIONS, WATERSHED DELINEATION

The Hydrolab unit was used for all measurements with the exception of June 26-27, 1990, when the variables measured and instruments used were as follows:

- DO - YSI Model 57 oxygen meter
- Conductivity - YSI Model 33 S-C-T meter
- pH - Markson Model 88 digital pH meter
- Temperature - mercury thermometer

A Secchi disc was used to measure water transparency (turbidity), and current velocities were measured with a Marsh-McBirney Model 201 flow meter.

### D.2.3 MACROINVERTEBRATE SAMPLING

Hester-Dendy artificial substrate samplers and Surber stream bottom samplers were employed throughout the study for sampling the macroinvertebrate communities. For the initial sampling in October - December, 1988, self contained underwater breathing apparatus (SCUBA) was used for qualitative sample collection in the Great Miami River. All other Great Miami River qualitative samples were collected with an Emery pipe dredge. The equipment and methods used in collection of benthic macroinvertebrate samples and water quality data are described below.

#### D.2.3.1 Hester-Dendy Artificial Substrate Sampler

Each sampler consisted of eight plates of 0.32 cm (1/8 inch) thick tempered hardboard cut into 7.6 cm (three inch) squares assembled on a 0.64 cm (1/4 inch) eyebolt with 1.27 cm (1/2 inch) diameter plastic spacers. A Hester-Dendy sampler is shown in Figure D.2-2. The spacers separated the plates as follows: four single spacers, two double spacer and one triple spacer. A cluster of four samplers was fastened between concrete block anchors with a floating plastic jug to mark the site.

The Hester-Dendy artificial substrates were deployed on the following dates:

- October 27-28, 1988 (Great Miami River only)
- May 9-10, 1989
- November 7-9, 1989
- March 28-29, 1990
- June 26-27, 1990

The substrates were retrieved on the following dates:

- December 1-2, 1988 (Great Miami River only)
- June 12-15, 1989
- December 11-13, 1989
- May 1-2, 1990
- August 1-2, 1990

Upon retrieval, the four samplers were separated and placed in individual heavy-gauge plastic bags. The bags were sealed in coolers with ice and returned to the analytical laboratory. The samplers were disassembled in the laboratory and the material adhering to the plates was scraped into white plastic basins. This was followed by sorting and fixation in a 10 percent buffered formalin solution. The specimens were subsequently transferred to a 70 percent ethyl alcohol solution as a permanent preservative.

D.2.3.2 Surber Sampler

The Surber sampler consists of a 0.595 mm mesh bag approximately 70 cm (27 inches) long, which is held open by a one square foot metal frame hinged at one side to another one square foot frame (quadrat) (Figure D.2-3). The samplers were employed in accordance with American Society for Testing and Materials (ASTM 1973) standard practice, described as follows:

1. The sampler is brought down quickly on the substrate to reduce the loss of rapidly moving organisms.
2. The sampler is positioned securely with the net pointing downstream.
3. Gaps between the substrate and the sampler frame are eliminated by shifting rocks and gravel along the outside edge of the sampler.
4. All rocks and large stones within the square foot quadrat are carefully rubbed with the hands to dislodge clinging or attached organisms. The rocks and stones are examined visually to ensure that organism removal is complete.
5. The remaining sediment is agitated with the hands to a depth of two to four inches (depending upon sediment composition) to dislodge epibenthic and burrowing organisms.
6. The quadrat is visually examined and any remaining organisms are placed in the mesh bag.

ASTM recommendations are that current velocity be 0.5 meter per second or greater, and that water depth not exceed one foot for this type of sampler (ASTM 1973).

Surber samples were collected from each station on Paddys Run upon retrieval of the Hester-Dendy samples. Five replicate samples were collected at each station. All organisms were carefully removed from the Surber bag with forceps and placed in a 10 percent buffered formalin solution. The samples were transported to the analytical laboratory for microscopic examination and identification. Sampling stations PR-6 and PR-8 have no pool areas with depth adequate for artificial substrate deployment. Due to the intermittent nature of the stream at these locations, Surber samples were collected only once at PR-6, and on two occasions at PR-8.

D.2.3.3 Emery Pipe Dredge

The Emery pipe dredge consists of a 45 cm (18 inches) length of 15 cm (6 inches) diameter steel pipe which is open on one end. A pivoting steel bridle on the open end allows a towing line to be

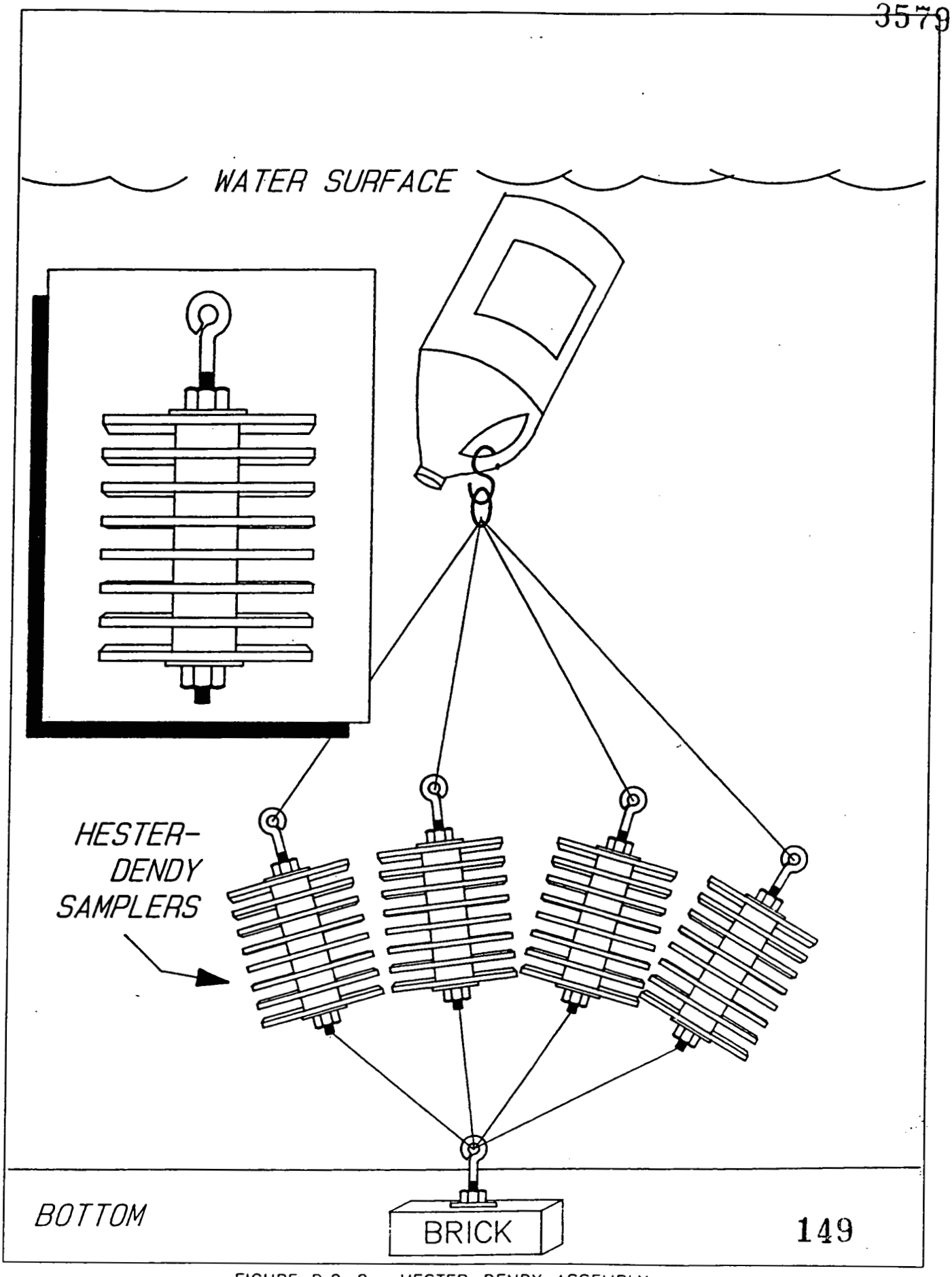



FIGURE D.2-2. HESTER-DENDY ASSEMBLY

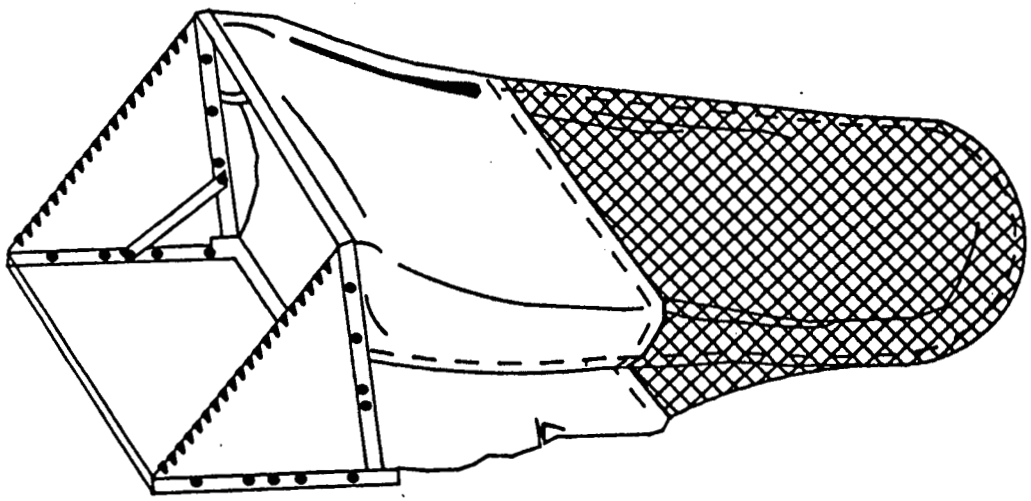


FIGURE D.2-3. SURBER SAMPLER

attached. The Emery pipe dredge is shown in Figure D.2-4. This device, which provides a qualitative sample of bottom fauna, is effective in coarse gravel and rocky areas and can be used in the strong currents which occur on the Great Miami River. These conditions preclude the use of Ekman or Ponar bottom samplers, clamshell dredges which provide a quantitative sample, but which must be lowered vertically to be effective. From a stationary vessel anchored in a current, these dredges descend at an angle which increases as current speed increases. In addition, rocks and cobbles in the sediment prevent the dredge jaws from closing completely, causing loss of the sample during retrieval.

The Emery dredge was towed behind a boat at a slow speed. The length of the tow at each sampling point was approximately 200 feet. Emery dredge samples were collected from the Great Miami River concurrent with retrieval of the Hester-Dendy samples. Samples were collected at each of five points on transects at the seven sampling stations. The five sampling points (SPs) were located as follows (left to right, facing downstream):

- SP1 - adjacent to the left bank
- SP2 - one half the distance between SP1 and midstream
- SP3 - midstream
- SP4 - one half the distance between SP5 and midstream
- SP5 - adjacent to the right bank

The samples were placed into one gallon polypropylene sampling jars and were preserved with 10 percent formalin. In the laboratory, all samples were screened using a number 35 U.S. Standard testing sieve (500 um openings). The number 35 sieve will retain all organisms that are large enough to allow accurate identification. The resulting material was sorted and the organisms preserved in 70 percent ethyl alcohol.

D.2.3.4 Grab Sampling with SCUBA

During the October - December 1988 sampling, samples were collected from the Great Miami River by divers using SCUBA. The samples were collected with stainless steel trowels and placed directly into one gallon polypropylene jars. The locations of sample collection (five point transects) and handling were identical to those employed for the Emergy pipe dredge samples described above.

D.2.4 MACROINVERTEBRATE IDENTIFICATION AND TAXONOMY

Organisms were identified to genus where possible and to family where genus determination was not possible. Identification of organisms was made using the keys developed by Mason (1973), Merritt and Cummins (1984), Parris (1975) and Pennak (1978). Final identification was made using Pennak (1978). Current taxonomic classification of macroinvertebrates was made using the taxonomy of Peckarsky et al. (1990) and Pennak (1978). A reference collection of identified genera was developed and updated with the ongoing sampling. Identified genera were numbered and a representative individual used for the reference collection.

For the purpose of data interpretation, an identified organism or group of organisms was considered to be a discrete taxon if one or more of the following conditions were met:

- Identification was peformed to genus or species level (tribe for chironomids).
- The organism or group was the only member of the taxon to which identification was made.
- When only two different members of a taxon were identified, they were counted as discrete taxa regardless of the level of identification.

D.2.5 DATA ANALYSIS

The data were analyzed both qualitatively and quantitatively. Individual taxa were classified by pollution tolerance (Weber 1973). Community structure was analyzed by calculating evenness, the Shannon diversity index, and density as described below. The Invertebrate Community Index (ICI) developed by OEPA (1988) was used to evaluate potential effects of the FEMP on the aquatic communities of Paddys Run and the Great Miami River. For all sampling techniques used, replicate samples at a given sampling location were summed for purposes of data anlaysis.

D.2.5.1 Diversity and Evenness

Diversity is a single statistic which incorporates the number of species and their relative abundance. It is high for a collection with many species of similar abundance, and is low when species are few and their abundances different. The following formula was used to calculate diversity:

$$H = \frac{n \log n - \sum_{i=1}^{k} f_i \log f_i}{n} \qquad (1)$$

where
k = number of species
n = total number of organisms
$f_i$ = number of organisms of species i
(The logarithmic base e was used in the calculations)

The maximum possible diversity for a set of data consisting of *k* categories may be calculated by the following equation:

$$H_{max} = \log k. \qquad (2)$$

Because the diversity calculation depends upon independent properties of a community, the interpretation of diversity data can be ambiguous. A community with few species that are evenly distributed may have a calculated diversity similar to a community with many species and uneven

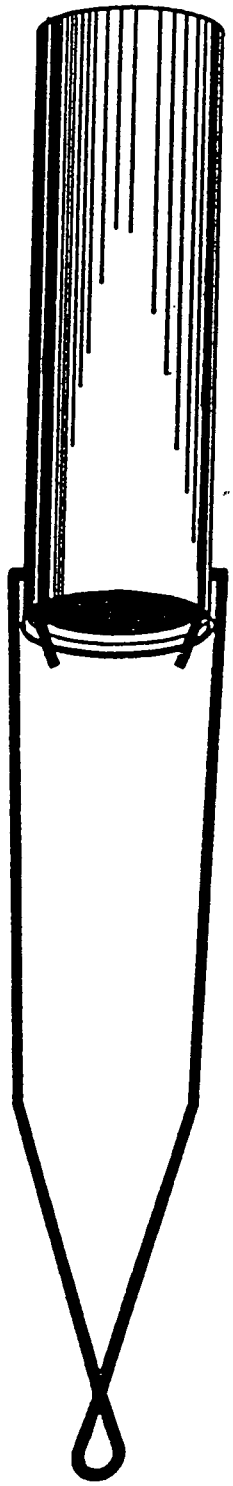


FIGURE D.2-4. EMERY PIPE DREDGE



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abundance. In order to correctly interpret diversity values it is essential to also calculate evenness, for which a number of methods are in use (Ludwig and Reynolds 1988). Evenness ($J$) was calculated according to Pielou (1966), as the ratio of the calculated diversity to the maximum diversity for a community of $k$ species, as follows:

$$J = \frac{H}{H_{max}} \qquad (3)$$

D.2.5.2 Density

Density of macroinvertebrates was calculated as the total number of individuals per square meter of substrate area. These calculations were made for Hester-Dendy artificial substrate and Surber samples. Densities were calculated separately to compare the artificial substrate data to the Surber data, which approximates densities found on the natural stream bottom substrates. Artificial substrates offer the advantage of providing surfaces of identical area and composition for colonization, eliminating substrate as a variable when comparing macroinvertebrate data among sampling stations. However, organism densities on the artificial substrates may not reflect densities present on the natural substrates. Since the Emery dredge provides only a qualitative sample, density was not calculated for those data.

D.2.5.3 Tolerance Classification

In addition to the previously described index calculations, all species were classified by their tolerance of decomposable organic waste according to Weber (1973). The three categories in this classification system are tolerant, facultative and intolerant, defined as follows:

- Tolerant: Organisms that are ordinarily associated with high levels of organic contamination. They are generally adapted for survival in an anaerobic environment.
- Facultative: Aquatic organisms that can survive and thrive in a broad range of environmental conditions. They are often associated with moderate organic pollution.
- Intolerant: Organisms that cannot tolerate significant organic contamination and generally require a well oxygenated environment.

Taxa not included in the tables of Weber (1973) were placed in the no index category. The percentage of organisms in each category was determined by dividing the number of taxa assigned to the category by the total number of taxa. For taxa with multiple tolerance classifications (for example, listed as both facultative and intolerant) the percentage in that taxon was divided evenly between or among the tolerance classes.

D.2.5.4 Invertebrate Community Index

OEPA (1988b) has developed biolgical criteria for determining whether state waters are attaining goals for use by aquatic organisms. One of these criteria, the ICI, is based on ten metrics (measures) of the

macroinvertebrate community (Table D.2-1). Data collected from Hester-Dendy and Surber sampling were used to calculate indivdual ICI values for each station for all five sampling events. ICI calculations were made following the procedure described in OEPA (1988b, 1989a). River mileage and watershed drainage areas were determined using 7.5 minute series USGS topographic maps (Shandon and Millville quadrangles). River mileage was calculated using a standard map measure. Watershed and sampling station drainage areas were first calculated using a computer automated drawing (CAD) microprocessor. Individual metrics were initially determined using the OEPA (1989a) addendum nomographs. In addition, the scores were checked using two computer programs provided by OEPA. One, a database entry field (ICISTRUC), is used for determination of individual metric values. The second program (BUG89), is used for determining scores from these values. The program performs regression analyses for scores that are on the isopleth line so that scoring is consistent for all values, and provides a printout of all values and scores. The FEMP outfall and the points where Paddys Run enters and leaves the FEMP were indicated on the ICI plots to help analyze the potential effects of the FEMP on the aquatic communities. Scores for all metrics are provided and discussed in Attachment D-I.

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## TABLE D.2-1

## MACROINVERTEBRATE COMMUNITY METRICS AND CRITERIA FOR CALCULATING THE INVERTEBRATE COMMUNITY INDEX AND ICI SCORES FOR EVALUATING BIOLOGICAL CONDITION[a]

| Metric | Score | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| 1. Total number of taxa | Varies with drainage area | | | |
| 2. Total number of mayfly taxa | Varies with drainage area | | | |
| 3. Total number of caddisfly taxa | Varies with drainage area | | | |
| 4. Total number of dipteran taxa | Varies with drainage area | | | |
| 5. Percent mayfly composition | 0 | >0,≤10 | >10,≤25 | >25 |
| 6. Percent caddisfly composition | Varies with drainage area | | | |
| 7. Percent tribe Tanytarsini midge composition | 0 | >0,≤10 | >10,≤25 | >25 |
| 8. Percent other dipteran and non-insect composition | Varies with drainage area | | | |
| 9. Percent tolerant organisms (as defined by OEPA (1988b)) | Varies with drainage area | | | |
| 10. Total number of qualitative Ephemeroptera/ Diptera/Trichoptera (EPT) taxa | Varies with drainage area | | | |

[a] A detailed description of ICI metrics is provided in Attachment D-I.

SOURCE: OEPA (1988b)

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# D.3.0 RESULTS

## D.3.1 GREAT MIAMI RIVER

### D.3.1.1 Water Quality Data

Water quality variables measured in the Great Miami River from December 1988 to August 1990 fell within ranges typical of well buffered freshwater ecosystems (Wetzel 1975). Table D.3-1A summarizes the data for each sampling station averaged across sampling times, and Table D.3-1B summarizes the values for each sampling time averaged across stations. Raw data for all sampling times and stations are presented in Attachment D.II.

In general, variable ranges were greater over time than between stations, and consistent differences among stations were not observed. For example, mean Secchi depth ranged from 0.03 to 0.79 m over time (Table D.3-1B), but ranged only from 0.37 to 0.51 among stations (Table D.3-1A). Secchi depth and current velocity showed no consistent variation seasonally or among stations (Tables D.3-1A,B), but velocity at different stations did tend to covary through time (Attachment D.II). Mean temperature during the study period ranged from 5.55 to 24.6 C (Table D.3-1B), with only a 1-2 C range among stations (Table D.3-1A, Attachment D.II).

DO varied inversely with temperature over time (Table D.3-1B, Attachment D.II), consistent with the increasing solubility of gases in water as temperature decreases. An exception to this occurred over the period from May to August 1990, when temperature and DO appeared to covary. This may have been a result of photosynthesis increasing with increasing water temperature. A decrease in mean current velocity over the same period, which would decrease mixing, could have also contributed by reducing the likelihood that photosynthetically derived oxygen would equilibrate with the atmosphere. Consistent differences in DO were not observed among stations.

Conductivity and ORP both reached maxima in December 1988 and November - December 1989, with lower values during warmer periods (Table D.3-1B). Consistent differences among stations were not observed.

### D.3.1.2 Benthic Macroinvertebrates

#### D.3.1.2.1 Emery Dredge and Grab Samples

October - December 1988

Grab sample data for October - December 1988 are summarized in Table D.3-2. The natural substrate community of reference Stations W-1 and GMR-1 was comprised mostly of aquatic worms and midges (Attachment D.I, Table D.3-9). Station GMR-2, located just below the FEMP discharge, had the greatest diversity compared to the lowest at downstream recovery Station W-3. Diversity at Station GMR-3, the first station downstream of the FEMP discharge, was intermediate between these.

**TABLE D.3-1A**

**GREAT MIAMI RIVER WATER QUALITY DATA, AVERAGED ACROSS TIMES FOR EACH SAMPLING STATION**

| | Secchi Depth (m) | | | Current Velocity (ft/s) | | | Temperature (°C) | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| W-1 | 0.1 - 1.0 | 0.49 | 0.26 | 0.3 - 3.03 | 1.19 | 0.95 | 3.8 - 24.3 | 14.3 | 7.8 |
| GMR-1 | 0 - 0.7 | 0.45 | 0.25 | 0.2 - 1.38 | 0.91 | 0.97 | 2.5 - 23.8 | 14.1 | 7.9 |
| GMR-2 | 0 - 0.7 | 0.43 | 0.24 | 1.1 - 3.13 | 2.10 | 0.91 | 2.8 - 23.6 | 14.1 | 7.8 |
| GMR-3 | 0.1 - 0.8 | 0.41 | 0.20 | 0.5 - 3.13 | 1.77 | 0.94 | 2.8 - 24.9 | 14.3 | 8.0 |
| W-3 | 0 - 1.1 | 0.51 | 0.38 | 0.7 - 4.0 | 1.46 | 1.26 | 2.6 - 25.1 | 14.3 | 8.3 |
| GMR-4 | 0 - 0.8 | 0.37 | 0.26 | 0 - 3.17 | 1.01 | 1.15 | 2.8 - 25.3 | 15.7 | 8.1 |
| W-4 | 0 - 1.4 | 0.51 | 0.43 | 0.2 - 3.32 | 1.35 | 0.94 | 3.1 - 25.6 | 14.8 | 8.5 |

| | Dissolved Oxygen (mg/ℓ) | | | pH | | | Conductivity (µmhos) | | | Oxidation Reduction Potential (Volts) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| W-1 | 7.71 - 13.12 | 10.38 | 1.81 | 7.72 - 8.58 | 8.12 | 0.30 | 529 - 985 | 801 | 145 | 0.163 - 0.318 | 0.242 | 0.069 |
| GMR-1 | 7.67 - 12.68 | 10.41 | 1.79 | 7.81 - 8.5 | 8.22 | 0.25 | 556 - 985 | 796 | 144 | 0.160 - 0.312 | 0.221 | 0.064 |
| GMR-2 | 7.68 - 12.96 | 10.28 | 1.64 | 7.62 - 8.68 | 8.22 | 0.34 | 357 - 986 | 772 | 198 | 0.175 - 0.308 | 0.231 | 0.056 |
| GMR-3 | 7.55 - 13.0 | 11.19 | 1.89 | 7.88 - 8.68 | 8.25 | 0.33 | 513 - 978 | 790 | 155 | 0.140 - 0.302 | 0.223 | 0.060 |
| W-3 | 7.71 - 15.8 | 11.85 | 2.49 | 7.9 - 8.63 | 8.25 | 0.31 | 617 - 968 | 800 | 130 | 0.150 - 0.292 | 0.225 | 0.059 |
| GMR-4 | 7.60 - 15.4 | 11.21 | 2.80 | 7.89 - 8.53 | 8.27 | 0.33 | 633 - 953 | 794 | 120 | 0.151 - 0.295 | 0.228 | 0.060 |
| W-4 | 7.70 - 18.4 | 12.13 | 3.49 | 7.54 - 8.56 | 8.16 | 0.46 | 627 - 950 | 802 | 117 | 0.170 - 0.288 | 0.229 | 0.049 |

## TABLE D.3-1B
## GREAT MIAMI RIVER WATER QUALITY DATA
## AVERAGED ACROSS STATIONS FOR EACH SAMPLING TIME

| Date | Secchi Depth (m) | | | Current Velocity (ft/s) | | | Temperature (°C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| December 1988 | 0.25 - 0.5 | 0.4 | 0.07 | 0.07 - 3.25 | 1.02 | 1.08 | 4.8 - 5.91 | 5.55 | 0.38 |
| June 1989 | 0 - 0.1 | 0.03 | 0.05 | 0.7 - 6.0 | 3.27 | 1.23 | 19.5 - 20.6 | 19.9 | 0.34 |
| November 1989 | 0.2 - 0.7 | 0.51 | 0.19 | 0 - 4.5 | 1.19 | 1.21 | 11.6 - 12.6 | 12.2 | 0.28 |
| December 1989 | 0.5 - 1.1 | 0.79 | 0.2 | 0.05 - 1.1 | 0.48 | 0.35 | 2.51 - 3.8 | 2.92 | 0.43 |
| March 1990 | 0.5 - 1.4 | 0.79 | 0.32 | 0 - 2.1 | 0.9 | 0.85 | 9.72 - 10.2 | 9.92 | 0.15 |
| May 1990 | 0.45 - 0.7 | 0.52 | 0.06 | 0.1 - 4.6 | 2.19 | 1.13 | 14.2 - 16.2 | 16.0 | 0.42 |
| June 1990 | 0.2 - 0.4 | 0.26 | 0.08 | 0.1 - 1.5 | 0.74 | 0.48 | 22.8 - 25.6 | 23.7 | 1.06 |
| August 1990 | 0.2 - 0.5 | 0.31 | 0.09 | 0 - 3.7 | 1.39 | 1.03 | 23.6 - 26.2 | 24.6 | 0.73 |

| Date | Dissolved Oxygen (mg/ℓ) | | | pH | | | Conductivity (μmhos) | | | Oxidation Reduction Potential (Volts) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| December 1988 | 12.3 - 13.3 | 12.8 | 0.29 | 7.27 - 8.67 | 8.1 | 0.3 | 854 - 877 | 862 | 6.69 | -0.473 - 2.0 | 0.3628 | 0.6168 |
| June 1989 | 7.43 - 7.85 | 7.66 | 0.1 | 7.12 - 7.9 | 7.77 | 0.19 | 204 - 635 | 547 | 127 | 0.167 - 0.208 | 0.19 | 0.0119 |
| November 1989 | 8.22 - 13.2 | 9.37 | 1.12 | 7.03 - 8.25 | 8.07 | 0.27 | 933 - 987 | 970 | 19.9 | 0.276 - 0.315 | 0.2907 | 0.0086 |
| December 1989 | 11.6 - 13.1 | 12.4 | 0.56 | 8.01 - 8.14 | 8.08 | 0.06 | 943 - 953 | 949 | 3.69 | 0.288 - 0.318 | 0.3017 | 0.0115 |
| March 1990 | 10.0 - 11.3 | 10.7 | 0.47 | 7.8 - 8.48 | 8.28 | 0.24 | 826 - 844 | 840 | 6.47 | 0.243 - 0.317 | 0.2633 | 0.0253 |
| May 1990 | 9.0 - 10.8 | 9.93 | 0.57 | 8.13 - 8.99 | 8.61 | 0.18 | 764 - 771 | 769 | 1.89 | 0.178 - 0.21 | 0.1861 | 0.0079 |
| June 1990 | 9.8 - 18.4 | 13.4 | 3.26 | a | a | a | 650 - 700 | 671 | 26.7 | a | a | a |
| August 1990 | 9.35 - 16.6 | 12.4 | 2.0 | 8.4 - 8.68 | 8.55 | 0.08 | 711 - 768 | 749 | 17.7 | 0.139 - 0.179 | 0.1583 | 0.0127 |

[a] No data

**TABLE D.3-2**
**GREAT MIAMI RIVER**
**SEDIMENT GRAB RESULTS SUMMARY**
**OCTOBER - DECEMBER 1988**

| Station | Number of Taxa | Diversity | Evenness |
|---|---|---|---|
| W-1 | 15 | 2.08 | 0.77 |
| GMR-1 | 9 | 1.73 | 0.79 |
| GMR-2 | 22 | 2.19 | 0.71 |
| GMR-3 | 7 | 1.57 | 0.73 |
| W-3 | 8 | 1.46 | 0.70 |
| GMR-4[a] | | | |
| W-4 | 12 | 1.93 | 0.78 |

[a] Station not sampled.

Diversity increased again at W-4, the furthest downstream reference station. Evenness was less variable, but was higher at the two upstream stations and W-4 than at the stations closer to the discharge point.

May - June 1989

As described above, the second sampling in May - June, 1989 was limited due to flood conditions which included unusually swift current (Table D.3-1). As a result, only 17 taxa were collected. These organisms include caddisflies, midges, aquatic worms, snails, and clams. The swift currents and sediment scouring resulted in severely reduced benthic populations. Stations W-1 and GMR-1 had the greatest number of taxa (five), while no organisms were found in any of the samples from GMR-3. Due to the paucity of data, diversity and evenness were not calculated.

November - December 1989

Emery dredge sample data for November - December, 1989 are summarized in Table D.3-3. Number of taxa, diversity, and evenness increased between the two upstream reference stations, W-1 and GMR-1. Station GMR-2, directly downstream of the FEMP outfall, contained the second highest number of taxa but had relatively low diversity and evenness values. Station GMR-3, approximately 0.75 miles below the outfall, had the most taxa and the highest diversity. The number of taxa decreased to 15 at Station W-3 (New Baltimore bridge), and diversity and evenness here were the lowest of any station.

**TABLE D.3-3**
**GREAT MIAMI RIVER**
**EMERY DREDGE RESULTS SUMMARY**
**NOVEMBER - DECEMBER 1989**

| Station | Number of Taxa | Diversity | Evenness |
|---|---|---|---|
| W-1 | 13 | 1.50 | 0.58 |
| GMR-1 | 15 | 2.18 | 0.80 |
| GMR-2 | 23 | 1.22 | 0.39 |
| GMR-3 | 25 | 2.31 | 0.72 |
| W-3 | 15 | 0.95 | 0.35 |
| GMR-4 | 10 | 1.48 | 0.64 |
| W-4 | 17 | 1.59 | 0.56 |

The lowest number of taxa occurred at GMR-4, which is located at the confluence of Paddys Run and the Great Miami River. This was most likely due to the heavy gravel mining activity in this area. The constant reworking and removal of bottom material and resulting high sediment loads interfere with substrate colonization by macrobenthic organisms.

March - May 1990

Emery dredge sample data for March - May, 1990 are summarized in Table D.3-4. The highest number of taxa, diversity, and evenness occurred at GMR-2, the outfall station. The lowest values were recorded at the farthest downstream stations, GMR-4 and W-4.

June - August 1990

Emery dredge sample data for June - August, 1990 are summarized in Table D.3-5. As found in October - December 1988 and March - May 1990, the highest number of taxa was found at Station GMR-2, adjacent to the FEMP outfall. The samples collected at GMR-1, upstream of the outfall, and W-4, downstream, also represented relatively rich benthic communities, with taxa and diversity values comparable to GMR-2.

The number of taxa found at other sampling stations ranged from six at GMR-3 to 11 at GMR-4. As stated above, Station GMR-4 also had relatively low numbers of benthic macroinvertebrates in previous samples, due to disturbance by gravel mining at this site. Prior to the present sampling event,

**TABLE D.3-4**
**GREAT MIAMI RIVER**
**EMERY DREDGE RESULTS SUMMARY**
**MARCH - MAY 1990**

| Station | Number of Taxa | Diversity | Evenness |
|---|---|---|---|
| W-1 | 10 | 1.58 | 0.69 |
| GMR-1 | 11 | 1.71 | 0.71 |
| GMR-2 | 13 | 1.85 | 0.72 |
| GMR-3 | 11 | 1.21 | 0.51 |
| W-3 | 10 | 1.39 | 0.60 |
| GMR-4 | 8 | 1.01 | 0.49 |
| W-4 | 8 | 0.95 | 0.46 |

**TABLE D.3-5**
**GREAT MIAMI RIVER**
**EMERY DREDGE RESULTS SUMMARY**
**JUNE - AUGUST 1990**

| Station | Number of Taxa | Diversity | Evenness |
|---|---|---|---|
| W-1 | 7 | 1.54 | 0.79 |
| GMR-1 | 15 | 2.17 | 0.80 |
| GMR-2 | 18 | 1.83 | 0.63 |
| GMR-3 | 6 | 1.34 | 0.75 |
| W-3 | 6 | 1.24 | 0.69 |
| GMR-4 | 11 | 1.72 | 0.72 |
| W-4 | 17 | 2.01 | 0.71 |

mining activity moved several hundred yards upstream, and the higher species diversity observed in these samples may reflect a recovering benthic community.

D.3.1.2.2 Hester-Dendy Artificial Substrate Samples

October - December 1988

Artificial substrate data for October - December 1988 are summarized in Table D.3-6. Samplers were recovered at all stations except GMR-4, where the samplers may have been destroyed by the gravel mining at the site. The station at Ross Bridge, W-1, contained the highest number of taxa and had the greatest density. Station GMR-1, upstream of the FEMP discharge, yielded fewer taxa, but had the highest diversity and the second highest evenness. Station W-3 had the lowest number of taxa and the lowest diversity and evenness values. Density decreased by a factor of nine from W-1 to GMR-1 and recovered somewhat at W-4. This was primarily due to variation in the number of caddisfly larvae (Attachment D.III)

May - June 1989

All artificial substrates deployed during this period were lost due to flooding.

November - December 1989

Artificial substrate data for November - December 1989 are summarized in Table D.3-7. The sampler at Station W-3 (Miamitown Bridge) was not found, although its location had been carefully recorded. The sampler at GMR-4 was also not recovered and may have been destroyed by the gravel mining at that site. The station at Ross Bridge, W-1, had the lowest diversity of the five stations where a sampler was recovered. Station GMR-1 had the highest diversity and evenness of the five stations, but the lowest density. Station GMR-2 had the highest density of all substrates recovered, but had a lower diversity than GMR-1. The sampler recovered at Station W-4 contained the highest number of taxa and the second highest diversity.

March - May 1990

Substrates were recovered at only three of the seven stations. At Station W-4, the concrete block anchor (minus the substrates) was found on shore, indicating vandalism. At Station GMR-4, the sampler may have been destroyed by gravel mining operations, vandalism (the area is heavily used by fishermen), or a storm. Samplers were also not recovered at Stations GMR-2 and W-3 for reasons unknown.

The organism assemblage colonizing the substrates at GMR-3 had the lowest diversity and evenness values due to numerical dominance by caddisfly larvae (Cheumatopsyche) (Table D.3-8, Attachment D.III). The density of organisms here was the highest of the three stations.

## TABLE D.3-6
## GREAT MIAMI RIVER
## HESTER-DENDY SAMPLER RESULTS SUMMARY
## OCTOBER - DECEMBER 1988

| Station | Number of Taxa | Diversity | Evenness | Density (organism/m$^2$) |
|---|---|---|---|---|
| W-1 | 11 | 1.61 | 0.67 | 377 |
| GMR-1 | 8 | 1.84 | 0.88 | 43 |
| GMR-2 | 8 | 1.65 | 0.79 | 46 |
| GMR-3 | 7 | 1.75 | 0.90 | 81 |
| W-3 | 5 | 0.87 | 0.54 | 57 |
| GMR-4[a] | | | | |
| W-4 | 5 | 1.08 | 0.67 | 108 |

[a] Artificial substrate not recovered.

## TABLE D.3-7
## GREAT MIAMI RIVER
## HESTER-DENDY SAMPLER RESULTS SUMMARY
## NOVEMBER - DECEMBER 1989

| Station | Number of Taxa | Diversity | Evenness | Density (organism/m$^2$) |
|---|---|---|---|---|
| W-1 | 7 | 0.87 | 0.45 | 318 |
| GMR-1 | 9 | 1.54 | 0.70 | 116 |
| GMR-2 | 8 | 1.26 | 0.61 | 689 |
| GMR-3 | 9 | 1.16 | 0.53 | 350 |
| W-3[a] | | | | |
| GMR-4[a] | | | | |
| W-4 | 15 | 1.34 | 0.50 | 390 |

[a] Artificial substrate not recovered.

**TABLE D.3-8**
**GREAT MIAMI RIVER**
**HESTER-DENDY SAMPLER RESULTS SUMMARY**
**MARCH - MAY 1990**

| Station | Number of Taxa | Diversity | Evenness | Density (organism/m$^2$) |
|---|---|---|---|---|
| W-1 | 14 | 1.42 | 0.54 | 614 |
| GMR-1 | 16 | 1.88 | 0.68 | 503 |
| GMR-2[a] | | | | |
| GMR-3 | 13 | 1.30 | 0.51 | 947 |
| W-3[a] | | | | |
| GMR-4[a] | | | | |
| W-4[a] | | | | |

[a] Artificial substrate not recovered.

June - August 1990

Summary data for the artificial substrates colonized in June - August 1990 are shown in Table D.3-9. All substrates were found undamaged and in the locations as deployed. This attests to the milder conditions which exist in this river during the summer months. No trends were evident among the stations, but the number of taxa found, diversity, and organism density were generally higher than in the previous sampling events. Densities were quite high in all samples, the greatest being at Station GMR-3, where a density of 4209 individuals per square meter was calculated. This high density was not due to dominance by a single taxon, but to large numbers of chironomids and caddisflies of several types (Attachment D.III). This sampling period was the only one in which the substrate was recovered at GMR-4. This sample contained 13 taxa and had the highest diversity and evenness.

D.3.1.2.3 Tolerance Classifications

October - December 1988

Table D.3-10 presents the tolerance classification percentages, as defined on page D-2-15, for both artificial substrate and sediment grab samples. With the exception of GMR-4, taxa belonging to all three tolerance classes were present at all stations in at least one of the sample types. The classes were relatively evenly distributed in the grab samples, while the artificial substrates contained few tolerant taxa.

## TABLE D.3-9
## GREAT MIAMI RIVER
## HESTER-DENDY SAMPLER RESULTS SUMMARY
## JUNE - AUGUST 1990

| Station | Number of Taxa | Diversity | Evenness | Density (organism/$m^2$) |
|---|---|---|---|---|
| W-1 | 13 | 1.84 | 0.72 | 2301 |
| GMR-1 | 10 | 1.62 | 0.70 | 565 |
| GMR-2 | 14 | 1.52 | 0.58 | 1634 |
| GMR-3 | 19 | 1.79 | 0.61 | 4209 |
| W-3 | 13 | 1.34 | 0.52 | 1682 |
| GMR-4 | 13 | 1.87 | 0.73 | 1119 |
| W-4 | 19 | 1.67 | 0.57 | 1348 |

## TABLE D.3-10
## GREAT MIAMI RIVER
## TOLERANCE CLASSIFICATION PERCENTAGES
## HESTER-DENDY AND SEDIMENT GRAB SAMPLES
## OCTOBER - DECEMBER 1988

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| Station | HD[a] | Grab[b] | HD | Grab | HD | Grab | HD | Grab |
| W-1 | 0 | 18 | 32 | 21 | 41 | 11 | 27 | 57 |
| GMR-1 | 6 | 11 | 25 | 28 | 44 | 28 | 25 | 33 |
| GMR-2 | 6 | 30 | 63 | 27 | 19 | 25 | 13 | 18 |
| GMR-3 | 0 | 21 | 29 | 50 | 29 | 14 | 43 | 14 |
| W-3 | 0 | 25 | 30 | 13 | 30 | 25 | 40 | 38 |
| GMR-4[c] | | | | | | | | |
| W-4 | 10 | 29 | 40 | 13 | 30 | 17 | 20 | 42 |

[a] Hester-Dendy artificial substrate

[b] Grab sample using SCUBA

[c] Artificial substrate not recovered - grab samples barren.

The most useful tolerance information is the presence or absence of intolerant taxa. These taxa are usually present only in areas not affected by significant organic pollution. The highest percentage of intolerant taxa was found in the artificial substrate samples from Stations W-1 and GMR-1. All stations had intolerant taxa present, with the lowest value for artificial substrate samples at GMR-2, and the lowest percentage for the grab samples at W-1. Overall, the tolerance percentage data show no apparent trends or patterns among the sampling stations.

May - June 1989

Tolerance classification percentages were not calculated for the Great Miami River for the second sampling event in May - June 1989 due to lack of sufficient data.

November - December 1989

In November - December 1989, tolerant organisms were most abundant in the dredge samples from GMR-1 (Table D.3-11). This may be due to the finer sediments present at this station, which tend to select for tolerant organisms. The samples from Station GMR-2, located directly downstream of the FEMP outfall, had high percentages of intolerant taxa in both the artificial substrate and dredge samples. However, intolerant taxa were common in all of the Great Miami River samples collected during this period, and the data show no obvious trends among the stations.

**TABLE D.3-11**
**GREAT MIAMI RIVER**
**TOLERANCE CLASSIFICATION PERCENTAGES**
**HESTER-DENDY AND EMERY DREDGE SAMPLES**
**NOVEMBER - DECEMBER 1989**

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| Station | HD[a] | Emery[b] | HD | Emery | HD | Emery | HD | Emery |
| W-1 | 7 | 8 | 21 | 50 | 43 | 27 | 29 | 15 |
| GMR-1 | 15 | 33 | 31 | 37 | 43 | 23 | 11 | 7 |
| GMR-2 | 9 | 8 | 26 | 28 | 43 | 47 | 22 | 17 |
| GMR-3 | 0 | 12 | 29 | 32 | 57 | 52 | 14 | 4 |
| W-3 | c | 13 | c | 38 | c | 31 | c | 19 |
| GMR-4 | c | 20 | c | 45 | c | 25 | c | 10 |
| W-4 | 11 | 21 | 25 | 44 | 50 | 29 | 14 | 6 |

[a] Hester-Dendy artificial substrate
[b] Emery pipe dredge
[c] Sampler not recovered

March - May 1990

Facultative and intolerant taxa were abundant in March - May 1990, with tolerant taxa present at lower percentages in most samples (Table D.3-12). The Emery dredge sample from Station GMR-3 had the highest percentage of intolerant taxa. Intolerant taxa were present at all stations but were more abundant at upstream Stations W-1 through GMR-3.

June - August 1990

Facultative and intolerant taxa were common in both sample types from all stations (Table D.3-13). Tolerant taxa were present in all samples but were generally less abundant than the facultative and intolerant groups. Overall, the tolerance percentage data showed no apparent trends or patterns among the sampling stations.

A comparison of sample types shows higher percentages of intolerant taxa in the artificial substrate samples, and higher percentages of tolerant taxa in the dredge samples. This may be due to habitat selection by members of those classes. Most mayflies, for example, are classified as intolerant and require a solid substrate. Many tolerant taxa, including worms and some dipteran larvae, burrow into unconsolidated substrates. Few of these taxa were found in the artificial substrate samples. Tolerant taxa may also be less able to colonize the artificial substrates, which are suspended in the water column and not accessible to all organisms.

## D.3.2 PADDYS RUN

### D.3.2.1 Water Quality Data

Water quality variables measured in Paddys Run from June 1989 to August 1990 fell within ranges typical of well buffered freshwater ecosystems (Wetzel 1975). Overall, ranges of water quality variables in Paddys Run were similar to those in the Great Miami River (Tables D.3-1A,B), given the more limited data available for comparison in Paddys Run. Table D.3-14A summarizes the data for each sampling station, averaged across sampling times, and Table D.3-14B summarizes the values for each sampling time, averaged across stations. Raw data for all sampling times and stations are presented in Attachment D.II.

It is difficult to make generalizations about seasonal and spatial variations in Paddys Run water quality, due to the limited data available for the stations downstream from PR-3. Secchi depth and current velocity were highly variable both among stations and through time (Tables D.3-14A,B). The remaining variables tended to vary more through time than among stations, consistent with the pattern observed for the Great Miami River in Section D.3.1.1. However, clear patterns of seasonal variability were not observed for variables other than temperature (Table D.3-14B). This reflects both the highly variable flow in Paddys Run and the gaps in data for the lower stations. These data gaps are themselves a result of the variable flow, as stations were omitted only when they were dry.

## TABLE D.3-12
## GREAT MIAMI RIVER
## TOLERANCE CLASSIFICATION PERCENTAGES
## HESTER-DENDY AND EMERY DREDGE SAMPLES
## MARCH - MAY 1990

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| Station | HD[a] | Emery[b] | HD | Emery | HD | Emery | HD | Emery |
| W-1 | 12 | 11 | 46 | 33 | 27 | 44 | 15 | 11 |
| GMR-1 | 16 | 23 | 41 | 32 | 31 | 27 | 13 | 18 |
| GMR-2 | c | 18 | c | 32 | c | 36 | c | 14 |
| GMR-3 | 13 | 23 | 42 | 23 | 29 | 45 | 17 | 9 |
| W-3 | c | 15 | c | 45 | c | 20 | c | 20 |
| GMR-4 | c | 25 | c | 31 | c | 19 | c | 25 |
| W-4 | c | 13 | c | 50 | c | 25 | c | 13 |

[a] Hester-Dendy artificial substrate

[b] Emery pipe dredge

[c] Sampler not recovered

## TABLE D.3-13
## GREAT MIAMI RIVER
## TOLERANCE CLASSIFICATION PERCENTAGES
## HESTER-DENDY AND EMERY DREDGE SAMPLES
## AUGUST 1990

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| Station | HD[a] | Emery[b] | HD | Emery | HD | Emery | HD | Emery |
| W-1 | 15 | 21 | 31 | 36 | 46 | 29 | 8 | 14 |
| GMR-1 | 15 | 10 | 35 | 27 | 30 | 37 | 20 | 27 |
| GMR-2 | 12 | 27 | 31 | 19 | 35 | 38 | 23 | 17 |
| GMR-3 | 10 | 25 | 25 | 42 | 44 | 17 | 21 | 17 |
| W-3 | 4 | 17 | 35 | 25 | 38 | 25 | 23 | 33 |
| GMR-4 | 4 | 36 | 31 | 23 | 42 | 32 | 23 | 9 |
| W-4 | 8 | 25 | 19 | 28 | 56 | 23 | 17 | 23 |

[a] Hester-Dendy artificial substrate

[b] Emery pipe dredge

## TABLE D.3-14A
## PADDYS RUN WATER QUALITY DATA
## AVERAGED ACROSS TIMES FOR EACH SAMPLING STATION

| | Secchi Depth (m) | | | Current Velocity (ft/s) | | | Temperature (°C) | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| PR-1 | 0.2 - 1.0 | 0.46 | 0.26 | 0.1 - 0.6 | 0.3 | 0.16 | 0 - 20.5 | 12.4 | 7.9 |
| PR-2 | 0.25 - 1.0 | 0.55 | 0.32 | 0 - 1.2 | 0.31 | 0.41 | 0 - 22.4 | 11.9 | 8.7 |
| PR-3 | 0.2 - 1.2 | 0.61 | 0.45 | 0.1 - 0.6 | 0.31 | 0.16 | 0 - 23.5 | 13.9 | 9.0 |
| PR-4 | 0.1 - 0.8 | 0.37 | 0.32 | 0 - 2.5 | 0.7 | 1.02 | 8.9 - 23.6 | 15.7 | 6.9 |
| PR-5 | 0.1 - 1.1 | 0.55 | 0.41 | 0 - 0.8 | 0.32 | 0.30 | 7.2 - 23.5 | 16.0 | 8.6 |
| PR-6 | 0.1 | 0.1 | a | 2.1 | 2.1 | a | 20.8 | 20.8 | a |
| PR-7 | 0.2 - 1.0 | 0.56 | 0.34 | 0 - 1.4 | 0.43 | 0.53 | 6.9 - 20.8 | 15.0 | 5.5 |
| PR-8[b] | 0.1 - 0.4 | 0.25 | 0.21 | 0.8 - 2.1 | 1.45 | 0.92 | 20.7 - 21.1 | 20.9 | 0.3 |

| | Dissolved Oxygen (mg/ℓ) | | | pH | | | Conductivity (µmhos) | | | Oxidation Reduction Potential (Volts) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| PR-1 | 7.58 - 16.3 | 10.43 | 3.21 | 6.96 - 8.99 | 7.92 | 0.65 | 164 - 699 | 596 | 193 | 0.183 - 0.287 | 0.235 | 0.039 |
| PR-2 | 8.2 - 12.92 | 9.7 | 1.59 | 7.62 - 8.59 | 7.93 | 0.33 | 184 - 705 | 593 | 187 | 0.178 - 0.323 | 0.255 | 0.059 |
| PR-3 | 8.5 - 14.4 | 10.39 | 2.10 | 7.68 - 8.9 | 8.16 | 0.44 | 230 - 681 | 590 | 161 | 0.171 - 0.283 | 0.222 | 0.042 |
| PR-4 | 7.15 - 15.33 | 11.58 | 3.61 | 7.77 - 8.73 | 8.24 | 0.44 | 498 - 673 | 614 | 71 | 0.182 - 0.246 | 0.204 | 0.030 |
| PR-5 | 8.35 - 15.26 | 10.42 | 2.81 | 7.76 - 8.44 | 8.17 | 0.29 | 550 - 690 | 646 | 57 | 0.178 - 0.255 | 0.217 | 0.043 |
| PR-6 | 7.0 | 7.0 | a | 7.85 | 7.85 | a | 486 | 486 | a | 0.185 | 0.185 | a |
| PR-7 | 6.41 - 12.64 | 8.84 | 2.17 | 7.25 - 7.85 | 7.57 | 0.24 | 108 - 742 | 565 | 218 | 0.192 - 0.376 | 0.267 | 0.066 |
| PR-8[b] | 7.23 - 12.2 | 9.72 | 3.51 | 7.81 - 8.14 | 7.98 | 0.23 | 483 - 691 | 587 | 147 | 0.187 - 0.193 | 0.190 | 0.004 |

[a] Sampled only during June 1989

[b] Sampled only during June 1989 and August 1990

**TABLE D.3-14B**

**PADDYS RUN WATER QUALITY DATA**
**AVERAGED ACROSS STATIONS FOR EACH SAMPLING TIME**

| | Secchi Depth (m) | | | Current Velocity (ft/s) | | | Temperature (°C) | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| June 1989 | 0.1 - 1.0 | 0.33 | 0.31 | 0.1 - 2.5 | 1.29 | 0.95 | 19.1 - 23.3 | 21.0 | 1.36 |
| November 1989 | 0.25 - 0.3 | 0.26 | 0.02 | 0 - 0.7 | 0.32 | 0.24 | 8.83 - 11.1 | 10.2 | 0.88 |
| December 1989 | 0.5 - 1.2 | 0.8 | 0.36 | 0 - 0.3 | 0.19 | 0.13 | 0 - 6.92 | 1.73 | 3.46 |
| March 1990 | 0.4 - 1.1 | 0.68 | 0.25 | 0.1 - 0.6 | 0.28 | 0.17 | 5.37 - 9.85 | 8.18 | 1.63 |
| April 1990 | 0.3 - 1.0 | 0.65 | 0.29 | 0.3 - 1.4 | 0.59 | 0.44 | 14.9 - 23.6 | 19.3 | 3.64 |
| June 1990 | 0.1 - 1.0 | 0.27 | 0.36 | 0 - 0.3 | 0.15 | 0.12 | 18.9 | 18.9 | a |
| August 1990 | 0.4 - 1.0 | 0.7 | 0.28 | 0.1 - 0.8 | 0.28 | 0.3 | 18.3 - 23.5 | 20.7 | 1.86 |

| | Dissolved Oxygen (mg/ℓ) | | | pH | | | Conductivity (µmhos) | | | Oxidation Reduction Potential (Volts) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| June 1989 | 6.14 - 9.54 | 7.75 | 1.13 | 7.71 - 8.08 | 7.88 | 0.14 | 483 - 699 | 590 | 104 | 0.171 - 0.192 | 0.182 | 0.006 |
| November 1989 | 7.76 - 9.44 | 8.66 | 0.65 | 6.96 - 7.77 | 7.53 | 0.31 | 108 - 676 | 578 | 230 | 0.246 - 0.313 | 0.277 | 0.029 |
| December 1989 | 6.88 - 12.6 | 9.34 | 2.4 | 7.25 - 7.77 | 7.61 | 0.24 | 164 - 742 | 330 | 276 | 0.283 - 0.376 | 0.308 | 0.046 |
| March 1990 | 12.6 - 16.3 | 14.5 | 1.45 | 7.72 - 8.52 | 8.22 | 0.35 | 656 - 705 | 678 | 17.8 | 0.205 - 0.323 | 0.247 | 0.042 |
| April 1990 | 9.28 - 11.6 | 10.7 | 0.86 | 7.65 - 8.44 | 8.15 | 0.31 | 637 - 670 | 658 | 14.4 | 0.18 - 0.237 | 0.204 | 0.021 |
| June 1990 | 8.3 - 15.2 | 9.88 | 2.62 | 7.85 - 8.99 | 8.56 | 0.42 | 550 - 600 | 575 | 27.4 | b | b | b |
| August 1990 | 8.54 - 12.2 | 10.1 | 1.58 | 7.32 - 8.14 | 7.74 | 0.33 | 628 - 701 | 680 | 29.7 | 0.193 - 0.233 | 0.216 | 0.018 |

[a] Data only for Station PR-7
[b] No data

D.3.2.2 Benthic Macroinvertebrates

D.3.2.2.1 Surber Samples

May - June 1989

Surber samples were collected at all stations on Paddys Run (Table D.3-15, Attachment D.III). Most abundant in these collections were midges, sow bugs, mayflies and beetles. The number of taxa collected ranged from three at PR-6 to 14 at PR-2. Diversity ranged from 0.49 at PR-4 to 2.40 at PR-2, while evenness ranged from 0.23 at PR-4 to 0.91 at PR-2 and PR-6. Densities were relatively low, especially at Stations PR-6, PR-7 and PR-8.

November - December 1989

The Surber sample data showed a trend of decreasing number of taxa and diversity from PR-1 through PR-5 (Table D.3-16). Paddys Run was dry at Stations PR-6 and PR-8 at the time of sampling and these stations were not sampled. Evenness was lowest at PR-3, reflecting the dominance of the isopod Lirceus in these samples (Attachment D.III). At PR-5, the five Surber samples yielded only one organism, a planorbid snail. It is likely that the stream was dry at this station during the weeks preceding sampling. The downstream station, PR-7, contained 13 taxa and had the highest organism density of the Surber samples.

March - May 1990

No trends were obvious in the Surber sample data (Table D.3-17). All stations had 20 or more taxa present and all diversities were greater than 2.0. Station PR-2 had the greatest number of taxa and the highest diversity. The highest density occurred at PR-5. The benthic populations were more abundant and more diverse than those sampled during the fall of 1989 at all stations except PR-1, which remained relatively constant.

June - August 1990

Stations PR-4 and PR-5 could not be sampled because Paddys Run was dry in these areas in early August of 1990. All stations sampled contained relatively high numbers of taxa (27-30) and had diversity values greater than 2.0 (Table D.3-18). All stations had similar numbers of taxa, diversity, and evenness, with density varying about two-fold.

D.3.2.2.2 Hester-Dendy Artificial Substrate Samples

May - June 1989

Hester-Dendy samplers were retrieved only from Stations PR-2, PR-3, and PR-4. The samples from PR-4 had the lowest diversity and evenness (Table D.3-19). This sampler cluster was recovered approximately 100 yards downstream of its original site of deployment. It is unknown whether the samplers had remained submerged for the five week sampling period or if they were only recently submerged. If the sampler was not constantly submerged, the organisms present may be representative

**TABLE D.3-15**
**PADDYS RUN**
**SURBER SAMPLER RESULTS SUMMARY**
**MAY - JUNE 1989**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/m$^2$) |
|---|---|---|---|---|
| PR-1 | 10 | 2.04 | 0.89 | 97 |
| PR-2 | 14 | 2.40 | 0.91 | 146 |
| PR-3 | 11 | 1.35 | 0.56 | 164 |
| PR-4 | 8 | 0.49 | 0.23 | 286 |
| PR-5 | 7 | 1.34 | 0.69 | 157 |
| PR-6 | 3 | 1.00 | 0.91 | 15 |
| PR-7 | 4 | 0.89 | 0.64 | 24 |
| PR-8 | 5 | 1.16 | 0.72 | 34 |

**TABLE D.3-16**
**PADDYS RUN**
**SURBER SAMPLER RESULTS SUMMARY**
**NOVEMBER - DECEMBER 1989**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/m$^2$) |
|---|---|---|---|---|
| PR-1 | 19 | 2.30 | 0.78 | 233 |
| PR-2 | 10 | 1.68 | 0.73 | 179 |
| PR-3 | 7 | 0.68 | 0.35 | 211 |
| PR-4 | 4 | 0.72 | 0.52 | 32 |
| PR-5 | 1 | a | a | 2 |
| PR-6[b] | | | | |
| PR-7 | 13 | 1.77 | 0.69 | 260 |
| PR-8[b] | | | | |

[a] One organism present - calculation not possible

[b] Station not sampled

**TABLE D.3-17**
**PADDYS RUN**
**SURBER SAMPLER RESULTS SUMMARY**
**MARCH - MAY 1990**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/$m^2$) |
|---|---|---|---|---|
| PR-1 | 20 | 2.52 | 0.84 | 424 |
| PR-2 | 30 | 2.66 | 0.78 | 428 |
| PR-3 | 23 | 2.48 | 0.79 | 293 |
| PR-4 | 23 | 2.44 | 0.78 | 407 |
| PR-5 | 24 | 2.31 | 0.73 | 887 |
| PR-7 | 23 | 2.24 | 0.71 | 573 |

**TABLE D.3-18**
**PADDYS RUN**
**SURBER SAMPLER RESULTS SUMMARY**
**JUNE - AUGUST 1990**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/$m^2$) |
|---|---|---|---|---|
| PR-1 | 30 | 2.80 | 0.82 | 766 |
| PR-2 | 27 | 2.15 | 0.65 | 741 |
| PR-3 | 28 | 2.60 | 0.78 | 777 |
| PR-4[a] | | | | |
| PR-5[a] | | | | |
| PR-7 | 29 | 2.47 | 0.73 | 1470 |
| PR-8 | 28 | 2.33 | 0.70 | 1668 |

[a] Station dry - no data

**TABLE D.3-19**
**PADDYS RUN**
**HESTER-DENDY SAMPLER RESULTS SUMMARY**
**MAY - JUNE 1989**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/m$^2$) |
|---|---|---|---|---|
| PR-2 | 16 | 1.78 | 0.64 | 525 |
| PR-3 | 7 | 1.64 | 0.84 | 151 |
| PR-4 | 6 | 0.62 | 0.34 | 153 |

of only a week or several days of colonization. The collection from PR-2 included mayflies and caddisflies, which were unique to this station. Station PR-2 had the largest number of taxa and the highest density. The Hester-Dendy collections retrieved from Stations PR-3 and PR-4 were composed primarily of midges. Although the number of taxa and density were similar, the diversity and evenness values were lower at Station PR-4.

November - December 1989

Samplers were recovered from Stations PR-1, PR-2, PR-3, PR-4, and PR-7. However, the stream at PR-4 was dry on the date of recovery. Even so, 28 aquatic sowbugs (Lirceus) were found on the sampler plates. At PR-5, a collapse of the stream bank had buried the sampler. The stream was also dry at this location.

Station PR-2 had the highest number of taxa and the highest diversity (Table D.3-20). Only one taxon (Lirceus) was found on the sampler at PR-4, making calculation of diversity and evenness impossible. Station PR-7, located approximately 0.8 miles downstream of the FEMP property boundary, contained only seven taxa but had the highest density. This station was chosen for artificial substrate deployment because, unlike Stations PR-6 and PR-8, the stream here does not normally go dry. Indeed, at the time of sampler retrieval in December 1989, although much of the lower portion of Paddys Run was dry, the pool at PR-7 had a depth of almost 1.0 meter.

March - May 1990

Substrates were recovered at all stations except PR-3. However, the samplers at Stations PR-2, PR-4, and PR-5 were found well downstream (up to 140 m) of their deployment locations. Samplers were found intact and submerged in shallow water. The effects of this movement on substrate colonization are uncertain, and it is interesting to note that the samplers that had moved had higher densities than the two that did not (Table D.3-21).

**TABLE D.3-20**
**PADDYS RUN**
**HESTER-DENDY SAMPLER RESULTS SUMMARY**
**NOVEMBER - DECEMBER 1989**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/$m^2$) |
|---|---|---|---|---|
| PR-1 | 2 | 0.69 | 1.00 | 5 |
| PR-2 | 12 | 2.18 | 0.88 | 86 |
| PR-3 | 10 | 1.95 | 0.85 | 65 |
| PR-4 | 1 | a | a | 75 |
| PR-5[b] | | | | |
| PR-7 | 7 | 1.20 | 0.62 | 229 |

[a] One organism present - calculation not possible
[b] Sampler buried - no data

**TABLE D.3-21**
**PADDYS RUN**
**HESTER-DENDY SAMPLER RESULTS SUMMARY**
**MARCH - MAY 1990**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/$m^2$) |
|---|---|---|---|---|
| PR-1 | 21 | 2.43 | 0.80 | 495 |
| PR-2 | 16 | 1.76 | 0.63 | 848 |
| PR-3[a] | | | | |
| PR-4 | 24 | 2.26 | 0.71 | 912 |
| PR-5 | 18 | 1.98 | 0.68 | 743 |
| PR-7 | 5 | 1.43 | 0.89 | 108 |

[a] Sampler not recovered

The substrates at reference Station PR-1 contained the highest number of taxa and the second highest diversity. The substrate from the second reference station, PR-2, had greater density than PR-1, but fewer taxa and lower diversity and evenness. Station PR-4 had the greatest number of taxa and highest density. Station PR-7 contained only five taxa, and had the lowest diversity and density.

June - August 1990

The artificial substrate samplers were recovered at all stations in the locations as deployed. However, between the time of deployment and the retrieval date of August 1, 1990, the stream went dry at Stations PR-4 and PR-5. Therefore, no artificial substrate data were obtained from these stations for this sampling period (Table D.3-22).

**TABLE D.3-22**
**PADDYS RUN**
**HESTER-DENDY SAMPLER RESULTS SUMMARY**
**JUNE - AUGUST 1990**

| Station | Number of Taxa | Diversity | Evenness | Density (organisms/m$^2$) |
|---|---|---|---|---|
| PR-1 | 8 | 1.49 | 0.71 | 132 |
| PR-2 | 15 | 1.97 | 0.73 | 826 |
| PR-3 | 14 | 1.99 | 0.75 | 288 |
| PR-4[a] | | | | |
| PR-5[a] | | | | |
| PR-7 | 7 | 1.57 | 0.80 | 132 |

[a] Station dry - no data

The substrates from PR-2 and PR-3 had the highest numbers of taxa and diversities, and PR-2 had the highest density. Reference Station PR-1 had similar diversity, density, and numbers of taxa to Station PR-7 and both had lower values than PR-2 and PR-3. The evenness values were similar for the four stations.

D.3.2.2.3 Tolerance Classifications

May - June 1989

Table D.3-23 presents the tolerance classification percentages for the taxa found in the Surber and artificial substrate samples. As previously noted in Section D.3.1.2.4, the most informative tolerance data is the presence or absence of taxa classified as intolerant. These organisms are generally found in

**TABLE D.3-23**
**PADDYS RUN**
**TOLERANCE CLASSIFICATION PERCENTAGES**
**HESTER-DENDY AND SURBER SAMPLES**
**MAY - JUNE 1989**

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| | HD[a] | Surber[b] | HD | Surber | HD | Surber | HD | Surber |
| PR-1 | | 15 | | 35 | | 30 | | 20 |
| PR-2 | 6 | 7 | 28 | 46 | 47 | 32 | 19 | 14 |
| PR-3 | 14 | 14 | 21 | 27 | 36 | 41 | 29 | 18 |
| PR-4 | 0 | 6 | 25 | 25 | 25 | 44 | 50 | 25 |
| PR-5 | | 7 | | 36 | | 14 | | 43 |
| PR-6 | | 0 | | 17 | | 50 | | 33 |
| PR-7 | | 0 | | 38 | | 38 | | 25 |
| PR-8 | | 10 | | 40 | | 30 | | 20 |

[a] Hester-Dendy artifical substrate
[b] Surber stream bottom sampler

low stress areas which have no significant organic contamination. Intolerant taxa comprised at least 25 percent of all the May - June 1989 samples with the exception of the PR-5 Surber sample. The Surber sample from PR-6 contained the highest percentage of intolerant taxa for all Paddys Run samples from this period. The PR-2 Hester-Dendy contained the highest percentage of intolerant taxa for this sample type. The highest percentage of tolerant taxa was found at PR-1 in the Surber sample.

November - December 1989

Intolerant species were present in samples from all locations with the highest percentage in the PR-1 artificial substrate sample (Table D.3-24). They were also abundant at downstream Station PR-7. Conversely, tolerant taxa were found in higher percentages at Stations PR-3 and PR-4 (Surber data).

March - May 1990

Intolerant taxa comprised the highest percentage of all samples from this period with the exception of the PR-7 artificial substrate sample (Table D.3-25). No trends were apparent among the sampling stations.

**TABLE D.3-24**
**PADDYS RUN**
**TOLERANCE CLASSIFICATION PERCENTAGES**
**HESTER-DENDY AND SURBER SAMPLES**
**NOVEMBER - DECEMBER 1989**

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| | HD[a] | Surber[b] | HD | Surber | HD | Surber | HD | Surber |
| PR-1 | 0 | 8 | 0 | 21 | 50 | 29 | 50 | 42 |
| PR-2 | 17 | 10 | 33 | 20 | 17 | 20 | 33 | 50 |
| PR-3 | 15 | 31 | 20 | 31 | 25 | 13 | 40 | 25 |
| PR-4 | 0 | 25 | 100 | 50 | 0 | 25 | 0 | 0 |
| PR-5 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 |
| PR-7 | 0 | 19 | 50 | 27 | 36 | 23 | 14 | 31 |

[a] Hester-Dendy artifical substrate

[b] Surber stream bottom sampler

**TABLE D.3-25**
**PADDYS RUN**
**TOLERANCE CLASSIFICATION PERCENTAGES**
**HESTER-DENDY AND SURBER SAMPLES**
**MARCH - MAY 1990**

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| | HD[a] | Surber[b] | HD | Surber | HD | Surber | HD | Surber |
| PR-1 | 24 | 0 | 24 | 25 | 33 | 45 | | 30 |
| PR-2 | 6 | 23 | 22 | 20 | 47 | 37 | 25 | 20 |
| PR-3 | | 4 | | 24 | | 36 | | 28 |
| PR-4 | 10 | 20 | 23 | 24 | 42 | 39 | 25 | 17 |
| PR-5 | 3 | 8 | 28 | 21 | 58 | 50 | 11 | 21 |
| PR-7 | 20 | 13 | 60 | 24 | 20 | 50 | 0 | 13 |

[a] Hester-Dendy artifical substrate

[b] Surber stream bottom sampler

June - August 1990

Intolerant taxa comprised a large percentage of both artificial substrate and Surber samples at all stations sampled (Table D.3-26). Lower percentages of facultative and tolerant taxa were found, and again, no trends were evident. Tolerant taxa were present in all samples with the exception of the PR-1 Hester-Dendy sample.

### D.3.3 INVERTEBRATE COMMUNITY INDEX

For each sample period, Hester-Dendy artificial substrate data for each sample location were summed and the number of taxa was recorded. Metric calculations were made according to OEPA (1988b, 1989a). Calculations of metrics 1-9 were made using the Hester-Dendy data and metric 10 was calculated using the Surber and Emery dredge samples (OEPA 1988b). Results and corresponding scores are detailed in Attachment D.I.

OEPA (1988b) recommends that data collection for ICI calculation be carried out between June 15 and September 30. Descriptions of ICI ranges as representing poor, fair, good, or exceptional water quality are based on samples collected during this period. Seasonal variations in ICI therefore do not necessarily indicate changes in water quality, but rather variations in the physical conditions (e.g. temperature) to which organisms are exposed. Use of descriptive terms for water quality below is intended to highlight differences among stations within a given sampling period.

#### D.3.3.1 Great Miami River ICI

ICI results for the Great Miami River are presented in Table D.3-27 and are plotted against river miles in Figure D.3-1. ICI values depend primarily upon artificial substrate data, and therefore no index calculation was possible where the substrate was not recovered. All Great Miami River artificial substrates were lost during the May - June 1989 sampling period.

In the October - December 1988 sampling, all substrates were recovered with the exception of GMR-4. The indices for the two upstream reference stations (W-1, GMR-1) were consistent with fair water quality (OEPA 1988b). The index for the outfall station GMR-2 was the lowest of all Great Miami River samples collected in this survey. Indices for the downstream stations suggested recovery, with the maximum downstream value at Station W-3. However, this apparent pattern may be an artifact of the small number of taxa recorded in this sampling (Table D.3-7), as discussed below in Section D.4.1.

In contrast to October - December 1988, the ICIs calculated from the November - December 1989 data were higher for the FEMP outfall station, GMR-2, than for the station directly upstream of the outfall, GMR-1 (Table D.3-27, Figure D.3-1). However, these samples too contained few taxa (Table D.3-7).

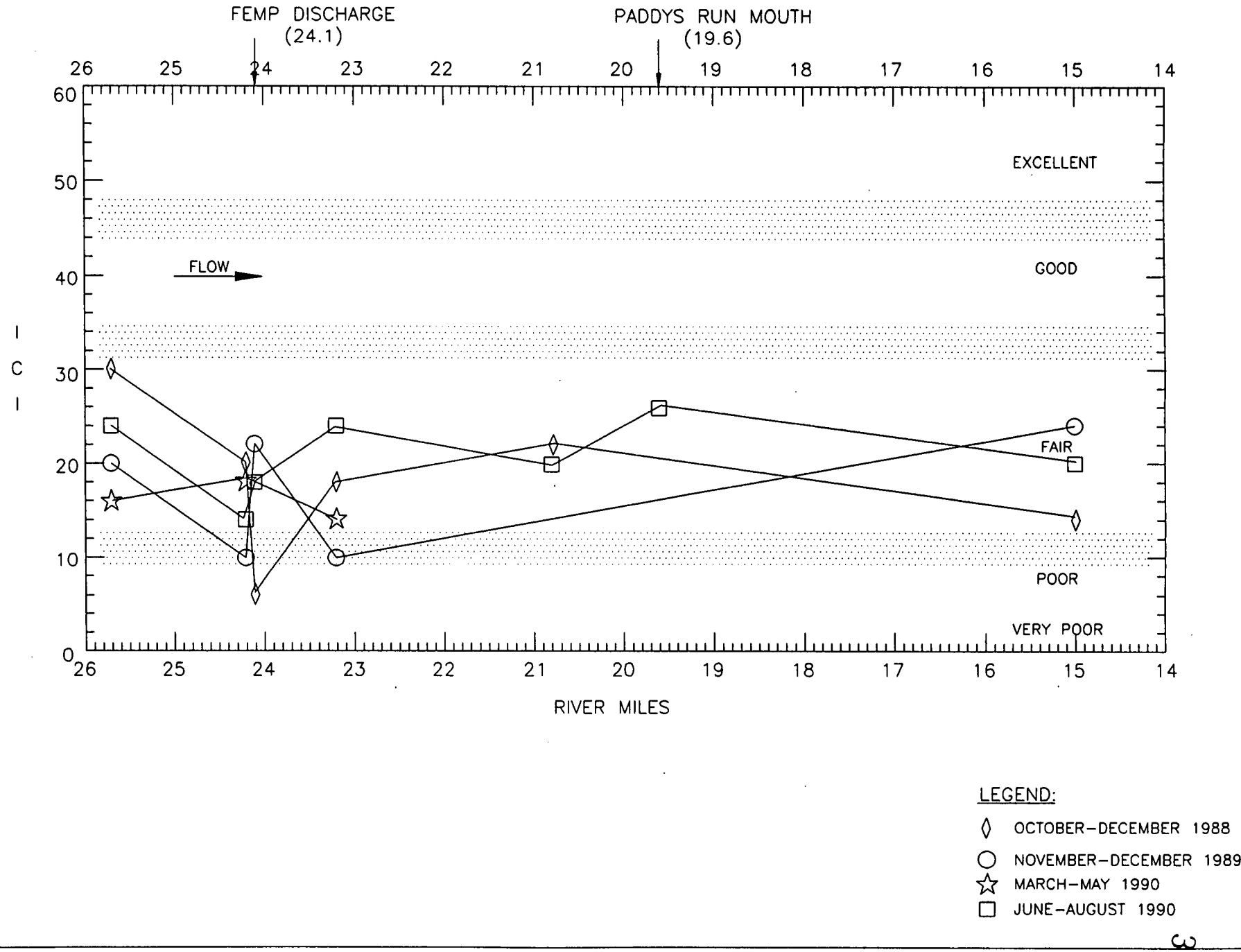


FIGURE D.3-1. LONGITUDINAL TREND OF THE INVERTEBRATE COMMUNITY INDEX (ICI) FOR THE GREAT MIAMI RIVER

313327.A_ICIGMR_SCR_CIN

## TABLE D.3-26
## PADDYS RUN
## TOLERANCE CLASSIFICATION PERCENTAGES
## HESTER-DENDY AND SURBER SAMPLES
## JUNE - AUGUST 1990

| | Percent Tolerant | | Percent Facultative | | Percent Intolerant | | Percent No Index | |
|---|---|---|---|---|---|---|---|---|
| | HD[a] | Surber[b] | HD | Surber | HD | Surber | HD | Surber |
| PR-1 | 0 | 23 | 19 | 13 | 69 | 43 | 13 | 20 |
| PR-2 | 54 | 2 | 21 | 31 | 18 | 44 | 7 | 22 |
| PR-3 | 13 | 11 | 21 | 23 | 58 | 48 | 8 | 18 |
| PR-4[c] | | | | | | | | |
| PR-5[c] | | | | | | | | |
| PR-7 | 14 | 7 | 50 | 28 | 36 | 45 | 0 | 21 |
| PR-8 | | 20 | | 18 | | 45 | | 18 |

[a] Hester-Dendy artifical substrate
[b] Surber stream bottom sampler
[c] Stream dry - no data

## TABLE D.3-27
## GREAT MIAMI RIVER
## INVERTEBRATE COMMUNITY INDEX (ICI)

| Station | River Mile | Oct.-Dec. 1988 | May-June 1989 | Nov.-Dec. 1989 | Mar.-May 1990 | June-Aug. 1990 |
|---|---|---|---|---|---|---|
| W-1 | 25.7 | 30 | ND[a] | 20 | 16 | 24 |
| GMR-1 | 24.2 | 20 | ND | 10 | 18 | 12 |
| GMR-2 | 24.1 | 6 | ND | 22 | ND | 18 |
| GMR-3 | 23.2 | 18 | ND | 10 | 14 | 24 |
| W-3 | 20.8 | 22 | ND | ND | ND | 20 |
| GMR-4 | 19.6 | ND | ND | ND | ND | 26 |
| W-4 | 15.0 | 14 | ND | 24 | ND | 20 |

[a] No data-artificial substrate not recovered.

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In March - May 1990, artificial substrates were recovered from only three of the seven stations. The ICIs calculated from these data fall into the range considered by OEPA (1988b) to reflect "fair" water quality.

All artificial substrates were recovered in June - August 1990, allowing calculation of ICIs for all stations (Table D.3-27, Figure D.3-1). All values were within the range suggesting fair water quality (OEPA 1988b). However, there was a 50 percent decrease in the ICI between upstream reference station W-1 and the second reference station, GMR-1, which is located approximately 1000 feet upstream of the FEMP outfall, to a value on the border between fair and poor. The ICI increased at the outfall station, GMR-2, and was 20 or greater at all downstream stations.

D.3.3.2 Paddys Run ICI

Summary ICI results for Paddys Run are presented in Table D.3-28 and are plotted against stream miles in Figure D.3-2. In May - June 1989, only three artificial substrates were recovered. Unusually heavy rains occurred at this time and Paddys Run was very high and turbid for much of the substrate colonization period. Nevertheless, the ICI for Station PR-2 was 28, one of the highest recorded. At PR-3 and PR-4, the index dropped to levels which would suggest "poor" water quality according to OEPA (1988b) criteria.

The November - December 1989 sampling took place during cold weather, and Paddys Run was frozen at the time of substrate retrieval. The ICI values from these samples are quite low, with only the PR-2 index falling into the fair water quality range. This suggests that seasonal temperature variations may cause stresses on macroinvertebrate communities comparable to those caused by pollution.

The remaining two Paddys Run samplings (March - May and June - August 1990) were conducted during relatively mild weather, and the ICI values generally indicate fair water quality. Notable is the ICI increase between PR-1 and PR-2, and the low indices for downstream Station PR-7. The ICIs calculated for both 1990 data sets suggest poor water quality at this station (Figure D.3-2). In August 1990 at the time of artificial substrate retrieval, Paddys Run was dry at Stations PR-4 and PR-5, and ICI calculations were not possible.

**TABLE D.3-28**
**PADDYS RUN**
**INVERTEBRATE COMMUNITY INDEX (ICI)**

| Station | Stream Mile | May-June 1989 | Nov.-Dec. 1989 | Mar.-May 1990 | June-Aug. 1990 |
|---|---|---|---|---|---|
| PR-1 | 3.5 | ND[a] | 10 | 14 | 24 |
| PR-2 | 3.4 | 28 | 14 | 28 | 26 |
| PR-3 | 3.1 | 8 | 12 | ND | 26 |
| PR-4 | 2.6 | 4 | 6 | 14 | ND |
| PR-5 | 2.2 | ND | ND | 20 | ND |
| PR-7 | 0.98 | ND | 10 | 4 | 8 |

[a] No data-artificial substrate not recovered or station dry.

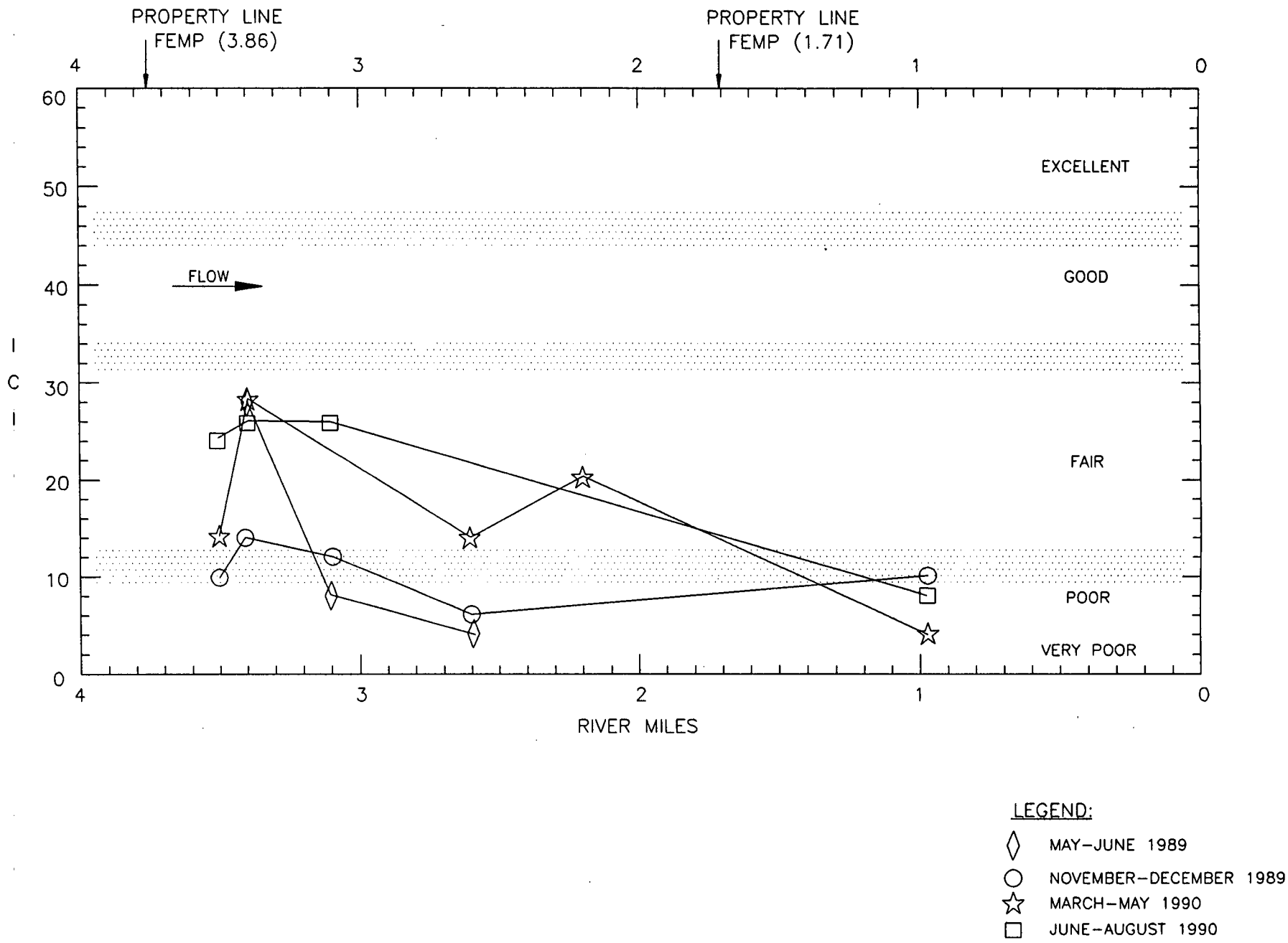


FIGURE D.3-2. LONGITUDINAL TREND OF THE INVERTEBRATE COMMUNITY INDEX (ICI) FOR PADDYS RUN

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# D.4.0 DISCUSSION AND SUMMARY

The principal objective of this study was to assess the potential effects of the FEMP on the macroinvertebrate community of the Great Miami River and Paddys Run in the vicinity of the FEMP. The Great Miami River was assessed to determine the potential effects of the FEMP's wastewater discharge on the benthic community, while Paddys Run was evaluated to determine potential effects of runoff from the FEMP. Sampling in both streams included reference stations above any influence of the FEMP, stations that may be influenced by the FEMP, and stations downstream which should be recovery areas from any influence of the FEMP.

While the benthic community does not represent the entire aquatic ecosystem, it is generally perceived as a sensitive indicator of environmental stress (Wilhm and Dorris 1968, OEPA 1988a). It is also a valuable indicator because of its place in the food chain. Benthic organisms eat many of the primary producers, for example benthic algae and phytoplankton, and are eaten by fish and other vertebrates. They are thus a link between levels in the food chain, and any perturbations in the benthic community are likely to be passed on to other trophic levels. The composition of the benthic community is influenced both by short-term events, for example, physical perturbation, and long-term environmental changes such as continuing toxicant inputs. The presence of a particular organism reflects environmental conditions that occurred during its period of development, which for many types of aquatic macroinvertebrates is a period spanning months to a year or more. The composition of the macroinvertebrate community typically reflects environmental variations over comparable time scales.

## D.4.1 GREAT MIAMI RIVER

The initial sampling took place in the late fall of 1988. The ICI values determined from these data showed a marked decrease in water quality from Station GMR-1, located 1000 feet upstream of the FEMP discharge, to GMR-2, the outfall station (Figure D.3-1). This decrease did not occur in subsequent sampling events and may be an artifact of ICI methodology. ICI metrics five through nine are determined from the percent of a sample composed of a given group of organisms (Attachment D.I). If the total number of taxa is small, the percent of the sample in each taxon will have a great effect on the metric score. All the taxa counts for the October - December 1988 artificial substrate data were relatively low, and the importance of each to the ICI scores increased accordingly. For example, the sample from Station W-3 contained only five taxa but had an ICI value of 22, the second highest. The five taxa present were members of high scoring groups (mayfly, caddisfly, midge). Compared to ICI values, diversity indices calculated for the 1988 data (Table D.3-18) show less variation, with the exception of Station W-3, where the low taxa count resulted in a low diversity index.

Taxa counts were also relatively low in the November - December 1989 artificial substrate samples (Table D.3-19). The ICI values determined from these data indicate a pattern opposite from the 1988

data for the stations directly above and below the outfall (GMR-1, GMR-2). The index was low at GMR-1 and relatively high at the outfall station (Table D.3-27, Figure D.3-1). Again, low taxa counts may result in ICI values which overemphasize differences between stations.

The taxa counts were somewhat higher in the March - May and June - August 1990 samples (Tables D.3-20, D.3-21), and the ICI values calculated from these data may be a better indicator of water quality. All ICIs calculated for these samples were in a range considered by OEPA (1988b) to indicate fair water quality. The ICIs and the diversity indices calculated for the June - August 1990 data (Tables D.3-27, D.3-21) show a similar pattern. The lowest value for both indices is from the station upstream of the outfall, GMR-1. Both indices also show improved conditions downstream of the outfall. Overall, the ICI and diversity values for the Great Miami River suggest that the FEMP discharge at RM 24.1 has minimal impact on the macroinvertebrate community.

Inferences based on a direct examination of taxa composition at the discharge station conflict with each other. Mayflies are intolerant of organic pollution, and an abundance of mayflies is an indicator of little or no organic enrichment in the discharge area (Weber 1973). The Chironomidae tribe Tanytarsini is also intolerant of organic enrichment (OEPA 1988a). GMR-2 had six mayfly taxa present during the June - August 1990 sampling, representing 42.6 percent of the total macroinvertebrate composition (Table D.I-5). This was the highest number of mayfly taxa found in the Great Miami River (Table D.I-2), suggesting little organic enrichment at GMR-2. However, no Tanytarsini midges were identified in GMR-2 samples (Table D.I-7), which would be consistent with the presence of organic enrichment. Both mayflies and Tanytarsini were present at stations above and below GMR-2, suggesting little organic enrichment at these locations. These results may indicate that Tanytarsini are more sensitive than mayflies to FEMP effluent, or that some factor other than organic enrichment controls the relative abundance of these two taxa.

### D.4.2 PADDYS RUN

The section of Paddys Run within the FEMP property is Stream Mile 1.07 to 3.86. Paddys Run receives surface runoff from the FEMP along much of this 2.79 mile length, and also receives point source input from the storm sewer outfall ditch, which carries overflow from the stormwater retention basins. The data collected from Paddys Run suggest that these waters would be classified as fair by OEPA criteria (OEPA 1988a). ICI trends suggested higher water quality at Station PR-2 than at the upper PR-1 station, with a decline in ICI values from Stations PR-2 to PR-7. Conditions at PR-7, as measured during the November - December 1989, March - May 1990, and June - August 1990 periods, are consistent with poor water quality as defined by OEPA criteria (OEPA 1988b). A similar trend in diversity was observed in both Hester-Dendy and Surber samples collected during these sample periods (Tables D.3-37 to D.3-44).

The elevated ICI and organism density in Hester-Dendy samples at PR-2 may indicate an enrichment effect. No direct discharge from the FEMP plant enters Paddys Run in this vicinity. This apparent effect may be due to an influx of organic waste and nutrients from nonpoint sources originating at the FEMP or on surrounding properties. During the March - May and June - August 1990 sampling events, a number of dairy cows were observed crossing Paddys Run between PR-1 and PR-2. Such activity could provide sources of organic waste and nutrients. The abundant periphyton growth (mostly filamentous algae) observed at Stations PR-2 and PR-3 tends to suggest enrichment at these points. It is notable that the ICI values calculated for Station PR-2 were nearly identical for three of the four sampling events. The November - December 1989 index was lower, as were the majority of ICI values for that sampling period. Reduced productivity, rather than reduced water quality, probably resulted in the low ICI values found during this sampling period. Unlike the Great Miami River, the Paddys Run communities below the enrichment area tend to decline in terms of environmental quality instead of stabilizing. This effect may be the result of the low flow conditions observed in Paddys Run. Nonpoint source pollution entering the stream would not be diluted as in the Great Miami River. Flow below PR-3 (SM 3.08) was characteristically lower than the stations above PR-3 and was intermittent or non-existent during dry periods. Intermittent flow conditions during the year could also contribute to reduced macroinvertebrate densities. The existence of these conditions during spring and summer would limit colonization of the benthic substrate (Gore 1985). This would in turn limit diversity through elimination of intolerant species such as mayflies and caddisflies in favor of midges, bivalves and certain gastropods (Pennak 1978).

### D.4.3 SUMMARY

The data collected and analyzed in this study do not indicate that the presence and operations of the FEMP result in anything more than minor enrichment of the waters of the Great Miami River and Paddys Run. No deleterious effect on the benthic macroinvertebrate communities of either water body was demonstrated. Rather, factors unrelated to the FEMP exert a significant controlling influence on the benthos. These factors include the seasonal intermittent nature of Paddys Run and the high sediment loads carried by the Great Miami River during periods of heavy precipitation. These factors reduce the quality of Paddys Run and the Great Miami River as habitat for macroinvertebrates and other aquatic life. ICI values estimated for these waters are consistent with ranges considered by OEPA (1988b) to represent fair to good water quality.

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# ATTACHMENT D.I

## CALCULATION OF THE INVERTEBRATE COMMUNITY INDEX FOR THE GREAT MIAMI RIVER AND PADDYS RUN

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# D.I CALCULATION OF THE INVERTEBRATE COMMUNITY INDEX FOR THE GREAT MIAMI RIVER AND PADDYS RUN

## D.I.1 Metric 1 - Total Taxa

The total number of macroinvertebrate taxa was determined for each station for each sample period using the Hester-Dendy summary data. Metric 1 data for individual stations and sample dates are presented in Table D.I-1. Total taxa encountered varied between station and sample data. The total number of taxa present ranged from zero to 19 in the Great Miami River and from zero to 24 in Paddys Run (Table D.I-1). Higher numbers of taxa were recorded for samples collected in spring and summer than in the fall. The greatest number of individual genera was recorded in June - August samples for both streams.

## D.I.2 Metric 2 - Number of Mayfly Taxa

The total mayfly taxa for each station are presented in Table D.I-2. Generally, larger numbers of mayfly taxa were found at the Great Miami River stations than at the Paddys Run stations. The number of taxa encountered on the Great Miami River ranged from zero to six, compared to zero to five on Paddys Run. As with Metric 1, larger numbers of mayfly taxa were found in the spring and summer samples than in the fall samples. Stenonema was the most abundant genus in both the Great Miami River and Paddys Run samples.

## D.I.3 Metric 3 - Number of Caddisfly Taxa

A larger number of caddisfly taxa was found in the Great Miami River samples than in the Paddys Run samples (Table D.I-3), ranging from one to five in the Great Miami River and zero to two in Paddys Run. The greatest number of caddisfly taxa was observed in the October - December 1988 samples for the Great Miami River and June - August 1990 for Paddys Run. Cheumatopsyche and Hydropsyche were the two most abundant genera observed in both Great Miami River and Paddys Run samples (Attachment D.III).

## D.I.4 Metric 4 - Number of Diptera Taxa

A larger number of dipteran taxa were present in Paddys Run than in the Great Miami River (Table D.I-4). Paddys Run contained zero to twelve taxa. The range in the Great Miami River was zero to 11. For both the Great Miami River and Paddys Run, the largest number of taxa was observed in the June - August 1990 samples. Parachironomus, Chironomus, Polypedilum, and Orthocladius were among the most abundant dipterans present (Attachment D.III). Another genus which was abundant, particularly in June - August 1990 samples, was the blackfly Simulium.

# TABLE D.I-1
# METRIC 1
# TOTAL NUMBER OF TAXA AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq.miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug.1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 11 | 2 | ND[a] | - | 7 | 0 | 14 | 2 | 13 | 2 |
| GMR-1 | 3796 | 8 | 0 | ND | - | 9 | 0 | 16 | 2 | 10 | 0 |
| GMR-2 | 3797 | 8 | 0 | ND | - | 8 | 0 | ND | - | 14 | 2 |
| GMR-3 | 3801 | 7 | 0 | ND | - | 9 | 0 | 13 | 2 | 19 | 2 |
| W-3 | 3814 | 5 | 0 | ND | - | ND | - | ND | - | 13 | 2 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 13 | 2 |
| W-4 | 3844 | 5 | 0 | ND | - | 15 | 2 | ND | - | 19 | 2 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 2 | 0 | 21 | 2 | 8 | 0 |
| PR-2 | 11.3 | 16 | 2 | 12 | 0 | 16 | 2 | 15 | 2 |
| PR-3 | 11.6 | 7 | 0 | 10 | 0 | ND | - | 14 | 2 |
| PR-4 | 12.2 | 6 | 0 | 1 | 0 | 24 | 2 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 18 | 2 | ND | - |
| PR-7 | 14.6 | ND | - | 7 | 0 | 5 | 0 | 7 | 0 |

[a]No data-artificial substrate not recovered or station not sampled.

# TABLE D-I-2
# METRIC 2
# NUMBER OF MAYFLY TAXA AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq.miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 2 | 0 | ND[a] | - | 2 | 0 | 2 | 0 | 3 | 2 |
| GMR-1 | 3796 | 2 | 0 | ND | - | 1 | 0 | 4 | 2 | 2 | 0 |
| GMR-2 | 3797 | 0 | 0 | ND | - | 2 | 0 | ND | - | 6 | 4 |
| GMR-3 | 3801 | 2 | 0 | ND | - | 1 | 0 | 2 | 0 | 4 | 2 |
| W-3 | 3814 | 1 | 0 | ND | - | ND | - | ND | - | 2 | 0 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 3 | 2 |
| W-4 | 3844 | 0 | 0 | ND | - | 3 | 2 | ND | - | 3 | 2 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0 | 0 | 3 | 2 | 3 | 2 |
| PR-2 | 11.3 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 |
| PR-3 | 11.6 | 0 | 0 | 1 | 0 | ND | - | 2 | 0 |
| PR-4 | 12.2 | 0 | 0 | 0 | 0 | 5 | 4 | ND | 0 |
| PR-5 | 12.4 | ND | - | ND | - | 2 | 0 | ND | - |
| PR-7 | 14.6 | ND | - | 1 | 0 | 0 | 0 | 2 | 0 |

[a]No data-artificial substrate not recovered or station not sampled.

# TABLE D.I-3
# METRIC 3
# NUMBER OF CADDISFLY TAXA AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 5 | 4 | ND[a] | - | 2 | 2 | 2 | 2 | 2 | 2 |
| GMR-1 | 3796 | 2 | 2 | ND | - | 1 | 0 | 2 | 2 | 2 | 2 |
| GMR-2 | 3797 | 3 | 2 | ND | - | 2 | 2 | ND | - | 2 | 2 |
| GMR-3 | 3801 | 2 | 2 | ND | - | 1 | 0 | 2 | 2 | 2 | 2 |
| W-3 | 3814 | 1 | 0 | ND | - | ND | - | ND | - | 2 | 2 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 3 | 2 |
| W-4 | 3844 | 3 | 2 | ND | - | 2 | 2 | ND | - | 3 | 2 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0 | 0 | 0 | 0 | 1 | 2 |
| PR-2 | 11.3 | 2 | 4 | 0 | 0 | 1 | 2 | 2 | 4 |
| PR-3 | 11.6 | 0 | 0 | 0 | 0 | ND | - | 2 | 4 |
| PR-4 | 12.2 | 0 | 0 | 0 | 0 | 0 | 0 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 2 | 4 | ND | - |
| PR-7 | 14.6 | ND | - | 0 | 0 | 0 | 0 | 0 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

# TABLE D.I-4
# METRIC 4
# NUMBER OF DIPTERAN TAXA AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 3 | 2 | ND[a] | - | 3 | 2 | 8 | 6 | 8 | 6 |
| GMR-1 | 3796 | 3 | 2 | ND | - | 4 | 2 | 6 | 4 | 3 | 2 |
| GMR-2 | 3797 | 0 | 0 | ND | - | 4 | 2 | ND | - | 5 | 2 |
| GMR-3 | 3801 | 2 | 0 | ND | - | 6 | 4 | 6 | 4 | 11 | 6 |
| W-3 | 3814 | 2 | 0 | ND | - | ND | - | ND | - | 7 | 4 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 7 | 4 |
| W-4 | 3844 | 2 | 0 | ND | - | 8 | 6 | ND | - | 11 | 6 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 1 | 0 | 12 | 2 | 4 | 0 |
| PR-2 | 11.3 | 10 | 2 | 4 | 0 | 7 | 2 | 11 | 2 |
| PR-3 | 11.6 | 7 | 2 | 6 | 0 | ND | - | 10 | 2 |
| PR-4 | 12.2 | 4 | 0 | 0 | 0 | 12 | 2 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 10 | 2 | ND | - |
| PR-7 | 14.6 | ND | - | 4 | 0 | 4 | 0 | 3 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

D.I.5 Metric 5 - Percent Mayfly Composition

Mayfly nymphs represented a greater percentage of the total number of taxa in the Great Miami River stations than the Paddys Run stations, ranging from zero to 42.6 percent in the Great Miami River stations and from zero to 37.5 percent in the Paddys Run stations. Mayfly percentages were more consistent across sample periods in the Great Miami River than in Paddys Run (Table D.I-5).

D.I.6 Metric 6 - Percent Caddisfly Composition

Caddisflies represented a larger percentage of the benthic community in the Great Miami River than in Paddys Run (Table D.I-6). Caddisflies represented 10.5 to 60.0 percent of the total taxa in the Great Miami River and zero to 14.3 percent in Paddys Run. The percentage of caddisflies was more consistent across sampling periods in the Great Miami River than in Paddys Run.

D.I.7 Metric 7 - Percent Tanytarsini Composition

This tribe of dipterans was selected as an individual metric by OEPA (1989) because the tribe is largely pollution intolerant. Microspectra, Rheotanytarsus, Paratanytarsus, Constempellina, and Subletta were the only genera encountered in the present study belonging to the tribe Tanytarsini. The percent composition for this tribe was consistently low for both the Great Miami River and Paddys Run, representing zero to 20 percent in the Great Miami River stations and zero to 14.3 percent in Paddys Run (Table D.I-7). These values tended to be higher during the warmer sampling periods.

D.I.8 Metric 8 - Percent Other Dipterans and Non-Insects Composition

This metric considered all other members of the order Diptera (non-tanytarsini, midges, blackflies, craneflies, mosquitos, biting midges, and anthomyids). Also included in this metric are non-insect biota like aquatic worms, isopods, amphipods, freshwater clams and mussels, crayfish, and leeches. The non-tanytarsini midges and aquatic worms were the most abundant groups in this metric.

Metric 8 represented the largest percentage of the taxa in this study. Both the Great Miami River and Paddys Run had consistently high percentages across stations and sampling periods. For Great Miami River data, the percentages ranged from 25.0 to 71.4 percent. Paddys Run data were somewhat higher, with a range of 50 - 100 percent composition (Table D.I-8).

D.I.9 Metric 9 - Percent Tolerant Organisms

Tolerant organisms were classified according to the list of tolerant macroinvertebrates in OEPA (1988). Tolerant organisms constituted zero - 37.5 percent of the invertebrates collected from the Great Miami River. Results for Paddys Run were slightly lower, tolerant organisms being zero - 42.9 percent of the invertebrates found (Table D.I-9). Tolerant organisms found in this study were mostly freshwater oligochaetes, and midges of the genera Chironomus, Dicrotendpipes, Glyptotendipes,

# TABLE D.I-5
# METRIC 5
# PERCENT MAYFLY COMPOSITION AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 18.2 | 6 | ND[a] | - | 28.6 | 6 | 14.3 | 4 | 23.1 | 6 |
| GMR-1 | 3796 | 25.0 | 6 | ND | - | 11.1 | 4 | 25.0 | 6 | 20.0 | 6 |
| GMR-2 | 3797 | 0.0 | 0 | ND | - | 25.0 | 6 | ND | - | 42.6 | 6 |
| GMR-3 | 3801 | 28.6 | 6 | ND | - | 11.1 | 4 | 15.4 | 4 | 21.1 | 6 |
| W-3 | 3814 | 20.0 | 6 | ND | - | ND | - | ND | - | 15.4 | 4 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 23.1 | 6 |
| W-4 | 3844 | 0.0 | 0 | ND | - | 20.0 | 6 | ND | - | 15.8 | 4 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0.0 | 0 | 14.3 | 4 | 37.5 | 6 |
| PR-2 | 11.3 | 12.5 | 4 | 16.7 | 4 | 12.5 | 4 | 13.3 | 4 |
| PR-3 | 11.6 | 0.0 | 0 | 10.0 | 2 | ND | - | 14.3 | 4 |
| PR-4 | 12.2 | 0.0 | 0 | 0.0 | 0 | 20.8 | 4 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 11.1 | 2 | ND | - |
| PR-7 | 14.6 | ND | - | 14.3 | 4 | 0.0 | 0 | 28.6 | 6 |

[a] No data-artificial substrate not recovered or station not sampled.

**TABLE D.I-6**
**METRIC 6**
**PERCENT CADDISFLY COMPOSITION AND**
**CORRESPONDING METRIC SCORE**

**GREAT MIAMI RIVER**

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 45.5 | 6 | ND[a] | - | 28.6 | 4 | 14.3 | 2 | 15.4 | 2 |
| GMR-1 | 3796 | 25.0 | 4 | ND | - | 22.2 | 4 | 12.5 | 2 | 20.0 | 2 |
| GMR-2 | 3797 | 37.5 | 4 | ND | - | 25.0 | 4 | ND | - | 14.3 | 2 |
| GMR-3 | 3801 | 28.6 | 4 | ND | - | 11.1 | 2 | 15.4 | 2 | 10.5 | 2 |
| W-3 | 3814 | 20.0 | 2 | ND | - | ND | - | ND | - | 15.4 | 2 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 23.1 | 4 |
| W-4 | 3844 | 60.0 | 6 | ND | - | 13.3 | 2 | ND | - | 15.8 | 2 |

**PADDYS RUN**

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0.0 | 0 | 0.0 | 0 | 12.5 | 6 |
| PR-2 | 11.3 | 12.5 | 6 | 0.0 | 0 | 6.3 | 6 | 13.3 | 6 |
| PR-3 | 11.6 | 0.0 | 0 | 0.0 | 0 | ND | - | 14.3 | 6 |
| PR-4 | 12.2 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 11.1 | 6 | ND | - |
| PR-7 | 14.6 | ND | - | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

**TABLE D.I-7**
**METRIC 7**
**PERCENT TANYTARSINI COMPOSITION AND CORRESPONDING METRIC SCORE**

**GREAT MIAMI RIVER**

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data | Score | May-June 1989 Data | Score | Nov.-Dec. 1989 Data | Score | Mar.-May 1990 Data | Score | June-Aug. 1990 Data | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 9.1 | 4 | ND[a] | - | 0.0 | 0 | 0.0 | 0 | 7.7 | 4 |
| GMR-1 | 3796 | 0.0 | 0 | ND | - | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| GMR-2 | 3797 | 0.0 | 0 | ND | - | 0.0 | 0 | ND | 0 | 0.0 | 0 |
| GMR-3 | 3801 | 0.0 | 0 | ND | - | 0.0 | 0 | 0.0 | 0 | 10.5 | 4 |
| W-3 | 3814 | 20.0 | 6 | ND | - | ND | - | ND | - | 15.4 | 6 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 15.4 | 6 |
| W-4 | 3844 | 0.0 | 0 | ND | - | 6.7 | 4 | ND | - | 5.3 | 2 |

**PADDYS RUN**

| Station | Drainage Area (sq. miles) | May-June 1989 Data | Score | Nov.-Dec. 1989 Data | Score | Mar.-May 1990 Data | Score | June-Aug. 1990 Data | Score |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |
| PR-2 | 11.3 | 6.3 | 2 | 8.3 | 2 | 0.0 | 0 | 6.7 | 2 |
| PR-3 | 11.6 | 14.3 | 4 | 10.0 | 4 | ND | - | 7.1 | 2 |
| PR-4 | 12.2 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 0.0 | 0 | ND | - |
| PR-7 | 14.6 | ND | - | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

# TABLE D.I-8
# METRIC 8
# PERCENT OTHER DIPTERAN AND NON-INSECT COMPOSITION AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug.1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 27.3 | 0 | ND[a] | - | 42.9 | 0 | 71.4 | 0 | 53.9 | 0 |
| GMR-1 | 3796 | 25.0 | 0 | ND | - | 66.7 | 0 | 50.0 | 0 | 50.0 | 0 |
| GMR-2 | 3797 | 50.0 | 0 | ND | - | 50.0 | 0 | ND | - | 42.9 | 0 |
| GMR-3 | 3801 | 28.6 | 0 | ND | - | 66.7 | 0 | 61.5 | 0 | 52.6 | 0 |
| W-3 | 3814 | 20.0 | 2 | ND | - | ND | - | ND | - | 46.2 | 0 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 38.5 | 0 |
| W-4 | 3844 | 40.0 | 0 | ND | - | 46.7 | 0 | ND | - | 57.9 | 0 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 50.0 | 2 | 76.2 | 0 | 50.0 | 2 |
| PR-2 | 11.3 | 62.5 | 2 | 50.0 | 2 | 50.0 | 2 | 66.7 | 0 |
| PR-3 | 11.6 | 85.7 | 0 | 70.0 | 0 | ND | - | 64.3 | 0 |
| PR-4 | 12.2 | 99.9 | 0 | 99.9 | 0 | 66.7 | 0 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 66.7 | 0 | ND | - |
| PR-7 | 14.6 | ND | - | 85.7 | 0 | 99.9 | 0 | 71.4 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

# TABLE D.I-9
# METRIC 9
# PERCENT TOLERANT ORGANISMS AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data Score | | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 0.0 | 6 | ND[a] | - | 0.0 | 6 | 35.7 | 0 | 23.1 | 0 |
| GMR-1 | 3796 | 0.0 | 6 | ND | - | 12.5 | 0 | 37.5 | 0 | 30.0 | 0 |
| GMR-2 | 3797 | 12.5 | 0 | ND | - | 0.0 | 6 | ND | - | 14.3 | 0 |
| GMR-3 | 3801 | 0.0 | 6 | ND | - | 28.6 | 0 | 23.1 | 0 | 10.5 | 0 |
| W-3 | 3814 | 0.0 | 6 | ND | - | ND | - | ND | - | 7.7 | 0 |
| GMR-4 | 3820 | ND | - | ND | - | ND | - | ND | - | 7.7 | 0 |
| W-4 | 3844 | 0.0 | 6 | ND | - | 7.1 | 0 | ND | - | 10.5 | 0 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data Score | | Nov.-Dec. 1989 Data Score | | Mar.-May 1990 Data Score | | June-Aug. 1990 Data Score | |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | ND | - | 0.0 | 6 | 28.6 | 0 | 25.0 | 2 |
| PR-2 | 11.3 | 12.5 | 4 | 8.3 | 6 | 6.3 | 6 | 20.0 | 2 |
| PR-3 | 11.6 | 28.6 | 0 | 0.0 | 6 | ND | - | 21.4 | 2 |
| PR-4 | 12.2 | 16.7 | 4 | 0.0 | 6 | 29.2 | 0 | ND | - |
| PR-5 | 12.4 | ND | - | ND | - | 27.8 | 0 | ND | - |
| PR-7 | 14.6 | ND | - | 0.0 | 6 | 40.0 | 0 | 42.9 | 0 |

[a] No data-artificial substrate not recovered or station not sampled.

Polypedilum, and Cricotopus. Physa and the freshwater limpet genus Ferrisa were the two tolerant gastropods encountered.

D.I.10 Metric 10 - Total Number of EPT Qualitative Taxa

This metric was determined using the Surber sampler and Emery dredge data collected during the study. The metric considers the total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa present at a particular station. The total number of EPT taxa varied considerably between sample periods, largely due to the hatching of early and late season nymphs of Ephemeroptera and Plecoptera. In the Great Miami River, the number of EPT taxa ranged from zero to six (Table D.I-10). The number of EPT taxa ranged from zero to nine in the Paddys Run samples.

# TABLE D.I-10
# METRIC 10
# TOTAL NUMBER OF EPT QUALITATIVE TAXA AND CORRESPONDING METRIC SCORE

## GREAT MIAMI RIVER

| Station | Drainage Area (sq. miles) | Oct.-Dec. 1988 Data | Score | May-June 1989 Data | Score | Nov.-Dec. 1989 Data | Score | Mar.-May 1990 Data | Score | June-Aug. 1990 Data | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-1 | 3788 | 3 | 0 | ND[a] | - | 2 | 0 | 3 | 0 | 3 | 0 |
| GMR-1 | 3796 | 0 | 0 | ND | - | 2 | 0 | 3 | 0 | 3 | 0 |
| GMR-2 | 3797 | 4 | 0 | ND | - | 6 | 2 | 2 | 0 | 4 | 0 |
| GMR-3 | 3801 | 2 | 0 | ND | - | 4 | 0 | 2 | 0 | 3 | 0 |
| W-3 | 3814 | 1 | 0 | ND | - | 4 | 0 | 2 | 0 | 2 | 0 |
| GMR-4 | 3820 | ND | - | ND | - | 2 | 0 | 3 | 0 | 2 | 0 |
| W-4 | 3844 | 2 | 0 | ND | - | 2 | 0 | 3 | 0 | 3 | 0 |

## PADDYS RUN

| Station | Drainage Area (sq. miles) | May-June 1989 Data | Score | Nov.-Dec. 1989 Data | Score | Mar.-May 1990 Data | Score | June-Aug. 1990 Data | Score |
|---|---|---|---|---|---|---|---|---|---|
| PR-1 | 10.8 | 2 | 0 | 5 | 2 | 7 | 4 | 8 | 4 |
| PR-2 | 11.3 | 5 | 2 | 2 | 0 | 8 | 4 | 8 | 4 |
| PR-3 | 11.6 | 4 | 2 | 0 | 0 | 6 | 2 | 7 | 4 |
| PR-4 | 12.2 | 2 | 0 | 0 | 0 | 6 | 2 | ND | - |
| PR-5 | 12.4 | 0 | 0 | 0 | 0 | 9 | 4 | ND | - |
| PR-7 | 14.6 | 0 | 0 | 3 | 0 | 9 | 4 | 5 | 2 |

[a] No data-artificial substrate not recovered or station not sampled.

# REFERENCES

Ohio Environmental Protection Agency, 1988, Biological Criteria for the Protection of Aquatic Life: Vol. II, Users Manual for Biological Field Assessment of Ohio Surface Waters, OEPA, Ecological Assessment Section, Columbus, OH.

Ohio Environmental Protection Agency, 1989, Addendum to: Biological Criteria for the Protection of Aquatic Life: Vol. II, Users Manual for Biological Field Assessment of Ohio Surface Waters, OEPA, Ecological Assessment Section, Columbus, OH.

# ATTACHMENT D.II

## WATER QUALITY DATA FOR THE GREAT MIAMI RIVER AND PADDYS RUN

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**TABLE D.II-1**

**GREAT MIAMI RIVER WATER QUALITY DATA**
**DECEMBER 1-2, 1988**

| | Parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secchi Depth (m) | | | Current Velocity[a] (ft./sec.) | | | Temperature[b] (°C) | | | Dissolved Oxygen[b] (mg/ℓ) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 0.40 | 0.40 | 0.40 | 0.85 | 3.22 | 0.72 | 5.41 | 5.45 | 5.43 | 13.09 | 13.02 | 13.26 |
| GMR-1 | 0.30 | 0.40 | 0.40 | 0.52 | 0.59 | 0.59 | 5.46 | 5.75 | 5.75 | 12.70 | 12.52 | 12.81 |
| GMR-2 | 0.25 | 0.40 | 0.30 | 0.72 | 0.43 | 1.90 | 5.84 | 5.85 | 5.91 | 13.02 | 13.03 | 12.83 |
| GMR-3 | 0.40 | 0.40 | 0.50 | 0.30 | 3.05 | 0.23 | 5.61 | 5.61 | 5.77 | 13.13 | 12.65 | 13.04 |
| W-3 | 0.50 | 0.50 | 0.50 | 0.07 | 0.30 | 1.18 | 4.81 | 4.80 | 4.80 | 12.31 | 12.43 | 12.59 |
| GMR-4 | c | c | c | c | c | c | c | c | c | c | c | c |
| W-4 | 0.40 | 0.40 | 0.40 | 0.20 | 3.25 | 0.30 | 5.90 | 5.77 | 5.89 | 12.64 | 13.26 | 12.62 |

See footnotes at end of table.

**TABLE D.II-1**
**(Continued)**

| | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH[b] | | | Conductivity[b] (µmhos) | | | Oxidation Reduction Potential[b] (volts) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 8.15 | 8.09 | 7.93 | 858 | 863 | 858 | 0.208 | 0.207 | 0.232 |
| GMR-1 | 8.20 | 8.28 | 8.11 | 854 | 860 | 856 | 0.182 | 0.155 | 0.180 |
| GMR-2 | 8.31 | 8.30 | 8.28 | 859 | 860 | 861 | 0.192 | 0.199 | 0.190 |
| GMR-3 | 7.64 | 8.08 | 7.97 | 861 | 857 | 860 | 0.213 | 0.177 | 0.184 |
| W-3 | 8.11 | 7.27 | 8.67 | 877 | 875 | 875 | 0.275 | 0.192 | -0.473[e] |
| GMR-4 | c | c | c | c | c | c | c | c | c |
| W-4 | 8.18 | d | 8.20 | 861 | 858 | 861 | 0.217 | 2.00[e] | 2.00[e] |

[a] Surface

[b] Parameter measured at 0.5 m depth if possible or maximum depth at sampling point

[c] Station not sampled

[d] Parameter not measured at this station.

[e] These data are suspect and were not included in calculations of means and standard deviations in Table D.3-1A,B.

Note: SP-1, left bank, SP-3, midstream; SP-5, right bank (bank location determined as facing downstream)

**TABLE D.II-2**
**GREAT MIAMI RIVER WATER QUALITY DATA**
**JUNE 15-16, 1989**

| | Parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secchi Depth (m) | | | Current Velocity[a] (ft./sec.) | | | Temperature[b] (°C) | | | Dissolved Oxygen[b] (mg/ℓ) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 0.1 | 0.1 | 0.1 | 2.5 | 4.5 | 2.1 | 19.95 | 19.96 | 19.99 | 7.65 | 7.85 | 7.64 |
| GMR-1 | 0.0 | 0.0 | 0.0 | 3.0 | 3.6 | 2.8 | 20.14 | 20.15 | 20.16 | 7.65 | 7.72 | 7.63 |
| GMR-2 | 0.0 | 0.0 | 0.0 | 1.8 | 5.0 | 2.6 | 20.54 | 20.55 | 20.56 | 7.67 | 7.75 | 7.62 |
| GMR-3 | 0.1 | 0.1 | 0.1 | 2.7 | 6.0 | 0.7 | 19.57 | 19.51 | 19.56 | 7.66 | 7.56 | 7.43 |
| W-3 | 0.0 | 0.0 | 0.0 | 4.5 | 4.5 | 3.0 | 19.54 | 19.60 | 19.59 | 7.80 | 7.68 | 7.64 |
| GMR-4 | 0.0 | 0.0 | 0.0 | 3.0 | 3.5 | 3.0 | 19.69 | 19.70 | 19.71 | 7.52 | 7.73 | 7.56 |
| W-4 | 0.0 | 0.0 | 0.0 | 4.1 | 4.0 | 1.85 | 19.82 | 19.83 | 19.92 | 7.80 | 7.73 | 7.58 |

See footnotes at end of table

**TABLE D.II-2**
**(Continued)**

| Station | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH[b] | | | Conductivity[b] (µmhos) | | | Oxidation Reduction Potential[b] (volts) | | |
| | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 7.72 | 7.71 | 7.74 | 538 | 520 | 530 | 0.187 | 0.186 | 0.179 |
| GMR-1 | 7.81 | 7.81 | 7.80 | 556 | 557 | 554 | 0.167 | 0.167 | 0.169 |
| GMR-2 | 7.42 | 7.69 | 7.74 | 575 | 204 | 291 | 0.184 | 0.191 | 0.192 |
| GMR-3 | 7.88 | 7.88 | 7.89 | 627 | 287 | 624 | 0.201 | 0.203 | 0.202 |
| W-3 | 7.90 | 7.90 | 7.90 | 596 | 627 | 628 | 0.193 | 0.193 | 0.192 |
| GMR-4 | 7.89 | 7.89 | 7.90 | 635 | 633 | 631 | 0.194 | 0.193 | 0.192 |
| W-4 | 7.76 | 7.73 | 7.12 | 631 | 622 | 628 | 0.208 | 0.208 | 0.188 |

[a] Surface

[b] Parameter measured at 0.5 m depth if possible or maximum depth at sampling point

Note: SP-1, left bank, SP-3, midstream; SP-5, right bank (bank location determined as facing downstream)

**TABLE D.II-3**

**GREAT MIAMI RIVER WATER QUALITY DATA**
**NOVEMBER 7-8, 1989**

| | Parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secchi Depth (m) | | | Current Velocity[a] (ft./sec.) | | | Temperature[b] (°C) | | | Dissolved Oxygen[b] (mg/ℓ) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 0.25 | 0.70 | 0.70 | 0.30 | 1.20 | 0.70 | 12.09 | 12.13 | 12.16 | 8.96 | 9.09 | 9.04 |
| GMR-1 | 0.70 | 0.70 | 0.70 | 0.60 | 0.60 | 0.50 | 12.12 | 12.10 | 12.11 | 9.42 | 8.95 | 8.94 |
| GMR-2 | 0.40 | 0.70 | 0.70 | 0.50 | 2.40 | 2.9 | 12.17 | 12.15 | 12.12 | 9.11 | 10.18 | 9.36 |
| GMR-3 | 0.60 | 0.40 | 0.20 | 0.40 | 2.40 | 0.50 | 12.48 | 12.59 | 12.59 | 9.63 | 13.19 | 9.64 |
| W-3 | 0.30 | 0.60 | 0.70 | 0.40 | 0.30 | 1.9 | 12.44 | 12.55 | 12.55 | 11.14 | 9.56 | 9.66 |
| GMR-4 | 0.25 | 0.25 | 0.25 | 0.0 | 4.50 | 0.10 | 11.61 | 11.76 | 11.74 | 8.30 | 8.32 | 8.22 |
| W-4 | 0.50 | 0.60 | 0.60 | 0.70 | 3.20 | 0.90 | 12.18 | 12.07 | 12.08 | 9.26 | 8.42 | 8.39 |

See footnotes at end of table.

**TABLE D.II-3**
**(Continued)**

| | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH[b] | | | Conductivity[b] (µmhos) | | | Oxidation Reduction Potential[b] (volts) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 8.15 | 8.17 | 8.04 | 984 | 985 | 985 | 0.301 | 0.304 | 0.315 |
| GMR-1 | 8.17 | 8.18 | 8.18 | 986 | 986 | 983 | 0.294 | 0.283 | 0.294 |
| GMR-2 | 8.19 | 8.18 | 8.18 | 986 | 987 | 985 | 0.290 | 0.287 | 0.290 |
| GMR-3 | 8.22 | 8.18 | 8.25 | 966 | 984 | 983 | 0.291 | 0.284 | 0.285 |
| W-3 | 8.15 | 8.24 | 8.24 | 945 | 978 | 981 | 0.286 | 0.285 | 0.285 |
| GMR-4 | 8.02 | 8.03 | 8.03 | 933 | 936 | 940 | 0.296 | 0.295 | 0.295 |
| W-4 | 7.03 | 7.73 | 7.92 | 948 | 950 | 951 | 0.276 | 0.283 | 0.286 |

[a] Surface

[b] Parameter measured at 0.5 m depth if possible or maximum depth at sampling point

Note: SP-1, left bank, SP-3, midstream; SP-5, right bank (bank location determined as facing downstream)

## TABLE D.II-4
## GREAT MIAMI RIVER WATER QUALITY DATA
## DECEMBER 11-12, 1989

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Current Velocity[a] (ft./sec.) | Temperature[b] (°C) | Dissolved Oxygen[b] (mg/ℓ) | pH[b] | Conductivity[b] (µmhos) | Secchi Depth (m) | ORP[b] (volts) |
| W-1 | 0.50 | 3.80 | 12.34 | 8.14 | 952 | 1.00 | 0.318 |
| GMR-1 | 0.30 | 2.51 | 13.04 | 8.01 | 949 | 0.70 | 0.312 |
| GMR-2 | 1.10 | 2.77 | 11.55 | 8.01 | 943 | 0.70 | 0.308 |
| GMR-3 | 0.50 | 2.82 | 11.85 | 8.05 | 951 | 0.80 | 0.302 |
| W-3 | 0.70 | 2.63 | 13.06 | 8.13 | 952 | 1.10 | 0.292 |
| GMR-4 | 0.05 | 2.80 | 12.35 | 8.05 | 953 | 0.50 | 0.292 |
| W-4 | 0.20 | 3.13 | 12.56 | 8.14 | 946 | 0.75 | 0.288 |

[a] Surface

[b] Parameter measured at 0.5 m depth

Note: All measurements taken at artificial substrate location.

## TABLE D.II-5
## GREAT MIAMI RIVER WATER QUALITY DATA
## MARCH 29, 1990

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Current Velocity[a] (ft./sec.) | Temperature[b] (°C) | Dissolved Oxygen[b] (mg/ℓ) | pH[b] | Conductivity[b] (µmhos) | Secchi Depth (m) | ORP[b] (volts) |
| W-1 | 0.30 | 9.72 | 10.04 | 7.80 | 844 | 0.50 | 0.317 |
| GMR-1 | 0.20 | 9.89 | 10.93 | 8.41 | 840 | 0.65 | 0.257 |
| GMR-2 | 2.0 | 9.81 | 10.22 | 8.35 | 844 | 0.70[c] | 0.271 |
| GMR-3 | 2.1 | 9.89 | 10.76 | 8.39 | 844 | 0.50[c] | 0.256 |
| W-3 | 0.80 | 9.94 | 11.15 | 8.15 | 826 | 1.0[c] | 0.249 |
| GMR-4 | 0.0 | 10.05 | 10.67 | 8.41 | 838 | 0.80 | 0.250 |
| W-4 | 0.9 | 10.16 | 11.34 | 8.48 | 842 | 1.4 | 0.243 |

[a] Surface

[b] Parameter measured at 0.5 m depth

[c] Secchi disc visible on bottom at this depth.

Note: All measurements taken at artificial substrate location.

**TABLE D.II-6**
**GREAT MIAMI RIVER WATER QUALITY DATA**
**MAY 3, 1990**

| | Parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secchi Depth (m) | | | Current Velocity[a] (ft./sec.) | | | Temperature[b] (°C) | | | Dissolved Oxygen[b] (mg/ℓ) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 0.60 | 0.60 | 0.70 | 1.80 | 2.10 | 2.20 | 16.07 | 16.08 | 16.07 | 9.49 | 9.43 | 9.40 |
| GMR-1 | 0.60 | 0.50 | 0.50 | 1.30 | 1.25 | 1.60 | 16.13 | 16.16 | 16.16 | 9.00 | 9.86 | 10.04 |
| GMR-2 | 0.50 | 0.50 | 0.50 | 2.40 | 3.40 | 4.60 | 16.21 | 16.21 | 14.23 | 9.04 | 9.00 | 9.77 |
| GMR-3 | 0.50 | 0.50 | 0.50 | 2.80 | 3.20 | 3.00 | 16.09 | 16.09 | 16.08 | 9.95 | 9.75 | 9.63 |
| W-3 | 0.50 | 0.50 | 0.50 | 2.00 | 2.60 | 3.80 | 16.06 | 16.09 | 16.17 | 10.84 | 10.59 | 10.62 |
| GMR-4 | 0.50 | 0.50 | 0.50 | 0.10 | 2.1 | 0.30 | 16.14 | 16.15 | 16.14 | 10.67 | 10.39 | 10.43 |
| W-4 | 0.50 | 0.50 | 0.45 | 2.60 | 2.50 | 0.40 | 16.15 | 16.14 | 16.15 | 10.10 | 10.34 | 10.21 |

See footnotes at end of table.

**TABLE D.II-6**
**(Continued)**

| Station | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH[b] | | | Conductivity[b] (µmhos) | | | Oxidation Reduction Potential[b] (volts) | | |
| | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 8.13 | 8.48 | 8.56 | 771 | 771 | 771 | 0.200 | 0.184 | 0.182 |
| GMR-1 | 8.32 | 8.57 | 8.40 | 769 | 769 | 770 | 0.194 | 0.178 | 0.187 |
| GMR-2 | 8.55 | 8.50 | 8.99 | 766 | 767 | 769 | 0.183 | 0.182 | 0.210 |
| GMR-3 | 8.68 | 8.68 | 8.68 | 770 | 769 | 771 | 0.179 | 0.180 | 0.180 |
| W-3 | 8.72 | 8.72 | 8.70 | 768 | 768 | 767 | 0.182 | 0.183 | 0.182 |
| GMR-4 | 8.72 | 8.71 | 8.71 | 769 | 770 | 764 | 0.183 | 0.184 | 0.185 |
| W-4 | 8.73 | 8.72 | 8.53 | 770 | 771 | 771 | 0.187 | 0.187 | 0.197 |

[a] Surface

[b] Parameter measured at 0.5 m depth if possible or maximum depth at sampling point

Note: SP-1, left bank, SP-3, midstream; SP-5, right bank (bank location determined as facing downstream)

**TABLE D.II-7**
**GREAT MIAMI RIVER WATER QUALITY DATA**
**JUNE 27, 1990**

| | Parameter | | | | | |
|---|---|---|---|---|---|---|
| Station | Current Velocity[a] (ft./sec.) | Temperature[b] (°C) | Dissolved Oxygen[b] (mg/ℓ) | pH | Conductivity[b] (μmhos) | Secchi Depth (m) |
| W-1 | 0.50 | 22.8 | 9.8 | c | 700 | 0.30 |
| GMR-1 | 0.40 | 22.8 | 10.0 | c | 650 | 0.20 |
| GMR-2 | 1.50 | 22.8 | 11.4 | c | 650 | 0.40 |
| GMR-3 | 1.20 | 23.3 | 12.8 | c | 650 | 0.30 |
| W-3 | 0.70 | 23.9 | 15.8 | c | 650 | 0.20 |
| GMR-4 | 0.10 | 24.4 | 15.4 | c | 700 | 0.20 |
| W-4 | 0.80 | 25.6 | 18.4 | c | 700 | 0.20 |

[a] Surface

[b] Parameter measured at 0.5 m depth

[c] Instrument malfunction - no data

Note: All measurements taken at artificial substrate location.

**TABLE D.II-8**
**GREAT MIAMI RIVER WATER QUALITY DATA**
**AUGUST 2, 1990**

| | Parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secchi Depth (m) | | | Current Velocity[a] (ft./sec.) | | | Temperature[b] (°C) | | | Dissolved Oxygen[b] (mg/ℓ) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 0.40 | 0.40 | 0.40 | 0.30 | 2.00 | 0.10 | 24.18 | 24.33 | 24.24 | 11.35 | 11.62 | 11.71 |
| GMR-1 | 0.40 | 0.50 | 0.40 | 0.20 | 0.50 | 1.50 | 23.73 | 23.89 | 23.90 | 10.34 | 10.08 | 10.16 |
| GMR-2 | 0.25 | 0.25 | 0.25 | 1.80 | 3.70 | 2.50 | 23.61 | 23.63 | 23.65 | 9.35 | 9.61 | 9.81 |
| GMR-3 | 0.25 | 0.35 | 0.25 | 1.10 | 2.10 | 2.50 | 24.98 | 24.85 | 24.74 | 13.08 | 13.07 | 12.85 |
| W-3 | 0.20 | 0.20 | 0.25 | 0.10 | 1.90 | 2.00 | 25.07 | 25.06 | 25.10 | 13.85 | 13.77 | 13.91 |
| GMR-4 | 0.25 | 0.50 | 0.30 | 1.40 | 1.80 | 1.00 | 25.32 | 25.27 | 25.25 | 13.51 | 13.65 | 13.75 |
| W-4 | 0.30 | 0.30 | 0.20 | 0.25 | 2.50 | 0.0 | 26.23 | 25.22 | 25.10 | 16.16 | 14.76 | 14.39 |

See footnotes at end of table

**TABLE D.II-8**
**(Continued)**

| | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH[b] | | | Conductivity[b] (µmhos) | | | Oxidation Reduction Potential[b] (volts) | | |
| Station | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 | SP-1 | SP-3 | SP-5 |
| W-1 | 8.56 | 8.57 | 8.60 | 765 | 766 | 763 | 0.162 | 0.165 | 0.163 |
| GMR-1 | 8.43 | 8.52 | 8.54 | 761 | 768 | 767 | 0.160 | 0.161 | 0.160 |
| GMR-2 | 8.40 | 8.44 | 8.44 | 767 | 767 | 767 | 0.179 | 0.174 | 0.171 |
| GMR-3 | 8.64 | 8.63 | 8.64 | 753 | 754 | 754 | 0.139 | 0.140 | 0.141 |
| W-3 | 8.65 | 8.61 | 8.62 | 739 | 742 | 741 | 0.148 | 0.150 | 0.150 |
| GMR-4 | 8.55 | 8.48 | 8.55 | 731 | 731 | 733 | 0.159 | 0.146 | 0.147 |
| W-4 | 8.68 | 8.51 | 8.48 | 711 | 724 | 728 | 0.154 | 0.177 | 0.178 |

[a] Surface

[b] Parameter measured at 0.5 m depth if possible or maximum depth at sampling point

Note: SP-1, left bank, SP-3, midstream; SP-5, right bank (bank location determined as facing downstream)

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## TABLE D.II-9
## PADDYS RUN WATER QUALITY DATA
## JUNE 13-14, 1989

| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
|---|---|---|---|---|---|---|---|
| | Parameter | | | | | | |
| PR-1 | 0.6 | 19.74 | 7.58 | 7.76 | 699 | 1.0[a] | 0.183 |
| PR-2 | 1.2 | 22.42 | 9.54 | 8.08 | 683 | 0.4[a] | 0.178 |
| PR-3 | 0.1 | 21.50 | 9.02 | 8.05 | 681 | 0.2[a] | 0.171 |
| PR-4 | 2.5 | 19.10 | 7.15 | 7.78 | 498 | 0.1 | 0.182 |
| PR-5 | 0.4 | 23.31 | 8.35 | 7.99 | 684 | 0.5[a] | 0.178 |
| PR-6 | 2.1 | 20.81 | 7.00 | 7.85 | 486 | 0.1 | 0.185 |
| PR-7 | b | 20.77 | 6.14 | 7.71 | 507 | 0.2[a] | 0.192 |
| PR-8 | 2.1 | 20.69 | 7.23 | 7.81 | 483 | 0.1 | 0.187 |

[a] Secchi disc visible on bottom at this depth.

[b] Parameter not taken at this station.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

## TABLE D.II-10
## PADDYS RUN WATER QUALITY DATA
## NOVEMBER 8-9, 1989

| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
|---|---|---|---|---|---|---|---|
| | Parameter | | | | | | |
| PR-1 | 0.2 | 9.57 | 7.76 | 6.96 | 672 | 0.30 | 0.274 |
| PR-2 | 0.0 | 8.83 | 8.20 | 7.62 | 673 | 0.25 | 0.310 |
| PR-3 | 0.4 | 10.48 | 8.97 | 7.68 | 676 | 0.25 | 0.261 |
| PR-4 | 0.4 | 11.08 | 9.44 | 7.77 | 673 | 0.25 | 0.246 |
| PR-5 | 0.2 | 10.09 | 9.20 | 7.76 | 663 | 0.25 | 0.255 |
| PR-6 | a | a | a | a | a | a | a |
| PR-7 | 0.7 | 11.08 | 8.41 | 7.41 | 108 | 0.25 | 0.313 |
| PR-8 | a | a | a | a | a | a | a |

[a] Station not sampled

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

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TABLE D.II-11

PADDYS RUN WATER QUALITY DATA
DECEMBER 11-13, 1989

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
| PR-1 | 0.25 | 0.01 | 12.58 | 7.70 | 164 | 0.5 | 0.287 |
| PR-2 | 0.2 | 0.0 | 9.39 | 7.73 | 184 | 1.0[c] | 0.284 |
| PR-3 | 0.3 | 0.0 | 8.50 | 7.77 | 230 | 1.2 | 0.283 |
| PR-4 | a | a | a | a | a | a | a |
| PR-5 | a | a | a | a | a | a | a |
| PR-6 | b | b | b | b | b | b | b |
| PR-7 | 0.0 | 6.92 | 6.88 | 7.25 | 742 | 0.5[c] | 0.376 |
| PR-8 | b | b | b | b | b | b | b |

[a] No data (stream dry).

[b] Station not sampled.

[c] Secchi disc visible on bottom at this depth.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

**TABLE D.II-12**
**PADDYS RUN WATER QUALITY DATA**
**MARCH 28, 1990**

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
| PR-1 | 0.3 | 8.68 | 16.30 | 8.37 | 675 | 0.4[b] | 0.227 |
| PR-2 | 0.1 | 5.37 | 12.92 | 7.72 | 705 | 0.8 | 0.323 |
| PR-3 | 0.6 | 9.09 | 14.40 | 8.52 | 656 | 0.5[b] | 0.222 |
| PR-4 | 0.3 | 8.93 | 15.33 | 8.50 | 663 | 0.6 | 0.205 |
| PR-5 | 0.2 | 7.18 | 15.26 | 8.38 | 690 | 1.1[b] | 0.253 |
| PR-6 | a | a | a | a | a | a | a |
| PR-7 | 0.2 | 9.85 | 12.64 | 7.82 | 678 | 0.7[b] | 0.253 |
| PR-8 | a | a | a | a | a | a | a |

[a] Station not sampled.

[b] Secchi disc visible on bottom at this depth.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

TABLE D.II-13
PADDYS RUN WATER QUALITY DATA
APRIL 30, 1990

| Station | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
| PR-1 | 0.35 | 16.09 | 11.54 | 8.15 | 669 | 0.3[b] | 0.214 |
| PR-2 | 0.4 | 14.85 | 10.38 | 7.94 | 670 | 0.7[b] | 0.210 |
| PR-3 | 0.3 | 19.02 | 11.58 | 8.28 | 661 | 1.0[b] | 0.197 |
| PR-4 | 0.3 | 23.63 | 10.77 | 8.43 | 637 | 0.8[b] | 0.183 |
| PR-5 | 0.8 | 23.45 | 10.40 | 8.44 | 644 | 0.8[b] | 0.180 |
| PR-6 | a | a | a | a | a | a | a |
| PR-7 | 1.4 | 18.97 | 9.28 | 7.65 | 669 | 0.3[b] | 0.237 |
| PR-8 | a | a | a | a | a | a | a |

[a] Station not sampled.

[b] Secchi disc visible on bottom at this depth.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

**TABLE D.II-14**
**PADDYS RUN WATER QUALITY DATA**
**JUNE 26, 1990**

| | Parameter | | | | | |
|---|---|---|---|---|---|---|
| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (µmhos) | Secchi Depth (m) |
| PR-1 | 0.3 | b | 8.7 | 8.99 | 600 | 0.2 |
| PR-2 | 0.2 | b | 8.9 | 8.59 | 550 | 0.1 |
| PR-3 | 0.2 | b | 9.3 | 8.90 | 600 | 0.1 |
| PR-4 | 0.0 | b | 15.2 | 8.73 | 600 | 0.1 |
| PR-5 | 0.0 | b | 8.9 | 8.30 | 550 | 0.1 |
| PR-6 | a | a | a | a | a | a |
| PR-7 | 0.2 | 18.9 | 8.3 | 7.85 | 550 | 1.0[c] |
| PR-8 | a | a | a | a | a | a |

[a] Station not sampled.

[b] Parameter not measured.

[c] Secchi disc visible on bottom at this depth.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

**TABLE D.II-15**
**PADDYS RUN WATER QUALITY DATA**
**AUGUST 1, 1990**

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | Current Velocity (ft./sec.) | Temperature (°C) | Dissolved Oxygen (mg/ℓ) | pH | Conductivity (μmhos) | Secchi Depth (m) | Oxygen Reduction Potential (volts) |
| PR-1 | 0.1 | 20.53 | 8.58 | 7.50 | 696 | 0.5[c] | 0.227 |
| PR-2 | 0.1 | 20.21 | 8.54 | 7.80 | 684 | 0.6 | 0.226 |
| PR-3 | 0.3 | 23.46 | 10.98 | 7.92 | 628 | 1.0[c] | 0.199 |
| PR-4 | a | a | a | a | a | a | a |
| PR-5 | a | a | a | a | a | a | a |
| PR-6 | b | b | b | b | b | b | b |
| PR-7 | 0.1 | 18.29 | 10.25 | 7.32 | 701 | 1.0[c] | 0.233 |
| PR-8 | 0.8 | 21.09 | 12.20 | 8.14 | 691 | 0.4[c] | 0.193 |

[a] Stream dry - no data.

[b] Station not sampled.

[c] Secchi disc visible on bottom at this depth.

Note: Current velocity measured at surface. Other parameters measured at 0.5 m when possible, or maximum depth of station.

# ATTACHMENT D.III

## MACROINVERTEBRATE SAMPLING DATA FOR THE GREAT MIAMI RIVER AND PADDYS RUN

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**TABLE D.III-1A**
**GREAT MIAMI RIVER**
**SEDIMENT GRAB SAMPLING RAW DATA**
**DECEMBER 1988**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | W-4 |
|---|---|---|---|---|---|---|---|---|
| Gastropoda | | | | | | | | |
| Basommatophora | | | | | | | | |
| Physidae | | | | | | | | |
| Physa | snail | T | | | 1 | | | |
| Mesogastropoda | | | | | | | | |
| Pleuroceridae | | | | | | | | |
| Pleurocera | snail | F | | 4 | 23 | | | |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | snail | N | 1 | | | | | |
| Hirudinea | | | | | | | | |
| Rhynchobdellida | | | | | | | | |
| Glossiphoniidae | | | | | | | | |
| Helobdella | leech | T | 1 | | 1 | | | |
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Elmidae | | | | | | | | |
| Stenelmis | riffle beetle | F, I | | | 1 | | | |
| Diptera | | | | | | | | |
| Ceratopogonidae | | | | | | | | |
| Dasyhelea | biting midge | T, F | 1 | | 2 | | | 1 |
| Chironominae | | | | | | | | |
| Chironomini | midge | N | 9 | 45 | 49 | 3 | 34 | 12 |
| Chironomus | midge | T, F | | | | 2 | | |
| Cryptochironomus | midge | T | 1 | | | | | |
| Endochironomus | midge | F, I | | | 2 | | | |
| Paralauterborniella | midge | N | 1 | 6 | | | | 1 |
| Polypedilum | midge | F, I | 1 | 1 | | | | |
| Pseudochironomus | midge | I | | | 5 | | | |
| Stenochironomus | midge | I | | 29 | 1 | | | |
| Tanytarsini | midge | I | 1 | 13 | 13 | 11 | 35 | 1 |
| Unknown | midge | N | 1[d] | 8[d] | 1[d] | | | 29[d] |
| Orthocladiinae | | | | | | | | |
| Orthocladius | midge | F, I | | | 1 | | | |
| Tanypodinae | | | | | | | | |
| Pentaneurini | midge | N | 1 | 4 | 1 | | | |
| Unknown | midge | N | | | | | | 1 |

See footnotes at end of table.

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**TABLE D.III-1A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | W-4 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Diptera | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | midge | N | 1[d] | 1[d] | 6[d] | 5[d] | 4[d] | |
| Ephemeroptera | | | | | | | | |
| Heptageniidae | | | | | | | | |
| Stenonema | mayfly | I | | | | | 1 | |
| Unknown | | | | | | | | |
| Unknown | mayfly | N | 1 | | 1 | | | |
| Odonata | | | | | | | | |
| Protoneuridae | | | | | | | | |
| Protoneura | damselfly adult | N | | | 1 | | | |
| Trichoptera | | | | | | | | |
| Hydropsychidae | | | | | | | | |
| Cheumatopsyche | caddisfly | F | | | 8 | 3 | | |
| Hydropsyche | caddisfly | I | | | 2 | | | |
| Potamyia | caddisfly | F | 1 | | 1 | 1 | | |
| Hydroptilidae | | | | | | | | |
| Unknown | caddisfly | I | | | | | | 1 |
| Unknown | | | | | | | | |
| Unknown | caddisfly | N | 3 | | 1[d] | 2[d] | | 1 |
| Nematoda | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | nematode | F | | 3 | | 1 | | |
| Oligochaeta | | | | | | | | |
| Haplotaxida | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | earthworm | N | 2 | | | | | |
| Lumbricina | | | | | | | | |
| Aeolosomatidae | | | | | | | | |
| Aeolosoma leidy | aquatic worm | N | 9 | | | | | |
| Lumbriculida | | | | | | | | |
| Lumbriculidae | | | | | | | | |
| Unknown | earthworm | T | | | 3 | | 2 | |
| Tubificida | | | | | | | | |
| Naididae | | | | | | | | |
| Ophidonais serpentia | aquatic worm | T | | | 16 | | 10 | 9 |
| Unknown | aquatic worm | F | 16 | 21 | 3 | 11 | 9 | 2 |

See footnotes at end of table.

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**TABLE D.III-1A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | W-4 |
|---|---|---|---|---|---|---|---|---|
| Oligochaeta | | | | | | | | |
| Tubificidae | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic worm | T | | | 1 | | | 3 |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic worm | T, F | | | | | | 1[d] |
| Pelecypoda | | | | | | | | |
| Heterodonta | | | | | | | | |
| Sphaeriidae | | | | | | | | |
| Unknown | clam | T | | | 2 | | | 1 |
| Unionidae | | | | | | | | |
| Uniomeras | freshwater mussel | N | | | | | 2 | |
| Unknown | | | | | | | | |
| Unknown | clam-juvenile | N | | | | | 1 | 1 |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4

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TABLE D.III-1B
GREAT MIAMI RIVER
HESTER DENDY SAMPLING RAW DATA
DECEMBER 1988

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | W-4 |
|---|---|---|---|---|---|---|---|---|
| Crustacea | | | | | | | | |
| Decapoda | | | | | | | | |
| Cambaridae | | | | | | | | |
| Orconectes | crayfish | F | | | 1 | | | |
| Ectoprocta | | | | | | | | |
| Phylactolaemata | | | | | | | | |
| Fredericellidae | | | | | | | | |
| Fredericella | bryozoa | N | | | 1 | | | |
| Gastropoda | | | | | | | | |
| Basommatophora | | | | | | | | |
| Acylidae | | | | | | | | |
| Ferrissia | limpet | T, F | | | 1 | | | |
| Mesogastropoda | | | | | | | | |
| Pleuroceridae | | | | | | | | |
| Pleurocera | snail | F | | | 8 | | | |
| Insecta | | | | | | | | |
| Diptera | | | | | | | | |
| Ceratopogonidae | | | | | | | | |
| Dasyhelea | biting midge | T, F | | 1 | | | | 2 |
| Chironomidae | | | | | | | | |
| Unknown | midge | N | 13 | | | | | |
| Chironominae | | | | | | | | |
| Chironomini | midge | N | 1 | 1 | | 8 | | 6 |
| Tanytarsini | midge | I | | 4 | | | 16 | |
| Orthocladiinae | | | | | | | | |
| Brillia | midge | I | 1 | | | | | |
| Tanypodinae | | | | | | | | |
| Pentaneurini | midge | N | | | | 1 | | |
| Unknown | | | | | | | | |
| Unknown | midge | N | | | | | 1 | |
| Ephemeroptera | | | | | | | | |
| Heptageniidae | | | | | | | | |
| Heptagenia | mayfly | F, I | 5 | 1 | | 5 | 2 | |
| Unknown | | | | | | | | |
| Unknown | mayfly | N | 1 | 1 | | 3 | | |
| Odonata | | | | | | | | |
| Coenagrionidae | | | | | | | | |
| Argia | damselfly | I | | | | 1 | | |

See footnotes at end of table.

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**TABLE D.III-1B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | W-4 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Plecoptera | | | | | | | | |
| Perlodidae | | | | | | | | |
| Isoperla | stonefly | I | | 1 | 1 | | | |
| Taeniopterygidae | | | | | | | | |
| Tawniopteryx | stonefly | I | 1 | | | | | |
| Trichoptera | | | | | | | | |
| Hydropsychidae | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 50 | | 2 | 6 | 1 | 25 |
| Diplectrona | caddisfly | F, I | 3 | | | | | |
| Hydropsyche | caddisfly | I | 43 | | | | | 5 |
| Potamyia | caddisfly | F | 21 | | 1 | | | |
| Unknown | caddisfly | F, I | | 2 | | 6 | | 1[d] |
| Polycentropididae | | | | | | | | |
| Polycentropus | caddisfly | F, I | 1 | 5 | 1 | | | 1 |
| Unknown | | | | | | | | |
| Unknown | caddisfly | N | 86[d] | | 1[d] | | 1 | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4

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**TABLE D.III-2**
**GREAT MIAMI RIVER**
**EMERY DREDGE SAMPLING RAW DATA**
**JUNE 1989**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2 | GMR-3[d] | W-3 | GMR-4 | W-4 |
| Gastropoda | | | | | | | | | |
| Basommatophora | | | | | | | | | |
| Lymnaeidae | | | | | | | | | |
| Lymnaea | snail | T, F | | 3 | | | | | |
| Planoribidae | | | | | | | | | |
| Gyraulus | snail | F | | 2 | | | | | |
| Unknown | snail | N | | | | | | | 1 |
| Mesogastropoda | | | | | | | | | |
| Pleuroceridae | | | | | | | | | |
| Goniobasis | snail | F, I | | 1 | 2 | | 1 | 2 | |
| Pleurocera | snail | F | | | | | 1 | | 1 |
| Unknown | snail | F | | 2 | | | | | |
| Insecta | | | | | | | | | |
| Coleoptera | | | | | | | | | |
| Elmidae | | | | | | | | | |
| Stenelmis | riffle beetle | F, I | | | | | | | 1 |
| Unknown | riffle beetle | F, I | 1 | | | | | | |
| Diptera | | | | | | | | | |
| Ceratopogonidae | | | | | | | | | |
| Dasyhelea | biting midge | T, F | | | 1 | | | | |
| Chironominae | | | | | | | | | |
| Polypedilum | midge | F, I | 3 | | | | | | |
| Unknown | midge | N | 2 | | | | | | |
| Simuliidae | | | | | | | | | |
| Simulium | black fly | I | 3 | | | | | | |

See footnotes at end of table.

**TABLE D.III-2**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3[d] | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Ephemeroptera | | | | | | | | | |
| Heptageniidae | | | | | | | | | |
| Heptagenia | mayfly | I, F | | | | | | | 1 |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 3 | | | | 1 | | 1 |
| Oligochaeta | | | | | | | | | |
| Tubificida | | | | | | | | | |
| Tubificidae | | | | | | | | | |
| Tubifex | aquatic worm | T | 1 | 8 | | | | 3 | |
| Unknown | aquatic worm | T | | | | | 1 | | |
| Pelecypoda | | | | | | | | | |
| Heterodonta | | | | | | | | | |
| Sphaeriidae | | | | | | | | | |
| Unknown | clam | T | | 1 | | | | | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Sampler contained no organisms.

**TABLE D.III-3A**
**GREAT MIAMI RIVER**
**EMERY DREDGE SAMPLING RAW DATA**
**DECEMBER 1989**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
| Gastropoda | | | | | | | | | |
| Basommatophora | | | | | | | | | |
| Ancylidae | | | | | | | | | |
| Ferrissia | limpet | T, F | | 1 | | | | | 2 |
| Lymnaeidae | | | | | | | | | |
| Lymnaea | snail | T, F | | 1 | | | | | 1 |
| Physidae | | | | | | | | | |
| Physa | snail | T | | 1 | | | | | 1 |
| Insecta | | | | | | | | | |
| Coleoptera | | | | | | | | | |
| Elmidae | | | | | | | | | |
| Stenelmis | riffle beetle | F, I | | | 3 | 1 | | | 5 |
| Unknown | riffle beetle | F, I | | | | 1 | | | |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Chironomus | midge | T, F | 10 | 27 | 51 | 19 | 7 | 3 | 5 |
| Cladotanytarsus | midge | F | | | | | | 5 | |
| Cryptochironomus | midge | T | | 2 | 2 | 3 | 1 | 1 | 2 |
| Dicrotendipes | midge | F, I | | 2 | 2 | 2 | | | 1 |
| Micropsectra | midge | I | | | | 3 | | | |
| Microtendipes | midge | I | | | | 1 | | | |
| Polypedilum | midge | F, I | 2 | 6 | 2 | 2 | | | 3 |
| Rheotanytarsus | midge | F | 21 | | 2 | | | | 4 |
| Tanytarsini | midge | I | 1 | | 5 | 4 | 4 | | 3 |
| Tribelos | midge | I | | 3 | 5 | 5 | 3 | | 2 |
| Diamesa | | | | | | | | | |
| Diamesa | midge | I | | | 1 | | | | |

See footnotes at end of table.

**TABLE D.III-3A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Orthocladiinae | | | | | | | | | |
| Cricotopus | midge | I | | | | 2 | | | |
| Metriocnemus | midge | I | | | 2 | | | | |
| Orthocladius | midge | F, I | | | 15 | 26 | 7 | 1 | 2 |
| Paracricotopus | midge | I | | | | 8 | | | |
| Psectrocladius | midge | I | | | | 17 | | | |
| Trissocladius | midge | N | | | 4 | | | | |
| Unknown | midge | N | | | 8[d] | | 1 | | |
| Prodiamesinae | | | | | | | | | |
| Monodiamesa | midge | N | 1 | | | | | | |
| Simuliidae | | | | | | | | | |
| Unknown | blackfly | T, F, I | | | 1 | | | | |
| Tanypodinae | | | | | | | | | |
| Pentaneurini | midge | N | 7 | | 5 | | 2 | | 1 |
| Procladius | midge | T, F | 7 | 4 | | 6 | 3 | 1 | |
| Tanypus | midge | F | | | | 2 | | | |
| Unknown | midge | N | | 1 | 2 | 1[d] | 4[d] | 4 | |
| Unknown | | | | | | | | | |
| Unknown | midge | N | | | 1[d] | | | | |
| Ephemeroptera | | | | | | | | | |
| Baetidae | | | | | | | | | |
| Unknown | mayfly | N | | | 1 | | | | |
| Caenidae | | | | | | | | | |
| Caenis | mayfly | F, I | | | | 1 | | | |
| Heptageniidae | | | | | | | | | |
| Heptagenia | mayfly | F, I | | | 1 | | 2 | | |
| Stenonema | mayfly | I | 1 | | 2 | | 1 | | |
| Unknown | mayfly | F, I | | | 1[d] | | | | |
| Oligoneuriidae | | | | | | | | | |
| Isonychia | mayfly | I | | | 5 | | | | |

See footnotes at end of table.

**TABLE D.III-3A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Ephemeroptera | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | mayfly | N | | | 1[d] | | | | |
| Lepidoptera | | | | | | | | | |
| Pyralidae | | | | | | | | | |
| Petrophila | moth | F | | | 2 | | | | |
| Plecoptera | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | stonefly | I | | | | 7 | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 75 | 8 | 411 | 83 | 186 | 26 | 75 |
| Hydropsyche | caddisfly | I | | | 57 | 4 | 7 | 1 | 6 |
| Unknown | caddisfly | F, I | | 3 | | | | | |
| Oligochaeta | | | | | | | | | |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | 1 | | | | | | |
| Tubificidae | | | | | | | | | |
| Unknown | aquatic worm | T | | 15 | | 8 | | | 3 |
| Pelecypoda | | | | | | | | | |
| Heterodonata | | | | | | | | | |
| Corbiculidae | | | | | | | | | |
| Corbicula | clam | I | 1 | 3 | 2 | 1 | | 1 | |
| Sphaeriidae | | | | | | | | | |
| Sphaerium | clam | F | 3 | 6 | | 4 | 1 | 1 | 1 |
| Turbellaria | | | | | | | | | |
| Macrostomida | | | | | | | | | |
| Macrostomidae | | | | | | | | | |
| Macrostomum | flatworm | F | | | | | 1 | | |

See footnotes at end of table.

**TABLE D.III-3A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
| Turbellaria | | | | | | | | | |
| Tricladida | | | | | | | | | |
| Planariidae | | | | | | | | | |
| Dugesia | flatworm | F | 1 | | | 3 | 4 | | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-3B
# GREAT MIAMI RIVER
# HESTER-DENDY SAMPLING RAW DATA
# DECEMBER 1989

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3[d] | GMR-4[d] | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Chironomus | midge | T, F | 3 | 23 | 4 | | | | 8 |
| Cryptochironomus | midge | T | | | | | | | 1 |
| Dicrotendipes | midge | F, I | | | | 1 | | | |
| Einfeldia | midge | N | | | | | | | 1 |
| Polypedilum | midge | F, I | | | | | | | 1 |
| Rheotanytarsus | midge | F | | | | | | | 1 |
| Tribelos | midge | I | 1 | | | | | | |
| Unknown | midge | N | | | | 2 | | | |
| Orthocladiinae | | | | | | | | | |
| Metriocnemus | midge | I | | | | | | | 1 |
| Nanocladius | midge | I | | | | 1 | | | |
| Orthocladius | midge | F, I | | 2 | 1 | 5 | | | |
| Simuliidae | | | | | | | | | |
| Prosimulium | blackfly | I | | | 1 | | | | |
| Simulium | blackfly | I | 5 | 2 | 54 | 1 | | | 5 |
| Unknown | blackfly | T, F, I | | 1 | 3[e] | | | | |
| Tanypodinae | | | | | | | | | |
| Unknown | midge | N | | | | 12 | | | 2 |
| Unknown | | | | | | | | | |
| Unknown | midge | N | | 1[e] | | 1[e] | | | |
| Ephemeroptera | | | | | | | | | |
| Baetidae | | | | | | | | | |
| Baetis | mayfly | I | | | | | | | 1 |
| Ephemerellidae | | | | | | | | | |
| Ephemerella | mayfly | N | | 2 | 9 | 15 | | | |
| Ephemeridae | | | | | | | | | |
| Ephemera | mayfly | N | 3 | | | | | | |

See footnotes at end of table.

**TABLE D.III-3B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3[d] | GMR-4[d] | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Ephemeroptera | | | | | | | | | |
| Heptageniidae | | | | | | | | | |
| Heptagenia | mayfly | F, I | | | | | | | 4 |
| Stenonema | mayfly | I | | | | | | | 15 |
| Siphlonuridae | | | | | | | | | |
| Unknown | mayfly | N | | | 3 | | | | |
| Unknown | | | | | | | | | |
| Unknown | mayfly | N | 1 | | | | | | |
| Odonata | | | | | | | | | |
| Agriidae | | | | | | | | | |
| Agrion | damselfly | N | | | | | | | 1 |
| Plecoptera | | | | | | | | | |
| Taeniopterygidae | | | | | | | | | |
| Taeniopteryx | stonefly | I | | | | 5 | | | 1 |
| Unknown | | | | | | | | | |
| Unknown | stonefly | I | | 2 | | | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 90 | | 135 | 88 | | | 97 |
| Hydropsyche | caddisfly | I | 15 | 8 | 49 | | | | 6 |
| Unknown | | | | | | | | | |
| Unknown | caddisfly | N | | | 1[e] | | | | |
| Oligochaeta | | | | | | | | | |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | | 2 | | | | | |
| Unknown | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | aquatic worm | T, F | | 1 | | | | | |

See footnotes at end of table.

**TABLE D.III-3B**
**(Continued)**

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Sampler contained no organisms.
[e] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-4A
# GREAT MIAMI RIVER
# EMERY DREDGE SAMPLING RAW DATA
# MAY 1990

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
| Aphasmidia | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | aquatic nematode | F | | | | | 1 | | |
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Chironomus | midge | T, F | | 1 | 9 | 1 | 1 | | |
| Cryptochironomus | midge | T | | 2 | | 3 | | | |
| Glyptotendipes | midge | T | | | 1 | | 2 | | |
| Parachironomus | midge | F | | | | | | | 12 |
| Polypedilum | midge | F, I | 4 | 5 | 4 | 3 | 3 | | 4 |
| Unknown | midge | N | 2 | 4[d] | 5[d] | 5[d] | 11[d] | | 50[d] |
| Diamesinae | | | | | | | | | |
| Diamesa | midge | I | | 1 | 7 | 8 | 11 | | |
| Unknown | | | | | | | | | |
| Unknown | midge | N | 24[d] | 24[d] | 33[d] | 27[d] | 58[d] | 5[d] | 8[d] |
| Orthocladiinae | | | | | | | | | |
| Brillia | midge | I | 1 | | | | | | |
| Cardiocladius | midge | N | | | | 1 | 1 | | |
| Cricotopus | midge | I | | | 1 | | | | |
| Orthocladius | midge | F, I | 6 | 4 | 45 | 14 | 36 | 2 | 7 |
| Unknown | midge | N | | | 5[d] | | | | |
| Simuliidae | | | | | | | | | |
| Simulium | blackfly | I | | | 5 | 1 | | | 1 |
| Tanypodinae | | | | | | | | | |
| Unknown | midge | N | 4 | 1 | 5 | | | 1 | |
| Ephemeroptera | | | | | | | | | |
| Heptageniidae | | | | | | | | | |
| Stenonema | midge | I | 3 | 1 | | | | 1 | 1 |

See footnotes on next page.

**TABLE D.III-4A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Oligoneuriidae | | | | | | | | | |
| Isonychia | mayfly | I | | | | 1 | | | |
| Megaloptera | | | | | | | | | |
| Sialidae | | | | | | | | | |
| Sialis | alderfly | F | | | 1 | | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 9 | 4 | 57 | | 5 | 2 | 4 |
| Hydropsyche | caddisfly | I | 2 | | 18 | | | | |
| Unknown | caddisfly | F, I | | | 5[d] | | | | |
| Hydroptilidae | | | | | | | | | |
| Unknown | caddisfly | I | | | | 1 | | | |
| Unknown | | | | | | | | | |
| Unknown | caddisfly | N | 7[d] | 3 | 25[d] | | 1 | 1 | 4 |
| Oligochaeta | | | | | | | | | |
| Lumbriculida | | | | | | | | | |
| Lumbriculidae | | | | | | | | | |
| Unknown | aquatic worm | T | | | | | | 2 | |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | 41 | 26 | 9 | 104 | 59 | 37 | 16 |
| Tubificidae | | | | | | | | | |
| Unknown | aquatic worm | T | 2 | 2 | 1 | 20 | | 3 | 154 |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative N = No Index
I = Intolerant T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-4B
# GREAT MIAMI RIVER
# HESTER-DENDY SAMPLING RAW DATA
# MAY 1990

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2[d] | GMR-3 | W-3[d] | GMR-4[d] | W-4[d] |
| Crustacea | | | | | | | | | |
| Isopoda | | | | | | | | | |
| Asellidae | | | | | | | | | |
| Lirceus | sow bug | F | 2 | | | 1 | | | |
| Insecta | | | | | | | | | |
| Coleoptera | | | | | | | | | |
| Dytiscidae | | | | | | | | | |
| Unknown | predacious diving beetle | N | | | | 1 | | | |
| Elmidae | | | | | | | | | |
| Unknown | riffle beetle | F, I | | 1 | | | | | |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Chironomus | midge | T, F | 6 | 1 | | 6 | | | |
| Dicrotendipes | midge | F, I | 1 | | | | | | |
| Endochironomus | midge | F, I | | | | 1 | | | |
| Glyptotendipes | midge | T | | 1 | | | | | |
| Parachironomus | midge | F | 28 | 30 | | 43 | | | |
| Phaenopsectra | midge | I | | 2 | | | | | |
| Polypedilum | midge | F, I | 2 | 4 | | | | | |
| Unknown | midge | N | 3[e] | 1[e] | | | | | |
| Diamesinae | | | | | | | | | |
| Unknown | midge | N | | 1 | | | | | |
| Orthocladiinae | | | | | | | | | |
| Orthocladius | midge | F, I | 1 | | | 5 | | | |
| Unknown | midge | N | 3 | | | | | | |
| Simuliidae | | | | | | | | | |
| Simulium | blackfly | I | | | | 3 | | | |
| Tanypodinae | | | | | | | | | |
| Tanypus | midge | F | 1 | | | | | | |
| Unknown | midge | N | 6 | | | 3 | | | |

See footnotes on next page.

**TABLE D.III-4B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | W-1 | GMR-1 | GMR-2[d] | GMR-3 | W-3[d] | GMR-4[d] | W-4[d] |
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | midge | N | 5[e] | 1[e] | | 9[e] | | | |
| Ephemeroptera | | | | | | | | | |
| Baetidae | | | | | | | | | |
| Unknown | mayfly | N | | 4 | | | | | |
| Caenidae | | | | | | | | | |
| Caenis | mayfly | F, I | | 3 | | 2 | | | |
| Heptageniidae | | | | | | | | | |
| Stenonema | mayfly | I | 17 | 35 | | 26 | | | |
| Tricorythidae | | | | | | | | | |
| Tricorythodes | mayfly | F | | 1 | | | | | |
| Unknown | | | | | | | | | |
| Unknown | mayfly | N | 5 | 2[e] | | 2[e] | | | |
| Megaloptera | | | | | | | | | |
| Corydalidae | | | | | | | | | |
| Corydalis | hellgramite | F, I | | 1 | | | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 143 | 69 | | 221 | | | |
| Hydropsyche | caddisfly | I | 10 | 24 | | | | | |
| Unknown | caddisfly | F, I | 7[e] | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | caddisfly | N | 15[e] | 4[e] | | 38 | | | |
| Oligochaeta | | | | | | | | | |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | | 5 | | | | | |
| Tubificidae | | | | | | | | | |
| Unknown | aquatic worm | T | 3 | 5 | | 2 | | | |

See footnotes at end of table.

**TABLE D.III-4B**
**(Continued)**

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Sampler contained no organisms.
[e] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-5A
# GREAT MIAMI RIVER
# EMERY DREDGE SAMPLING RAW DATA
# AUGUST 1990

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Gastropoda | | | | | | | | | |
| Basommatophora | | | | | | | | | |
| Ancylidae | | | | | | | | | |
| Ferrissia | limpet | T, F | | | 1 | | | | |
| Lymnaeidae | | | | | | | | | |
| Fossaria | pond snail | T | | | | | | 1 | |
| Planorbidae | | | | | | | | | |
| Unknown | snail | N | | 1 | | | | | |
| Unknown | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | snail | N | | | | | 1 | | |
| Insecta | | | | | | | | | |
| Coleoptera | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | beetle adult | T | | 2 | 1 | | | | 1 |
| Collembola | | | | | | | | | |
| Isotomidae | | | | | | | | | |
| Isotomurus | springtail | N | | | 1 | | | | |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Chironomini | midge | N | | 1 | | | | 3 | 1 |
| Crytochironomus | midge | T | | | | | | 2 | 15 |
| Microtendipes | midge | I | 1 | | 2 | | | | |
| Polypedilum | midge | F, I | 20 | 23 | 75 | 13 | | 37 | 21 |
| Pseudochironomus | midge | I | | 19 | 12 | | | 4 | 1 |
| Rheotanytarsus | midge | F | | 1 | | | | | 1 |
| Stictochironomus | midge | I | | 2 | | | | | |
| Sublettea | midge | N | | | | | | | 1 |
| Unknown | midge | N | 5[d] | 4[d] | | | | | 7[d] |

See footnotes on next page.

**TABLE D.III-5A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Orthocladiinae | | | | | | | | | |
| Cricotopus | midge | I | | 2 | | | | | |
| Smittia | midge | N | | | 3 | | | | |
| Simuliidae | | | | | | | | | |
| Simulium | blackfly | I | | | 186 | | 16 | 1 | 64 |
| Unknown | blackfly | T, F, I | | | 137 | | | | 25 |
| Tabanidae | | | | | | | | | |
| Unknown | horsefly | T | | | 1 | | | | |
| Tanypodinae | | | | | | | | | |
| Procladius | midge | T, F | 3 | 4 | 3 | 12 | | | 1 |
| Unknown | midge | N | | 10 | 4 | | | | 5 |
| Tipulidae | | | | | | | | | |
| Unknown | cranefly | T, F | | | 3 | | | | |
| Unknown | | | | | | | | | |
| Unknown | midge | N | 36[d] | 139[d] | 44[d] | 1[d] | 33 | 13[d] | 58[d] |
| Ephemeroptera | | | | | | | | | |
| Ephemerellidae | | | | | | | | | |
| Ephemerella | mayfly | N | | | | | | | 3 |
| Heptangeniidae | | | | | | | | | |
| Stenonema | mayfly | I | | | 5 | | | 1 | |
| Oligoneuriidae | | | | | | | | | |
| Isonychia | mayfly | I | | | 3 | | | | |
| Unknown | | | | | | | | | |
| Unknown | mayfly | N | 1 | 4 | 1[d] | 1 | | | |
| Odonata | | | | | | | | | |
| Gomphidae | | | | | | | | | |
| Aphylla | dragonfly | F, I | | 1 | | | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 16 | | 138 | 5 | 9 | 12 | 16 |
| Hydropsyche | caddisfly | I | | 3 | 101 | | | | 1 |
| Unknown | caddisfly | F, I | 18 | | 16[d] | | | | 13[d] |

**TABLE D.III-5A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Trichoptera | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | caddisfly | F, I | | 7 | 3[d] | 1 | 3 | | 6[d] |
| Oligochaeta | | | | | | | | | |
| Haplotaxida | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | aquatic worm | T, F | | | | | | | 1 |
| Lumbriculida | | | | | | | | | |
| Lumbriculidae | | | | | | | | | |
| Lumbriculus | aquatic worm | T | | | | | | 13 | 7 |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | | | | | | | 6 |
| Tubificidae | | | | | | | | | |
| Unknown | aquatic worm | T | 5 | | 1 | 1 | 1 | 34 | |
| Turbellaria | | | | | | | | | |
| Tricladida | | | | | | | | | |
| Planariidae | | | | | | | | | |
| Dugesia | flatworm | F | | 3 | | | | 2 | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

**TABLE D.III-5B**
**GREAT MIAMI RIVER**
**HESTER-DENDY SAMPLING RAW DATA**
**AUGUST 1990**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | | | | | | | | | |
| Unknown | aquatic nematode | F | | | 4 | | 1 | | |
| Gastropoda | | | | | | | | | |
| Basommatophora | | | | | | | | | |
| Ancylidae | | | | | | | | | |
| Ferrissia | limpet | T, F | | | | 1 | | | |
| Insecta | | | | | | | | | |
| Coleoptera | | | | | | | | | |
| Elmidae | | | | | | | | | |
| Stenelmis | riffle beetle | F, I | | 5 | | 1 | 1 | | 2 |
| Diptera | | | | | | | | | |
| Chironominae | | | | | | | | | |
| Axarus | midge | N | | | | 1 | | | |
| Chironomini | midge | N | | | | | | | 1 |
| Dicrotendipes | midge | F, I | 10 | | | | | | 4 |
| Glyptotendipes | midge | T | 1 | | 20 | | | | |
| Goeldichironomus | midge | N | | | | | 1 | | |
| Micropsectra | midge | I | | | | 43 | 4 | 12 | 2 |
| Microtendipes | midge | I | 14 | | | 5 | 2 | | 1 |
| Phaenopsectra | midge | I | | | | | | | 1 |
| Polypedilum | midge | F, I | 52 | 13 | 83 | 233 | 53 | 72 | 84 |
| Pseudochironomus | midge | I | 15 | | | | | 5 | |
| Rheotanytarsus | midge | F | 22 | | | 155 | 6 | 4 | |
| Tribelos | midge | I | | | | | | | 1 |
| Unknown | midge | N | | | 4[d] | | 2[d] | | 18[d] |
| Diamesinae | | | | | | | | | |
| Diamesa | midge | I | | | | 3 | | | |
| Unknown | midge | N | | | | | 2 | 1 | |

See footnotes on next page.

**TABLE D.III-5B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Diptera | | | | | | | | | |
| Orthocladiinae | | | | | | | | | |
| Unknown | midge | N | | | 1 | | | | 1 |
| Prodiamesinae | | | | | | | | | |
| Odontomesa | midge | N | | | | 3 | | | |
| Simuliidae | | | | | | | | | |
| Simulium | blackfly | I | | | | 7 | | | 15 |
| Unknown | blackfly | T, F, I | | | | 5 | | | |
| Tanypodinae | | | | | | | | | |
| Procladius | midge | T, F | 48 | 23 | 30 | 53 | 11 | 34 | 8 |
| Unknown | midge | N | | 7 | 8 | | | 3 | 16 |
| Tipulidae | | | | | | | | | |
| Unknown | cranefly | T, F | 1 | | | 3 | | | |
| Unknown | | | | | | | | | |
| Unknown | midge | N | 134[d] | 56[d] | 22[d] | 120[d] | 18[d] | 65[d] | 50[d] |
| Ephemeroptera | | | | | | | | | |
| Baetidae | | | | | | | | | |
| Acentrella | mayfly | N | 7 | | 1 | 1 | 2 | | |
| Unknown | mayfly | N | | 4 | 3 | 1 | | | 3 |
| Caenidae | | | | | | | | | |
| Caenis | mayfly | F, I | | | 1 | | | | |
| Ephemerellidae | | | | | | | | | |
| Ephemerella | mayfly | N | | | | | | 12 | |
| Heptangeniidae | | | | | | | | | |
| Stenonema | mayfly | I | 81 | 69 | 11 | 23 | 25 | 18 | 31 |
| Unknown | mayfly | F, I | | | 2 | | | | |
| Oligoneuriidae | | | | | | | | | |
| Isonychia | mayfly | I | 23 | | 2 | 19 | | 9 | 3 |
| Unknown | | | | | | | | | |
| Unknown | mayfly | N | 26[d] | 11[d] | 4[d] | 17[d] | 4[d] | 40[d] | 28[d] |

See footnotes at end of table.

**TABLE D.III-5B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] W-1 | GMR-1 | GMR-2 | GMR-3 | W-3 | GMR-4 | W-4 |
|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | |
| Trichoptera | | | | | | | | | |
| Hydropsychidae | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 278 | 79 | 250 | 413 | 137 | 108 | 225 |
| Hydropsyche | caddisfly | I | 97 | 5 | 191 | 332 | 270 | 16 | 100 |
| Potamyia | caddisfly | F | | | | | | 1 | |
| Unknown | caddisfly | F, I | | | 56[d] | 43[d] | 27[d] | 12[d] | 125[d] |
| Limnephilidae | | | | | | | | | |
| Unknown | caddisfly | F, I | | | | | | | 1 |
| Unknown | | | | | | | | | |
| Unknown | caddisfly | F, I | 46[d] | 9[d] | 40[d] | 83[d] | 59[d] | 4[d] | 34[d] |
| Oligochaeta | | | | | | | | | |
| Tubificida | | | | | | | | | |
| Naididae | | | | | | | | | |
| Unknown | aquatic worm | F | | 1 | | | | | |
| Tubificidae | | | | | | | | | |
| Unknown | aquatic worm | T | | 4 | | | | | |
| Pelecypoda | | | | | | | | | |
| Heterodonta | | | | | | | | | |
| Sphaeriidae | | | | | | | | | |
| Unknown | clam | T | | | | | | | 2 |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-6A
## PADDYS RUN
## SURBER SAMPLING RAW DATA
## MAY - JUNE 1989

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-6 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crustacea | | | | | | | | | | |
| Decapoda | | | | | | | | | | |
| Cambarinae | | | | | | | | | | |
| Orconectes | crayfish | F | | | | | 1 | | | |
| Isopoda | | | | | | | | | | |
| Asellidae | | | | | | | | | | |
| Lirceus | sow bug | F | 3 | 7 | | | 12 | | 1 | 2 |
| Insecta | | | | | | | | | | |
| Coleoptera | | | | | | | | | | |
| Dytiscidae | | | | | | | | | | |
| Hydroporinae | predaceous diving beetle | N | 1 | | | | | | | |
| Elmidae | | | | | | | | | | |
| Ordobrevia | riffle beetle | N | | | | | 7 | | | |
| Stenelmis | riffle beetle | F, I | 14 | 9 | 2 | | | 1 | 1 | |
| Unknown | riffle beetle | F, I | 4 | 4 | | | | | | |
| Haliplidae | | | | | | | | | | |
| Peltodytes | crawling water beetle | N | | | | | 2 | | | |
| Collembola | | | | | | | | | | |
| Unknown | | | | | | | | | | |
| Unknown | springtails | N | | | | 1 | | | | |
| Diptera | | | | | | | | | | |
| Ceratopogonidae | | | | | | | | | | |
| Unknown | biting midge | T, F | | 1 | | | | | | |
| Chironominae | | | | | | | | | | |
| Chironomini | midge | N | 7 | 11 | 22 | 1 | 10 | 3 | 8 | 10 |
| Chironomus | midge | T, F | 5 | 8 | 41 | 120 | 40 | | | 1 |
| Glyptotendipes | midge | T | | | 1 | | | | | |
| Polypedilum | midge | F, I | | 9 | | 1 | | | | |
| Tanytarsini | midge | I | | | | | | | 1 | |
| Unknown | midge | N | | | 2[d] | | | | | |
| Culicidae | | | | | | | | | | |
| Anopheles | mosquito | I | 3 | | 1 | 5 | | 3 | | 2 |

See footnotes on next page.

**TABLE D.III-6A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-6 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | | |
| Diptera | | | | | | | | | | |
| Orthocladiinae | | | | | | | | | | |
| Unknown | midge | N | | 2 | | | | | | |
| Simuliidae | | | | | | | | | | |
| Simulium | blackfly | I | | 5 | 1 | 1 | 1 | | | |
| Tipulidae | | | | | | | | | | |
| Tipula | cranefly | I | | | 3 | | | | | |
| Ephemeroptera | | | | | | | | | | |
| Baetidae | | | | | | | | | | |
| Unknown | mayfly | N | | | 1 | | | | | |
| Caenidae | | | | | | | | | | |
| Caenis | mayfly | F, I | | 2 | 2 | | | | | |
| Heptageniidae | | | | | | | | | | |
| Epeorus | mayfly | F, I | | 1 | | | | | | |
| Heptagenia | mayfly | F, I | 4 | 3 | 1 | 3 | | | | 1 |
| Ironodes | mayfly | F, I | | 1 | | | | | | |
| Unknown | mayfly | F, I | 1 | | | 1 | | | | |
| Trichoptera | | | | | | | | | | |
| Hydropsychidae | | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | | 5 | 1 | | | | | |
| Oligochaeta | | | | | | | | | | |
| Tubificida | | | | | | | | | | |
| Tubificidae | | | | | | | | | | |
| Unknown | aquatic worm | T | 3 | | | | | | | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative N = No Index
I = Intolerant T = Tolerant
[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

# TABLE D.III-6B
# PADDYS RUN
# HESTER-DENDY SAMPLING RAW DATA
# MAY - JUNE 1989

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1[d] | PR-2 | PR-3 | PR-4 | PR-5[d] | PR-6[d] | PR-7[d] | PR-8[d] |
|---|---|---|---|---|---|---|---|---|---|---|
| Crustacea | | | | | | | | | | |
| Isopoda | | | | | | | | | | |
| Asellidae | | | | | | | | | | |
| Lirceus | sow bug | F | | 7 | | 3 | | | | |
| Gastropoda | | | | | | | | | | |
| Basommatophora | | | | | | | | | | |
| Unknown | | | | | | | | | | |
| Unknown | snail | N | | | | 1 | | | | |
| Insecta | | | | | | | | | | |
| Coleoptera | | | | | | | | | | |
| Dytiscidae | | | | | | | | | | |
| Unknown | predaceous diving beetle | N | | 1 | | | | | | |
| Diptera | | | | | | | | | | |
| Ceratopogonidae | | | | | | | | | | |
| Dasyhelea | biting midge | T, F | | 1 | 5 | | | | | |
| Chironominae | | | | | | | | | | |
| Chironomini | midge | N | | 20 | 14 | 49 | | | | |
| Chironomus | midge | T, F | | 1 | 22 | | | | | |
| Polypedilum | midge | F, I | | 81 | 3 | 1 | | | | |
| Tanytarsini | midge | I | | 5 | 5 | | | | | |
| Culicidae | | | | | | | | | | |
| Anopheles | mosquito | I | | 2 | | | | | | |
| Orthocladiinae | | | | | | | | | | |
| Psectrocladius | midge | I | | 2 | | | | | | |
| Simuliidae | | | | | | | | | | |
| Simulium | blackfly | I | | 49 | 5 | | | | | |
| Tanypodinae | | | | | | | | | | |
| Pentaneurini | midge | N | | 10 | 2 | 2 | | | | |

See footnotes on next page.

**TABLE D.III-6B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1[d] | PR-2 | PR-3 | PR-4 | PR-5[d] | PR-6[d] | PR-7[d] | PR-8[d] |
|---|---|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | | | |
| Diptera | | | | | | | | | | |
| Tipulidae | | | | | | | | | | |
| Tipula | cranefly | I | | 1 | | 1 | | | | |
| Ephemeroptera | | | | | | | | | | |
| Heptageniidae | | | | | | | | | | |
| Heptagenia | mayfly | F, I | | 1 | | | | | | |
| Ironodes | mayfly | F, I | | 1 | | | | | | |
| Trichoptera | | | | | | | | | | |
| Hydropsychidae | | | | | | | | | | |
| Cheumatopsyche | caddisfly | F | | 10 | | | | | | |
| Hydropsyche | caddisfly | I | | 3 | | | | | | |

[a] See Plate 1-1
[b] Class
Order
Family/Subfamily
Genus or Tribe
[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant
[d] Sampler contained no organisms.

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**TABLE D.III-7A**
**PADDYS RUN**
**SURBER SAMPLING RAW DATA**
**NOVEMBER - DECEMBER 1989**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | | |
| Chromadorida | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | nematode | F | | | | 1 | | |
| Archnida | | | | | | | | |
| Aranea | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic spider | N | | | | | | 1 |
| Crustacea | | | | | | | | |
| Amphipoda | | | | | | | | |
| Crangoyctidae | | | | | | | | |
| Crangonyx | scud | F | | | 5 | | | 1 |
| Isopoda | | | | | | | | |
| Asellidae | | | | | | | | |
| Lirceus | sow bug | F | 27 | 19 | 81 | 12 | | 44 |
| Gastropoda | | | | | | | | |
| Basommatophora | | | | | | | | |
| Lymnaeidae | | | | | | | | |
| Lymnaea | snail | T, F | | | 1 | | | 19 |
| Planorbidae | | | | | | | | |
| Gyraulus | snail | F | | | | | 1 | |
| Pulmonata | | | | | | | | |
| Physidae | | | | | | | | |
| Physa | snail | T | 5 | 27 | 7 | | | 14 |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | snail | N | | 1 | | | | |
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Dytiscidae | | | | | | | | |
| Agabus | diving beetle | N | 2 | | | | | 1 |
| Hydrophilidae | | | | | | | | |
| Hydrophilus | water scavenger beetle | T | | | 1 | | | |

See footnotes at end of table.

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**TABLE D.III-7A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Psephenidae | | | | | | | | |
| Psephenus | water penny | N | 9 | 4 | | | | |
| Diptera | | | | | | | | |
| Anthomyiidae | | | | | | | | |
| Limnophora | sewage fly | N | | 1 | | | | |
| Chironominae | | | | | | | | |
| Chironomini | midge | N | 21 | 1 | | | | |
| Einfeldia | midge | N | 1 | | | | | |
| Geoldichironomus | midge | N | 1 | | | | | |
| Rheotanytarsus | midge | F | 1 | | | | | |
| Tribelos | midge | I | 1 | | | | | |
| Unknown | midge | N | | | 1 | | | |
| Orthocladiinae | | | | | | | | |
| Unknown | midge | N | 2 | | | | | |
| Simuliidae | | | | | | | | |
| Simulium | blackfly | I | | | | 1 | | |
| Tabanidae | | | | | | | | |
| Tabanus | horsefly | I | 2 | 1 | | | | |
| Tanypodinae | | | | | | | | |
| Procladius | midge | T, F | 3 | | | | | |
| Tipulidae | | | | | | | | |
| Tipula | cranefly | I | 3 | | 1 | | | 25 |
| Unknown | | | | | | | | |
| Unknown | unknown | N | 8[d] | | | | | |
| Ephemeroptera | | | | | | | | |
| Baetidae | | | | | | | | |
| Baetis | mayfly | I | | | | | | 1 |
| Ephemerellidae | | | | | | | | |
| Ephemerella | mayfly | N | 12 | 20 | | | | 1 |
| Ephemeridae | | | | | | | | |
| Hexagenia | mayfly | F, I | 3 | | | | | |
| Oligoneuriidae | | | | | | | | |
| Isonychia | mayfly | I | | | | | | 1 |

See footnotes at end of table.

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**TABLE D.III-7A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Hemiptera | | | | | | | | |
| Corixidae | | | | | | | | |
| Trichocorixa | water boatman | F | | | | | | 11 |
| Lepidoptera | | | | | | | | |
| Pyralidae | | | | | | | | |
| Unknown | aquatic caterpiller | F | | 1 | | | | |
| Megaloptera | | | | | | | | |
| Sialidae | | | | | | | | |
| Sialis | alderfly | F | 1 | | | | | |
| Odonata | | | | | | | | |
| Lestidae | | | | | | | | |
| Lestes | dragonfly | N | | | 1 | | | 1 |
| Trichoptera | | | | | | | | |
| Helicopsychidae | | | | | | | | |
| Unknown | caddisfly | N | 1 | | | | | |
| Hydropsychidae | | | | | | | | |
| Hydropsyche | caddisfly | N | 4 | 8 | | | | |
| Philopotamidae | | | | | | | | |
| Chimarra | caddisfly | I | 1 | | | | | |
| Oligochaeta | | | | | | | | |
| Lumbriculida | | | | | | | | |
| Lumbriculidae | | | | | | | | |
| Unknown | earth worm | T | | | | 1 | | 1 |

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

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**TABLE D.III-7B**
**PADDYS RUN**
**HESTER-DENDY SAMPLING RAW DATA**
**NOVEMBER - DECEMBER 1989**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5[d] | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | | |
| Chromadorida | | | | | | | | |
| Camacolaimidae | | | | | | | | |
| Unknown | aquatic nematode | F | | | | | | 2 |
| Crustacea | | | | | | | | |
| Amphipoda | | | | | | | | |
| Talitridae | | | | | | | | |
| Hyalella | amphipod | T, F | | | 9 | | | |
| Isopoda | | | | | | | | |
| Asellidae | | | | | | | | |
| Lirceus | sow bug | F | | 8 | 1 | 28 | | 18 |
| Gastropoda | | | | | | | | |
| Basommatophora | | | | | | | | |
| Lymnaeidae | | | | | | | | |
| Lymnaea | snail | T, F | | 1 | | | | |
| Pulmonata | | | | | | | | |
| Physidae | | | | | | | | |
| Physa | snail | T | | 4 | | | | |
| Insecta | | | | | | | | |
| Diptera | | | | | | | | |
| Ceratopogonidae | | | | | | | | |
| Bezzia | biting midge | T | | | 2 | | | |
| Chironominae | | | | | | | | |
| Chironomini | midge | N | | 1 | 1 | | | 51 |
| Einfeldia | midge | N | | 2 | | | | |
| Kiefferulus | midge | T, I | | 1 | | | | |
| Phaenosectra | midge | I | | | | | | 1 |
| Rheotanytarsus | midge | F | | 1 | | | | |
| Stictochironomus | midge | I | | | | | | 6 |
| Tanytarsini | midge | I | | | 2 | | | |
| Tribelos | midge | I | 1 | | 1 | | | 6 |
| Orthocladiinae | | | | | | | | |
| Eukiefferiella | midge | N | | | 1 | | | |

See footnotes at end of table.

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**TABLE D.III-7B**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5[d] | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Diptera | | | | | | | | |
| Tanypodinae | | | | | | | | |
| Pentaneurini | midge | N | | | 2 | | | |
| Ephemeroptera | | | | | | | | |
| Caenidae | | | | | | | | |
| Caenis | mayfly | F, I | | 5 | 4 | | | 1 |
| Ephemerellidae | | | | | | | | |
| Ephemerella | mayfly | N | | 2 | | | | |
| Hemiptera | | | | | | | | |
| Corixidae | | | | | | | | |
| Trichocorixa | water boatman | F | | 1 | | | | |
| Plecoptera | | | | | | | | |
| Leuctridae | | | | | | | | |
| Leuctra | stonefly | N | | 5 | | | | |
| Unknown | stonefly | N | 1 | | 1 | | | |
| Perlodidae | | | | | | | | |
| Isoperla | stonefly | I | | 1 | | | | |

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Sampler contained no organisms.

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**TABLE D.III-8A**
**PADDYS RUN**
**SURBER SAMPLING RAW DATA**
**MARCH - MAY 1990**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic nematode | F | 1 | | | 1 | | |
| Archnoidae | | | | | | | | |
| Hydracarina | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic mite | N | | | 1 | | | |
| Crustacea | | | | | | | | |
| Amphipoda | | | | | | | | |
| Talitridae | | | | | | | | |
| Hyallela | amphipod | F | | | | | | 1 |
| Unknown | amphipod | F | | | 1 | | | |
| Isopoda | | | | | | | | |
| Asellidae | | | | | | | | |
| Lirceus | sow bug | F | 10 | 9 | 15 | 30 | 20 | 11 |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | crustacean | N | 1 | | | | | |
| Gastropoda | | | | | | | | |
| Basommatophora | | | | | | | | |
| Physidae | | | | | | | | |
| Unknown | snail | T | | 1 | | | 1 | |
| Unknown | | | | | | | | |
| Unknown | snail | N | | | 1 | | | |
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Elmidae | | | | | | | | |
| Stenelmis | riffle beetle | F, I | 6 | 4 | 2 | 6 | 33 | 2 |
| Unknown | riffle beetle | F, I | 11 | 6 | 3 | | 1 | |
| Hydrophilidae | | | | | | | | |
| Unknown | water scavenger beetle | T | | 2 | | | | |
| Psephenidae | | | | | | | | |
| Psephenus | riffle beetle | N | 2 | 1 | 6 | | | |

See footnotes at end of table.

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**TABLE D.III-8A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | beetle | T | | | | 1 | | 1 |
| Diptera | | | | | | | | |
| Chironominae | | | | | | | | |
| Chironomus | midge | T, F | | 11 | | 6 | | |
| Glypototendipes | midge | T | | 10 | | | | |
| Parachironomus | midge | F | | 1 | | | | |
| Polypedilum | midge | F, I | 9 | 5 | 2 | | 4 | |
| Unknown | midge | N | | 47[d] | 1 | 7 | 3 | 9 |
| Diamesinae | | | | | | | | |
| Diamesa | midge | I | 10 | 12 | 3 | 6 | 6 | 10 |
| Orthocladiinae | | | | | | | | |
| Brillia | midge | I | | | 4 | 1 | 2 | 1 |
| Cardiocladius | midge | N | 3 | 3 | 7 | 6 | 5 | 2 |
| Cricotopus | midge | I | | 14 | | 3 | | |
| Orthocladius | midge | F, I | 47 | 63 | 43 | 20 | 7 | 55 |
| Symposiocladius | midge | N | | 1 | | | | |
| Unknown | midge | N | | 19[d] | | 5[d] | | |
| Simuliidae | | | | | | | | |
| Simulium | blackfly | I | | 2 | | | 124 | 67 |
| Tabanidae | | | | | | | | |
| Tabanus | horsefly | I | 3 | 3 | 1 | 1 | | |
| Unknown | horsefly | T | | 1 | | | | |
| Tanypodinae | | | | | | | | |
| Unknown | midge | N | 9 | 3 | 2 | 1 | 5 | |
| Tipulidae | | | | | | | | |
| Tipula | cranefly | I | 2 | | | | 1 | 1 |
| Unknown | cranefly | T, F | | 1 | | | | |
| Unknown | | | | | | | | |
| Unknown | midge | N | 57[d] | 81[d] | 70[d] | 55[d] | 18[d] | 27[d] |
| Ephemeroptera | | | | | | | | |
| Baetidae | | | | | | | | |
| Unknown | mayfly | N | 2 | 10 | | | 18 | |
| Ephemeridae | | | | | | | | |
| Unknown | mayfly | N | 28 | 7 | 9 | 7 | 8 | 8 |

See footnotes at end of table.

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**TABLE D.III-8A**
**(Continued)**



| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Ephemeroptera | | | | | | | | |
| Heptageniidae | | | | | | | | |
| Stenonema | mayfly | I | 13 | 15 | 5 | 23 | 16 | 8 |
| Unknown | mayfly | F, I | | | | | | 2 |
| Unknown | | | | | | | | |
| Unknown | mayfly | N | | 1[d] | | | | |
| Hemiptera | | | | | | | | |
| Gerridae | | | | | | | | |
| Unknown | water strider | T | | | | 1 | | |
| Veliidae | | | | | | | | |
| Unknown | water strider | T | | | | | | 3 |
| Plecoptera | | | | | | | | |
| Chloroperlidae | | | | | | | | |
| Haploperla | stonefly | I | | 1 | | 3 | | 1 |
| Nemouridae | | | | | | | | |
| Amphinemura | stonefly | I | | | | | 3 | |
| Nemoura | stonefly | I | 2 | | 2 | | 29 | 16 |
| Perlodidae | | | | | | | | |
| Isogenoides | stonefly | I | | 5 | | | | 6 |
| Isoperla | stonefly | I | 21 | 2 | 15 | 49 | 93 | 54 |
| Pteronarcyidae | | | | | | | | |
| Pteronarcys | stonefly | I | | | | | 3 | |
| Unknown | | | | | | | | |
| Unknown | stonefly | I | 2[d] | | | | | |
| Trichoptera | | | | | | | | |
| Hydropsychidae | | | | | | | | |
| Cheumatopsyche | caddisfly | F | 11 | 1 | 2 | 1 | 5 | 1 |
| Hydroptilidae | | | | | | | | |
| Unknown | caddisfly | I | 6 | 1 | 2 | 7 | 16 | 4 |
| Unknown | | | | | | | | |
| Unknown | caddisfly | F, I | | 1[d] | | 2[d] | | |

See footnotes at end of table.

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**TABLE D.III-8A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Oligochaeta | | | | | | | | |
| Lumbriculida | | | | | | | | |
| Lumbriculidae | | | | | | | | |
| Unknown | aquatic worm | T | | | 2 | 1 | 3 | 2 |
| Tubificida | | | | | | | | |
| Naididae | | | | | | | | |
| Unknown | aquatic worm | F | | | 7 | 7 | 6 | 1 |
| Tubificidae | | | | | | | | |
| Tubifex | tubifex worm | T | | 3 | | 1 | | |
| Unknown | aquatic worm | T | | 1 | | | | |

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

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**TABLE D.III-8B**
**HESTER-DENDY SAMPLING RAW DATA**
**PADDYS RUN**
**MARCH - MAY 1990**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3[d] | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | | | | | | | | |
| Unknown | aquatic nematode | F | 1 | | | | | |
| Crustacea | | | | | | | | |
| Amphipoda | | | | | | | | |
| Talitridae | | | | | | | | |
| Hyallela | amphipod | F | | | | 1 | | |
| Isopoda | | | | | | | | |
| Asellidae | | | | | | | | |
| Lirceus | sow bug | F | 14 | 22 | | 100 | 18 | 5 |
| Insecta | | | | | | | | |
| Coleoptera | | | | | | | | |
| Elmidae | | | | | | | | |
| Stenelmis | riffle beetle | F, I | | 1 | | | | |
| Unknown | | | | | | | | |
| Unknown | beetle | T | | 1 | | | | |
| Diptera | | | | | | | | |
| Chironominae | | | | | | | | |
| Chironomus | midge | T, F | 4 | | | 1 | 2 | |
| Chironomini | midge | N | | 7 | | | | |
| Cryptochironomus | midge | T | | | | | | 1 |
| Dicrotendipes | midge | F, I | | | | | 1 | |
| Glyptotendipes | midge | T | 11 | | | 16 | | |
| Parachironomus | midge | F | 2 | | | 1 | 3 | 10 |
| Phaenopsectra | midge | I | 2 | | | | 3 | |
| Polypedilum | midge | F, I | 2 | 10 | | 14 | 5 | 5 |
| Tribelos | midge | I | 7 | | | 1 | | |
| Unknown | midge | N | 3[e] | 10[e] | | 37[e] | 1[e] | 12[e] |
| Diamesinae | | | | | | | | |
| Diamesa | midge | I | 20 | 42 | | 38 | 52 | |
| Unknown | midge | N | | | | 4 | | |

See footnotes at end of table.

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**TABLE D.III-8B**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3[d] | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Diptera | | | | | | | | |
| Orthocladiinae | | | | | | | | |
| Brillia | midge | I | | 4 | | 1 | 12 | |
| Cardiocladius | midge | N | 2 | 31 | | 15 | 18 | |
| Cricotopus | midge | I | | | | 1 | | |
| Metriocnemus | midge | I | | | | 6 | | |
| Orthocladius | midge | F, I | 32 | 160 | | 77 | 94 | 4 |
| Trissocladius | midge | N | 1 | | | | | |
| Unknown | midge | N | 5[e] | | | | | |
| Tanypodinae | | | | | | | | |
| Procladius | midge | T, F | 2 | | | | | |
| Unknown | midge | N | 2 | 1 | | | | |
| Tipulidae | | | | | | | | |
| Tipula | cranefly | I | | | | | 1 | |
| Unknown | | | | | | | | |
| Unknown | midge | N | 8[e] | 23[e] | | 27[e] | 36[e] | 3[e] |
| Ephemeroptera | | | | | | | | |
| Baetidae | | | | | | | | |
| Baetis | mayfly | I | 5 | | | | | |
| Unknown | mayfly | N | 9[e] | | | 4 | | |
| Ephemerellidae | | | | | | | | |
| Ephemerella | mayfly | N | | | | 4 | | |
| Ephemeridae | | | | | | | | |
| Unknown | mayfly | N | 2 | 2 | | 19 | 3 | |
| Heptageniidae | | | | | | | | |
| Stenonema | mayfly | I | 10 | 6 | | 4 | 10 | |
| Leptophlebiidae | | | | | | | | |
| Habrophlebia | mayfly | N | | | | 16 | | |
| Unknown | | | | | | | | |
| Unknown | mayfly | N | | | | 3[e] | | |
| Hemiptera | | | | | | | | |
| Nepidae | | | | | | | | |
| Ranatra | water scorpion | T | 1 | | | | | |

See footnotes at end of table.

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**TABLE D.III-8B**
**(Continued)**



| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3[d] | PR-4 | PR-5 | PR-7 |
|---|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | | |
| Plecoptera | | | | | | | | |
| Nemouridae | | | | | | | | |
| Nemoura | stonefly | I | | 6 | | 5 | | |
| Perlodidae | | | | | | | | |
| Isogenoides | stonefly | I | | 9 | | 5 | 6 | |
| Isoperla | stonefly | I | 34 | 12 | | 3 | 6 | |
| Trichoptera | | | | | | | | |
| Hydropsychidae | | | | | | | | |
| Cheumatopsyche | caddisfly | F | | 1 | | | | |
| Hydropsyche | caddisfly | I | | | | | 1 | |
| Hydroptilidae | | | | | | | | |
| Unknown | caddisfly | I | | | | | 1 | |
| Unknown | | | | | | | | |
| Unknown | caddisfly | F, I | | | | | 1[e] | |
| Oligochaeta | | | | | | | | |
| Tubificida | | | | | | | | |
| Naididae | | | | | | | | |
| Unknown | aquatic worm | F | | | | 1 | 2 | |
| Tubificidae | | | | | | | | |
| Tubifex | tubifex worm | T | 4 | | | 2 | | |
| Unknown | aquatic worm | T | 1 | | | | | |

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Sampler contained no organisms.

[e] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

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**TABLE D.III-9A**
**PADDYS RUN**
**SURBER SAMPLING RAW DATA**
**JUNE - AUGUST 1990**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|
| Aphasmidia | | | | | | | |
| Unknown | | | | | | | |
| Unknown | | | | | | | |
| Unknown | aquatic nematode | F | | | | 3 | |
| Arachnida | | | | | | | |
| Araneomorpha | | | | | | | |
| Pisauridae | | | | | | | |
| Unknown | fisher spider | N | 1 | | | | |
| Crustacea | | | | | | | |
| Decapoda | | | | | | | |
| Cambaridae | | | | | | | |
| Orconectes | crayfish | F | | 2 | | | |
| Isopoda | | | | | | | |
| Asellidae | | | | | | | |
| Lirceus | sow bug | F | | | 6 | 7 | 50 |
| Gastropoda | | | | | | | |
| Basommatophora | | | | | | | |
| Ancylidae | | | | | | | |
| Ferrissia | freshwater limpet | T, F | | | | | 1 |
| Lymnaeidae | | | | | | | |
| Fossaria | pond snail | T | | | | 1 | |
| Physidae | | | | | | | |
| Physa | pond snail | T | | | | 7 | 1 |
| Insecta | | | | | | | |
| Coleoptera | | | | | | | |
| Dytiscidae | | | | | | | |
| Hydrovatus | predaceous diving beetle | N | | | 5 | | |
| Unknown | predaceous diving beetle | N | | | | | 2 |
| Elmidae | | | | | | | |
| Ancyronyx | riffle beetle | I | 5 | 1 | 1 | 9 | |
| Stenelmis | riffle beetle | F, I | 30 | 61 | 33 | 4 | 9 |
| Psephenidae | | | | | | | |
| Psephenus | riffle beetle | N | 7 | | | | 1 |

See footnotes at end of table.

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**TABLE D.III-9A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | |
| Coleoptera | | | | | | | |
| Scarabaeidae | | | | | | | |
| Popillia japonica | Japanese beetle | N | | | 1 | | |
| Unknown | | | | | | | |
| Unknown | beetle | T | 4 | | | 2[d] | 3[d] |
| Collembola | | | | | | | |
| Isotomidae | | | | | | | |
| Isotomurus palustris | spring tail | N | | | 1 | | |
| Diptera | | | | | | | |
| Anthomyiidae | | | | | | | |
| Limnophora | anthomyiid | F | | 1 | | 3 | |
| Chironominae | | | | | | | |
| Constempellina | midge | N | 1 | 2 | 4 | 3 | |
| Dicrotendipes | midge | F, I | 10 | | | 14 | 3 |
| Glyptotendipes | midge | T | 13 | | | 6 | 5 |
| Micropsectra | midge | I | | | 9 | 10 | |
| Microtendipes | midge | I | 10 | 5 | 12 | 11 | 1 |
| Polypedilum | midge | F, I | 16 | 6 | 4 | 24 | 4 |
| Tribelos | midge | I | | | 1 | | |
| Unknown | midge | N | 4[d] | | | | 170[d] |
| Diamesinae | | | | | | | |
| Diamesa | midge | I | 32 | | | 44 | 24 |
| Unknown | midge | N | | 1 | | | |
| Liriopeidae | | | | | | | |
| Unknown | cranefly | N | | | | | 1 |
| Orthocladiinae | | | | | | | |
| Brillia | midge | I | 2 | | | 4 | |
| Cardiocladius | midge | N | | | | 46 | |
| Cricotopus | midge | I | 8 | 5 | 4 | 34 | 20 |
| Orthocladius | midge | F, I | | 2 | | | |
| Paracricotopus | midge | N | | 4 | | | |
| Psectrocladius | midge | I | 5 | 1 | | 3 | 13 |
| Simuliidae | | | | | | | |
| Prosimulium | blackfly | I | | | 6 | | |
| Simulium | blackfly | I | 2 | 4 | 5 | 176 | 161 |
| Unknown | blackfly | T, F, I | | 1[d] | | | 9 |

See footnotes at end of table.

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**TABLE D.III-9A**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | |
| Diptera | | | | | | | |
| Tabanidae | | | | | | | |
| Chrysops | horsefly | N | | 2 | | | |
| Tabanus | horsefly | I | | 2 | | | 1 |
| Unknown | horsefly | T | 2 | | | | |
| Tanypodinae | | | | | | | |
| Procladius | midge | T, F | 11 | 8 | 18 | 11 | 11 |
| Psectrotanypus | midge | F | | | 1 | | |
| Tanypus | midge | F | | 1 | | | |
| Unknown | midge | N | 6 | 6[d] | | 31 | 1 |
| Tipulidae | | | | | | | |
| Hexatoma | cranefly | I | | | 1 | | |
| Unknown | cranefly | T, F | 1 | 6[d] | 8 | | 4 |
| Unknown | | | | | | | |
| Unknown | midge | N | 44[d] | 88[d] | 21[d] | 72[d] | 29[d] |
| Ephemeroptera | | | | | | | |
| Baetidae | | | | | | | |
| Acentrella | mayfly | N | 29 | 38 | 71 | 92 | 95 |
| Unknown | mayfly | N | | | | | 1[d] |
| Caenidae | | | | | | | |
| Caenis | mayfly | F, I | 5 | 1 | 2 | 2 | |
| Heptageniidae | | | | | | | |
| Stenonema | mayfly | I | 7 | 14 | 29 | 3 | 89 |
| Unknown | | | | | | | |
| Unknown | mayfly | N | 3[d] | 1[d] | | | |
| Hemiptera | | | | | | | |
| Corixidae | | | | | | | |
| Unknown | water boatman | F | | 1 | | | |
| Hebridae | | | | | | | |
| Unknown | water bug | T | | | | | 1 |
| Unknown | | | | | | | |
| Unknown | water bug | T | 1 | | 1 | | |
| Veliidae | | | | | | | |
| Microvelia | riffle bug | T | 1 | | | | |

See footnotes at end of table.

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**TABLE D.III-9A**
**(Continued)**

| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8 |
|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | |
| Hymenoptera | | | | | | | |
| Unknown | | | | | | | |
| Unknown | ant | N | | | | 1 | |
| Lepidoptera | | | | | | | |
| Pyralidae | | | | | | | |
| Unknown | freshwater caterpillar | F | | | | 1 | |
| Odonata | | | | | | | |
| Calopterygidae | | | | | | | |
| Unknown | damselfly | I | | | | | 1 |
| Trichoptera | | | | | | | |
| Helicopsychidae | | | | | | | |
| Helicopsyche | caddisfly | N | 2 | 1 | | | |
| Hydropsychidae | | | | | | | |
| Cheumatopsyche | caddisfly | F | 72 | 137 | 69 | 55 | 25 |
| Hydropsyche | caddisfly | I | 14 | 16 | 15 | 1 | 18 |
| Unknown | caddisfly | F, I | | 20[d] | | | |
| Hydroptilidae | | | | | | | |
| Unknown | caddisfly | I | 40 | 10 | 21 | | 17 |
| Philopotamidae | | | | | | | |
| Chimarra | caddisfly | I | 18 | 10 | 29 | | 1 |
| Unknown | | | | | | | |
| Unknown | caddisfly | N | 5[d] | 3[d] | 1[d] | 2[d] | 3[d] |
| Oligochaeta | | | | | | | |
| Haplotaxida | | | | | | | |
| Haplotaxidae | | | | | | | |
| Unknown | semiaquatic worm | N | | | | 1 | |
| Tubificida | | | | | | | |
| Tubificidae | | | | | | | |
| Unknown | tubifex worm | T | 1 | | 2 | | |
| Turbellaria | | | | | | | |
| Tricladida | | | | | | | |
| Planariidae | | | | | | | |
| Phagocata | flat worm | F | | 8 | 2 | | |

See footnotes at end of table.

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**TABLE D.III-9A**
**(Continued)**

---

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

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**TABLE D.III-9B**
**PADDYS RUN**
**HESTER-DENDY SAMPLING RAW DATA**
**JUNE - AUGUST 1990**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8[d] |
|---|---|---|---|---|---|---|---|
| Crustacea | | | | | | | |
| Isopoda | | | | | | | |
| Asellidae | | | | | | | |
| Lirceus | sow bug | F | | | | 6 | |
| Hydrozoa | | | | | | | |
| Hydroida | | | | | | | |
| Hydridae | | | | | | | |
| Hydra | hydra | F | | | | 1 | |
| Insecta | | | | | | | |
| Diptera | | | | | | | |
| Chironominae | | | | | | | |
| Constempellina | midge | N | | 1 | 2 | | |
| Cryptochironomus | midge | T | | 3 | | | |
| Dicrotendipes | midge | F, I | 4 | 17 | 24 | 18 | |
| Glyptotendipes | midge | T | | 8 | 2 | 7 | |
| Microtendipes | midge | I | 7 | 4 | 11 | | |
| Polypedilum | midge | F, I | 3 | 46 | | 1 | |
| Unknown | midge | N | | 20[e] | | 9[e] | |
| Diamesinae | | | | | | | |
| Diamesa | midge | I | 3 | 3 | 1 | | |
| Orthocladiinae | | | | | | | |
| Brillia | midge | I | | 1 | 3 | | |
| Cricotopus | midge | I | | | 12 | | |
| Unknown | midge | N | | 2[e] | | | |
| Simuliidae | | | | | | | |
| Simulium | blackfly | I | | 1 | | | |
| Tanypodinae | | | | | | | |
| Procladius | midge | T, F | | 8 | 11 | | |
| Unknown | midge | N | | 5 | 1 | | |
| Tipulidae | | | | | | | |
| Unknown | cranefly | T, F | | | 1 | | |
| Unknown | | | | | | | |
| Unknown | midge | N | 6[e] | 69[e] | 19[e] | 1[e] | |

See footnotes at end of table.

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**TABLE D.III-9B**
**(Continued)**

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| Scientific Name[b] | Common Name | Tolerance Index[c] | Sampling Site[a] PR-1 | PR-2 | PR-3 | PR-7 | PR-8[d] |
|---|---|---|---|---|---|---|---|
| Insecta | | | | | | | |
| Ephemeroptera | | | | | | | |
| Baetidae | | | | | | | |
| Acentrella | mayfly | N | 1 | | | | |
| Caenidae | | | | | | | |
| Caenis | mayfly | F, I | 1 | 10 | 2 | 2 | |
| Heptageniidae | | | | | | | |
| Stenonema | mayfly | I | 23 | 36 | 34 | 10 | |
| Unknown | | | | | | | |
| Unknown | mayfly | N | | 12[e] | | | |
| Trichoptera | | | | | | | |
| Hydropsychidae | | | | | | | |
| Cheumatopsyche | caddisfly | F | | 91 | 2 | | |
| Hydropsyche | caddisfly | I | 1 | 73 | | | |
| Unknown | caddisfly | F, I | | 48[e] | | | |
| Philopotamidae | | | | | | | |
| Chimarra | caddisfly | I | | | 1 | | |
| Unknown | | | | | | | |
| Unknown | caddisfly | N | | 20[e] | | 1[e] | |

[a] See Plate 1-1

[b] Class
Order
Family/Subfamily
Genus or Tribe

[c] F = Facultative
I = Intolerant
N = No Index
T = Tolerant

[d] Sampler contained no organisms.

[e] Not included in taxa counts. Counting rules are discussed in Section D.2.4.

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APPENDIX E

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# APPENDIX E
# ACUTE AND CHRONIC TOXICITY TESTING OF FEMP EFFLUENT

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# LIST OF ACRONYMS

| | |
|---|---|
| APHA | American Public Health Association |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| ChV | chronic value |
| CWA | Clean Water Act |
| DOE | U.S. Department of Energy |
| $EC_{50}$ | concentration affecting 50 percent of the population |
| EIS | Environmental Impact Statement |
| EMSL | Environmental Monitoring Systems Laboratory |
| EPA | U.S. Environmental Protection Agency |
| FFCA | Federal Facilities Compliance Agreement |
| FEMP | Fernald Environmental Management Project |
| FS | feasibility study |
| IT | IT Corporation |
| $LC_{50}$ | concentration lethal to 50 percent of the population |
| LOEC | lowest observable effect concentration |
| NEPA | National Environmental Policy Act |
| NOEC | no observable effect concentration |
| NPDES | National Pollutant Discharge Elimination System |
| RI | remedial investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| RVR | Round Valley Reservoir |
| SDS | sodium dodecyl sulfate |
| WMCO | Westinghouse Materials Company of Ohio |

# E.1.0 INTRODUCTION



## E.1.1 SITE DESCRIPTION AND HISTORY

The Fernald Environmental Management Project (FEMP) is a contractor-operated federal facility where pure uranium metals were produced for the U.S. Department of Energy (DOE) between 1951 and 1989. The FEMP is located on a 1050-acre site in a rural agricultural area approximately 20 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler Counties (Figure E-1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the Production Area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In July 1986, DOE signed a Federal Facility Compliance Agreement (FFCA) with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), concerning environmental impacts associated with the FEMP. In 1990, the FFCA was amended by a Consent Agreement under CERCLA Sections 120 and 106(a). Pursuant to the provisions of the FFCA and Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS Environmental Impact Statement (RI/FS - EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major Federal actions.

## E.1.2 LOCATION AND FUNCTION OF THE FEMP EFFLUENT LINE

The FEMP effluent line (Figure E-1-2) is a permitted discharge regulated by a National Pollutant Discharge Elimination System (NPDES) permit (OEPA No. 1IO00004*BD) and DOE orders, with compliance monitoring performed at Manhole 175 before the effluent leaves the FEMP boundary. The average effluent flow, radionuclide concentrations, and NPDES data for 1989 are presented in Table E-1-1. Four sources at the FEMP may contribute to the effluent discharge (Figure E-1-3). When the FEMP was in production, process wastewater was discharged to a general sump and then to the biodenitrification facility to remove nitrates. This treated wastewater would then be combined with sanitary sewage, the second effluent source, treated to remove biological contaminants, and discharged to Manhole 175. The third source of effluent is the Water Treatment Plant and coal pile runoff. Groundwater used as a water supply at the FEMP is treated in the plant and the resulting sludge is sent to the general sump. Any liquid remaining after the sludge is settled out is discharged to Manhole 175. Runoff from the coal pile is also sent to the general sump following settling out of

solids. The fourth effluent source is stormwater runoff. Runoff from the waste pit area, collected in the Clearwell, is treated in the biodenitrification facility and discharged to Manhole 175 via the sewage treatment plant. Stormwater runoff from the production area is collected in stormwater retention basins, located on the south side of the production area, and is then pumped to Manhole 175. During extreme rainfalls, if the storm water retention basins overflow, storm water is discharged through the Storm Sewer Outfall Ditch to Paddys Run. 3579

Potential remedial actions and removal actions being considered for the FEMP may affect the quantity or quality of FEMP effluent. For example, contaminated groundwater in the Great Miami Buried Valley Aquifer and in perched groundwater tables on the property may be pumped out, treated to remove radionuclides, and discharged to the Great Miami River via the main effluent line (DOE 1990a, b). In order to meet CERCLA and NEPA requirements to evaluate the potential effects of changes in the effluent composition or quality on aquatic organisms in the Great Miami River, it was necessary to determine the effects of the existing discharge on aquatic organisms. This was accomplished by testing the effluent for toxicity and by surveying the macroinvertebrate community in the river above and below the discharge point. The results of the toxicity study are described below. The macroinvertebrate study is described in Appendix D.

### E.1.3 BACKGROUND AND DEFINITION OF EFFLUENT TOXICITY TESTING

The Clean Water Act (CWA) requires that "the discharge of toxic pollutants in toxic amounts be prohibited." This requirement is typically met by regulating the discharge of specific pollutants based on human health concerns, aquatic life protection criteria (EPA 1986), and laboratory tests of toxicity to aquatic organisms. However, effluent limitations alone do not always provide the necessary protection to aquatic organisms, due to additive, synergistic, or antagonistic effects among toxic substances in complex effluents, or to a lack of complete data on the composition of the effluent. Toxicity tests, which directly determine the effect of an effluent on aquatic organisms, provide a measure not only of the concentrations of toxic substances in an effluent, but also of the availability of those substances to organisms and of any interactive effects of different toxins.

EPA has developed a number of standard bioassay tests for determining the toxicity of effluents to aquatic organisms (Peltier and Weber 1985, Weber et al. 1989). These tests measure both acute (lethality) and chronic (inhibited growth and reproduction) effects. Specifically, the results of acute bioassays demonstrate life-threatening effects of effluents and gross sensitivity to contaminants, while chronic bioassays show greater sensitivity to lower toxicant levels and monitor more subtle responses. Such responses, including impairments in fecundity, offspring survival, or growth ability, may have long term effects on the survival of organisms in the natural environment.

The typical endpoint measured in acute toxicity tests is the effluent concentration causing fifty percent mortality ($LC_{50}$) in a stated period of time (Peltier and Weber 1985). Typical endpoints measured in 282

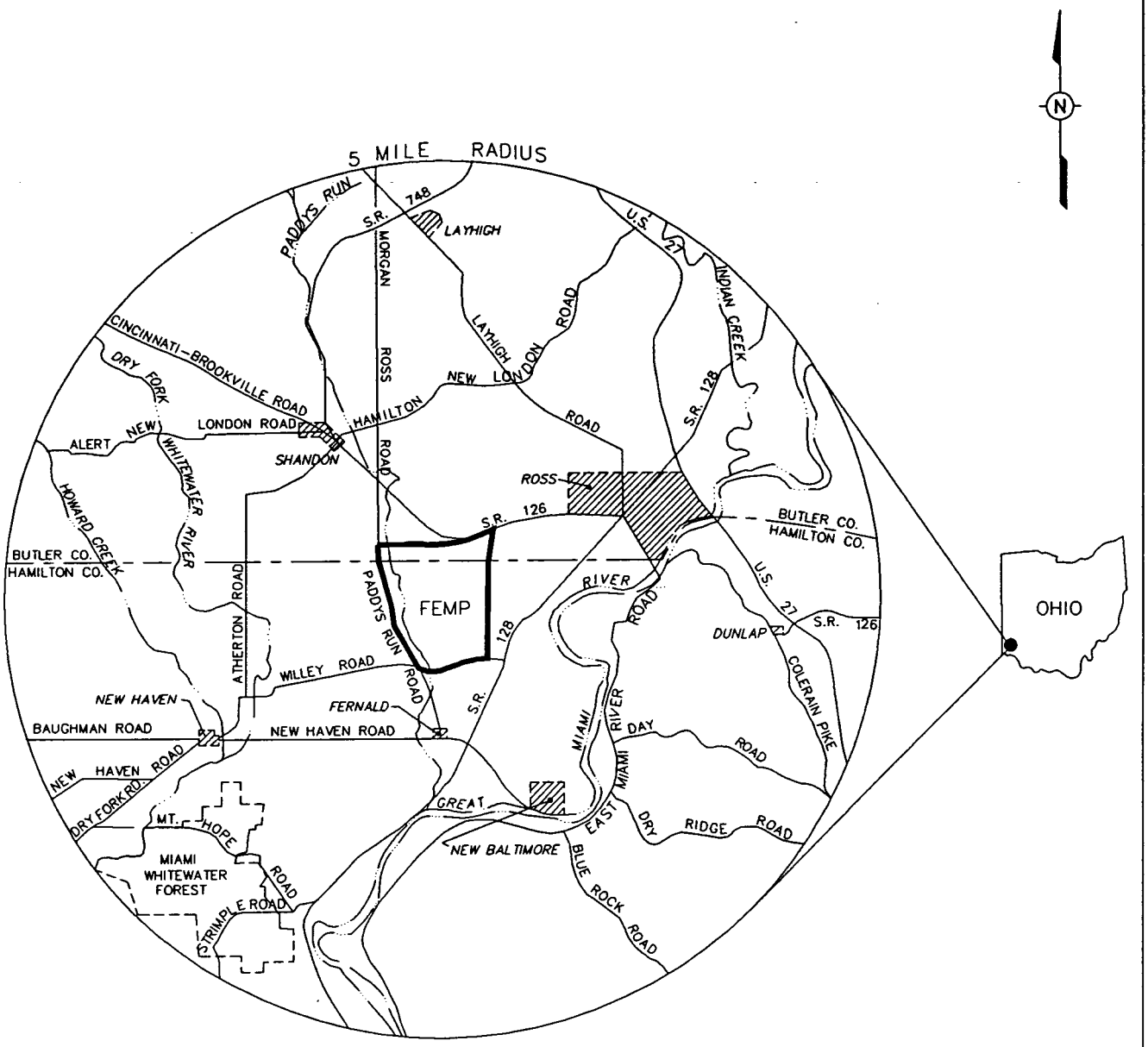


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FIGURE E.1-1. FIVE-MILE RADIUS MAP, FEMP

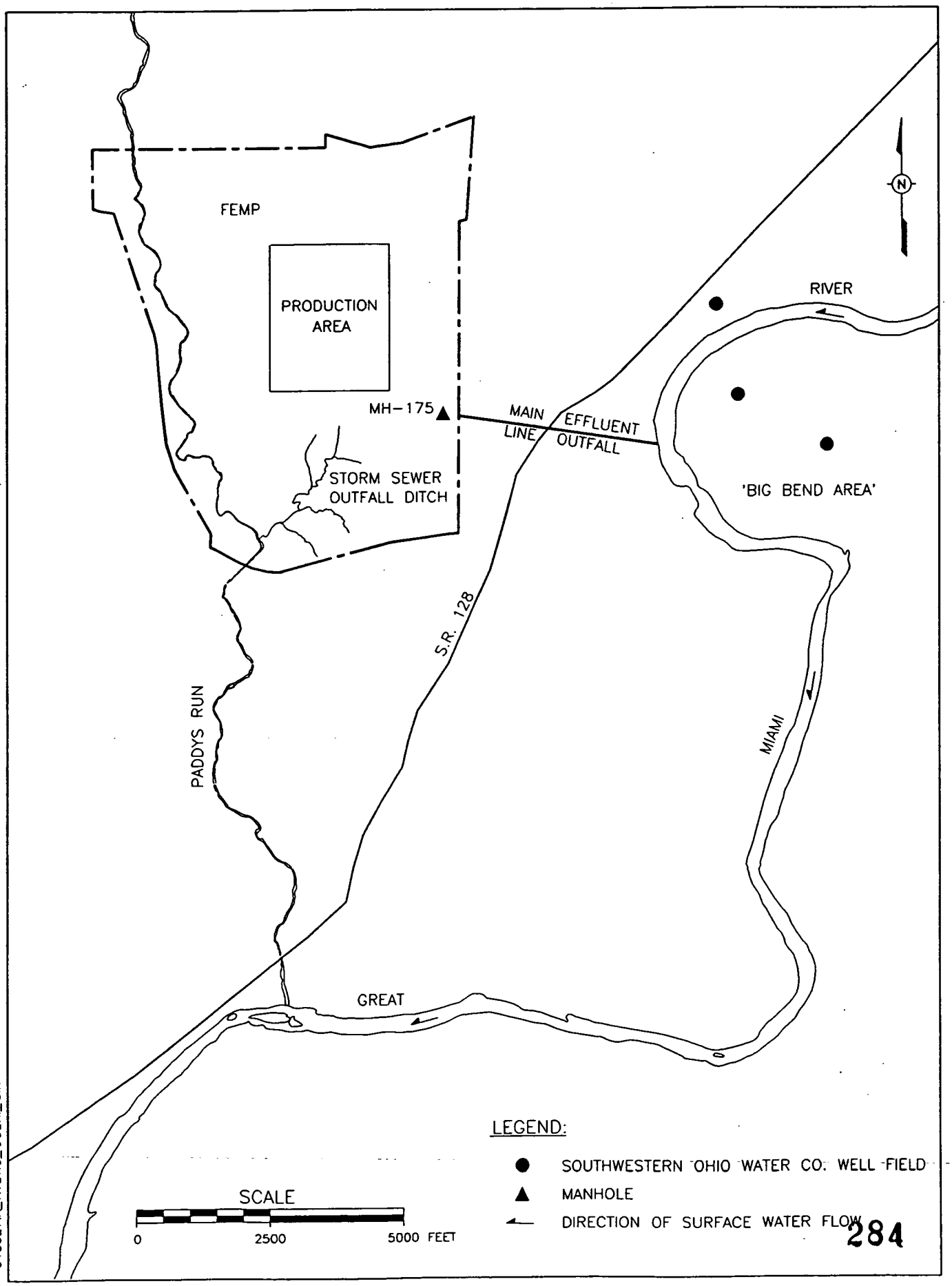


FIGURE E.1-2. SURFACE WATER HYDROLOGY AND MAIN EFFLUENT LINE AT THE FEMP

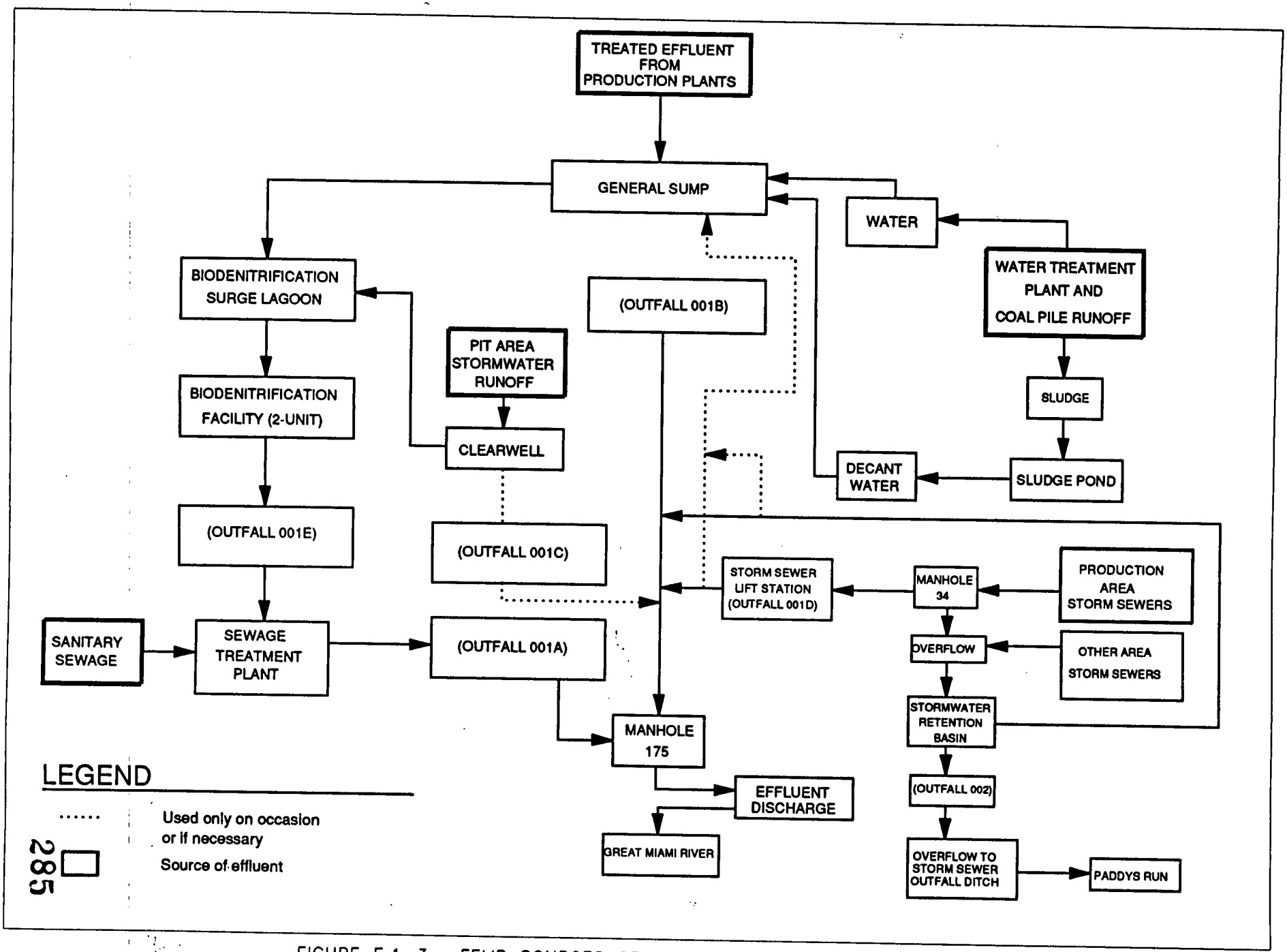


FIGURE E.1-3. FEMP SOURCES OF EFFLUENT TO MANHOLE 175

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## TABLE E-1-1
## AVERAGE FLOW, RADIONUCLIDE CONCENTRATIONS, AND NPDES DATA FOR FEMP EFFLUENT, 1989

| Variable | Units | Average[a] |
|---|---|---|
| Flow Rate | MGD[b] | 0.68 |
| Plutonium - 239/240[c] | pCi/ℓ | 0.11 |
| Thorium - 230 | pCi/ℓ | 0.27 |
| Thorium - 232 | pCi/ℓ | 0.78 |
| Thorium - 234 | pCi/ℓ | 300 |
| Uranium - 234 | pCi/ℓ | 240 |
| Uranium - 235 | pCi/ℓ | 12 |
| Uranium - 236 | pCi/ℓ | 8.4 |
| Uranium - 238 | pCi/ℓ | 300 |
| pH | SU[d] | 7.4 to 9.3 |
| Suspended solids | mg/ℓ | 17 |
| Oil and grease | mg/ℓ | <5.1 |
| Residual chlorine | mg/ℓ | <0.04 |

[a] Arithmetic means. For details of sampling techniques and average computations, see WMCO (1990a).

[b] MGD, millions of gallons per day

[c] Average concentrations of radionuclides not listed were below detection limits.

[d] SU, standard units, the negative log of the hydrogen ion concentration. Only the range was reported.

SOURCE: WMCO (1990a)

chronic toxicity tests are the "no observed effect concentration" (NOEC), the "lowest observed effect concentration" (LOEC), and the effluent concentration causing a fifty percent effect (relative to a control) ($EC_{50}$) on some biological variable such as growth rate (Weber et al. 1989). The chronic value (ChV), the geometric mean of the NOEC and LOEC, may also be reported for chronic tests.

Two kinds of acute toxicity tests were conducted on FEMP effluent, one with a cladoceran species, Daphnia pulex, and the other with the fathead minnow, Pimephales promelas. Three kinds of chronic toxicity tests were performed, on the green alga Selenastrum capricornutum, a cladoceran, Ceriodaphnia dubia, and the fathead minnow. These tests are commonly used in effluent toxicity testing, and the methods are well established, as described above. The three species used for chronic testing also constitute a simple aquatic food chain, which accounts for the possibility that direct effects of an effluent on one ecological level may be passed on indirectly to other levels. For example, a decrease in algal abundance may lead to a decrease in the abundance of invertebrates that feed on algae, which in turn affects game fish dependent on invertebrates as food.

Selenastrum capricornutum is a unicellular green alga commonly used for assessing the effects of effluents on primary producers (plants) in receiving waters. The importance of green algae in toxicity testing lies in their use as a food source by many invertebrate species and in the fact that they are easily grown in pure culture. Green algae can supply most daphnid (cladoceran) nutrient requirements. The endpoint in the chronic algal bioassay is inhibition of growth, as measured by the NOEC and LOEC.

Cladocerans are small, planktonic, freshwater crustaceans commonly found in lakes and large rivers. They are widely distributed in aquatic habitats throughout the world, play an important role as herbivores feeding on algae, and serve as prey for many vertebrate species, particularly fish. These characteristics, in addition to a relatively short life cycle, make cladocerans an important test organism for measuring both acute and chronic responses to wastewater discharges. The endpoint measured in the acute daphnid test (Daphnia pulex) is mortality ($LC_{50}$). The endpoints measured in the chronic daphnid test (Ceriodaphnia dubia) are reproduction and mortality ($LC_{50}$, NOEC, and LOEC).

Fathead minnows, Pimephales promelas, are an important test species due to their widespread distribution throughout the United States. In addition, the fathead minnow is an important forage fish in the freshwater food chain and is readily cultured in the laboratory (Norberg and Mount 1985). The EPA considers fathead minnows the desired vertebrate species for toxicity testing (Peltier and Weber 1985). Mortality ($LC_{50}$) is the endpoint used in the acute toxicity test, and growth and mortality (NOEC and LOEC for both) are the endpoints recorded in the chronic test.

# E.2.0 METHODOLOGY

## E.2.1 SAMPLE COLLECTION AND HANDLING

During September 1988, FEMP effluent was collected as a grab sample by allowing effluent from the end of the discharge pipe, immediately before its release into the Great Miami River, to drain into a bucket. All other effluent collections (May 1989, June 1989, January 1990, and May 1990) were taken from Manhole 175 with an ISCO automated sampler. Daily samples were 24-hour composites consisting of grab samples collected every 30 minutes.

All samples were transferred into polypropylene bottles (cubitainers) and shipped on ice by overnight courier or hand-delivered by sampling personnel to the bioassay laboratory. Effluent samples from the FEMP site were subsampled before shipment, and the subsamples sent to an analytical laboratory for radionuclide screening. All samples were determined to contain quantities of source material less than those which would require special handling under 10CFR40.13 (less than one-twentieth of one percent of the sample by weight). Effluent samples received in the bioassay laboratory remained unopened until confirmation of their safety was received. Samples were held at 4°C in darkness until ready for use. Holding times were less than 72 hours, as specified by EPA guidance (Peltier and Weber 1985, Weber et al. 1989).

Great Miami River water for acclimation, test controls, and effluent dilution was collected as grab samples from the south bank of the river upstream from the FEMP effluent line and adjacent to the old State Route 126 bridge in Ross, Ohio, and shipped to the bioassay laboratory under the same conditions as effluent samples. Dates of effluent and diluent collections are listed in Table E-2-1. At the laboratory, both effluent and diluent samples were passed through a 30-µm nylon mesh screen to remove indigenous organisms. In addition, the diluent used for the algal chronic test was passed through a 0.45-µm pore diameter filter before use.

## E.2.2 CULTURING AND ACCLIMATION OF TEST ORGANISMS

All organisms used in toxicity tests were cultured at the bioassay laboratory. In-house culturing provides a readily available supply of organisms with a documented history and consistent responses to a given toxicant. Acclimation of organisms to the receiving water ensures that the responses observed are due to the effluent, rather than to the receiving water with which the effluent is diluted. Cladocerans and fathead minnows were acclimated to Great Miami River water before testing, as described below. Acclimation of algal cultures is impractical and is not included in the EPA protocol (Weber et al. 1989).

## TABLE E-2-1
## FEMP EFFLUENT SAMPLE AND DILUTION WATER COLLECTION DATES

| Sample Identity | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| Effluent[a] | 9/24[b] | 5/8 | 6/13[b,c] | 1/15 | 4/30 |
| | 9/25[b] | 5/9 | 6/14 | 1/16 | 5/1 |
| | 9/27[b] | 5/10 | 6/15 | 1/17 | 5/2 |
| | | 5/11 | 6/16 | 1/18 | 5/3 |
| | | 5/12 | 6/17 | 1/19 | 5/4 |
| | | 5/13 | 6/18 | 1/20 | 5/5 |
| | | 5/14 | 6/19 | 1/21 | 5/6 |
| | | | 6/20 | | 5/9[d] |
| Diluent[b] | 9/24 | 5/8 | 6/13 | 1/15 | 4/30 |
| | 9/27 | 5/9 | 6/14 | 1/16 | 5/1 |
| | | 5/12 | 6/15 | 1/17 | 5/2 |
| | | | 6/16 | 1/18 | 5/3 |
| | | | 6/20 | 1/19 | 5/4 |
| | | | | 1/21 | 5/5 |
| | | | | | 5/6 |

[a] Effluent samples were 24-hour composite samples unless indicated.

[b] Collected as grab samples.

[c] Not used for tests. Malfunction of automated sampler prevented collection of a 24-hour composite.

[d] Used for algal test only. Malfunction of Psychrotherm incubator postponed initiation of algal test.

E.2.2.1 Algae

Selenastrum capricornutum was cultured in Woods Hole medium (Stein 1973). Batch cultures were inoculated aseptically to an initial density of approximately 10,000 cells/mℓ. Cultures were maintained in 250-mℓ Erlenmeyer flasks stopped with cotton and held in an environmental chamber at 20±2 °C in 24-hour continuous lighting (approximately 400 foot-candles).

E.2.2.2 Cladocerans

Stock cultures of Daphnia pulex and Ceriodaphnia dubia were routinely kept by the laboratory as reliable in-house sources of daphnids. All cultures were maintained following EPA guidelines (Peltier and Weber 1985). Stock cultures consisted of 20 to 30 mixed-age daphnids, and were fed the algae Ankistrodesmus falcatus or Selenastrum capricornutum in accordance with Goulden and Henry (1984) and Cowgill et al. (1985). Daphnid species were cultured in filtered Round Valley Reservoir (RVR) water from Lebanon, New Jersey, according to Goulden and Henry (1984). RVR water was used as the culture water because nutrient, pH, and hardness levels are optimal for daphnid culturing. Daphnids were maintained in this water up to the time of acclimation to Great Miami River water.

Cladocerans were acclimated to Great Miami River water collected at Ross Bridge, as described above, at least one week prior to the start of toxicity tests. Neonates less than 24 hours old were removed from stock cultures to start the acclimation cultures for the tests. Acclimation cultures consisted of single-aged daphnids which were raised under optimal conditions to ensure large broods and healthy neonates for the test. Optimal conditions included daily feedings, regular water changes, and daily removal of juveniles to avoid overcrowding the daphnids. When all animals were reproducing, new acclimation cultures were started with neonates from the first acclimation cultures. These acclimation procedures continued until the tests began. Less than 24 hours before the tests, all neonates were removed from the acclimation cultures and discarded. Therefore, all neonates drawn from the acclimation cultures just prior to test initiation were single-aged daphnids less than 24 hours old.

E.2.2.3 Fathead Minnows

Fathead minnows (Pimephales promelas) used for bioassay testing were cultured at the laboratory in accordance with Denny (1987). Sexually mature fish were maintained in 20 gallon all-glass aquaria containing soft-reconstituted water (before December 1989) or fresh RVR water (after December 1989). Aquaria were serviced by a recirculating carbon treatment and filter system. Eggs were laid on the underside of polyvinyl chloride huts, which were removed from the tanks on a daily basis. Huts were transferred to hatching trays, and a few drops of methylene blue were added to the water to prevent fungal growth. The eggs were allowed to hatch and the larvae were monitored for the first few days of life. Fathead minnows were fed brine shrimp (Artemia) twice daily.

Fathead minnows less than 30 days old were used for acute testing. Minnows used for acute testing were counted and transferred with a large-bore pipet to 20-gallon glass aquaria within 16 days of

hatching. The health of the organisms and the water quality were monitored until the testing age was reached. Monitoring of survival and water quality variables took place over the entire life span of the minnows to certify them disease-free and eligible for use in toxicity testing. The chronic tests were conducted with newly hatched fry less than 24 hours old. The eggs and fry were cultured and handled as previously described.

For acute testing, gradual acclimation of minnows less than 30 days old to Great Miami River water was conducted by slowly dripping the water through 1/4 inch-diameter Tygon tubes into five-gallon glass aquaria until a greater than 90 percent replacement of water occurred. This drip acclimation procedure is preferable to an immediate water change because a controlled gradation of changeover from holding water to test diluent occurs, which minimizes potential effects of differences in water characteristics on the test organisms. A minimum of 24 hours was used for the changeovers from holding to acclimation water. The minnows remained in Great Miami River water for at least an additional 24 hours before test initiation.

Acclimation of fathead minnow fry for chronic testing was conducted by placing eggs in Great Miami River water. Twenty-four hours before the start of the test, any fry that had hatched were removed. This ensured that all fry used for tests were less than 24 hours old.

### E.2.3 TEST DESIGN

#### E.2.3.1 Acute Testing

##### E.2.3.1.1 Daphnia pulex

Less than 24 hours before the test initiations, all existing neonates were removed and discarded from the acclimation cultures to ensure that all neonates used for the test were less than 24 hours old when introduced to test chambers. Replicate chambers of five effluent concentrations (100, 50, 25, 12.5, and 6.25 percent effluent), plus controls of Great Miami River water, were prepared. Test chambers were 250-mℓ Tripour polypropylene beakers filled to a volume of 200 mℓ. Ten Daphnia pulex neonates were introduced to each replicate chamber with a wide-bore pipet, carefully releasing the animals below the air/water interface. This technique ensures that air will not be trapped under a daphnid's carapace.

Daily renewals of test concentrations were accomplished by preparing new test solutions in Tripour beakers, recording water quality variables, and gently transferring the individual daphnids with a pipet as previously described. Temperature, conductivity, dissolved oxygen, and pH were measured and recorded daily for the controls and the low (6.25 percent), medium (25 percent), and high (100 percent) test concentrations, following EPA guidance (Peltier and Weber 1985). These variables were also measured on occasion in the other concentrations, but are not reported here. Alkalinity and hardness were measured daily for all test concentrations, except for the September 1988 testing, when they were measured for control and 100 percent effluents only. The latter procedure is the minimum

suggested by Peltier and Weber (1985). Temperature, pH, conductivity, and hardness were measured in the first two rounds of testing with a Solomat Minilab MPM 2000 meter and associated probes. In the last three rounds of testing, temperature was measured with a mercury thermometer traceable to the National Bureau of Standards, dissolved oxygen was measured with a YSI Model 57 polarographic oxygen meter and probe, conductivity was recorded with a YSI Model 33 MSCT salinity/conductivity/ temperature meter, and pH was measured with an Orion or a Markson pH meter. Alkalinity and hardness were determined during all tests by titration according to American Public Health Association (1985).

Due to the short duration of the test (48 hours), feeding of the organisms was not required (Peltier and Weber 1985). The effect measured for the 48-hour Daphnia pulex acute toxicity test was mortality, in particular the median lethal concentration ($LC_{50}$), the concentration at which 50 percent mortality would be observed.

E.2.3.1.2 Fathead Minnows

Fathead minnow juveniles less than 30 days old were tested under daily renewal conditions for 96 hours. Test chambers were 5.7-liter all-glass aquaria filled to a volume of 3.0 liters (September 1988), one-liter Tripour beakers filled to a volume of 1.0 liter (May 1989, June 1989 and January 1990), and one-liter glass beakers filled to a volume of 1.0 liter (May 1990). Replicated chambers of five effluent concentrations (100, 50, 25, 12.5 and 6.25 percent effluent), plus controls of Great Miami River water, were prepared by parallel dilutions. Ten minnows were exposed in each replicate chamber for a total of 20 organisms per concentration. The minnows were not fed during the test.

For daily renewals, test solutions were either poured from the test chambers (May 1990) or siphoned from the test chambers through a mesh-covered tygon tube. Fresh solutions were prepared by mixing the proper amounts of effluent and dilution water in a four-liter graduated cylinder. The fresh solutions were then introduced to the test chambers by gently pouring down the sides of the test chambers to minimize the turbulence and stress to the test organisms. Test chambers were refilled to the initial volume. Loading of fish in the test chambers conformed to EPA guidance (Peltier and Weber 1985), which states that loading must not exceed 0.4 g/ℓ of test solution at temperatures above 20°C. Water quality variables were measured as described above for the daphnid acute test.

E.2.3.2 Chronic Testing

E.2.3.2.1 Selenastrum capricornutum

Test chambers were sterilized 250-mℓ Erlenmeyer flasks filled to a volume of 125 mℓ (September 1988) and 100 mℓ (May 1989, June 1989, January 1990 and May 1990). Each test concentration (100, 50, 25, 12.5 and 6.25 percent effluent), as well as controls of Great Miami River water, was prepared in triplicate. The algal test inoculum was prepared from a four- to seven-day old batch culture, which was centrifuged to prepare a concentrated inoculum. The cell density of the

inoculum was checked with a hemacytometer, and proper volumes of inoculum were then introduced to each flask to bring the initial cell density to 10,000 cells/mℓ. Immediately after inoculation, a final check of the initial cell density on a representative sample of the flasks was made.

Flasks were incubated under continuous illumination at 400±40 foot-candles and 25±1 °C in a Psychrotherm Model G21 incubator, according to Horning and Weber (1985) and Weber et al. (1989). Flasks were gently shaken by hand a minimum of twice daily during testing. At 96 hours, the test was terminated and algal growth in each flask was determined by counting cells in a representative sample of test solution using a hemacytometer. The use of the hemacytometer also enabled any cell abnormalities to be detected and noted.

The endpoint measured in this assay was population growth. The NOEC and LOEC were calculated according to Horning and Weber (1985) and Weber et al. (1989). The NOEC is defined as the highest concentration of toxicant which causes no observable adverse effect on the test organism, for example inhibition of growth. The LOEC is defined as the lowest toxicant concentration which causes an adverse effect on the organism. The ChV was also calculated, as the geometric mean of the NOEC and the LOEC. Water quality variables were measured as described above for the daphnid acute test, following Weber et al. (1989).

E.2.3.2.2 Ceriodaphnia dubia

Neonates used in testing were less than 24 hours old and born within a four-hour period. This was assured by drawing all neonates from the cultures either every two hours, and using the two oldest broods providing sufficient numbers for testing (September 1988, May 1989, and June 1989), or every four hours and using the oldest brood (January 1990 and May 1990).

Test chambers were 30 mℓ polypropylene cups filled to a volume of 15 mℓ. Ten replicates of each concentration (100, 50, 25, 12.5 and 6.25 percent effluent), plus controls of Great Miami River water, were prepared. One organism was introduced into each test chamber. The seven-day Ceriodaphnia dubia test is a static daily renewal test. Fresh solutions were prepared daily in 30 mℓ cups, and the test organisms were transferred to the new solutions using a wide-bore pipet. Daphnids were released below the water/air interface to reduce the risk of air being trapped under the carapace. Reproduction was measured at the end of each 24-hour period by counting the neonates in the "old" solution after transferring the test organism. The temperature was maintained at 25±1 °C by placing test chambers in a styrofoam float in a temperature controlled water bath (Forma Scientific). Ambient laboratory lighting (50 to 100 foot-candles with a 16-hour light and 8-hour dark photoperiod) was maintained. The test animals were fed daily either a unicellular green alga, Ankistrodesmus falcatus (September 1988, May 1989, and June 1989) or Selenastrum capricornutum (January 1990 and May 1990), to an initial density of 100,000 cells/mℓ. The test was terminated after seven days, and the NOEC and LOEC for survival and reproduction calculated as described above. $LC_{50}$'s were not calculated,

because no mortality occurred in these tests, as described below. Water quality variables were measured as described above for the daphnid acute test, following Weber et al. (1989).

E.2.3.2.3 Fathead minnows

Fathead minnows less than 24 hours old were used for this seven-day chronic bioassay. Test chambers consisted of one-liter polypropylene beakers filled to a volume of 1 liter (September 1988), one-liter polypropylene beakers filled to a volume of 500 mℓ (May 1989 and June 1989), and 600-mℓ polypropylene beakers filled to a volume of 500 mℓ (January 1990 and May 1990). Five effluent concentrations (100, 50, 25, 12.5 and 6.25 percent effluent), plus controls of Great Miami River water, were prepared in duplicate (September 1988), triplicate (May 1989, June 1989 and January 1990) and quadruplicate (May 1990). Organisms were transferred randomly from hatching trays to non-toxic food-grade two-ounce cups using a wide-bore pipet. The cups were then partially submerged in the beakers to allow the fish to swim freely into the test solutions. Ten fish were placed in each beaker. Following daily observations of survival and behavior, test solutions were slowly poured from the beakers to the minimum water level (approximately 1 cm) which still allowed unstressed swimming by the fish. Fresh solutions were prepared and introduced to the test chambers as with the fathead minnow acute testing. Minnows were fed newly hatched brine shrimp (Artemia) twice daily to ensure adequate food for survival and growth. Remaining food and organism wastes were removed from the beakers daily by gentle siphon.

After seven days of exposure, the test was ended and surviving fish were weighed. To determine the dry weight of the organisms, aluminum weighing pans were dried in a VWR Model 1305U oven for a minimum of 4 hours at 100 - 105 °C and then transferred to a Boekel desiccator to prevent absorption of ambient moisture while the pans were returning to room temperature. After reaching room temperature the pans were weighed to the nearest 0.1 mg on a Mettler Model AE2000 balance (September 1988, May 1989 and June 1989) or to the nearest 0.01 mg on an A&D Model ER-182A balance (January 1990 and May 1990) to provide an initial weight for each weighing pan. All surviving fish from each test chamber were rinsed with deionized and distilled water and transferred to the pre-weighed pans. These pans were then subjected to an identical drying, cooling and weighing process to provide a final weight. These data were used to calculate the mean dry weight per fish per beaker, to ensure that the organism loading (weight per volume of test solution) was within EPA guidelines. The NOEC and LOEC for survival and growth were calculated as described above. Water quality variables were measured as described above for the daphnid acute test, following Weber et al. (1989).

E.2.3.3 Reference Toxicant Testing

In order to establish that organism responses to potential toxicants were consistent over time, the tests described above were periodically conducted using reference toxicants, following EPA guidance (Peltier and Weber 1985, Horning and Weber 1985, Weber et al. 1989, EPA no date a,b). Factors

affecting these responses include age, genetic strain, holding and handling procedures, and test temperature. The reference toxicant used for acute tests was sodium dodecyl sulfate (SDS). Chronic reference toxicant tests were performed using SDS or copper sulfate. Quality control ampules of SDS and copper sulfate were obtained from EPA's Environmental Monitoring Systems Laboratory (EMSL) in Cincinnati, Ohio whenever possible. Acceptable ranges of responses to reference toxicants from this source appear in the guidance manuals and in EPA (no date a,b) cited above. Due to recent unavailability of SDS ampules from EMSL, a 95-percent SDS powder from J.T. Baker Chemical Co. was used for testing in 1990. Acceptable ranges of responses to this SDS were established through repeated testing, graphing responses on control charts, as described by Peltier and Weber (1985) and Weber et al. (1989).

SDS was selected as a reference toxicant, following EPA guidance (Peltier and Weber 1985, Weber et al. 1989) and because the bioassay laboratory has developed an historical database for this toxicant. Copper sulfate was chosen because it is easy to analytically verify the concentration in solution and because the bioassay laboratory has developed an historical database for this toxicant. Analytical verifications of chemical stock were performed for all chronic reference toxicant tests which used copper sulfate.

### E.2.4 STATISTICAL ANALYSES

Survival data from acute tests (fathead minnow and *Daphnia pulex*) were analyzed using a computer program developed by EPA (Peltier and Weber 1985) to determine the $LC_{50}$ value. Probit analysis, moving average, and nonlinear interpolation are the preferred methods for calculating this value. Partial mortality (greater than zero percent but less than 100 percent) within two test concentrations is required for probit analysis and the moving average method. If the statistical assumptions that data are normally distributed and variances are homogeneous are satisfied, confidence limits can be calculated for the $LC_{50}$. However, it is common in effluent testing for no partial mortalities to occur within a test dilution series. In this instance, nonlinear interpolation is an appropriate data analysis technique, but confidence limits cannot be calculated.

The NOEC and LOEC in chronic tests were calculated by determining whether there were significant differences in results between controls and test concentrations at the 0.05 confidence level. Growth and reproduction data were analyzed using Dunnett's procedure to compare each concentration with the control to determine if any of the test concentrations differed significantly from the control. Dunnett's procedure is based on the assumptions that the observations are independent and normally distributed and that the variance of the observations is homogeneous across all concentrations and the controls.

Data were tested for normality with a Chi-square Goodness of Fit Test. If the data were normally distributed, the homogeneity of variances across treatments was determined using Hartley's and

Bartlett's tests. The two tests are similar, but Bartlett's test is not as sensitive to unequal sample sizes. Ceriodaphnia tests often result in unequal sample sizes for reproduction data. Algal growth data had to be transformed using a log base 10 transformation to meet the assumptions of normality and homogeneity of variances.

Results of the fathead minnow and Ceriodaphnia dubia tests were screened such that test concentrations showing significant survival differences from controls were not used in further analyses of growth or reproduction data (Weber et al. 1989). Survival data for the fathead minnow test in December 1988 and the Ceriodaphnia dubia test in May 1989 were analyzed using Fisher's Exact Test. This statistical method tests whether the proportion of living or dead animals in controls is different from that in any of the test concentrations. Statistical analyses were not performed on survival data for Ceriodaphnia dubia and fathead minnow chronic tests in which at least 80 percent survival occurred in all effluent concentrations and controls.

# E.3.0 RESULTS

Test results are summarized in Table E-3-1 and are described in detail below. No acute toxicity was detected in any of the Daphnia pulex or fathead minnow tests (Table E-3-1). Chronic toxicity was detected in September 1988, June 1989, and January 1990 in the alga test, and in September 1988 in the Ceriodaphnia dubia test. Algal growth was stimulated by FEMP effluent in the May 1989 and May 1990 tests. No chronic toxicity to fathead minnows was observed. The Ceriodaphnia dubia tests in May and June 1989 were invalidated due to unacceptable mortality in controls, as detailed below.

The uranium concentration in the effluent and NPDES permit-regulated effluent quality variables were recorded by WMCO during all toxicity testing periods (Table E-3-2). No correlation was observed between uranium concentration or effluent quality variables and toxicity. Indeed, uranium in the effluent was highest during the May 1989 test period, when neither acute nor chronic toxicity was observed (Table E-3-1).

## E.3.1 ACUTE TOXICITY TESTS

### E.3.1.1 Cladoceran (Daphnia pulex)

Neither a median lethal concentration ($LC_{50}$) nor a median effective concentration ($EC_{50}$) could be calculated in the Daphnia pulex acute tests. Complete survival was evident in all test treatments as well as the controls for all rounds of testing (Table E-3-3). The $LC_{50}$ values were therefore reported as greater than 100 percent effluent (Table E-3-1). In addition, no abnormal behavior was observed among the daphnids exposed to effluent or Great Miami River water. Survival data for all rounds of testing are listed in Attachment I. Water quality variables were within the limits specified by EPA (Peltier and Weber 1985) and are reported in Attachment II.

### E.3.1.2 Fathead Minnow (Pimephales promelas)

Twenty percent mortality occurred in the 100 percent effluent concentration in May 1990 (Table E-3-4). Survival in all other treatments was at least 90 percent. The $LC_{50}$ values were therefore reported as greater than 100 percent effluent (Table E-3-1). In addition, no abnormal behavior was noted, indicating no apparent sublethal stress to the juvenile minnows.

The lengths of the test fish varied from 9 to 18 mm (Table E-3-5). During each round of testing, the length range was in compliance with EPA guidelines (Peltier and Weber 1985), which state that the largest fish must not exceed one and one-half times the length of the smallest fish. The wet weight of the fish varied from 0.002 to 0.057 g (Table E-3-6). Differences in the size of fish among rounds of testing and among effluent concentrations can be attributed to differences in fish age and variability in fatty tissues within developing fathead minnows within a round of testing. With increasing age, variability develops in lipid content (fatty tissue) and consequent weight. All loading factors (grams of organisms wet weight per volume of solution) were within the limits advised by EPA (Peltier and

## TABLE E-3-1
## SUMMARY OF RESULTS
## $LC_{50}$, NOEC, AND LOEC PERCENT EFFLUENT FOR ALL TESTS[a]

| Test Species and Endpoint | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| Daphnia pulex $LC_{50}$ | >100 | >100 | >100 | >100 | >100 |
| Pimephales promelas $LC_{50}$ | >100 | >100 | >100 | >100 | >100 |
| Selenastrum capricornutum NOEC/LOEC | 6.25/ 12.5 | 100/ >100[b] | <6.25/ 6.25 | 50/ 100 | 100/ >100[b] |
| Ceriodaphnia dubia NOEC/LOEC | 12.5/ 25 | [c] | [c] | 100/ >100 | 100/ >100 |
| Pimephales promelas NOEC/LOEC | 100/ >100 | 100/ >100 | 100/ >100 | 100/ >100 | 100/ >100 |

[a] Values in table are percent effluent for the end point stated.

[b] Growth stimulated by effluent.

[c] Values invalidated due to excessive control mortality.

## TABLE E-3-2

## EFFLUENT RADIATION AND DISCHARGE MONITORING DATA-MEAN MEASUREMENTS DURING EFFLUENT SAMPLING FOR TOXICITY[a]

| Variable | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| River Flow[b] (cfs) | 447.03 (15.59) | 7703.69 (2725.71) | 6026.22 (3091.54) | 3239.41 (2361.34) | 9700.18 (7679.82) |
| Effluent Flow (cfs) | 0.730 (0.410) | 1.109 (0.115) | 1.733 (0.390) | 0.756 (0.213) | 1.148 (0.541) |
| Total Alpha (pCi/ℓ) | 1530 (1645) | 774 (122) | 295 (82) | 622 (257) | 342 (160) |
| Total Beta (pCi/ℓ) | 722 (275) | 552 (170) | 193 (31) | 256 (113) | 79 (37) |
| Total Uranium (mg/ℓ) | 0.70 (0.11) | 1.76 (0.30) | 0.49 (0.06) | 0.94 (0.41) | 0.62 (0.19) |
| Calculated Total U-238 (pCi/ℓ) | 0.70 (0.11) | 1.76 (0.30) | 0.49 (0.06) | 0.94 (0.41) | 0.62 (0.19) |
| Total Residual Chlorine (mg/ℓ) | 0.04[c] | 0.08[c] | 0.03[c] | 0.03[c] | NA[d] |
| Nitrate (mg/ℓ) | 1.3[c] | 6.2[c] | 2.4[c] | 3.6[c] | 2.8 (0.4) |
| Total Suspended Solids (mg/ℓ) | 4[c] | 26[c] | 11[c] | 7[c] | 5 (1) |
| Ammonia (mg/ℓ) | NA[d] | 0.22[c] | 0.10[c] | 0.35[c] | 0.14 (0.01) |
| pH | 8.1 (0.2) | 8.2 (0.2) | 8.0 (0.1) | 8.1 (0.4) | 8.2 (0.4) |

[a] Values are arithmetic mean and standard deviation () for the effluent sampling dates in Table E-2-1.

[b] (Mean flow at Hamilton gauge) x 1.0469. Multiplier calculated from Hamilton gauge data and flow rates at FEMP presented in IT (1988).

[c] Based on one measurement only

[d] NA, Not Available

SOURCE: WMCO (1990b)

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## TABLE E-3-3
## CLADOCERAN (DAPHNIA PULEX) ACUTE TOXICITY TEST PERCENT SURVIVAL AFTER 48 HOURS[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 6.25 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 12.5 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 25 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 50 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 100 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |

[a] Values shown are mean and standard deviation ().

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## TABLE E-3-4

## FATHEAD MINNOW (PIMEPHALES PROMELAS) ACUTE TOXICITY TEST PERCENT SURVIVAL AFTER 96 HOURS[a]

| | Testing Period | | | | |
|---|---|---|---|---|---|
| Effluent Concentration (%) | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 6.25 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 12.5 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 25 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 50 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |
| 100 | 100 (0) | 100 (0) | 100 (0) | 100 (0) | 100 (0) |

[a] Values shown are arithmetic mean and standard deviation ().

## TABLE E-3-5
## FATHEAD MINNOW (PIMEPHALES PROMELAS) ACUTE TOXICITY TEST MEAN LENGTH (mm)[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 12.5 (2.1) | 12.7 (1.5) | 17.0 (0.9) | 10.6 (1.0) | 11.0 (1.0) |
| 6.25 | 12.3 (1.4) | 11.3 (1.0) | 17.2 (0.8) | b | b |
| 12.5 | 10.5 (0.5) | 12.2 (1.0) | 16.8 (1.0) | b | b |
| 25 | 11.5 (1.4) | 12.2 (1.6) | 16.2 (1.2) | b | b |
| 50 | 11.0 (0.9) | 12.0 (0.9) | 16.5 (1.2) | b | b |
| 100 | 10.8 (1.2) | 11.8 (1.5) | 16.3 (1.0) | b | b |

[a] Values shown are arithmetic mean and standard deviation ().

[b] All surviving minnows measured only in controls.

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## TABLE E-3-6
## FATHEAD MINNOW (PIMEPHALES PROMELAS) ACUTE TOXICITY TEST MEAN DRY LENGTH (g)[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 0.0275 (0.019) | 0.03 (0.01) | 0.045 (0.008) | 0.007 (0.004) | 0.009 (0.004) |
| 6.25 | 0.0206 (0.007) | 0.02 (0.01) | 0.045 (0.008) | b | b |
| 12.5 | 0.0147 (0.007) | 0.02 (0.01) | 0.041 (0.011) | b | b |
| 25 | 0.0132 (0.003) | 0.03 (0.01) | 0.036 (0.007) | b | b |
| 50 | 0.0195 (0.005) | 0.02 (0.01) | 0.041 (0.011) | b | b |
| 100 | 0.0190 (0.006) | 0.02 (0.01) | 0.045 (0.008) | b | b |

[a] Values shown are arithmetic mean and standard deviation ().

[b] All surviving minnows measured only in controls.

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Weber 1985). Survival, weight and length data for all rounds of testing appear in Attachment I. Water quality variables were within the limits specified by EPA (Peltier and Weber 1985) and are reported in Attachment II.

E.3.2 CHRONIC TOXICITY TESTS

E.3.2.1 Alga (Selenastrum capricornutum)

FEMP effluent had a stimulatory effect on algal growth in the May 1989 and May 1990 tests (Table E-3-7). In May 1989, final algal cell counts ranged from an average of 1,048,000 cells/mℓ in the controls to 2,051,000 cells/mℓ in the undiluted effluent. Dunnett's procedure indicated a significant increase in growth in all effluent concentrations except 25 percent. In May 1990, final algal cell counts ranged from an average of 201,000 cells/mℓ in the controls to 322,000 cells/mℓ in the undiluted effluent (Table E-3-7). Dunnett's procedure indicated a significant increase in growth in 100 percent effluent. Since no growth inhibition was observed in these tests, the NOEC was reported as 100 percent and the LOEC and ChV as greater than 100 percent (Table E-3-1).

In September 1988, June 1989, and January 1990, FEMP effluent had an inhibitory effect on algal growth. In September 1988, counts ranged from an average of 1,340,000 cells/mℓ in the controls to 580,000 cells/mℓ in the undiluted effluent (Table E-3-7). Dunnett's procedure indicated significant decreases in growth at effluent concentrations of 12.5 percent and greater (Tables E-3-1 and E-3-7). The ChV was 8.8 percent effluent. In June 1989, final cell counts ranged from an average of 2,049,000 cells/mℓ in the controls to 460,000 cells/mℓ in the undiluted effluent (Table E-3-7). Dunnett's procedure indicated significant decreases in growth at all effluent concentrations. Since no concentration was tested which had no effect, the ChV was less than 6.25 percent effluent (Table E-3-1). In January 1990, final algal cells counts ranged from an average of 1,099,000 cells/mℓ in the controls to 359,000 cells/mℓ in the undiluted effluent (Table E-3-7). The 6.25 percent effluent concentration was invalidated due to possible contamination of the test flasks. Final algal cell counts averaged 96,000 cells/mℓ in this concentration with total mortality occurring in one replicate chamber. Dunnett's procedure indicated a significant decrease in growth at 100 percent effluent only. The NOEC and LOEC were thus 50 percent and 100 percent respectively, with a ChV of 70.7 percent effluent (Table E-3-1).

Growth data for all rounds of testing are listed in Attachment I. Water quality variables were within the limits specified by EPA (Weber et al. 1989) and are reported in Attachment II.

E.3.2.2 Cladoceran (Ceriodaphnia dubia)

In the September 1988 test, Ceriodaphnia dubia reproductive was significantly reduced, compared to controls, at effluent concentrations of 25 percent and greater (Tables E-3-1 and E-3-8). Reproduction

TABLE E-3-7

ALGA (SELENASTRUM CAPRICORNUTUM) CHRONIC TOXICITY TEST
MEAN CELLS/mℓ AFTER 96 HOURS (X $10^6$)[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 1.34 (0.18) | 1.05 (0.04) | 2.05 (0.12) | 1.10 (0.08) | 0.20 (0.00) |
| 6.25 | 1.22 (0.20) | 1.31[d] (0.02) | 1.85[c] (0.14) | 0.10[b] (0.10) | 0.18 (0.00) |
| 12.5 | 0.94[c] (0.08) | 1.26[d] (0.02) | 1.42[c] (0.45) | 0.91 (0.09) | 0.18 (0.00) |
| 25 | 0.63[c] (0.13) | 1.11 (0.07) | 1.32[c] (0.17) | 0.53 (0.31) | 0.23 (0.04) |
| 50 | 0.66[c] (0.03) | 1.71[d] (0.04) | 1.00[c] (0.10) | 0.46[c] (0.18) | 0.25 (0.05) |
| 100 | 0.58[c] (0.15) | 2.05[c] (0.03) | 0.46[c] (0.04) | 0.35[c] (0.14) | 0.32[c] (0.07) |

[a] Values shown are arithmetic mean and standard deviation ().

[b] Invalidated due to total mortality in one replicate.

[c] Significant decrease (P<0.05) in growth compared to control.

[d] Significant increase (P<0.05) in growth compared to control.

ranged from 24.1 neonates/adult in the controls to 13.5 neonates/adult in the undiluted effluent. The ChV was 17.7 percent effluent. Survival was 100 percent for all concentrations and controls (Table E-3-9).

The tests in May and June 1989 were invalidated prior to completion due to excessive control mortality (Table E-3-9). In May, control mortality was 40 percent after five days of exposure and mortality in 6.25 percent effluent was 30 percent. All other organisms survived. Though invalid, the test was allowed to run to completion. All remaining organisms survived to the end of the test. Statistically greater reproduction than the controls occurred in 100, 50 and 25 percent effluent. No NOEC, LOEC, or ChV was reported for this test. In June, control mortality was 90 percent after four days, mortality in 6.25 percent effluent was 70 percent, and mortality in 12.5 and 25 percent effluent was 10 percent. All other organisms survived. The organisms had only begun to reproduce at this point, preventing any analysis of reproductive data, and the test was terminated. No NOEC, LOEC, or ChV was reported for these data. Organisms exposed to laboratory grade RVR freshwater during the June 1989 test period had 100 percent survival and acceptable reproduction. This indicates that the quality of the Great Miami River water used as dilution and control water in the May and June 1989 tests was not acceptable.

In January and May 1990, FEMP effluent had no inhibitory effect on survival or reproduction of Ceriodaphnia dubia (Tables E-3-8 and E-3-9). After 7 days of exposure, survival was at least 90 percent in all test treatments and controls. No test treatment showed a significant difference from the control. The NOEC was therefore reported as 100 percent and the LOEC and ChV as greater than 100 percent effluent for these two tests (Table E-3-1). Survival and reproduction data for all rounds of testing appear in Attachment I. Water quality variables were within the limits specified by EPA (Weber et al. 1989) and are reported in Attachment II.

E.3.2.3 Fathead Minnow (Pimephales promelas)

The fathead minnow chronic tests resulted in no significant differences from controls in survival or growth for all concentrations tested. Survival in all test concentrations and controls was at least 80 percent (Table E-3-10). Dunnett's procedure indicated no significant difference in the final dry weights per organism for any of the effluent concentrations, compared to the controls (Table E-3-11). The NOEC was therefore reported as 100 percent, with a LOEC and ChV greater than 100 percent effluent (Table E-3-1). Survival and weight data for all rounds of testing appear in Attachment I. Water quality variables were within the limits specified by EPA (Weber et al. 1989) and are reported in Attachment II.

## TABLE E-3-8
## CLADOCERAN (CERIODAPHNIA DUBIA) CHRONIC TOXICITY TEST PERCENT SURVIVAL AFTER 7 DAYS[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989[b] | January 1990 | May 1990 |
| 0 | 100 | 60 | 10 | 100 | 100 |
| 6.25 | 100 | 70 | 30 | 90 | 100 |
| 12.5 | 100 | 100 | 90 | 100 | 100 |
| 25 | 100 | 100 | 90 | 100 | 100 |
| 50 | 100 | 100 | 100 | 100 | 100 |
| 100 | 100 | 100 | 100 | 100 | 100 |

[a] Percent survival is based on the single set of ten organisms used in each concentration, so standard deviation could not be calculated.

[b] Test terminated after four days.

## TABLE E-3-9

## CLADOCERAN (CERIODAPHNIA DUBIA) CHRONIC TOXICITY TEST MEAN NUMBER OF NEONATES/SURVIVING ADULT[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989[b] | June 1989 | January 1990 | May 1990 |
| 0 | 24.1 (6.1) | 17.2 (2.7) | c | 18.8 (7.3) | 30.1 (3.4) |
| 6.25 | 22.5 (3.6) | 18.3 (3.1) | c | 17.8 (11.1) | 28.5 (5.5) |
| 12.5 | 20.6 (3.5) | 16.2 (5.7) | c | 20.9 (8.1) | 30.2 (4.4) |
| 25 | 16.5[d] (3.1) | 19.6[e] (4.9) | c | 19.8 (11.7) | 30.8 (6.4) |
| 50 | 14.4[d] (1.9) | 22.2[e] (4.9) | c | 19.8 (11.7) | 27.0 (9.5) |
| 100 | 13.5[d] (1.9) | 26.2[e] (3.2) | c | 16.9 (14.0) | 29.7 (2.8) |

[a] Values shown are arithmetic mean and standard deviation ().

[b] Test invalid due to excessive control mortality.

[c] Test terminated after four days due to control mortality of 90 percent.

[d] Significantly less (P<0.05) reproduction than controls.

[e] Significantly greater (P<0.05) reproduction than controls.

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## TABLE E-3-10
## FATHEAD MINNOW (PIMEPHALES PROMELAS) CHRONIC TOXICITY TEST PERCENT SURVIVAL AFTER 7 DAYS[a]

| Effluent Concentration (%) | Testing Period | | | | |
|---|---|---|---|---|---|
| | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 100 (0) | 85 (5) | 95 (5) | 93 (4.7) | 90 (12.2) |
| 6.25 | 100 (0) | 85 (5) | 90 (0) | 100 (0) | 98 (4.3) |
| 12.5 | 100 (0) | 80 (10) | 100 (0) | 97 (4.7) | 93 (8.3) |
| 25 | 95 (5) | 95 (5) | 100 (0) | 97 (4.7) | 98 (4.3) |
| 50 | 85 (5) | 95 (5) | 100 (0) | 90 (0) | 100 (0) |
| 100 | 90 (0) | 85 (15) | 100 (0) | 100 (0) | 95 (5.0) |

[a] Values shown are arithmetic mean and standard deviation ().

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## TABLE E-3-11

## FATHEAD MINNOW (PIMEPHALES PROMELAS) CHRONIC TOXICITY TEST MEAN FINAL DRY WEIGHT PER ORGANISM (mg)[a]

| | Testing Period | | | | |
|---|---|---|---|---|---|
| Effluent Concentration (%) | September 1988 | May 1989 | June 1989 | January 1990 | May 1990 |
| 0 | 0.33 (0.02) | 0.36 (0.05) | 0.33 (0.02) | 0.46 (0.05) | 0.49 (0.05) |
| 6.25 | 0.27 (0.03) | 0.29 (0.07) | 0.33 (0.03) | 0.37 (0.04) | 0.47 (0.03) |
| 12.5 | 0.32 (0.01) | 0.27 (0.04) | 0.37 (0.02) | 0.41 (0.09) | 0.47 (0.05) |
| 25 | 0.32 (0.01) | 0.33 (0.04) | 0.33 (0.01) | 0.41 (0.02) | 0.47 (0.08) |
| 50 | 0.33 (0.01) | 0.29 (0.06) | 0.26 (0.05) | 0.46 (0.03) | 0.45 (0.03) |
| 100 | 0.33 (0.04) | 0.26 (0.03) | 0.30 (0.02) | 0.37 (0.03) | 0.56 (0.05) |

[a] Values shown are arithmetic mean and standard deviation ().

### E.3.3 REFERENCE TOXICANTS

Results of reference toxicant testing are detailed in Attachment III. All results agreed with either EPA established ranges (EPA, no date a,b) or the toxicology laboratory's database, indicating that organism responses to toxicants were consistent over the period of FEMP effluent testing. Control charts and copies of laboratory bench sheets are available in the FEMP RI/FS project files.

## E.4.0 DISCUSSION AND CONCLUSIONS



FEMP effluent was tested for acute and chronic toxicity five times over a two year period from September 1988 to May 1990. As described above, no acute toxicity was detected in any of the Daphnia pulex or fathead minnow tests (Table E-3-1). Chronic toxicity was detected in September 1988, June 1989, and January 1990 in the alga test, and in September 1988 in the Ceriodaphnia dubia test. Algal growth was stimulated by FEMP effluent in the May 1989 and May 1990 tests. No chronic toxicity to fathead minnows was observed. The Ceriodaphnia dubia tests in May and June 1989 were invalidated due to unacceptable mortality in controls. There was no correlation of toxicity with uranium concentrations or other water quality variables in the effluent (Table E-3-2).

Any toxic effects of FEMP effluent on aquatic organisms in the Great Miami River would be mitigated by dilution. The lowest concentration of effluent causing toxicity was 6.25 percent in the alga test in June 1989 (Table E-3-1). This reduced growth of the alga by 10 percent (Table E-3-7). The lowest effluent concentration causing toxicity to an animal was 25 percent, in the September 1988 Ceriodaphnia dubia test (Table E-3-1), where reproduction was reduced by 32 percent (Table E-3-8). The maximum daily effluent flow rate in 1989 was 1.5 mgd (2.33 cubic feet per second (cfs)) (WMCO 1990a). If this effluent flow coincided with the 7-day, 10-year low flow in the Great Miami River of 280 cfs (IT 1988), the effluent would be diluted to 0.8 percent by volume. If the effects observed in the laboratory were linear with concentration, 0.8 percent effluent would have reduced algal growth by 1.3 percent and ceriodaphnid reproduction by one percent in the examples cited above. It is unlikely that such differences would be detectable in the field or in the laboratory, given the variability typically observed with these techniques (for example Tables E-3-7, E-3-9). At average river flow of 3460 cfs (IT 1988), an effluent flow of 2.33 cfs would be diluted to 0.07 percent. Dilution would be proportionately greater, and toxicity lower, at lower effluent flow rates or higher river flow rates.

Extrapolation of laboratory toxicity test results to the field should be treated with caution. However, these results suggest that toxic effects of FEMP effluent on organisms in the Great Miami River would be difficult to detect below the mixing zone. The results of a study directed at detecting such effects on the macroinvertebrate community in the river and in Paddys Run, which appear in Appendix D of this EIS, suggest that the effluent may slightly enrich the community immediately adjacent to the outfall. No evidence was found of harmful effects of the FEMP on aquatic organisms in the Great Miami River. Further evaluations of the effects of the FEMP and of potential remedial actions on aquatic organisms in the Great Miami River appear in the sitewide risk assessment and in the text of the EIS.

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# ATTACHMENT E-I
# RAW SURVIVAL, REPRODUCTION, AND GROWTH DATA

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TABLE E-I-1
DAPHNIA PULEX (WATER FLEA) ACUTE TEST
PERCENT SURVIVING
SEPTEMBER 1988

| Effluent (Percent) | Replicate | Testing Interval (Hours) 0 | 24 | 48 |
|---|---|---|---|---|
| 0.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |

TABLE E-I-2

DAPHNIA PULEX (WATER FLEA) ACUTE TEST
PERCENT SURVIVING
MAY 1989

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | |
|---|---|---|---|---|
| | | 0 | 24 | 48 |
| 0.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |

TABLE E-I-3

DAPHNIA PULEX (WATER FLEA) ACUTE TEST
PERCENT SURVIVING
JUNE 1989

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | |
|---|---|---|---|---|
| | | 0 | 24 | 48 |
| 0.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |

# TABLE E-I-4

## DAPHNIA PULEX (WATER FLEA) ACUTE TEST
## PERCENT SURVIVING
## JANUARY 1990

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | |
|---|---|---|---|---|
| | | 0 | 24 | 48 |
| 0.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |

# TABLE E-I-5

## DAPHNIA PULEX (WATER FLEA) ACUTE TEST
## PERCENT SURVIVING
## MAY 1990

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | |
|---|---|---|---|---|
| | | 0 | 24 | 48 |
| 0.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 |
| | B | 100 | 100 | 100 |

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## TABLE E-I-6
## PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST
## PERCENT SURVIVING
## SEPTEMBER 1988

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 24 | 48 | 72 | 96 |
| 0.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |

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## TABLE E-I-7

## PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST PERCENT SURVIVING MAY 1989

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 24 | 48 | 72 | 96 |
| 0.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |

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## TABLE E-I-8
## PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST
## PERCENT SURVIVING
## JUNE 1989

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 24 | 48 | 72 | 96 |
| 0.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |

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## TABLE E-I-9
## PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST
## PERCENT SURVIVING
## JANUARY 1990

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 24 | 48 | 72 | 96 |
| 0.0 | A | 100 | 100 | 90 | 90 | 90 |
| | B | 100 | 100 | 90 | 90 | 90 |
| 6.25 | A | 100 | 100 | 80 | 80 | 80 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 90 | 90 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 80 | 80 | 80 | 100 |

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TABLE E-I-10

PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST
PERCENT SURVIVING
MAY 1990

| Effluent (Percent) | Replicate | Testing Interval (Hours) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 24 | 48 | 72 | 96 |
| 0.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 90 | 90 |
| | B | 100 | 100 | 90 | 90 | 90 |
| 100.0 | A | 100 | 100 | 80 | 80 | 70 |
| | B | 100 | 100 | 90 | 90 | 90 |

TABLE E-I-11

SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TESTS
FINAL CELL COUNTS
(X $10^4$ cells/mℓ)

| Effluent (Percent) | Replicate | Testing Period: Sept. 1988 | May 1989 | June 1989 | Jan. 1990 | May 1990 |
|---|---|---|---|---|---|---|
| 0.0 | A | 114.8 | 100.4 | 194.9 | 117.6 | 19.8 |
| | B | 149.9 | 105.5 | 218.1 | 101.6 | 20.4 |
| | C | 138.5 | 108.6 | 201.8 | 110.5 | 20.1 |
| 6.25 | A | 102.4 | 133.0 | 200.8 | 0.0[a] | 17.6 |
| | B | 122.4 | 129.4 | 176.8 | 19.4 | 17.9 |
| | C | 142.3 | 129.8 | 176.6 | 9.5 | 17.8 |
| 12.5 | A | 100.8 | 127.9 | 191.8 | 81.1 | 22.5 |
| | B | 85.3 | 125.9 | 103.9 | 93.1 | 18.8 |
| | C | 96.0 | 124.8 | 131.3 | 99.1 | 17.0 |
| 25.0 | A | 57.3 | 103.6 | 151.3 | 18.8 | 19.4 |
| | B | 53.4 | 113.3 | 120.3 | 76.6 | 27.3 |
| | C | 77.0 | 117.3 | 125.0 | 64.9 | 23.0 |
| 50.0 | A | 62.5 | 166.5 | 108.9 | 66.3 | 22.1 |
| | B | 67.7 | 174.5 | 101.8 | 37.5 | 31.0 |
| | C | 68.4 | 172.3 | 89.3 | 33.8 | 22.6 |
| 100.0 | A | 75.3 | 203.3 | 50.5 | 41.3 | 39.0 |
| | B | 50.5 | 208.0 | 44.5 | 19.1 | 32.8 |
| | C | 46.8 | 204.1 | 43.0 | 45.9 | 24.8 |

[a] Total mortality occurred in this test chamber. The 6.25 percent effluent treatment was invalidated because the low counts suggested possible contamination of the test flasks.

## TABLE E-I-12

## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## PERCENT SURVIVING
## SEPTEMBER 1988

| Effluent (Percent) | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 6.25 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12.5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## TABLE E-I-13

## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## PERCENT SURVIVING
## MAY 1989

| Effluent (Percent) | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 60 | 60 | 60 |
| 6.25 | 100 | 100 | 100 | 100 | 100 | 70 | 70 | 70 |
| 12.5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

## TABLE E-I-14
## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## PERCENT SURVIVING
## JUNE 1989

| Effluent (Percent) | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | 100 | 100 | 100 | 100 | 10 | a | a | a |
| 6.25 | 100 | 100 | 100 | 100 | 30 | a | a | a |
| 12.5 | 100 | 100 | 100 | 100 | 90 | a | a | a |
| 25.0 | 100 | 100 | 100 | 100 | 90 | a | a | a |
| 50.0 | 100 | 100 | 100 | 100 | 100 | a | a | a |
| 100.0 | 100 | 100 | 100 | 100 | 100 | a | a | a |

[a] The test was terminated after four days due to the excessive control mortality.

## TABLE E-I-15
## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## PERCENT SURVIVING
## JANUARY 1990

| Effluent (Percent) | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 6.25 | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| 12.5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

TABLE E-I-16

CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
PERCENT SURVIVING
MAY 1990

| Effluent (Percent) | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 6.25 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12.5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | 100 | 100 | 90 | 90 | 90 | 90 | 90 | 90 |

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TABLE E-I-17

CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
DAILY REPRODUCTION DATA
NUMBER OF NEONATES
SEPTEMBER 1988

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 0.0 | A | 0 | 5 | 5 | 11 | 12 |
| | B | 0 | 3 | 7 | 13 | 11 |
| | C | 0 | 3 | 4 | 10 | 8 |
| | D | 0 | 2 | 3 | 15 | 7 |
| | E | 0 | 2 | 2 | 13 | 5 |
| | F | 0 | 3 | 5 | 14 | 3 |
| | G | 0 | 0 | 3 | 12 | 1 |
| | H | 0 | 4 | 2 | 9 | 11 |
| | I | 0 | 2 | 2 | 11 | 2 |
| | J | 0 | 3 | 4 | 8 | 1 |
| 6.25 | A | 0 | 2 | 5 | 9 | 10 |
| | B | 0 | 2 | 4 | 13 | 5 |
| | C | 0 | 1 | 3 | 10 | 3 |
| | D | 0 | 3 | 5 | 8 | 10 |
| | E | 0 | 2 | 7 | 11 | 8 |
| | F | 0 | 2 | 3 | 9 | 9 |
| | G | 0 | 1 | 2 | 8 | 7 |
| | H | 0 | 1 | 2 | 14 | 7 |
| | I | 0 | 1 | 2 | 12 | 6 |
| | J | 0 | 2 | 1 | 10 | 5 |
| 12.5 | A | 0 | 1 | 2 | 10 | 3 |
| | B | 0 | 4 | 2 | 7 | 5 |
| | C | 0 | 3 | 3 | 12 | 9 |
| | D | 0 | 0 | 3 | 11 | 7 |
| | E | 0 | 0 | 5 | 8 | 6 |
| | F | 0 | 1 | 5 | 7 | 9 |
| | G | 0 | 2 | 4 | 12 | 3 |
| | H | 0 | 4 | 1 | 10 | 5 |
| | I | 0 | 0 | 2 | 10 | 4 |
| | J | 0 | 3 | 2 | 15 | 6 |

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TABLE E-I-17
(Continued)

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 25.0 | A | 0 | 0 | 1 | 6 | 6 |
| | B | 0 | 1 | 5 | 8 | 5 |
| | C | 0 | 2 | 6 | 10 | 3 |
| | D | 0 | 1 | 3 | 11 | 4 |
| | E | 0 | 4 | 3 | 5 | 7 |
| | F | 0 | 2 | 1 | 8 | 3 |
| | G | 0 | 0 | 4 | 7 | 4 |
| | H | 0 | 1 | 1 | 10 | 3 |
| | I | 0 | 2 | 1 | 7 | 9 |
| | J | 0 | 1 | 3 | 4 | 3 |
| 50.0 | A | 0 | 1 | 1 | 10 | 1 |
| | B | 0 | 0 | 1 | 6 | 6 |
| | C | 0 | 3 | 2 | 8 | 2 |
| | D | 0 | 0 | 3 | 6 | 4 |
| | E | 0 | 3 | 5 | 2 | 8 |
| | F | 0 | 0 | 3 | 7 | 2 |
| | G | 0 | 3 | 1 | 5 | 5 |
| | H | 0 | 2 | 2 | 9 | 3 |
| | I | 0 | 2 | 3 | 10 | 2 |
| | J | 0 | 3 | 1 | 8 | 1 |
| 100.0 | A | 0 | 2 | 1 | 9 | 2 |
| | B | 0 | 2 | 0 | 10 | 3 |
| | C | 0 | 0 | 0 | 9 | 2 |
| | D | 0 | 0 | 0 | 8 | 3 |
| | E | 0 | 0 | 0 | 13 | 2 |
| | F | 0 | 0 | 2 | 12 | 3 |
| | G | 0 | 2 | 2 | 3 | 5 |
| | H | 0 | 2 | 0 | 11 | 2 |
| | I | 0 | 2 | 0 | 8 | 3 |
| | J | 0 | 1 | 0 | 9 | 2 |

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TABLE E-I-18

CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
DAILY REPRODUCTION DATA
NUMBER OF NEONATES
MAY 1988

| Effluent (Percent) | Replicate | Testing Interval (Days) | | | | |
|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 |
| 0.0 | A | 0 | 4 | a | a | a |
| | B | 0 | 4 | a | a | a |
| | C | 0 | 5 | 8 | 0 | 0 |
| | D | 0 | 6 | a | a | a |
| | E | 0 | 4 | 6 | 3 | 3 |
| | F | 0 | 5 | 6 | 4 | 7 |
| | G | 0 | 5 | 8 | 5 | 0 |
| | H | 0 | 3 | 7 | 7 | 0 |
| | I | 0 | 4 | a | a | a |
| | J | 0 | 5 | 5 | 4 | 3 |
| 6.25 | A | 0 | 3 | 6 | 5 | 0 |
| | B | 0 | 4 | 8 | 9 | 0 |
| | C | 0 | 4 | 7 | 7 | 0 |
| | D | 0 | 3 | 5 | 6 | 0 |
| | E | 0 | 5 | 4 | 5 | 8 |
| | F | 0 | 4 | 6 | 1 | 10 |
| | G | 0 | 5 | 4 | 9 | 0 |
| | H | 0 | 4 | a | a | a |
| | I | 0 | 3 | a | a | a |
| | J | 0 | 7 | a | a | a |
| 12.5 | A | 0 | 5 | 8 | 2 | 16 |
| | B | 0 | 5 | 4 | 7 | 0 |
| | C | 0 | 3 | 6 | 9 | 0 |
| | D | 0 | 4 | 5 | 8 | 0 |
| | E | 0 | 4 | 5 | 6 | 0 |
| | F | 0 | 3 | 6 | 3 | 1 |
| | G | 0 | 3 | 5 | 5 | 0 |
| | H | 0 | 3 | 4 | 3 | 9 |
| | I | 0 | 3 | 2 | 5 | 0 |
| | J | 0 | 2 | 5 | 2 | 1 |

See footnote at end of table.

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**TABLE E-I-18**
**(Continued)**

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 25.0 | A | 0 | 2 | 8 | 0 | 9 |
| | B | 0 | 3 | 9 | 2 | 11 |
| | C | 0 | 3 | 6 | 7 | 13 |
| | D | 0 | 5 | 5 | 0 | 12 |
| | E | 0 | 2 | 4 | 5 | 0 |
| | F | 0 | 3 | 10 | 8 | 0 |
| | G | 0 | 2 | 1 | 7 | 4 |
| | H | 0 | 3 | 8 | 6 | 2 |
| | I | 0 | 2 | 2 | 2 | 11 |
| | J | 0 | 5 | 4 | 3 | 7 |
| 50.0 | A | 0 | 4 | 4 | 2 | 13 |
| | B | 0 | 0 | 7 | 8 | 12 |
| | C | 0 | 5 | 6 | 4 | 13 |
| | D | 0 | 5 | 7 | 9 | 0 |
| | E | 0 | 3 | 5 | 8 | 0 |
| | F | 0 | 4 | 7 | 0 | 11 |
| | G | 0 | 4 | 6 | 3 | 9 |
| | H | 0 | 0 | 0 | 3 | 9 |
| | I | 0 | 3 | 8 | 3 | 14 |
| | J | 0 | 4 | 5 | 4 | 10 |
| 100.0 | A | 0 | 3 | 8 | 1 | 13 |
| | B | 0 | 4 | 5 | 0 | 15 |
| | C | 0 | 4 | 7 | 0 | 19 |
| | D | 0 | 3 | 9 | 0 | 19 |
| | E | 0 | 4 | 6 | 3 | 15 |
| | F | 0 | 4 | 1 | 10 | 11 |
| | G | 0 | 2 | 7 | 0 | 16 |
| | H | 0 | 4 | 6 | 1 | 15 |
| | I | 0 | 3 | 7 | 1 | 8 |
| | J | 0 | 2 | 10 | 3 | 13 |

[a] No neonates due to test organism mortality.

TABLE E-I-19

CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
DAILY REPRODUCTION DATA
NUMBER OF NEONATES
JUNE 1989

| Effluent (Percent) | Replicate | Testing Interval (Days)[a] 3 | 4 |
|---|---|---|---|
| 0.0 | A | 0 | 3 |
| | B | 0 | 2 |
| | C | 0 | 0 |
| | D | 0 | 0 |
| | E | 0 | 2 |
| | F | 0 | 3 |
| | G | 0 | 3 |
| | H | 0 | 3 |
| | I | 0 | 6 |
| | J | 0 | 4 |
| 6.25 | A | 0 | 3 |
| | B | 0 | 0 |
| | C | 0 | 0 |
| | D | 0 | 4 |
| | E | 0 | 3 |
| | F | 0 | 3 |
| | G | 0 | 3 |
| | H | 0 | 1 |
| | I | 0 | 3 |
| | J | 0 | 3 |
| 12.5 | A | 0 | 4 |
| | B | 0 | 3 |
| | C | 0 | 4 |
| | D | 0 | 3 |
| | E | 0 | 5 |
| | F | 0 | 2 |
| | G | 0 | 3 |
| | H | 0 | 3 |
| | I | 0 | 5 |
| | J | 0 | 1 |

See footnote at end of table.

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**TABLE E-I-19**
**(Continued)**

| Effluent (Percent) | Replicate | Testing Interval (Days)[a] 3 | 4 |
|---|---|---|---|
| 25.0 | A | 0 | 3 |
| | B | 0 | 3 |
| | C | 0 | 3 |
| | D | 0 | 4 |
| | E | 0 | 4 |
| | F | 0 | 4 |
| | G | 0 | 0 |
| | H | 0 | 5 |
| | I | 0 | 4 |
| | J | 0 | 5 |
| 50.0 | A | 0 | 4 |
| | B | 0 | 2 |
| | C | 0 | 2 |
| | D | 0 | 3 |
| | E | 0 | 4 |
| | F | 0 | 4 |
| | G | 0 | 3 |
| | H | 0 | 5 |
| | I | 0 | 4 |
| | J | 0 | 2 |
| 100.0 | A | 0 | 3 |
| | B | 0 | 3 |
| | C | 0 | 4 |
| | D | 0 | 4 |
| | E | 0 | 3 |
| | F | 0 | 4 |
| | G | 0 | 3 |
| | H | 0 | 1 |
| | I | 0 | 5 |
| | J | 0 | 1 |

[a] Test terminated after four days due to excessive control mortality.

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# TABLE E-I-20

## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## DAILY REPRODUCTION DATA
## NUMBER OF NEONATES
## JANUARY 1990

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 0.0 | A | 0 | 2 | 0 | 0 | 0 |
| | B | 0 | 0 | 0 | 0 | 15 |
| | C | 0 | 5 | 9 | 0 | 13 |
| | D | 0 | 3 | 0 | 0 | 10 |
| | E | 0 | 4 | 8 | 0 | 10 |
| | F | 0 | 6 | 8 | 2 | 13 |
| | G | 0 | 4 | 0 | 5 | 10 |
| | H | 0 | 8 | 2 | 0 | 8 |
| | I | 0 | 2 | 9 | 0 | 8 |
| | J | 0 | 6 | 6 | 0 | 12 |
| 6.25 | A | 0 | 3 | 5 | 0 | 10 |
| | B | 0 | 3 | 1 | 4 | 9 |
| | C | 0 | 2 | 10 | 0 | 13 |
| | D | 0 | 0 | 0 | 0 | 0 |
| | E | 0 | 4 | 2 | 4 | 12 |
| | F | 0 | 0 | 0 | 3 | 10 |
| | G | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 3 | 9 | 0 | 16 |
| | I | 0 | 4 | 8 | 2 | 13 |
| | J | 0 | 4 | 2 | 3 | a |
| 12.5 | A | 0 | 1 | 0 | 2 | 16 |
| | B | 0 | 3 | 6 | 0 | 12 |
| | C | 0 | 3 | 9 | 2 | 13 |
| | D | 0 | 5 | 0 | 0 | 11 |
| | E | 0 | 4 | 7 | 0 | 14 |
| | F | 0 | 5 | 10 | 1 | 13 |
| | G | 0 | 4 | 11 | 0 | 14 |
| | H | 0 | 4 | 0 | 1 | 14 |
| | I | 0 | 0 | 0 | 0 | 0 |
| | J | 0 | 3 | 7 | 0 | 14 |

See footnote at end of table.

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**TABLE E-I-20**
**(Continued)**

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 25.0 | A | 0 | 0 | 0 | 0 | 0 |
| | B | 0 | 1 | 3 | 0 | 10 |
| | C | 0 | 0 | 0 | 8 | 0 |
| | D | 0 | 3 | 8 | 9 | 16 |
| | E | 0 | 2 | 8 | 1 | 18 |
| | F | 0 | 3 | 11 | 1 | 14 |
| | G | 0 | 2 | 8 | 6 | 16 |
| | H | 0 | 4 | 0 | 0 | 14 |
| | I | 0 | 3 | 10 | 0 | 13 |
| | J | 0 | 0 | 0 | 6 | 0 |
| 50.0 | A | 0 | 2 | 0 | 6 | 13 |
| | B | 0 | 4 | 8 | 0 | 15 |
| | C | 0 | 1 | 0 | 0 | 14 |
| | D | 0 | 5 | 0 | 0 | 13 |
| | E | 0 | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 | 0 |
| | G | 0 | 4 | 0 | 0 | 14 |
| | H | 0 | 4 | 8 | 0 | 16 |
| | I | 0 | 0 | 9 | 0 | 12 |
| | J | 0 | 2 | 0 | 0 | 14 |
| 100.0 | A | 0 | 0 | 0 | 13 | 14 |
| | B | 0 | 0 | 2 | 0 | 0 |
| | C | 0 | 3 | 4 | 0 | 15 |
| | D | 0 | 1 | 2 | 7 | 10 |
| | E | 0 | 0 | 3 | 0 | 0 |
| | F | 0 | 4 | 8 | 0 | 17 |
| | G | 0 | 0 | 0 | 0 | 0 |
| | H | 0 | 0 | 0 | 0 | 0 |
| | I | 0 | 0 | 9 | 0 | 15 |
| | J | 0 | 5 | 7 | 14 | 16 |

[a] No neonates due to death of test organism.

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# TABLE E-I-21

## CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST
## DAILY REPRODUCTION DATA
## NUMBER OF NEONATES
## MAY 1990

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 0.0 | A | 0 | 2 | 4 | 17 | 10 |
| | B | 2 | 2 | 3 | 8 | 9 |
| | C | 0 | 3 | 2 | 14 | 10 |
| | D | 0 | 2 | 5 | 14 | 8 |
| | E | 3 | 3 | 6 | 12 | 6 |
| | F | 0 | 3 | 4 | 14 | 8 |
| | G | 2 | 3 | 3 | 17 | 9 |
| | H | 0 | 4 | 4 | 12 | 11 |
| | I | 1 | 5 | 5 | 15 | 10 |
| | J | 0 | 3 | 2 | 12 | 9 |
| 6.25 | A | 0 | 5 | 7 | 12 | 10 |
| | B | 0 | 0 | 6 | 12 | 8 |
| | C | 3 | 2 | 4 | 12 | 8 |
| | D | 0 | 4 | 3 | 9 | 10 |
| | E | 0 | 4 | 5 | 17 | 6 |
| | F | 2 | 3 | 0 | 16 | 9 |
| | G | 0 | 2 | 3 | 14 | 3 |
| | H | 1 | 2 | 5 | 17 | 9 |
| | I | 0 | 4 | 2 | 10 | 1 |
| | J | 3 | 5 | 0 | 16 | 11 |
| 12.5 | A | 0 | 3 | 2 | 13 | 6 |
| | B | 0 | 5 | 5 | 14 | 12 |
| | C | 1 | 3 | 3 | 17 | 11 |
| | D | 0 | 3 | 5 | 13 | 9 |
| | E | 0 | 2 | 4 | 11 | 8 |
| | F | 0 | 2 | 6 | 14 | 8 |
| | G | 0 | 4 | 2 | 14 | 14 |
| | H | 2 | 3 | 2 | 18 | 9 |
| | I | 0 | 3 | 0 | 18 | 13 |
| | J | 0 | 5 | 0 | 13 | 12 |

See footnote at end of table.

**TABLE E-I-21**
**(Continued)**

| Effluent (Percent) | Replicate | Testing Interval (Days) 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 25.0 | A | 0 | 5 | 3 | 12 | 11 |
| | B | 0 | 4 | 2 | 5 | 8 |
| | C | 0 | 3 | 4 | 21 | 9 |
| | D | 0 | 0 | 0 | 17 | 10 |
| | E | 1 | 4 | 7 | 21 | 9 |
| | F | 0 | 3 | 3 | 19 | 7 |
| | G | 0 | 2 | 4 | 13 | 9 |
| | H | 0 | 2 | 2 | 17 | 8 |
| | I | 0 | 3 | 1 | 14 | 7 |
| | J | 0 | 4 | 5 | 19 | 10 |
| 50.0 | A | 0 | 4 | 2 | 19 | 7 |
| | B | 0 | 3 | 2 | 20 | 11 |
| | C | 0 | 3 | 4 | 17 | 10 |
| | D | 0 | 1 | 6 | 5 | 0 |
| | E | 0 | 2 | 5 | 0 | 0 |
| | F | 0 | 2 | 1 | 17 | 7 |
| | G | 0 | 2 | 5 | 18 | 12 |
| | H | 0 | 4 | 2 | 10 | 12 |
| | I | 0 | 4 | 2 | 12 | 7 |
| | J | 0 | 3 | 5 | 15 | 9 |
| 100.0 | A | 0 | 4 | 5 | 18 | 0 |
| | B | 2 | 2 | 0 | 18 | 10 |
| | C | 0 | 3 | 3 | 16 | 6 |
| | D | 0 | 2 | 5 | 14 | 7 |
| | E | 2 | 2 | 3 | 10 | 11 |
| | F | 0 | 0 | 0 | 18 | 11 |
| | G | a | a | a | a | a |
| | H | 0 | 3 | 5 | 15 | 12 |
| | I | 0 | 3 | 2 | 18 | 10 |
| | J | 0 | 4 | 2 | 15 | 5 |

[a] No neonates due to death of test organism.

## TABLE E-I-22

## PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST
## PERCENT SURVIVING
## SEPTEMBER 1988

| Effluent (Percent) | Replicate | Testing Interval (Days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 80 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |

TABLE E-I-23

PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST
PERCENT SURVIVING
MAY 1989

| Effluent (Percent) | Replicate | Testing Interval (Days) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | A | 100 | 100 | 100 | 90 | 90 | 90 | 90 | 80 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| 6.25 | A | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| | B | 100 | 90 | 90 | 90 | 90 | 80 | 80 | 80 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 | 80 | 70 | 70 |
| | B | 100 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 90 | 90 | 90 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 80 | 80 | 70 | 70 | 70 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

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TABLE E-I-24

PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST
PERCENT SURVIVING
JUNE 1988

| Effluent (Percent) | Replicate | Testing Interval (Days) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 90 | 90 | 90 | 90 | 90 |
| 6.25 | A | 100 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| | B | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

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# TABLE E-I-25

## PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST
## PERCENT SURVIVING
## JANUARY 1990

| Effluent (Percent) | Replicate | Testing Interval (Days) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | A | 100 | 100 | 90 | 90 | 90 | 90 | 90 | 90 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| | C | 100 | 100 | 100 | 100 | 90 | 90 | 90 | 90 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

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**TABLE E-I-26**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**PERCENT SURVIVING**
**MAY 1990**

| Effluent (Percent) | Replicate | Testing Interval (Days) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 90 | 90 | 90 | 90 | 90 | 90 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | D | 100 | 100 | 100 | 100 | 100 | 100 | 80 | 70 |
| 6.25 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | D | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12.5 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| | D | 100 | 100 | 100 | 100 | 100 | 100 | 80 | 80 |
| 25.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | D | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 |
| 50.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | D | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100.0 | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | C | 100 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| | D | 100 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |

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**TABLE E-I-27**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TESTS**
**MEAN FINAL DRY WEIGHT PER MINNOW (mg)**

| Effluent (Percent) | Replicate | Testing Period | | | | |
|---|---|---|---|---|---|---|
| | | Sept. 1988 | May 1989 | June 1989 | Jan. 1990 | May 1990 |
| 0.0 | A | 0.31 | 0.31 | 0.35 | 0.393 | 0.481 |
| | B | 0.34 | 0.41 | 0.31 | 0.504 | 0.493 |
| | C | | | | 0.484 | 0.409 |
| | D | | | | | 0.556 |
| 6.25 | A | 0.24 | 0.36 | 0.36 | 0.404 | 0.493 |
| | B | 0.29 | 0.22 | 0.30 | 0.314 | 0.503 |
| | C | | | | 0.381 | 0.445 |
| | D | | | | | 0.436 |
| 12.5 | A | 0.31 | 0.30 | 0.35 | 0.391 | 0.461 |
| | B | 0.33 | 0.23 | 0.38 | 0.533 | 0.547 |
| | C | | | | 0.312 | 0.402 |
| | D | | | | | 0.456 |
| 25.0 | A | 0.33 | 0.36 | 0.33 | 0.430 | 0.341 |
| | B | 0.31 | 0.29 | 0.32 | 0.384 | 0.497 |
| | C | | | | 0.411 | 0.506 |
| | D | | | | | 0.536 |
| 50.0 | A | 0.32 | 0.34 | 0.31 | 0.457 | 0.466 |
| | B | 0.33 | 0.23 | 0.21 | 0.496 | 0.478 |
| | C | | | | 0.416 | 0.466 |
| | D | | | | | 0.401 |
| 100.0 | A | 0.29 | 0.23 | 0.32 | 0.375 | 0.573 |
| | B | 0.37 | 0.28 | 0.28 | 0.329 | 0.499 |
| | C | | | | 0.391 | 0.637 |
| | D | | | | | 0.520 |

**ATTACHMENT E-II**
**WATER QUALITY DATA**

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**TABLE E-II-1**
**DAPHNIA PULEX (WATER FLEA) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**SEPTEMBER 1988**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 21.8 (0.5)[a] | 21.8 (0.6) | 21.8 (0.5) | 21.7 (0.6) | 21.5 (0.6) | 21.2 (0.2) |
| Dissolved Oxygen (mg/ℓ) | 8.0 (0.1) | 8.1 (0.1) | 8.1 (0.2) | 8.1 (0.1) | 8.2 (0.1) | 8.1 (0.1) |
| pH | 7.63 (0.42) | 7.88 (0.17) | 7.90 (0.17) | 7.94 (0.18) | 8.00 (0.19) | 8.07 (0.18) |
| Conductivity (µhos/cm) | 711 (12) | 786 (78) | 744 (9) | 767 (17) | 807 (33) | 887 (59) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 170 (0) | b | b | b | b | 217 (5) |
| Hardness (mg/ℓ as $CaCO_3$) | 257 (14) | b | b | b | b | 337 (5) |

[a] Arithmetic mean and standard deviation, ( ).

[b] Alkalinity and hardness measured for 0 and 100 percent effluent only.

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**TABLE E-II-2**

**DAPHNIA PULEX (WATER FLEA) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1989**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 20.8 (0.5)[a] | 20.8 (0.6) | 20.8 (0.6) | 20.9 (0.6) | 20.8 (0.6) | 20.4 (0.9) |
| Dissolved Oxygen (mg/ℓ) | 8.3 (0.1) | 8.4 (0.3) | 8.2 (0.1) | 8.2 (0.1) | 8.4 (0.2) | 8.3 (0.2) |
| pH | 7.97 (0.10) | 8.01 (0.12) | 8.01 (0.11) | 7.96 (0.16) | 7.96 (0.13) | 7.87 (0.11) |
| Conductivity (µhos/cm) | 672 (24) | 681 (19) | 682 (21) | 688 (35) | 701 (77) | 726 (160) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 214 (5) | 223 (14) | 214 (5) | 203 (14) | 187 (21) | 143 (5) |
| Hardness (mg/ℓ as $CaCO_3$) | 308 (18) | 311 (15) | 313 (10) | 296 (13) | 273 (13) | 223 (14) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-3**
**DAPHNIA PULEX (WATER FLEA) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JUNE 1989**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 20.0 (0.0)[a] | 20.0 (0.0) | 20.0 (0.0) | 20.0 (0.0) | 20.0 (0.0) | 20.0 (0.0) |
| Dissolved Oxygen (mg/ℓ) | 8.0 (0.4) | 8.1 (0.2) | 8.2 (0.1) | 8.3 (0.2) | 8.3 (0.0) | 8.5 (0.1) |
| pH | 7.91 (0.22) | 7.93 (0.23) | 8.01 (0.19) | 8.02 (0.21) | 8.05 (0.19) | 8.02 (0.13) |
| Conductivity (µhos/cm) | 525 (54) | 511 (54) | 511 (50) | 502 (53) | 517 (27) | 522 (30) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 194 (31) | 184 (16) | 181 (16) | 176 (21) | 161 (15) | 125 (8) |
| Hardness (mg/ℓ as $CaCO_3$) | 254 (27) | 231 (23) | 237 (24) | 229 (23) | 205 (14) | 157 (10) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-4**
**DAPHNIA PULEX (WATER FLEA) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JANUARY 1990**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 21.5 (0.0)[a] | 21.5 (0.0) | 21.5 (0.0) | 21.5 (0.0) | 21.5 (0.0) | 21.7 (0.3) |
| Dissolved Oxygen (mg/ℓ) | 9.2 (0.8) | 9.4 (0.7) | 9.4 (0.7) | 9.5 (0.5) | 9.4 (0.5) | 9.3 (0.2) |
| pH | 8.20 (0.21) | 8.22 (0.20) | 8.23 (0.21) | 8.23 (0.20) | 8.18 (0.16) | 8.06 (0.18) |
| Conductivity (µmhos/cm) | 800 (77) | 750 (44) | 750 (45) | 717 (26) | 717 (26) | 650 (77) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 251 (14) | 263 (18) | 249 (1) | 228 (15) | 189 (7) | 113 (6) |
| Hardness (mg/ℓ as $CaCO_3$) | 375 (12) | 359 (2) | 351 (23) | 338 (17) | 293 (6) | 215 (19) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-5**

**DAPHNIA PULEX (WATER FLEA) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1990**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 20.7 (0.3)[a] | 20.7 (0.3) | 20.7 (0.3) | 20.7 (0.3) | 20.5 (0.4) | 20.5 (0.4) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.5) | 7.9 (0.5) | 7.9 (0.4) | 8.0 (0.4) | 7.9 (0.4) | 7.9 (0.4) |
| pH | 8.44 (0.17) | 8.45 (0.18) | 8.43 (0.18) | 8.40 (0.17) | 8.31 (0.16) | 7.74 (0.10) |
| Conductivity (µhos/cm) | 667 (26) | 667 (52) | 667 (52) | 650 (45) | 650 (45) | 617 (68) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 231 (7) | 227 (11) | 219 (8) | 201 (7) | 169 (8) | 101 (8) |
| Hardness (mg/ℓ as $CaCO_3$) | 357 (5) | 357 (5) | 353 (5) | 327 (23) | 303 (29) | 227 (14) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-6**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**SEPTEMBER 1988**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 21.4 (0.3)[a] | 21.4 (0.3) | 21.4 (0.4) | 21.4 (0.3) | 21.4 (0.4) | 21.4 (0.7) |
| Dissolved Oxygen (mg/ℓ) | 7.4 (0.4) | 7.4 (0.6) | 7.4 (0.5) | 7.5 (0.5) | 7.7 (0.2) | 7.9 (0.1) |
| pH | 7.87 (0.08) | 7.90 (0.06) | 7.86 (0.15) | 7.93 (0.10) | 7.92 (0.11) | 7.94 (0.14) |
| Conductivity (µhos/cm) | 803 (16) | 813 (5) | 799 (39) | 831 (12) | 851 (28) | 891 (48) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 188 (8) | 190 (11) | 191 (6) | 196 (5) | 199 (7) | 210 (12) |
| Hardness (mg/ℓ as $CaCO_3$) | 291 (12) | 294 (12) | 289 (13) | 302 (10) | 309 (24) | 321 (22) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-7**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1989**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 20.9 (0.7)[a] | 20.9 (0.7) | 20.9 (0.6) | 20.9 (0.6) | 20.7 (0.5) | 20.5 (0.7) |
| Dissolved Oxygen (mg/ℓ) | 8.1 (0.1) | 8.2 (0.1) | 8.2 (0.1) | 8.2 (0.1) | 8.3 (0.1) | 8.3 (0.4) |
| pH | 7.90 (0.12) | 7.98 (0.07) | 8.00 (0.07) | 7.97 (0.12) | 7.97 (0.10) | 7.93 (0.12) |
| Conductivity (µhos/cm) | 670 (15) | 681 (14) | 686 (18) | 692 (28) | 704 (57) | 731 (117) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 226 (29) | 218 (13) | 214 (11) | 207 (13) | 192 (24) | 159 (16) |
| Hardness (mg/ℓ as $CaCO_3$) | 317 (19) | 317 (19) | 307 (8) | 304 (22) | 282 (29) | 222 (27) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-8**
**PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JUNE 1989**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 21.7 (0.9)[a] | 21.7 (0.9) | 21.7 (0.9) | 21.7 (0.9) | 21.6 (0.9) | 21.4 (0.8) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.4) | 7.9 (0.5) | 7.9 (0.6) | 8.2 (0.6) | 8.1 (0.6) | 8.1 (0.6) |
| pH | 7.87 (0.13) | 7.90 (0.14) | 7.97 (0.09) | 7.87 (0.13) | 7.89 (0.13) | 7.84 (0.15) |
| Conductivity (µhos/cm) | 617 (93) | 614 (95) | 610 (91) | 568 (87) | 551 (80) | 524 (80) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 203 (31) | 199 (26) | 193 (23) | 177 (17) | 156 (8) | 114 (13) |
| Hardness (mg/ℓ as $CaCO_3$) | 274 (40) | 260 (43) | 260 (35) | 243 (26) | 210 (13) | 153 (18) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-9**
**PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JANUARY 1990**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 20.5 (1.0)[a] | 20.5 (1.0) | 20.5 (1.0) | 20.5 (1.0) | 20.5 (1.0) | 20.7 (1.1) |
| Dissolved Oxygen (mg/ℓ) | 9.4 (1.0) | 9.6 (0.9) | 9.5 (0.9) | 9.6 (0.8) | 9.5 (0.9) | 9.3 (0.6) |
| pH | 8.01 (0.14) | 8.02 (0.14) | 8.02 (0.14) | 8.00 (0.15) | 7.93 (0.17) | 7.72 (0.26) |
| Conductivity (µhos/cm) | 785 (71) | 760 (61) | 750 (47) | 740 (39) | 750 (47) | 760 (131) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 259 (22) | 261 (21) | 245 (10) | 234 (16) | 200 (20) | 125 (39) |
| Hardness (mg/ℓ as $CaCO_3$) | 379 (14) | 374 (32) | 348 (23) | 346 (27) | 317 (42) | 238 (60) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-10**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) ACUTE TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1990**

| Variable | Effluent Percent | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 6.25 | 12.5 | 25 | 50 | 100 |
| Temperature (°C) | 21.0 (0.5)[a] | 20.9 (0.4) | 21.0 (0.3) | 21.0 (0.3) | 20.9 (0.5) | 20.9 (0.5) |
| Dissolved Oxygen (mg/ℓ) | 7.8 (0.9) | 7.9 (0.8) | 8.1 (0.7) | 8.1 (0.7) | 8.1 (0.5) | 8.2 (0.5) |
| pH | 8.35 (0.20) | 8.34 (0.18) | 8.30 (0.16) | 8.25 (0.14) | 8.15 (0.15) | 7.80 (0.14) |
| Conductivity (µhos/cm) | 665 (41) | 680 (42) | 680 (26) | 670 (26) | 665 (24) | 630 (54) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 229 (2) | 220 (7) | 215 (4) | 196 (4) | 163 (3) | 101 (11) |
| Hardness (mg/ℓ as $CaCO_3$) | 356 (22) | 334 (20) | 324 (23) | 312 (26) | 284 (33) | 220 (18) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-11**
**SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**SEPTEMBER 1988**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 24.0[a] (0.0)[b] | 24.0[a] (0.0)[b] | 24.0[a] (0.0)[b] | 24.0[a] (0.0)[b] |
| pH | 7.96[c] | 7.96[c] | 7.96[c] | 8.00[c] |
| Conductivity[c] (µhos/cm) | 600 | 650 | 650 | 700 |
| Alkalinity[d] (mg/ℓ as $CaCO_3$) | | | | |
| Hardness[d] (mg/ℓ as $CaCO_3$) | | | | |

[a] Temperature measured on environmental chamber, rather than in test flasks, except for initial measurement.

[b] Arithmetic mean and standard deviation, ( ).

[c] Initial measurement only.

[d] Variable not measured.

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**TABLE E-II-12**

**SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1989**

| Variable | Effluent Percent | | | |
|---|---|---|---|---|
| | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 24.6[a] (0.4)[b] | 24.6[a] (0.4) | 24.5[a] (0.5) | 24.5[a] (0.5) |
| pH[c] | 8.08 | 8.13 | 8.13 | 7.99 |
| Conductivity[c] (µhos/cm) | 677 | 692 | 762 | 934 |
| Alkalinity[c] (mg/ℓ as $CaCO_3$) | 290 | 230 | 280 | 150 |
| Hardness[c] (mg/ℓ as $CaCO_3$) | 310 | 410 | 380 | 400 |

[a] Temperature measured on environmental chamber except for initial measurement.
[b] Arithmetic mean and standard deviation, ( ).
[c] Initial measurement only.

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**TABLE E-II-13**

**SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JUNE 1989**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.0[a] (0.0)[b] | 25.0[a] (0.0)[b] | 25.0[a] (0.0)[b] | 25.0[a] (0.0)[b] |
| pH | 8.07 | 8.12 | 8.11 | 8.09 |
| Conductivity[c] (µhos/cm) | 757 | 748 | 720 | 639 |
| Alkalinity[c] (mg/ℓ as $CaCO_3$) | 280 | 240 | 230 | 230 |
| Hardness[c] (mg/ℓ as $CaCO_3$) | 330 | 320 | 280 | 340 |

[a] Temperature measured on environmental chamber except for initial measurement.

[b] Arithmetic mean and standard deviation, ( ).

[c] Initial measurement only.

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**TABLE E-II-14**

**SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JANUARY 1990**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.3[a] (0.3)[b] | 25.3[a] (0.3) | 25.3[a] (0.3) | 25.3[a] (0.3) |
| pH[c] | 7.72 | 8.01 | 8.15 | 8.21 |
| Conductivity[c] (µhos/cm) | 500 | 500 | 750 | 750 |
| Alkalinity[c] (mg/ℓ as $CaCO_3$) | 256 | 256 | 240 | 128 |
| Hardness[c] (mg/ℓ as $CaCO_3$) | 368 | 384 | 340 | 232 |

[a] Temperature meausred on environmental chamber except for initial measurement.

[b] Arithmetic mean and standard deviation, ( ).

[c] Initial measurement only.

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**TABLE E-II-15**

**SELENASTRUM CAPRICORNUTUM (GREEN ALGA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1990**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 24.5[a] (0.4)[b] | 24.5[a] (0.4) | 24.5[a] (0.4) | 24.5[a] (0.4) |
| pH[c] | 8.21 | 8.21 | 8.18 | 7.78 |
| Conductivity[c] (µhos/cm) | 650 | 650 | 600 | 500 |
| Alkalinity[c] (mg/ℓ as $CaCO_3$) | 210 | 210 | 190 | 90 |
| Hardness[c] (mg/ℓ as $CaCO_3$) | 330 | 320 | 290 | 190 |

[a] Temperature meausred on environmental chamber except for initial measurement.

[b] Arithmetic mean and standard deviation, ( ).

[c] Initial measurement only.

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**TABLE E-II-16**

**CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**SEPTEMBER 1988**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 23.8 (0.5)[a] | 23.8 (0.5) | 23.8 (0.5) | 23.8 (0.5) |
| Dissolved Oxygen (mg/ℓ) | 8.1 (0.5) | 8.2 (0.4) | 8.3 (0.5) | 7.8 (0.9) |
| pH | 7.94 (0.17) | 7.96 (0.16) | 8.00 (0.16) | 8.06 (0.17) |
| Conductivity (µhos/cm) | 747 (53) | 803 (73) | 810 (54) | 933 (60) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 176 (17) | 187 (26) | 190 (20) | 217 (26) |
| Hardness (mg/ℓ as $CaCO_3$) | 280 (39) | 287 (34) | 296 (35) | 343 (42) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-17**

**CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1989**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.0 (0.7)[a] | 25.0 (0.7) | 25.0 (0.7) | 24.8 (0.7) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.7) | 7.7 (0.7) | 7.7 (0.8) | 7.7 (0.9) |
| pH | 8.09 (0.25) | 8.14 (0.19) | 8.14 (0.18) | 8.00 (0.22) |
| Conductivity (µhos/cm) | 713 (85) | 709 (83) | 687 (45) | 715 (110) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 205 (14) | 211 (11) | 205 (11) | 164 (21) |
| Hardness (mg/ℓ as $CaCO_3$) | 318 (38) | 319 (37) | 304 (35) | 233 (31) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-18**

**CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JUNE 1989**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.0 (0.0)[a] | 25.0 (0.0) | 25.0 (0.0) | 25.0 (0.0) |
| Dissolved Oxygen (mg/ℓ) | 7.8 (0.2) | 8.0 (0.4) | 8.1 (0.5) | 8.1 (0.5) |
| pH | 8.01 (0.36) | 8.02 (0.33) | 8.06 (0.27) | 8.11 (0.47) |
| Conductivity (µhos/cm) | 564 (116) | 564 (110) | 547 (80) | 522 (88) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 210 (41) | 194 (19) | 185 (21) | 127 (20) |
| Hardness (mg/ℓ as $CaCO_3$) | 270 (33) | 258 (42) | 244 (30) | 153 (16) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-19**

**CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JANUARY 1990**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.3 (0.3)[a] | 25.3 (0.3) | 25.3 (0.3) | 25.4 (0.4) |
| Dissolved Oxygen (mg/ℓ) | 8.9 (1.0) | 9.0 (0.9) | 9.0 (1.0) | 8.8 (0.9) |
| pH | 8.07 (0.22) | 8.09 (0.20) | 8.04 (0.25) | 7.89 (0.20) |
| Conductivity (µhos/cm) | 764 (99) | 757 (79) | 779 (108) | 836 (255) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 243 (27) | 234 (28) | 209 (29) | 104 (15) |
| Hardness (mg/ℓ as $CaCO_3$) | 356 (39) | 347 (33) | 314 (29) | 207 (30) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-20**

**CERIODAPHNIA DUBIA (WATER FLEA) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1990**

| Variable | Effluent Percent | | | |
|---|---|---|---|---|
| | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.1 (0.2)[a] | 25.1 (0.2) | 25.1 (0.2) | 25.1 (0.2) |
| Dissolved Oxygen (mg/ℓ) | 7.6 (0.6) | 7.7 (0.6) | 7.8 (0.6) | 7.8 (0.5) |
| pH | 8.36 (0.45) | 8.34 (0.41) | 8.31 (0.36) | 8.06 (0.37) |
| Conductivity (µhos/cm) | 571 (173) | 591 (156) | 593 (102) | 657 (84) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 199 (47) | 196 (46) | 182 (27) | 113 (19) |
| Hardness (mg/ℓ as $CaCO_3$) | 319 (77) | 304 (56) | 303 (43) | 241 (30) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-21**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**SEPTEMBER 1988**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 23.8 (0.5)[a] | 23.8 (0.5) | 23.8 (0.5) | 23.8 (0.5) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.9) | 8.0 (0.5) | 8.3 (0.8) | 8.1 (1.0) |
| pH | 7.85 (0.15) | 7.94 (0.20) | 8.02 (0.28) | 8.04 (0.26) |
| Conductivity (µhos/cm) | 863 (111) | 876 (104) | 927 (130) | 1003 (149) |
| Alkalinity[b] (mg/ℓ as $CaCO_3$) | 183 (13) | --- | --- | 216 (12) |
| Hardness[b] (mg/ℓ as $CaCO_3$) | 297 (15) | --- | --- | 339 (30) |

[a] Arithmetic mean and standard deviation, ( ).

[b] Measured in controls and 100 percent effluent only.

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**TABLE E-II-22**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1989**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.0 (0.7)[a] | 25.1 (0.6) | 25.1 (0.6) | 25.0 (0.5) |
| Dissolved Oxygen (mg/ℓ) | 7.4 (0.9) | 7.4 (0.9) | 7.3 (1.0) | 7.2 (1.0) |
| pH | 8.01 (0.14) | 8.07 (0.11) | 8.04 (0.12) | 7.92 (0.09) |
| Conductivity (µhos/cm) | 749 (185) | 749 (194) | 726 (142) | 771 (194) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 207 (16) | 210 (10) | 206 (12) | 166 (24) |
| Hardness (mg/ℓ as $CaCO_3$) | 324 (53) | 325 (51) | 304 (35) | 234 (55) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-23**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JUNE 1989**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.1 (0.6)[a] | 25.1 (0.6) | 25.1 (0.6) | 25.1 (0.6) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.3) | 8.0 (0.3) | 8.0 (0.4) | 8.0 (0.5) |
| pH | 7.96 (0.26) | 7.99 (0.24) | 8.02 (0.18) | 7.95 (0.09) |
| Conductivity (µhos/cm) | 579 (95) | 581 (93) | 553 (71) | 510 (87) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 218 (35) | 208 (25) | 193 (20) | 126 (19) |
| Hardness (mg/ℓ as $CaCO_3$) | 291 (38) | 289 (54) | 256 (30) | 155 (14) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-24**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**JANUARY 1990**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.3 (0.3)[a] | 25.3 (0.3) | 25.3 (0.3) | 25.4 (0.5) |
| Dissolved Oxygen (mg/ℓ) | 9.0 (1.0) | 8.8 (1.1) | 8.9 (1.1) | 8.8 (0.9) |
| pH | 8.01 (0.16) | 8.01 (0.16) | 8.04 (0.13) | 7.93 (0.22) |
| Conductivity (µhos/cm) | 764 (99) | 757 (79) | 779 (107) | 835 (254) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 243 (27) | 234 (28) | 209 (29) | 104 (15) |
| Hardness (mg/ℓ as $CaCO_3$) | 356 (39) | 347 (33) | 314 (29) | 207 (30) |

[a] Arithmetic mean and standard deviation, ( ).

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**TABLE E-II-25**

**PIMEPHALES PROMELAS (FATHEAD MINNOW) CHRONIC TEST**
**WATER QUALITY DATA**
**MEAN MEASUREMENTS**
**MAY 1990**

| | Effluent Percent | | | |
|---|---|---|---|---|
| Variable | 0 | 6.25 | 25 | 100 |
| Temperature (°C) | 25.1 (0.2)[a] | 25.1 (0.2) | 25.1 (0.2) | 25.1 (0.2) |
| Dissolved Oxygen (mg/ℓ) | 7.7 (0.7) | 7.8 (0.6) | 7.9 (0.6) | 7.9 (0.5) |
| pH | 8.32 (0.40) | 8.35 (0.40) | 8.27 (0.34) | 8.10 (0.39) |
| Conductivity (µhos/cm) | 571 (173) | 591 (156) | 593 (102) | 657 (84) |
| Alkalinity (mg/ℓ as $CaCO_3$) | 199 (47) | 195 (46) | 182 (27) | 113 (19) |
| Hardness (mg/ℓ as $CaCO_3$) | 319 (77) | 304 (56) | 303 (43) | 241 (30) |

[a] Arithmetic mean and standard deviation, ( ).

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# ATTACHMENT E-III
# REFERENCE TOXICANT DATA

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**TABLE E-III-1**

**REFERENCE TOXICANT DATA SUMMARY**
**DAPHNIA PULEX (WATER FLEA)**

| Date of Test Start | Age of Organisms | Test Type | Reference Toxicant and Source | Endpoint | Expected Range[a] |
|---|---|---|---|---|---|
| October 18, 1988 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 16.6 mg/ℓ | 9.5 - 20.5 mg/ℓ |
| May 8, 1989 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 9.3 mg/ℓ | 9.5 - 20.5 mg/ℓ |
| June 13, 1989 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 14.8 mg/ℓ | 9.5 - 20.5 mg/ℓ |
| February 21, 1990 | <24 hours | 48-hour acute | SDS 95 percent powder J.T. Baker | 48-hour $LC_{50}$ = 19.8 mg/ℓ | 18.5 - 20.4 mg/ℓ |
| June 1, 1990 | <24 hours | 48-hour acute | SDS 95 percent powder J.T. Baker | 48-hour $LC_{50}$ = 18.7 mg/ℓ | 18.5 - 20.4 mg/ℓ |

[a] For EPA - supplied reference toxicants, expected range from EPA, (no date).
For SDS powder, expected range is the laboratory's database range.

## TABLE E-III-2
## REFERENCE TOXICANT DATA SUMMARY
## CERIODAPHNIA DUBIA (WATER FLEA)

| Date of Test Start | Age of Organisms | Test Type | Reference Toxicant and Source | Endpoint | Expected Range[a] |
|---|---|---|---|---|---|
| October 18, 1988 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 12.4 mg/ℓ | 8.7 - 19.0 mg/ℓ |
| May 8, 1989 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 11.3 mg/ℓ | 8.7 - 19.0 mg/ℓ |
| June 13, 1989 | <24 hours | 48-hour acute | SDS EPA ampule | 24-hour $LC_{50}$ = 18.2 mg/ℓ | 8.7 - 19.0 mg/ℓ |
| June 13, 1989 | <24 hours | 7-day chronic | SDS EPA ampule | 7-day NOEC = 1.25 mg/ℓ | 0.3125 - 1.25 mg/ℓ |
| January 17, 1990 | <24 hours | 7-day chronic | SDS 95 percent powder J.T. Baker | 7-day NOEC = 0.625 mg/ℓ | 0.3125 - 1.25 mg/ℓ |
| June 1, 1990 | <24 hours | 7-day chronic | $CuSO_4$ EPA ampule | 7-day NOEC = 0.125 µg/ℓ | 0.0625 - 0.25 µg/ℓ |

[a] For EPA - supplied reference toxicants, expected range from EPA, (no date).
For SDS powder, expected range is the laboratory's database range.

## TABLE E-III-3

## REFERENCE TOXICANT DATA SUMMARY
## PIMEPHALES PROMELAS (FATHEAD MINNOW)

| Date of Test Start | Age of Organisms | Test Type | Reference Toxicant and Source | Endpoint | Expected Range[a] |
|---|---|---|---|---|---|
| September 5, 1988 | 28 days | 96-hour acute | SDS EPA ampule | 96-hour $LC_{50}$ = 7.5 mg/ℓ | 6.2 - 9.6 mg/ℓ |
| October 10, 1988 | <24 hours | 96-hour acute | SDS EPA ampule | 96-hour $LC_{50}$ = 7.4 mg/ℓ | 6.2 - 9.6 mg/ℓ |
| May 8, 1989 | 26 days | 96-hour acute | SDS EPA ampule | 96-hour $LC_{50}$ = 9.6 mg/ℓ | 6.2 - 9.6 mg/ℓ |
| May 9, 1989 | <24 hours | 96-hour acute | SDS EPA ampule | 96-hour $LC_{50}$ = 8.3 mg/ℓ | 6.2 - 9.6 mg/ℓ |
| June 13, 1989 | 27 days | 96-hour acute | SDS EPA ampule | 96-hour $LC_{50}$ = 7.1 mg/ℓ | 6.2 - 9.6 mg/ℓ |
| June 13, 1989 | <24 hours | 7-day chronic | SDS EPA ampule | 7-day NOEC = 5.0 mg/ℓ | 2.5 - 10.0 mg/ℓ |
| January 17, 1990 | <24 hours | 7-day chronic | SDS 95 percent powder J.T. Baker | 7-day NOEC = 20 mg/ℓ | 10 - 40 mg/ℓ |
| January 29, 1990 | 26 days | 96-hour acute | SDS 95 percent powder J.T. Baker | 96-hour $LC_{50}$ = 24.1 mg/ℓ | 20.0 - 33.6 mg/ℓ |
| May 1, 1990 | 18 days | 96-hour acute | SDS 95 percent powder J.T. Baker | 96-hour $LC_{50}$ = 31.4 mg/ℓ | 20.8 - 33.6 mg/ℓ |
| May 1, 1990 | <24 hours | 7-day chronic | $CuSO_4$ EPA ampule | 7-day NOEC = 25 µg/ℓ | 12.5 - 50 µg/ℓ |

[a] For EPA - supplied reference toxicants, expected range from EPA, (no date).
For SDS powder, expected range is the laboratory's database range.

**TABLE E-III-4**

**REFERENCE TOXICANT DATA SUMMARY**
**SELENASTRUM CAPRICORNUTUM (GREEN ALGA)**

| Date of Test Start | Age of Organisms | Test Type | Reference Toxicant and Source | Endpoint | Expected Range[a] |
|---|---|---|---|---|---|
| November 10, 1988 | 4 - 7 days | 96-hour chronic | SDS EPA ampule | 96-hour NOEC = 1.25 mg/ℓ | 0.625 - 2.5 mg/ℓ |
| November 9, 1989 | 4 - 7 days | 96-hour chronic | SDS EPA ampule | 96-hour NOEC = 1.25 mg/ℓ | 0.625 - 2.5 mg/ℓ |
| December 15, 1989 | 4 - 7 days | 96-hour chronic | SDS 95 percent powder J.T. Baker | 96-hour NOEC = 0.625 mg/ℓ | 0.625 - 2.5 mg/ℓ |
| January 26, 1990 | 4 - 7 days | 96-hour chronic | SDS 95 percent powder J.T. Baker | 96-hour NOEC = 0.625 mg/ℓ | 0.625 - 2.5 mg/ℓ |
| May 17, 1990 | 4 - 7 days | 96-hour chronic | SDS 95 percent powder J.T. Baker | 96-hour NOEC = 1.25 mg/ℓ | 0.625 - 2.5 mg/ℓ |

[a] For EPA - supplied reference toxicants, expected range from EPA, (no date).
For SDS powder, expected range is the laboratory's database range.

APPENDIX F

# APPENDIX F

## ACUTE TOXICITY TESTING OF SOILS AND SEDIMENTS FROM THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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# LIST OF ACRONYMS

| | |
|---|---|
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| DOE | U.S. Department of Energy |
| EIS | environmental impact statement |
| EPA | U.S. Environmental Protection Agency |
| FEMP | Fernald Environmental Management Project |
| FMPC | Feed Materials Production Center |
| FS | feasibility study |
| NEPA | National Environmental Policy Act |
| RI | remedial investigation |
| RI/FS | remedial investigation/feasibility study |
| RVR | Round Valley Reservoir |
| SDS | sodium dodecyl sulfate |
| SRC | Spruce Run Creek |
| WEMCO | Westinghouse Environmental Management Company of Ohio |
| WMCO | Westinghouse Materials Company of Ohio |

# F.1.0 INTRODUCTION

## F.1.1 SITE DESCRIPTION AND HISTORY

The Fernald Environmental Management Project (FEMP) is a contractor-operated federal facility where pure uranium metals were produced for the U.S. Department of Energy (DOE) between 1951 and 1989. The FEMP is located on a 1050-acre site in a rural agricultural area approximately 20 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler counties (Figure F.1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the production area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In July 1986, DOE signed a Federal Facility Compliance Agreement (FFCA) with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), concerning environmental impacts associated with the FEMP. In 1990, the FFCA was amended by a Consent Agreement under CERCLA Sections 120 and 106(a). Pursuant to the provisions of the FFCA and the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS environmental impact statement (RI/FS - EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major federal actions. In order to expedite remedial actions at the FEMP, separate RI/FS reports are being prepared for each of five operable units. They are:

- Operable Unit 1 - Waste Pits 1 through 6, Clearwell, and Burn Pit
- Operable Unit 2 - Solid Waste Unit
- Operable Unit 3 - Production Area and Suspect Areas
- Operable Unit 4 - Silos 1, 2, 3, and 4
- Operable Unit 5 - All Environmental Media

Operable Units 1 through 4 are referred to below as the "source" operable units. Detailed descriptions of the operable units are provided in Section 3.0 of this EIS.

F.1.2 PURPOSE OF SOIL AND SEDIMENT TOXICITY TESTING AT THE FEMP

Soils and sediments at the FEMP have been contaminated with a variety of substances, principally radionuclides (DOE 1990, WMCO 1989), and remediation of these media is within the scope of all five operable units at the FEMP. The nature and extent of contamination in soils and sediments within the boundaries of the source operable units (1 through 4) will be discussed in the respective RI/FS reports. All other soils and sediments will be discussed in the RI/FS reports for Operable Unit 5, Environmental Media.

A primary element in the RI/FS process is the preparation of a baseline risk assessment, which serves as the basis for determining potential risks to human health and the environment in the absence of any remedial actions. Assessment of the potential risks of a hazardous and radioactive consitituents at a site to human and environmental receptors requires characterization of the chemicals present in the waste, their toxicity, and potential exposure pathways. Although radionuclide levels in FEMP soils and sediments have been extensively characterized, data on inorganic and organic contaminants are limited. In addition, due to the complex nature of soils and sediments and their interactions with organisms, it is difficult to predict the effects of contaminants in these media using only data on contaminant concentrations. However, a variety of techniques have been developed to test the toxicity of complex media such as whole effluents and soils and sediments (e.g., Greene et al. 1988, Warren-Hicks et al. 1989). The results of these tests reflect not only the concentrations of the materials present, but also their availability to organisms (Greene et al. 1988), thereby providing information not available from contaminant concentration data. Further, toxicity tests are specifically recommended by EPA (1989) to support ecological risk assessments at hazardous waste sites.

For these reasons, a preliminary study was conducted to determine the toxicity of soils and sediments collected at the FEMP. RI/FS data were examined to determine locations of relatively high or low radionuclide levels in soils and sediments. Two soil and two sediment samples were then collected, one from a high-radionuclide site and one from a low-radionuclide site in each case. The samples were then tested for toxicity following standard protocols as described below (Greene et al. 1988, Nebecker et al. 1984).

## F.2.0 METHODOLOGY

Tests were designed to assess the potential for the formation of toxic leachates from soil and sediment samples collected from the FEMP. Two methods were employed, each designed to assay a different compartment of the aquatic ecosystem. Solid-phase testing represents the action of surface waters on stream bottoms and holding basins and will predict the ability of toxic materials to migrate from the substrate into the water column. Elutriate testing approximates formation of leachate by groundwater

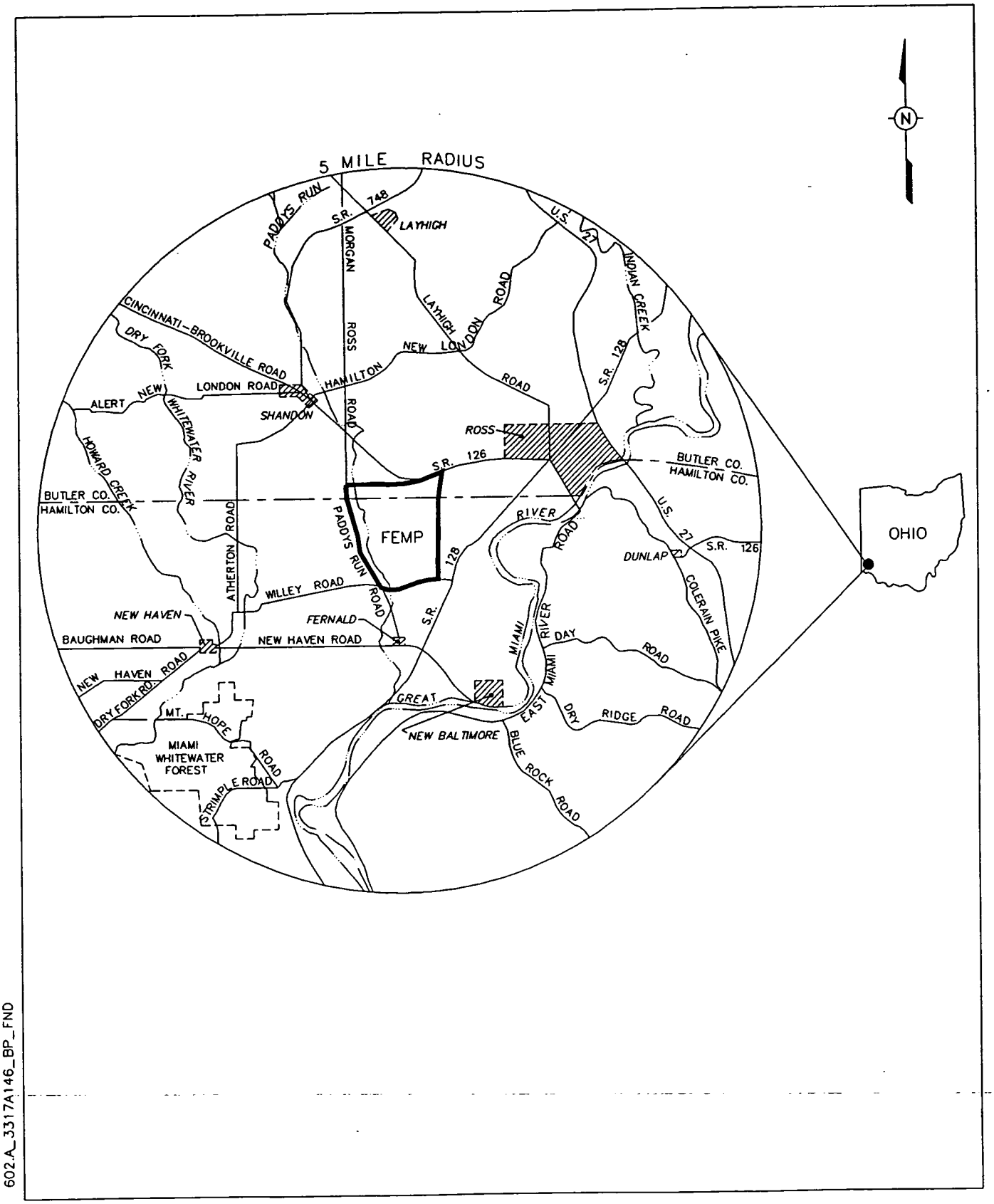


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FIGURE F.1-1. FIVE-MILE RADIUS MAP, FEMP

flowing through contaminated substrates into a larger water body, e.g., a stream. In both cases, the migratory ability of pollutants is mediated by the physicochemical nature of the compounds, the composition of the substrate, and the chemistry of the receiving waters. As an example, highly lipophilic or organometallic compounds are nonpolar and tend to bind to substrate particles, decreasing their availability to aquatic organisms. Polar substances, however, may be solubilized into the water column, depending on hydrogen ion concentration (pH) and the presence of other dissolved substances, increasing their bioavailability. The composition of the test medium, for example the quality of the water used, can therefore influence the outcome of toxicity tests.

Fathead minnows (Pimephales promelas) were used in one set of solid phase bioassays to assess the leachability of toxic substances from sediments and soils into the water column. Second instar larvae of the midge Chironomus tentans, detritivores which live in sediment, were used in a second set of solid phase bioassays. Finally, neonates of the cladoceran Daphnia magna were exposed to elutriates. D. magna is used extensively in toxicity testing (Peltier and Weber 1985) and is an important food source for larger invertebrates and fish.

### F.2.1 SAMPLE COLLECTION AND HANDLING

On May 2 and 4, 1990, two soil and two sediment samples were collected at the FEMP (Figure F.2-1). The substrates were chosen on the basis of their relative radioactivity as determined by a Geiger-Mueller probe, after consulting RI/FS data to determine likely sites of relatively low and high radionuclide contamination. The coordinates of the sampling sites, in Ohio State Planar Coordinates, were:

Site 1535 (Higher Radioactivity Soil) -- E 1,382.881.83; N 480,145.86
Site 1536 (Lower Radioactivity Soil) -- E 1,382,975.56; N 479,460.67
Site 1537 (Higher Radioactivity Sediment) -- E 1,380,473.52; N 478,086.78
Site 1538 (Lower Radioactivity Sediment) -- E 1,379,278.00; N 476,200.00

Site 1535 and Site 1536 were north and south of the sewage treatment plant area, respectively. Site 1537 was located in the storm sewer outfall ditch, a tributary to Paddys Run. This ditch was dry at the time of sample collection. Site 1538 was located in Paddys Run at Willey Road, downstream from the intersection with the storm sewer outfall ditch. The samples from Sites 1535 and 1536 are referred to below as high rad and low rad soil respectively. The samples from Sites 1537 and 1538 are referred to respectively as high rad and low rad sediment.

Samples were collected to a depth of six inches with a stainless steel trowel and sieved in the field using a No. 18 sieve. No additional water was added during sieving. The samples were placed in two-liter polypropylene bottles (cubitainers) and shipped on ice to the toxicology laboratory where they were stored at 4°C for up to 30 days before testing (see below). Concurrently, subsamples were

sent to an analytical laboratory for radiological screening and radionuclide analysis. The results of the screening were received on May 7, 1990. All samples were determined to contain quantities of radioactive source material less than those which would require special handling under 10CFR40.13 (less than 0.0005 percent of the sample by weight), and therefore no special handling was required.

A sample of sediment from Spruce Run Creek (SRC) in Clinton, New Jersey, was also collected, sieved and stored with the other samples, to serve as a control sediment for solid phase testing. It has been tested extensively at the toxicology laboratory and is used to substantiate the health of the organisms. Similarly, water collected from Round Valley Reservoir (RVR) in Lebanon, New Jersey, served as the test water, control water, and elutriate diluent. It has also been tested extensively at the toxicology laboratory and was used for culturing the test organisms.

### F.2.2 SAMPLE PREPARATION AND TESTING

Acute solid phase testing was conducted according to methodologies adapted from Nebecker et al. (1984) and Peltier and Weber (1985). A small amount of filtered RVR water was added to each sample, producing a slurry. The sediment slurry was swirled and shaken to provide a well-mixed sample. The sediment slurry was added in a 1:4 (v:v) substrate:water ratio with filtered RVR water to a one-liter polypropylene beaker, with a final volume of one liter of liquid. The chambers were allowed to settle overnight and aeration was initiated one hour before introduction of the test organisms. The beakers were covered with mesh to support the Pasteur pipettes supplying aeration.

#### F.2.2.1 Solid Phase Testing with Pimephales promelas

Static nonrenewal solid phase bioassays were performed with juvenile fathead minnows (*Pimephales promelas*). The fish were 29 days old and were cultured at the toxicology laboratory in RVR water. They were maintained on a regimen of TetraMin® fish food and *Artemia* (brine shrimp) nauplii until 24 hours before the start of the test. The test was conducted from May 9 to May 13, 1990.

Each beaker (three replicates per sample) received ten fathead minnows randomly selected from the culture aquarium. Since the testing protocols (Peltier and Weber 1985) require greater than 90 percent control survival for test validity, eleven test organisms were placed in control chambers in order to decrease the probability of test invalidity due to natural mortality. Dissolved oxygen and temperature were recorded daily. Conductivity, pH, alkalinity, and hardness were recorded at the beginning and end of the tests. Any water lost to evaporation was replenished as necessary, with the water added slowly through the mesh chamber covers to minimize disturbance of the sediments. Due to the turbidity of the water in the chambers, the fish were not counted until the end of the 96-hour test. Three fish from each chamber were also measured and weighed at the end of the test to determine the organism loading (weight per volume of test chamber) during the test, following Peltier and Weber (1985).

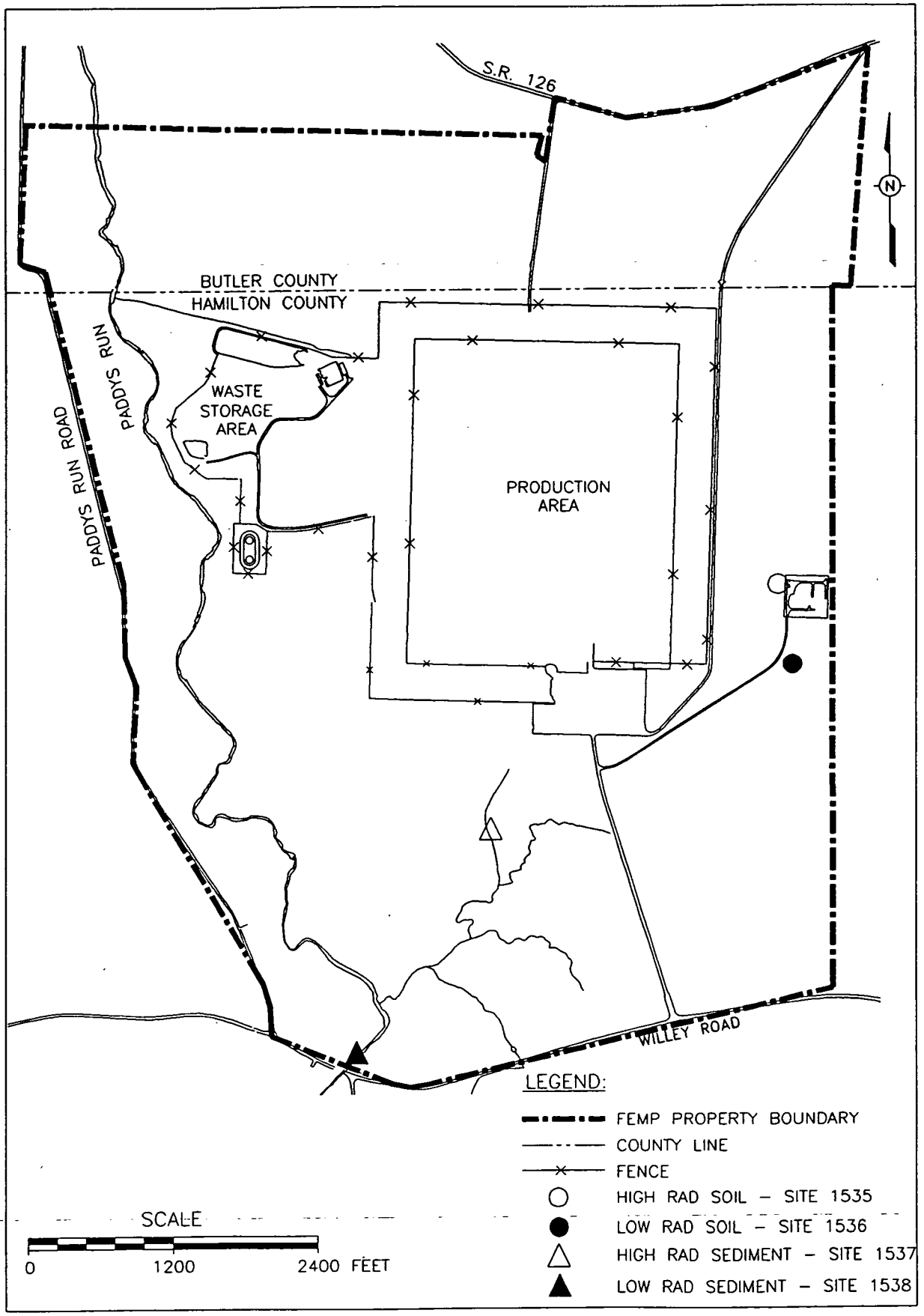


FIGURE F.2-1. RI/FS SAMPLING SITES FOR SOIL AND SEDIMENT TOXICITY TESTING

F.2.2.2 Solid Phase Testing with Chironomus tentans

Static nonrenewal solid phase bioassays were performed using second instar midge larvae (Chironomus tentans) as the test species. Chironomids were cultured following the methodology of Nebecker et al. (1984). The organisms were maintained in all-glass aquaria with torn paper towels as substrate and fed a diet of powdered cereal leaves and TetraMin® fish food ad libitum. Moderately hard reconstituted water was used in all culture chambers and partially changed weekly, at which time water quality variables were measured as described above.

Solid phase test organisms were obtained by removing adult flies from the culture aquaria via aspiration and placing them in a four-liter glass breeding chamber overnight. Egg masses were then collected and transferred to two-liter glass dishes containing a sprinkling of dried cereal leaves and TetraMin®. Additional food was given ad libitum, with care taken to prevent detrimental fungal growth in the nurseries. The 10-day test was conducted from June 1 to June 11, 1990. On June 1, 1990, 11-day old second instars were selected at random and pipetted into plastic cups for observation and counting prior to introduction into the triplicate test chambers. Twenty larvae were placed in each beaker. The controls contained 21 larvae in order to decrease the probability of test invalidity due to natural organism mortality. Initial and final water quality variables were recorded and dissolved oxygen and temperature were monitored for the 10-day duration of the test. At the end of the test the sediments were passed through a No. 18 sieve, retaining all surviving organisms which then were counted.

F.2.2.3 Elutriate Testing with Daphnia magna

Elutriates were prepared in accordance with U.S. Army Corps of Engineers/EPA (1985) and Peltier and Weber (1985). Each sediment and soil sample was mixed in a 1:4 (v:v) substrate:water ratio with filtered RVR water in a commercial variable-speed blender for 30 minutes and then allowed to settle for at least one hour. The supernatants were pipetted off and centrifuged at 10,000 rpm for ten minutes in a Sorvall Superspeed Model RC2-B automatic refrigerated centrifuge with a Sorvall Instruments SS-34 rotor. They were then vacuum filtered through Whatman 0.45 µm membrane filters. Five dilutions of the filtered supernatants were prepared with RVR water, in duplicate, for testing: 100, 50, 25, 12.5, and 6.25 percent, plus a control of RVR water.

Daphnids were grown in active culture at the toxicology laboratory following procedures outlined in Goulden and Henry (1984). They were held in filtered RVR water in two-liter glass beakers and fed the green alga Ankistrodesmus falcatus daily to an initial density of $2.0 \times 10^5$ cells/mℓ of culture water. The organisms were cultured in an environmental chamber at 20 ± 2°C, with 16 hours light: 8 hours dark.

To start the test, ten neonatal Daphnia magna (less than 24 hours old) were placed in a 250 mℓ beaker, with two beakers for each dilution of each elutriate. The daphnids were then monitored for immobility (equivalent to mortality) and behavioral abnormalities for 48 hours. Dissolved oxygen, pH, conductivity, temperature, alkalinity, and hardness were recorded at the beginning and end of the test. Alkalinity and hardness were measured only in control and 100 percent elutriate treatments.

Each elutriate bioassay was performed with a separate lot of daphnids to assure a brood size of sufficient number for the tests. All broods were obtained from the same stock culture on successive days. The testing schedule was as follows:

- Site 1535, high rad soil, May 15 to May 17, 1990
- Site 1536, low rad soil, May 16 to May 18, 1990
- Site 1537, high rad sediment, May 17 to May 19, 1990
- Site 1538, low rad sediment, May 18 to May 20, 1990

### F.2.3 REFERENCE TOXICANT TESTING

As part of standard quality assurance and quality control measures, reference toxicant testing was initiated prior to the entire set of FEMP bioassays. This procedure is used to document that test organisms are healthy enough for toxicity testing and that any differences in the responses observed among treatments reflect real differences in the samples, rather than differences in the organisms used. Both Pimephales promelas and Daphnia magna were tested with a reference toxicant (sodium dodecyl sulfate, SDS) from May 1 to May 5, 1990. Pimephales promelas were exposed to 160, 80, 40, 20, and 10 mg/ℓ of SDS for 96 hours, following the protocol described above. Daphnia magna were exposed to 32, 16, 8, 4, and 2 mg/ℓ of SDS for 48 hours, following the protocol described above. To date, no reference toxicant test has been developed for use with Chironomus tentans.

Previous reference toxicant testing in the toxicology laboratory was conducted using Quality Control SDS ampules from the EPA Environmental Monitoring Systems Laboratory in Cincinnati, Ohio. However, since these are no longer available, a 95 percent SDS powder (J.T. Baker Chemical Co., Lot A28705) has been substituted. No ranges of toxicity of this SDS have been established by EPA. Therefore, repeated testing within the laboratory is used to establish acceptable ranges.

## F.3.0 RESULTS AND DISCUSSION

### F.3.1 REFERENCE TOXICANTS

The concentrations of SDS that would result in 50 percent mortality ($LC_{50}$) of Pimephales promelas and Daphnia magna were determined by nonlinear interpolation to be 31.5 and 12.5 mg/ℓ SDS, respectively. The acceptable ranges, based on previous tests conducted at the toxicology laboratory,

are 19.1 to 37.9 mg/ℓ of SDS for Pimephales promelas and 8.5 to 20.9 mg/ℓ of SDS for Daphnia magna. The responses of the organisms were therefore considered normal and the animals acceptable for use in tests.

### F.3.2 RADIONUCLIDE CONCENTRATIONS IN SOILS AND SEDIMENTS

The radionuclide concentrations in the soil and sediment samples tested for toxicity are presented in Table F.3-1. The reference samples had lower radionuclide concentrations than the site samples. The greatest difference between low rad and high rad concentrations was in the concentration of uranium, with a five-fold difference between soils and a ten-fold difference between sediments (Table F.3-1).

### F.3.3 PIMEPHALES PROMELAS SOLID PHASE TEST

Neither the FEMP samples nor the control sediment demonstrated any measurable acute toxicity to fathead minnows. At the end of 96 hours, the sediment from Site 1537 caused 10 percent mortality (Table F.3-2), the highest mortality of the five substrates tested. However, this is within the EPA accepted variability allowed for natural mortality (Peltier and Weber 1985). A Student's t-test indicated no statistically significant difference in survival among any of the samples. Average length and wet weight of the fish in the various treatments were not statistically different. There were no significant differences in water quality variables between low rad and high rad samples (Table F.3-3).

### F.3.4 CHIRONOMUS TENTANS SOLID PHASE TEST

At the end of the ten-day solid phase test, greater than 96 percent survival of Chironomus tentans was observed (Table F.3-4). Therefore, the sediments and soils are reported not to be acutely toxic to Chironomus tentans. Tables F.3-4 and F.3-5 summarize the survival and water quality data from the control and the four FEMP samples. There were no significant differences in survival or water quality variables between low rad and high rad samples.

### F.3.5 DAPHNIA MAGNA ELUTRIATE TEST

The only mortality observed during the 48-hour Daphnia magna elutriate bioassay was one organism in one chamber of the low rad sediment sample 100 percent elutriate concentration. The reported LC50 for all samples was, therefore, greater than 100 percent elutriate and no sample showed acute toxicity to daphnids. Table F.3-6 summarizes the water quality data recorded in the control (RVR) and 100 percent elutriate treatments. There were no significant differences between low rad and high rad samples.

## TABLE F.3-1

## RADIONUCLIDE CONCENTRATIONS IN SOIL AND SEDIMENT SAMPLES TESTED FOR TOXICITY [a, b]

| Sample | Cesium 137 | Radium 226 | Radium 228 | Strontium 90 | Thorium 228 | Thorium 230 | Thorium 232 | Total Thorium | Uranium 234 | Uranium 235/236 | Uranium 238 | Total Uranium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Rad Soil (1536)[c] | 0.31 | 0.91 | 1.03 | 1.52 | 1.24 | 1.54 | 0.86 | 7.77 | 6.18 | <0.6 | 6.32 | 20.7 |
| High Rad Soil (1535) | 0.41 | 1.09 | 1.34 | 3.44 | 1.40 | 4.92 | 1.32 | 11.9 | 30.9 | 1.51 | 32.4 | 115 |
| Low Rad Sediment (1538) | <0.2 | 0.53 | <0.5 | <0.5 | 0.28 | 0.63 | 0.18 | 3.34 | <0.6 | <0.6 | <0.6 | 1.81 |
| High Rad Sediment (1537) | <0.2 | 0.90 | 0.70 | 1.30 | 1.07 | 2.41 | 0.62 | 5.57 | 5.25 | 0.760 | 5.93 | 20.3 |

[a] Concentrations in pCi/g dry weight, except for total thorium and total uranium, both µg/g.

[b] Concentrations of ruthenium-106, neptunium-237, plutonium-238, plutonium-239/240, and technetium-99 were below detection limits in all samples.

[c] Sample number.

**TABLE F.3-2**

**SUMMARY DATA FOR 96-HOUR PIMEPHALES PROMELAS SOLID PHASE TEST**

| Sample | Survival[a] (Percent) | | Length[b] (mm) | | Weight[b] (g) | |
|---|---|---|---|---|---|---|
| | Mean[c] | SD[d] | Mean[c] | SD | Mean[c] | SD |
| Control | 97.0 | 5.25 | 14.1 | 1.17 | 0.0222 | 0.0089 |
| Low Rad Soil (1536)[e] | 96.7 | 5.77 | 14.3 | 1.41 | 0.0289 | 0.0064 |
| High Rad Soil (1535) | 93.3 | 5.77 | 14.7 | 1.87 | 0.0266 | 0.0121 |
| Low Rad Sediment (1538) | 96.7 | 5.77 | 13.6 | 1.24 | 0.0276 | 0.0106 |
| High Rad Sediment (1537) | 90.0 | 10.00 | 14.6 | 0.88 | 0.0375 | 0.0068 |

[a] Sample size equals 3.

[b] Sample size equals 9 (3 fish in each of 3 replicates).

[c] Arithmetic mean.

[d] SD, standard deviation.

[e] Sample number.

**TABLE F.3-3**

**WATER QUALITY DATA FOR PIMEPHALES PROMELAS SOLID PHASE TEST**

| Sample | Dissolved Oxygen[a] (mg/ℓ) | | pH[b] | | Temperature[a] (°C) | | Conductivity[c] (µmhos/cm) | | Alkalinity[d] (mg/ℓ as $CaCO_3$) | | Hardness[d] (mg/ℓ as $CaCO_3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean[e] | SD[f] | Mean[e] | SD | Mean[e] | SD | Mean[e] | SD | Mean[e] | SD | Mean[e] | SD |
| Control | 7.2 | 0.32 | 7.32 | 0.083 | 21.1 | 0.23 | 138 | 2.9 | 42 | 2.8 | 122 | 2.8 |
| Low Rad Soil (1536)[g] | 7.1 | 0.36 | 6.90 | 0.188 | 21.2 | 0.25 | 158 | 2.9 | 102 | 2.8 | 146 | 2.8 |
| High Rad Soil (1535) | 7.4 | 0.24 | 7.13 | 0.033 | 21.2 | 0.25 | 145 | 0.0 | 66 | 2.8 | 122 | 2.8 |
| Low Rad Sediment (1538) | 7.2 | 0.27 | 7.76 | 0.075 | 21.2 | 0.25 | 207 | 5.8 | 86 | 2.8 | 146 | 2.8 |
| High Rad Sediment (1537) | 7.2 | 0.19 | 7.58 | 0.118 | 21.2 | 0.25 | 203 | 5.8 | 130 | 2.8 | 166 | 2.8 |

[a] Sample size equals 15.

[b] Sample size equals 6.

[c] Sample size equals 3.

[d] Sample size equals 2.

[e] Arithmetic mean.

[f] SD, standard deviation.

[g] Sample number.

TABLE F.3-4

SURVIVAL DATA FOR CHIRONOMUS TENTANS
SOLID PHASE TEST

| | Survival Percent | |
|---|---|---|
| Sample | Mean[a] | SD[b] |
| Control | 100.0 | 0.00 |
| Low Rad Soil (1536) | 98.3 | 2.89 |
| High Rad Soil (1535) | 98.3 | 2.89 |
| Low Rad Sediment (1538) | 96.7 | 2.89 |
| High Rad Sediment (1537) | 100.0 | 0.00 |

[a] Arithmetic mean. Sample size equals 3.

[b] SD, standard deviation.

**TABLE F.3-5**

**WATER QUALITY DATA FOR CHIRONOMUS TENTANS SOLID PHASE TEST**

| Sample | Dissolved Oxygen[a] (mg/ℓ) | | pH[b] | | Temperature[a] (°C) | | Conductivity[b] (µmhos/cm) | | Alkalinity[c] (mg/ℓ as $CaCO_3$) | | Hardness[c] (mg/ℓ as $CaCO_3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean[d] | SD[e] | Mean[d] | SD | Mean[d] | SD | Mean[d] | SD | Mean[d] | SD | Mean[d] | SD |
| Control | 8.3 | 0.31 | 7.38 | 0.124 | 20.9 | 0.49 | 138 | 16.9 | 32 | 0.0 | 62 | 2.8 |
| Low Rad Soil (1536)[f] | 8.2 | 0.36 | 7.61 | 0.202 | 21.0 | 0.53 | 193 | 42.4 | 98 | 2.8 | 134 | 2.8 |
| High Rad Soil (1535) | 8.3 | 0.29 | 7.64 | 0.242 | 21.1 | 0.51 | 182 | 38.4 | 72 | 0.0 | 114 | 2.8 |
| Low Rad Sediment (1538) | 8.2 | 0.34 | 8.02 | 0.128 | 20.9 | 0.58 | 213 | 47.7 | 106 | 2.8 | 134 | 2.8 |
| High Rad Sediment (1537) | 8.2 | 0.29 | 7.93 | 0.152 | 20.9 | 0.60 | 242 | 75.2 | 152 | 0.0 | 188 | 0.0 |

[a] Sample size equals 33.

[b] Sample size equals 6.

[c] Sample size equals 2.

[d] Arithmetic mean.

[e] SD, standard deviation.

[f] Sample number.

## TABLE F.3-6
## WATER QUALITY DATA FOR DAPHNIA MAGNA ELUTRIATE TEST

| Sample | Dissolved Oxygen (mg/ℓ) | | pH | | Temperature (°C) | | Conductivity (µmhos/cm) | | Alkalinity (mg/ℓ as $CaCO_3$) | | Hardness (mg/ℓ as $CaCO_3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean[a] | SD[b] | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Control | 7.6 | 0.21 | 7.49 | 0.151 | 21.6 | 0.44 | 131 | 5.0 | 38 | 4.8 | 60 | 13.5 |
| Low Rad Soil (1536)[c] | 6.7 | 0.21 | 7.07 | 0.078 | 21.5 | 0.71 | 160 | 14.1 | 36 | 5.7 | 94 | 8.5 |
| High Rad Soil (1535) | 6.1 | 0.14 | 7.34 | 0.106 | 22.0 | 0.00 | 150 | 0.0 | 47 | 4.2 | 103 | 9.9 |
| Low Rad Sediment (1538) | 7.4 | 0.00 | 8.16 | 0.191 | 21.5 | 0.71 | 325 | 0.0 | 110 | 8.5 | 138 | 2.8 |
| High Rad Sediment (1537) | 6.6 | 0.35 | 7.91 | 0.297 | 21.8 | 0.35 | 298 | 31.8 | 100 | 0.0 | 136 | 5.7 |

[a] Arithmetic means of initial and final values for one replicate of each sample. Water quality data were recorded only for controls and 100% elutriates.

[b] SD, standard deviation.

[c] Sample number.

## F.3.6 CONCLUSIONS

The results obtained in this study should be treated with caution. The sample size was very limited, and sampling sites were chosen on the basis of radionuclide levels, without regard to any possible nonradioactive constituents present. Data are not available on nonradioactive constituents in FEMP soils, and concentrations of these constituents would not necessarily be correlated with radionuclide concentrations. In addition, any organic constituents present could have been volatilized or degraded during the holding period.

However, almost no mortality was observed in toxicity tests of soils and sediments collected from areas of the FEMP with a 50-fold range of radionuclide concentrations (Table F.3-1). Total uranium concentrations in these samples ranged from approximately background in the low rad sediment to 115 μg/g in the high rad soil. The latter value is more than twice the tentative remediation standard for the FEMP of 50 μg/g (35 pCi/g). Solubilization of materials from soils and sediments containing comparable levels of radionuclides would therefore not appear to represent an acute toxic hazard to aquatic organisms. Although low levels of dissolved contaminants could be accumulated to toxic levels by organisms, existing data (e.g., DOE 1990, WMCO 1989) suggest that this is not a significant phenomenon in aquatic habitats adjacent to the FEMP. Further testing would be required to establish whether leachates from soils or sediments with uranium levels greater than 115 μg/g represent a hazard to aquatic organisms, or whether contaminants present in these media constitute a hazard to terrestrial organisms on or adjacent to the property.

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APPENDIX G

# APPENDIX G

## SURVEYS FOR THREATENED AND ENDANGERED SPECIES AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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# LIST OF ACRONYMS



| | |
|---|---|
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| DOE | U.S. Department of Energy |
| DOW | Division of Wildlife, Ohio Department of Natural Resources |
| EPA | U.S. Environmental Protection Agency |
| EIS | environmental impact statement |
| ESA | Endangered Species Act |
| FEMP | Fernald Environmental Management Project |
| FWS | U.S. Fish and Wildlife Service |
| NEPA | National Environmental Policy Act |
| ODNR | Ohio Department of Natural Resources |
| RI/FS | remedial investigation/feasibility study |
| RI/FS-EIS | remedial investigation/feasibility study-environmental impact statement |
| RM | river miles |
| WMCO | Westinghouse Materials Company of Ohio |

# G.1.0 INTRODUCTION



## G.1.1 SITE DESCRIPTION AND HISTORY

The Fernald Environmental Management Project (FEMP) is a contractor-operated federal facility where pure uranium metals were produced for the U.S. Department of Energy (DOE) between 1951 and 1989. The FEMP is located on a 1050 acre site in a rural agricultural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler counties (Figure G-1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the production area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In July 1986, DOE signed a Federal Facility Compliance Agreement (FFCA) with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), concerning environmental impacts associated with the FEMP. In 1990, the FFCA was amended by a Consent Agreement under CERCLA Sections 120 and 106(a). Pursuant to the provisions of the FFCA and the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS-Environmental Impact Statement (RI/FS-EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major federal actions.

## G.1.2 REQUIREMENTS FOR PROTECTION OF THREATENED AND ENDANGERED SPECIES DURING REMEDIATION

Section 121 of CERCLA requires that remedial actions at hazardous waste sites meet the substantive, but not the administrative or permitting, requirements of other federal and state environmental laws, including the Endangered Species Act (ESA) of 1973. Section 7(a)(2) of the ESA, as amended, requires federal agencies, "in consultation with and with the assistance of" the Secretaries of the Interior and Commerce, to ensure that their actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species...." Further, EPA guidance on ecological investigations at CERCLA sites (EPA 1988, 1989) emphasizes identification of the threatened and endangered species resident on the site, including delineation of any critical habitat essential to the survival of these organisms. In order for remedial activities at the FEMP to meet the requirements of ESA, CERCLA, and associated EPA guidance, it was therefore necessary to determine whether threatened or endangered species were present at the FEMP, and to identify any critical habitat.

G.1.3 IDENTIFICATION OF THREATENED AND ENDANGERED SPECIES

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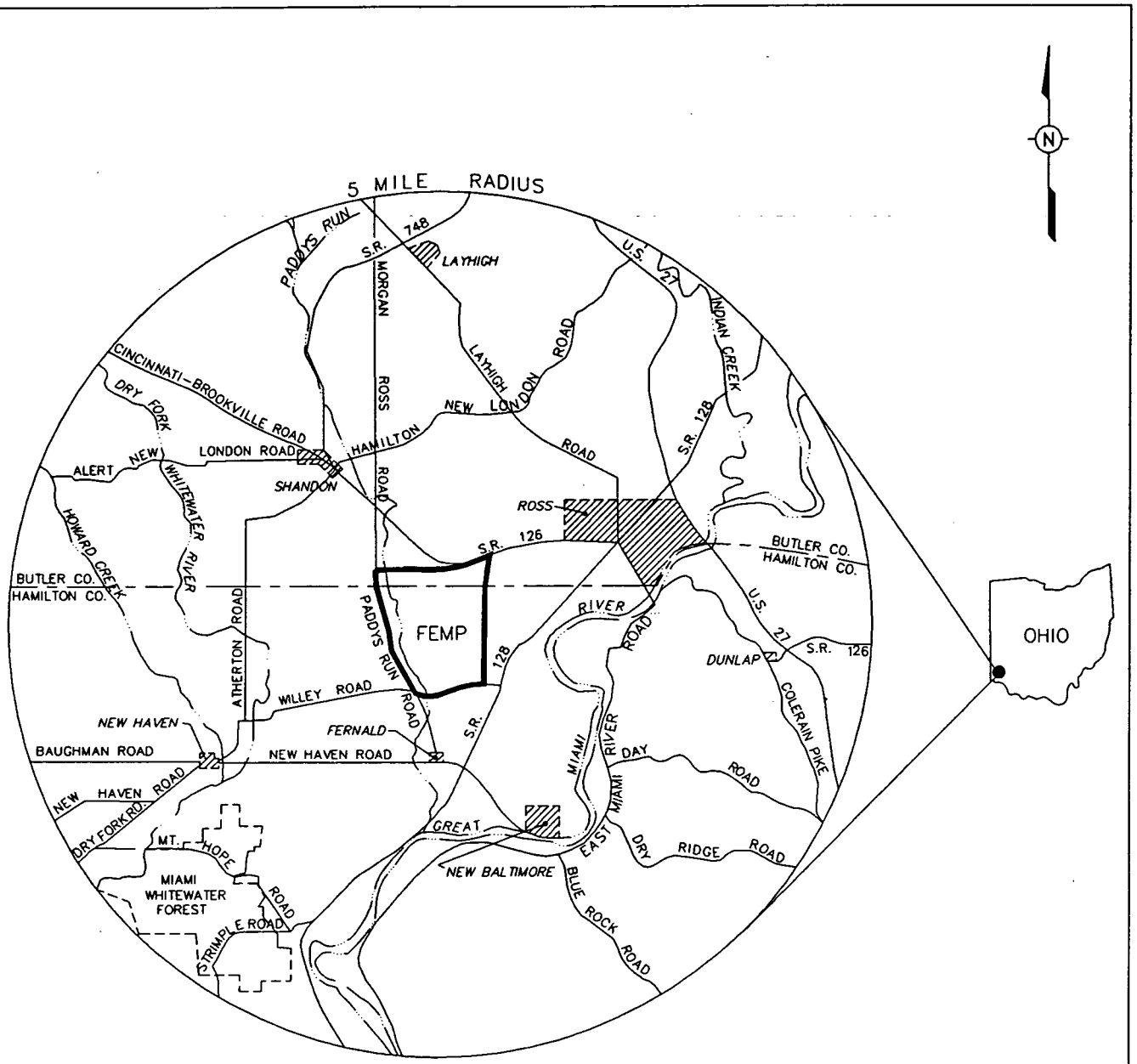
Preliminary discussions with officials of the U.S Fish and Wildlife Service (FWS) and the Ohio Department of Natural Resources (ODNR), Division of Wildlife (DOW) (Attachment I) resulted in the identification of one federally listed endangered species, the Indiana bat (Myotis sodalis), and one state-listed endangered species, the cave salamander (Eurycea lucifuga), whose ranges overlap the area of the FEMP. The Indiana bat was listed as an endangered species under the authority of the ESA (50 CFR 17 Rev. 8/77), and the cave salamander was listed as a state endangered species under authority of the ODNR, (DOW Order 1501:31-23-01). Detailed surveys were performed to determine whether these species and critical habitat for them were present at or in the vicinity of the FEMP, as described in Section G.2.0.




602.A_3317A146_BP_FND

FIGURE G.1-1. FIVE-MILE RADIUS MAP, FEMP

# G.2.0 METHODOLOGY



## G.2.1 INDIANA BAT (Myotis sodalis)

A survey was conducted to evaluate potential Indiana bat habitat and attempts to capture bats were made during June to August 1988. The area covered by the survey consisted of the riparian habitats and floodplains of the Great Miami River and Paddys Run (Figure G.2-1). Surveys were conducted along the Great Miami River beginning at the I-275 bridge, 0.5 river miles (RM) south-southeast of the bridge at Miamitown, and extending to the Bolton Water Works, 1.7 RM northeast of U.S. Route 27. Paddys Run was surveyed from the point where it crosses State Route 126 to its confluence with the Great Miami River. The study area covered a total of 13.9 miles of the Great Miami River and 4.7 miles of Paddys Run.

Habitats along the Great Miami River were surveyed visually from roads and from a boat. Paddys Run was surveyed on foot. Habitat was classified by its potential for use by Indiana bats as follows:

- Excellent - Mature woodland with dead trees, extending more than thirty yards beyond the stream edge on one or both banks
- Good - Mature woodland on one or both banks but not extending far beyond the stream edge
- Fair - Immature woodland on one or both banks
- Poor - No woodland habitat on one or both banks

The percentage of total habitat in each category was estimated by dividing the river miles in the category by the total surveyed river miles. Following identification of habitats with a high potential for supporting Indiana bats, owners of the adjacent land were approached and permission obtained to study these areas more intensively by monitoring echolocation sounds and attempting to capture bats.

Bats were captured using mist nets at eight sites, located over small streams and other flyways, on 13 nights between June 24, 1988 and August 10, 1988. Net sites were assigned consecutive Roman numerals in the order in which they were sampled. The nets were positioned under overhanging vegetation and suspended by ropes from trees or stretched on poles to completely enclose the open space. Garden net was used in some cases to help seal openings around the mist nets. At times this positioning was not possible, and mist nets were raised with considerable open space around them. Nets were tended from dusk until after midnight. Captured bats were identified to species, age, sex, and reproductive condition, temporarily marked for individual recognition, and released at the site of capture.

Bat activity was also monitored with echolocation detection equipment, which converts ultrasonic sounds produced by bats to the human hearing range and allows identification of bats to genus. Echolocation detection equipment was used at five net sites over eight nights, as well as at five additional sites over five nights where netting was impractical due to the density of the vegetation. Sites where only echolocation detection equipment was used to census bats were assigned consecutive capital letters in the order in which they were used. Bat activity was recorded in terms of bat passes. Each pass consisted of a series of echolocation pulses separated from other series by more than two seconds.



G.2.2 CAVE SALAMANDER (Eurycea lucifuga)

A survey was performed during May to August, 1988 to locate potential cave salamander habitat and look for individuals at the FEMP and in the vicinity. The study area extended from the Great Miami River north to New London Road in Butler County (Figure G.2-2). The northeastern border of the study area was formed by Layhigh Road, and the western border was formed by Paddys Run Road.

ODNR (Case 1986) provided a list of known locations of salamanders in Hamilton County. Additionally, local investigators were contacted to determine where populations of cave salamanders may exist within or near the study area. Local museums and published accounts were consulted for prior documentation of local populations and museum accessioned specimens.

An initial field reconnaissance was conducted to establish familiarity with the study area and to identify potential habitat for a detailed survey. The initial reconnaissance was conducted by driving roads within the study area and talking with local residents to identify areas for further study. The areas that appeared to have potential as cave salamander habitat were surveyed on foot, thoroughly investigating for individuals, larvae, eggs, or other sign.

Permission was obtained to survey in detail the Ross Trails Girl Scout Camp, located in the northeastern portion of the study area, and Camp Fort Scott, located in the southeastern portion of the study area near the Great Miami River. Privately owned lands were surveyed following landowner approval. Surveys were also conducted along Paddys Run and in the deciduous woodland in the northern part of the FEMP.

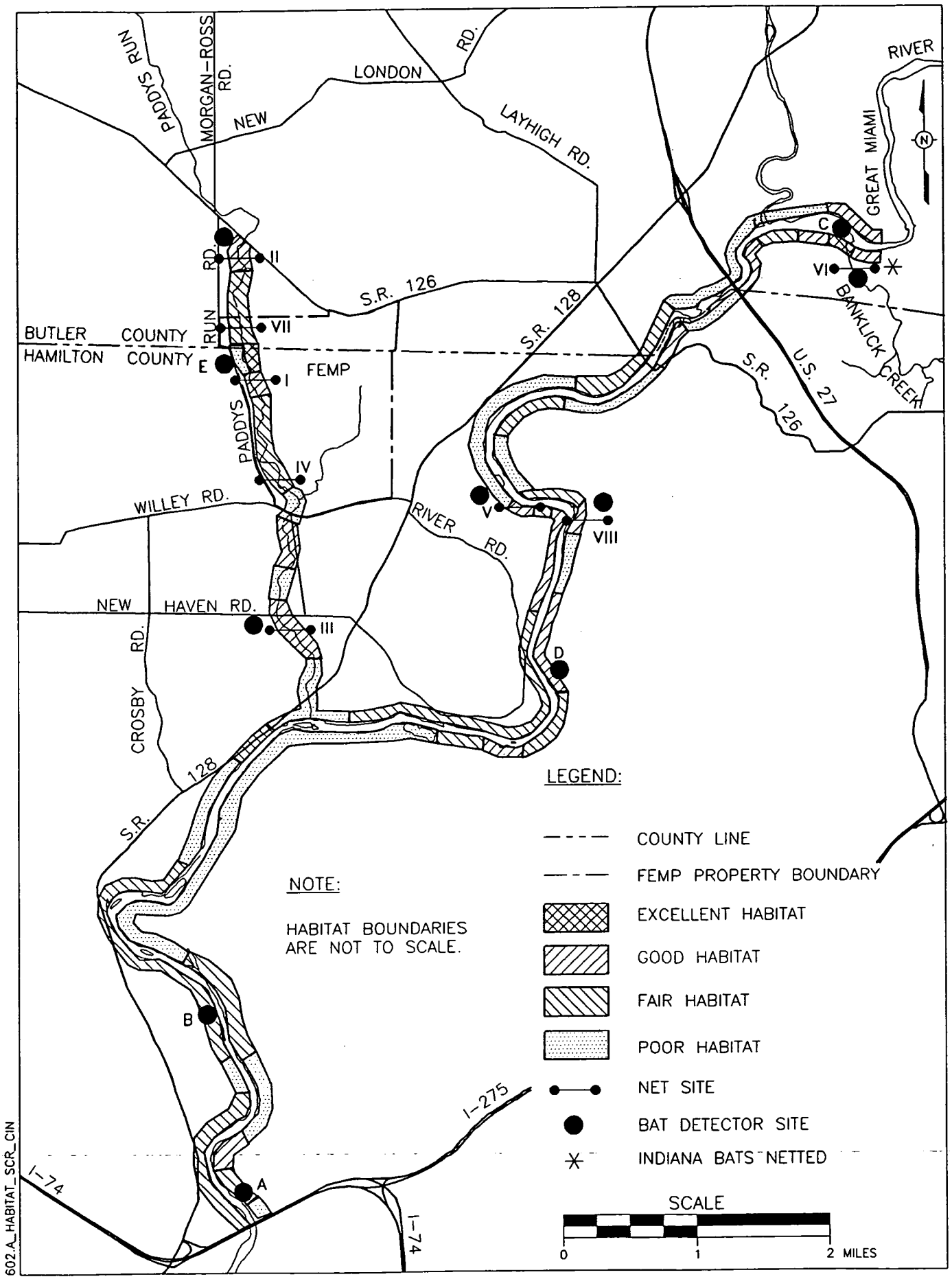



FIGURE G.2-1. INDIANA BAT SAMPLING SITES AND HABITAT EVALUATION AT THE FEMP AND VICINITY

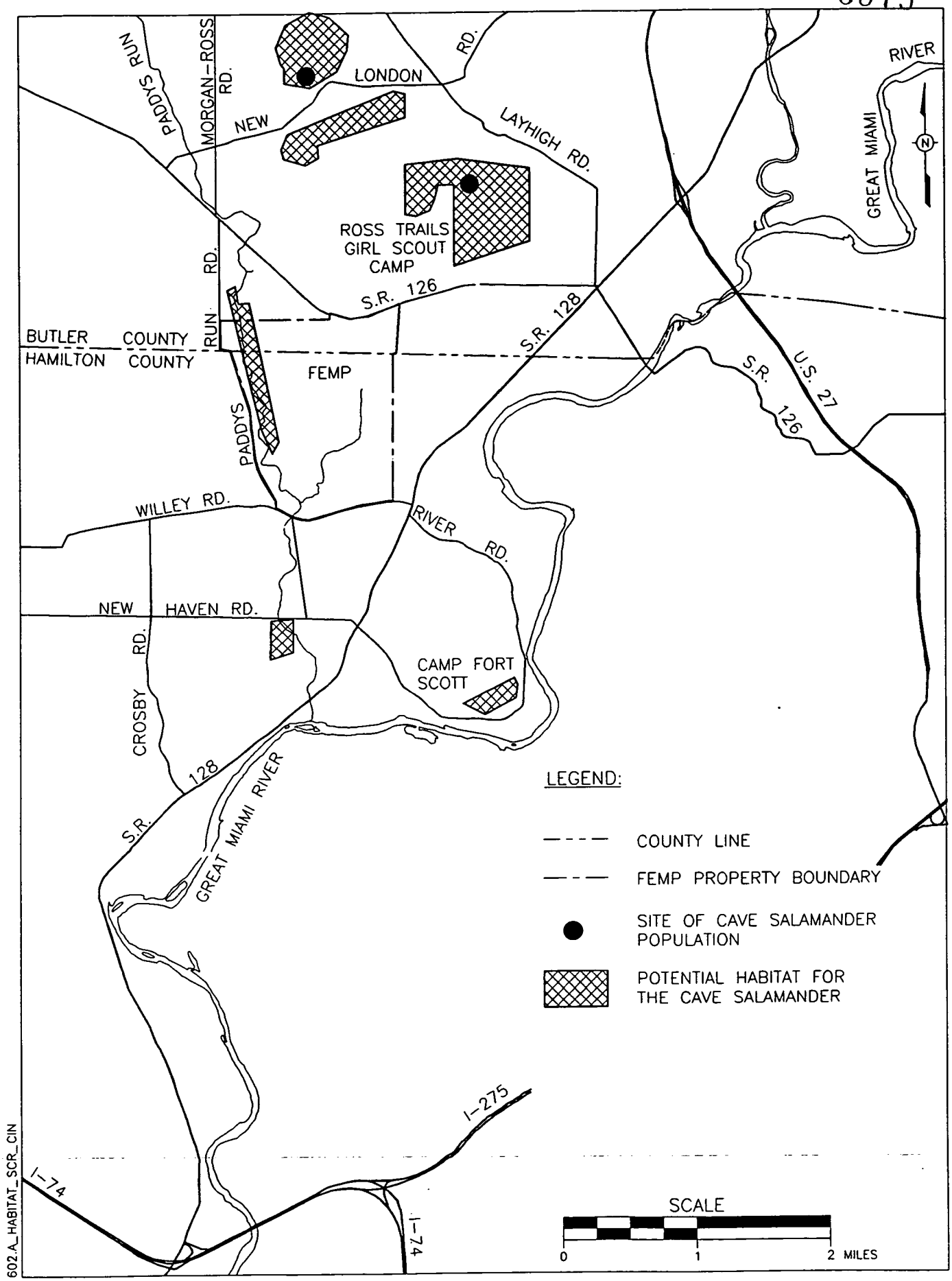



FIGURE G.2-2. POPULATION LOCATIONS AND POTENTIAL HABITAT FOR THE CAVE SALAMANDER IN THE VICINITY OF THE FEMP

# G.3.0 RESULTS



## G.3.1 INDIANA BAT

Potential Indiana bat habitat within the study area ranged in quality from good to poor (Figure G.2-1). Very little habitat was considered excellent, due to a general lack of dead trees suitable for colonies. Of the habitat along the banks of the Great Miami River, one percent was classified as excellent, 16 percent was good, 43 percent was fair, and 40 percent was poor. Most of the good habitat was in the northern portion of the study area. Habitat along the banks of Paddys Run was somewhat better, with four percent considered excellent, 23 percent good, 54 percent fair, and 19 percent poor. A majority of the good habitat was located in the northern portion of the FEMP (Figure G.2-1).

A total of 63 bats representing five species was captured by mist netting (Table G-3-1). Indiana bats were captured only at Site VI, approximately 3.3 miles northeast of the FEMP boundary on Banklick Creek, a tributary to the Great Miami River near Ross, Ohio (Figure G.2-1). Of the eight bats captured, three were adult females, two of which had reproduced during the summer of 1988; two were immature females; two were immature males; and one was an adult male. Eight bats representing several other species were also captured at Site VI (Table G-3-1).

Nearly 30 percent of the total activity recorded by echolocation detection equipment was Myotis sp., occurring primarily at Site VI (including Site C), where 43 percent of the bat activity was this genus. Site VI accounted for 68 percent of the total Myotis activity recorded in this study. Myotis sp. activity was also recorded at six additional sites (Table G-3-2), including Sites II, III, and E on Paddys Run within the FEMP, where one to 22 passes were recorded. One species of this genus, a little brown bat (Myotis lucifugus), was captured in a mist net over Paddys Run (Table G-3-1).

## G.3.2 CAVE SALAMANDER

Potential cave salamander habitat is shown in Figure G.2-2. In general, minimal habitat was found, with the Ross Trails Girl Scout Camp and Camp Fort Scott providing the only wooded areas large enough to constitute optimal habitat. Potential cave salamander habitat was identified within Camp Fort Scott along one permanent, spring-fed stream and multiple ephemeral streams in the eastern portion of the camp (Figure G.2-2). Although the cave salamander was not found in these areas, the northern dusky salamander (Desmognathus fuscus fuscus), often found in habitats similar to the cave salamander, was observed in the area. Marginal habitat occurs along Paddys Run, including an area on the FEMP between Willey Road and Route 126.

A population of cave salamanders was located at Ross Trails Girl Scout Camp on May 25 and 26, 1988, at a point where a spring emerged from beneath large limestone slabs near the camp's western boundary. Seven individuals were observed in this area. Although no other cave salamander

## TABLE G.3-1
## BAT CAPTURE RESULTS FROM MIST NET SURVEYS

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| Date 1988 | Site[a] | Sex | Indiana Bat (Myotis sodalis) | Little Brown Bat (Myotis lucifugus) | Big Brown Bat (Eptesicus fuscus) | Red Bat (Lasiurus borealis) | Silverhaired Bat (Lasoinycteris noctivigans) |
|---|---|---|---|---|---|---|---|
| 24 June | I | M | 0 | 0 | 0 | 0 | 1 |
| | | F | 0 | 0 | 0 | 2 | 0 |
| 25 June | II | M | 0 | 0 | 2 | 0 | 0 |
| | | F | 0 | 0 | 4 | 0 | 0 |
| 28 June | III | M | 0 | 0 | 2 | 3(1)[b] | 0 |
| | | F | 0 | 0 | 1 | 3 | 0 |
| 29 June | III | M | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 1(1) | 0 | 0 | 0 |
| 30 June | IV | M | 0 | 0 | 0 | 2 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 |
| 1 July | V | M | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 1 | 0 | 0 |
| 11 July | II | M | 0 | 0 | 1 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 |
| 26 July | VI | M | 0 | 0 | 2 | 0 | 0 |
| | | F | 1 | 0 | 1 | 0 | 0 |
| 1 Aug | VI | M | 1(1) | 0 | 1(1) | 0 | 0 |
| | | F | 1 | 0 | 1 | 0 | 0 |
| 2 Aug | III | M | 0 | 0 | 1 | 2 | 0 |
| | | F | 0 | 0 | 1(1) | 0 | 0 |
| 3 Aug | VI | M | 2(1) | 0 | 0 | 0 | 0 |
| | | F | 3(2) | 0 | 0 | 1 | 0 |
| 9 Aug | VII | M | 0 | 0 | 6(4) | 3 | 0 |
| | | F | 0 | 0 | 6(3) | 3(2) | 0 |
| 10 Aug | VIII | M | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 1 | 0 | 0 |
| Total | | | 8(4) | 1(1) | 32(9) | 21(4) | 1 |
| Percent | | | 12.7 | 1.6 | 50.8 | 33.3 | 1.6 |

[a] Study site location coordinates are listed in Table G-II-2.

[b] Numbers in parentheses represent the total numbers of bats which were immature.

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## TABLE G.3-2
## BAT ACTIVITY RECORDED BY ECHOLOCATION MONITORING

| Site[a] | Date[b] 1988 | Number of Passes Recorded | | |
|---|---|---|---|---|
| | | Myotis | Eptesicus | Lasiurus |
| III | 28 June | 2 | 4 | 0 |
| V | 1 July | 2 | 8 | 1 |
| A | 6 July | 0 | 0 | 13 |
| B | 7 July | 0 | 0 | 0 |
| II | 11 July | 1 | 4 | 0 |
| C | 25 July | 30 | 20 | 1 |
| VI | 26 July | 23 | 15 | 1 |
| VI | 1 Aug | 10 | 22 | 37 |
| III | 2 Aug | 5 | 4 | 6 |
| VI | 3 Aug | 16 | 8 | 0 |
| D | 4 Aug | 5 | 3 | 3 |
| E | 5 Aug | 22 | 32 | 79 |
| VIII | 10 Aug | 1 | 2 | 26 |
| Total | | 117 | 122 | 167 |
| Percent | | 28.8 | 30.0 | 41.2 |

[a] Study site location coordinates are listed in Table G-II-2.

[b] Echolocation monitoring periods are listed in Table G-II-1.

populations were found at Ross Trails Girl Scout Camp, other suitable habitat was found, including ravines and stream-side habitats with limestone, fallen trees, and sink holes (Figure G.2-2). The northern dusky salamander was also present in this habitat. The Miami University vertebrate collection also documents a population at New London Road (catalog number A-488), as shown in Figure G.2-2.

Cave salamanders were not located in the other potential habitats surveyed, including the areas along Paddys Run on the FEMP or the area west of Christian Road. However, the northern dusky salamander and long-tailed salamander (Eurycea longicauda), which are often found in the same habitat as the cave salamander, were found at a site west of Christian Road. The area along Paddys Run north of Willey Road offers limited areas of suitable habitat where rivulets flow along limestone slabs. It was considered doubtful that cave salamanders occur within the habitat south of New Haven Road due to the absence of limestone on the site (Figure G.2-2).

# G.4.0 DISCUSSION AND CONCLUSIONS



## G.4.1 INDIANA BAT

The bat fauna found in this study is similar in species composition, diversity, and capture rate to that found in other studies of this kind (Cope et al. 1978, Humphrey 1975). In other studies conducted in areas known to contain summer colonies of Indiana bats, they represented 13 percent of the bats captured (Cope et al. 1978). This number is the same as that in the present study (Table G-3-1). Foraging ranges of Indiana bats have been reported to extend from one-half to three-quarters of a mile from the colony tree (Humphrey et al. 1977, Cope et al. 1978). The capture of significant numbers of this species at Net Site VI at Banklick Creek therefore indicates the presence of an active colony nearby, although the colony location was not determined.

Myotis spp. may have been underrepresented at other net sites due to difficulty in positioning the nets. Bats of this genus are frequently more difficult to catch than other genera, as indicated by Myotis activity recorded with the echolocation detection equipment at three net sites where no members of this genus were caught (Table G-3-2). Therefore, although no Indiana bats were captured by mist net on Paddys Run, the data presented do not preclude the presence of the species in this area (including the FEMP). Further, the presence of the Indiana bat in the general study area indicates that all habitat classified as good should be considered to have high potential for containing Indiana bats.

Optimal summer habitat consists of mature woods lining both sides of small- to medium-sized streams, with the bats occupying the summer habitat from mid-May to mid-September (Humphrey et al. 1977). Good quality foraging habitat may be more critical than the presence of good colony trees (Cope et al. 1978). Indiana bats forage at heights of two to thirty meters under overhanging canopies of vegetation (Humphrey et al. 1977). These bats eat mostly Lepidopteran and aquatic insects (Belwood 1979). Populations have been estimated to be between 60 and 90 individuals per kilometer of foraging habitat (Cope et al. 1978).

In the winter, Indiana bats typically hibernate in caves. Hibernating Indiana bats have been observed in caves in southern Indiana and Kentucky in large numbers, and are known to use caves as hibernacula in Adams, Highland, and Hocking counties in Ohio (USFWS 1983). The bats enter the caves in October and emerge in April (Hall 1962). Females disperse from these hibernacula to form summer maternity colonies in Indiana, Kentucky, Ohio, and Michigan (Barbour and Davis 1969) where parturition and maturation of the young take place (Cooperrider et al. 1986). Indiana bats therefore appear to occupy a wide area in the region of the FEMP, but no individuals have been captured on the property, and the majority of potential habitat would be considered of marginal quality.

G.4.2 CAVE SALAMANDER

The cave salamander, a state endangered species (DOW Order 1501:31-23-01), ranges from southern Indiana and extreme southwestern Ohio south to Alabama and Georgia, and from northeastern Oklahoma eastward to western Virginia (Hutchinson 1966). Ohio populations are limited to Adams County (Daniel 1984), Hamilton County (Denny no date), and Butler County (Davis 1990). The most recent records from Adams County are from 1964, but both Hamilton and Butler counties have well-documented active populations.

In the surveys described above, cave salamander populations were found only near New London Road, north of the FEMP, and at the Ross Trails Girl Scout Camp northeast of the FEMP. However, the species may occupy other suitable habitat near or within the study area as well. The months of June, July, and August 1988 included the worst drought conditions in recorded history in southwestern Ohio. The probability of locating salamanders while surveying during these extreme conditions was low because salamanders would have retreated underground during the drought. It is therefore possible that extant populations of the cave salamander went undetected during the survey. The species' frequent association with cool springs may allow for capture of individuals even during the hottest part of the summer in more typical weather years.

Cave salamanders are generally confined to limestone areas, especially near caves, under limestone slabs near springs, or under stones and logs in forested ravines. In Ohio, cave salamanders are also known to inhabit wells and areas in proximity to moist sink holes. The most probable sites surveyed in the present study where additional populations may occur, based on habitat characteristics, are:

- Camp Fort Scott, north and east of the high voltage power line, especially along the permanent, spring-fed stream
- Ross Trails Girl Scout Camp, particularly along streams and ravines in the southern part of the camp
- In a small area west of Christian Road

The observation of other salamander species which typically occupy habitats in conjunction with the cave salamander also indicates the potential for undetected populations to occur in these areas.

G.4.3 OTHER SPECIES

The cobblestone tiger beetle (Cicendela margipennis) was found during the Indiana bat survey on a gravel bar in the Great Miami River, approximately two RM west-southwest of the bridge at New Baltimore, Ohio. Three specimens were captured and were identified by Dr. William Buskirk, Professor of Biology at Earlham College. They were placed in his private collection for future

reference. The total population on the gravel bar was estimated to be 30 to 40 individuals. Another gravel bar was surveyed during the course of the Indiana bat survey, but no additional beetles of this species were found.

The cobblestone tiger beetle is listed as a federal category two species. Category two species are considered possibly appropriate for listing as threatened or endangered, but data are insufficient to support proposing to protect them under the ESA. These observations are insufficient to draw any substantive conclusions regarding the status or distribution of the cobblestone tiger beetle in the vicinity of the FEMP.

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# REFERENCES



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# ATTACHMENT G-I
# CORRESPONDENCE

ODNR
OHIO DEPARTMENT OF
NATURAL RESOURCES
Fountain Square
Columbus, Ohio 43224

3579

December 16, 1986

Mr. Richard C. Clark
Advanced Sciences Inc.
P.O. Box 475
Ross, OH 45061

Dear Mr. Clark:

After reviewing our maps and files, I find the Heritage Program has no records for rare or endangered species at the Fernald Feed Materials Production Center. There are no existing or proposed state nature preserves or scenic rivers in the vicinity of the Fernald facility, and we are unaware of any unique ecological sites within your study area.

Because the Heritage Program has not surveyed Ohio and relies on information supplied by a number of individuals and organizations, a lack of records for any particular area is not a statement that special plant or animal species are absent from a site.

As requested, I have enclosed a copy of our 1986-1987 plant status list and administrative rules. I have also included a flier describing our 1984-1985 Ohioendangered and threatened plant book. This book provides habitat and range data for many of our current state endangered and threatened plants. You may find this information useful in your 1987 field survey.

Please contact me if I can be of any further assistance.

Sincerely,

Patricia D. Jones

Patricia D. Jones
Data Management Supervisor

PDJ/sl

Enclosures



Richard F. Celeste, Governor

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
Columbus Field Office
Post Office Box 3990
Columbus, Ohio 43216-5000


IN REPLY REFER TO: 3579

December 8, 1986

Mr. Richard C. Clark
Advanced Science, Inc.
7308 South Alton Way, Suite K
Englewood, Colorado 80112

Dear Mr. Clark:

This responds to your November 20, 1986 letter requesting information on Federally listed endangered species at the Feed Materials Production Center in Hamilton and Bulter Counties, Ohio.

This technical assistance letter is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and is consistent with the intent of the National Environmental Policy Act of 1969 and the U. S. Fish and Wildlife Service's Mitigation Policy. It does not, however, constitute the report of the Secretary of the Interior under Section 2(b) of the Act, nor does it represent the review comments of the Department of the Interior on any forthcoming environmental document.

The only Federally listed endangered, threatened or listed species in the project area is the Indiana bat. This bat uses caves or mine shafts as overwintering areas. We have no knowledge of such sites in Butler or Hamilton Counties. For summer/nursery habitat, the Indiana bat utilizes trees with exfoliating bark. The bat normally feeds on insects along medium sized streams. Attached is a list of all Federally listed species in Ohio, their habitat, and counties of occurrence. Also enclosed is a list of major responsibilities of Federal Agencies under the Endangered Species Act of 1973, amended.

We appreciate the opportunity to comment. If we can be of further assistance, please advise.

Sincerely yours,

Kent E. Kroonemeyer

Kent E. Kroonemeyer
Supervisor

Attachments

cc: Chief, Ohio Division of Wildlife, Columbus, OH
ODNR, Outdoor Recreation Serv, M. Colvin, Columbus, OH

FILE 8.5.3

ODNR
OHIO DEPARTMENT OF
NATURAL RESOURCES
Division of Wildlife
Fountain Square
Columbus, Ohio 43224
614-265-6330

3579

October 1, 1986

Mr. Richard Clark
ASI
P.O. Box 475
Ross, OH 45061

Dear Mr. Clark:

The following are known locations of cave salamanders (*Eurycea lucifuga*) for Hamilton County, Ohio. No records exist for Butler County.

1. Mt. Airy Forest
2. Groesbeck, Colerain Twp.
3. 1 mile east northeast of New Baltimore, Colerain Twp.
4. Sheits Rd. near Blue Rock Rd., Colerain Twp.

Sincerely,

Denis S. Case
Assistant Administrator
Wildlife Management & Research

DSC:gh

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# ATTACHMENT G-II
# INDIANA BAT ECHOLOCATION
# MONITORING PERIODS AND SAMPLING SITES

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## TABLE G.II-1
## INDIANA BAT ECHOLOCATION MONITORING PERIODS

| Date 1988 | Site[a] | Cumulative[b] Time (Min.) | Period of Time | |
|---|---|---|---|---|
| | | | Begin | End |
| 28 June | III | 40 | 2155 | 2354 |
| 1 July | V | 135 | 2125 | 0000 |
| 6 July | A | 77 | 2128 | 2245 |
| 7 July | B | 100 | 2120 | 2300 |
| 11 July | II | 20 | 2120 | 2140 |
| 25 July | C | 51 | 2115 | 2208 |
| 26 July | VI | 95 | 2115 | 0015 |
| 1 Aug | VI | 95 | 2110 | 0000 |
| 2 Aug | III | 75 | 2150 | 0042 |
| 3 Aug | VI | 58 | 2106 | 2340 |
| 4 Aug | D | 80 | 2055 | 2245 |
| 5 Aug | E | 109 | 2054 | 2250 |
| 10 Aug | VIII | 80 | 2100 | 2326 |

[a] Site location coordinates are listed in Attachment II-2.

[b] Total period of echolocation equipment operation.

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## TABLE G-II-2
## INDIANA BAT SAMPLING SITES

| Site | Location[a] North x East |
|---|---|
| I | 482,320 x 1,377,410 |
| II | 486,910 x 1,377,400 |
| III | 471,500 x 1,379,290 |
| IV | 477,160 x 1,379,130 |
| V | 476,610 x 1,388,010 |
| VI | 486,180 x 1,401,520 |
| VII | 483,720 x 1,377,300 |
| VIII | 476,680 x 1,390,840 |
| A | 449,300 x 1,377,250 |
| B | 455,890 x 1,376,410 |
| C | 486,500 x 1,401,520 |
| D | 471,090 x 1,389,310 |
| E | 483,690 x 1,377,310 |

[a] Ohio State Plane Coordinates, South Zone, in feet.

# APPENDIX H

## RADIONUCLIDE AND CHEMICAL ANALYSES OF BIOLOGICAL SAMPLES FROM THE FEMP AND VICINITY

APPENDIX H

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## LIST OF ACRONYMS

| | |
|---|---|
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| EIS | environmental impact statement |
| FEMP | Fernald Environmental Management Project |
| FFCA | Federal Facilities Compliance Agreement |
| NEPA | National Environmental Policy Act |
| RI/FS | remedial investigation/feasibility study |
| RI/FS-EIS | remedial investigation/feasibility study-environmental impact statement |
| WEMCO | Westinghouse Environmental Management Company of Ohio |

# H.1.0 INTRODUCTION



## H.1.1 SITE DESCRIPTION AND HISTORY

The Fernald Environmental Management Project (FEMP) is a contractor-operated federal facility where pure uranium metals were produced for the U.S. Department of Energy (DOE) between 1951 and 1989. The FEMP is located on a 1050 acre site in a rural agricultural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler counties (Figure H.1-1). Production facilities, which occupy approximately 136 acres, are located in the center of the FEMP. Land use outside the production area and waste storage areas is predominantly agricultural, including 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted on the FEMP in 1973 as part of an environmental improvement project are located in the northeast and southwest portions of the facility. Paddys Run, an intermittent ungaged stream, runs roughly parallel to the western boundary of the FEMP, and a number of small ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor.

In July 1986, DOE signed a Federal Facility Compliance Agreement (FFCA) with the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), concerning environmental impacts associated with the FEMP. In 1990, the FFCA was amended by a Consent Agreement under CERCLA Sections 120 and 106(a). Pursuant to the provisions of the FFCA and the Consent Agreement, DOE is conducting a remedial investigation/feasibility study (RI/FS) so that appropriate remedial activities at the FEMP can be formulated, assessed, and implemented. In addition, DOE is preparing a RI/FS-Environmental Impact Statement (RI/FS-EIS) examining the environmental impacts of potential remedial activities to comply with National Environmental Policy Act (NEPA) requirements for environmental evaluations of major federal actions.

## H.1.2 OBJECTIVES OF BIOLOGICAL SAMPLING AT THE FEMP

Risk assessment at hazardous waste sites requires data on the fate and transport of contaminants from waste sources to air, water, soil, and organisms. Direct measurement of contaminant concentrations in organisms is requisite for assessing potential risks to the organisms themselves and potential risks, via the food chain, to other ecological or human receptors (EPA 1989a,b). A variety of biological samples was collected from the FEMP environs and offsite control areas during the RI to determine the level of potential contaminant uptake by plants and animals. Samples were collected in accordance with the Biological Resources Sampling Plan, a supporting document to the approved RI/FS Work Plan. The objectives of the Biological Resources Sampling Plan were:

- To determine if any radiological or hazardous substance release to the FEMP environs results in significant uptake, assimilation, and transfer through ecological habitats, including surface water, sediments and adjacent wetlands;

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- To determine if any radiological or hazardous substance release to the FEMP environs results in uptake and assimilation in agricultural products and crops;
- To determine if the above represent significant pathways to human receptors; and
- To determine if federal or state threatened or endangered species exist within the FEMP environs, and the potential risk which is posed to their existence or welfare through contaminant release from the FEMP.

This appendix reports data corresponding to the first two objectives. The third objective is addressed in Section 5.0, Current Site Risks, and in human health risk assessments presented in RI/FS reports. Investigations supporting the fourth objective are reported in Appendix G, Threatened and Endangered Species at the FEMP.

## H.2.0 METHODS

This section details the methods and procedures used to collect the samples and to prevent cross-contamination. All laboratory analyses were conducted by International Technology Corp. in Oak Ridge, TN.

### H.2.1 VEGETATION SAMPLING

On- and off-property samples included garden produce, agricultural crops, grasses, forbs, shrubs, pine needles, mosses, and algae. Produce and crops were collected from the sites indicated in Figure H.2-1 and from reference sites located upwind from the FEMP in Brookville, IN. The locations of these sites are stated in Figure H.2-1. Sample locations for general flora (Figure H.2-2) were selected using the Ohio State Plane coordinate system (1000-foot centers). Sampling was also conducted in habitats such as wetlands, where contaminants can become concentrated. Other sites were chosen because of their location relative to depositional patterns from FEMP stack emissions, that is, to the north and east of the FEMP (downwind), and to the south and west (upwind).

For general flora, at each sample location, a 0.5 x 0.5 m ($0.25m^2$) quadrat was placed over vegetation at the 1000-foot grid stake, surveyed for sampling purposes. At the same site, a soil sample was collected from a point diagonally opposite the vegetation sampling point, always within 0.5 m of the vegetation sample. Collection procedures were as follows:

- Shears, trowels, and shovels were pre-washed at the decontamination facility using biodegradable soap, rinsed thoroughly with deionized water, and dried using alcohol wipes and paper towels.

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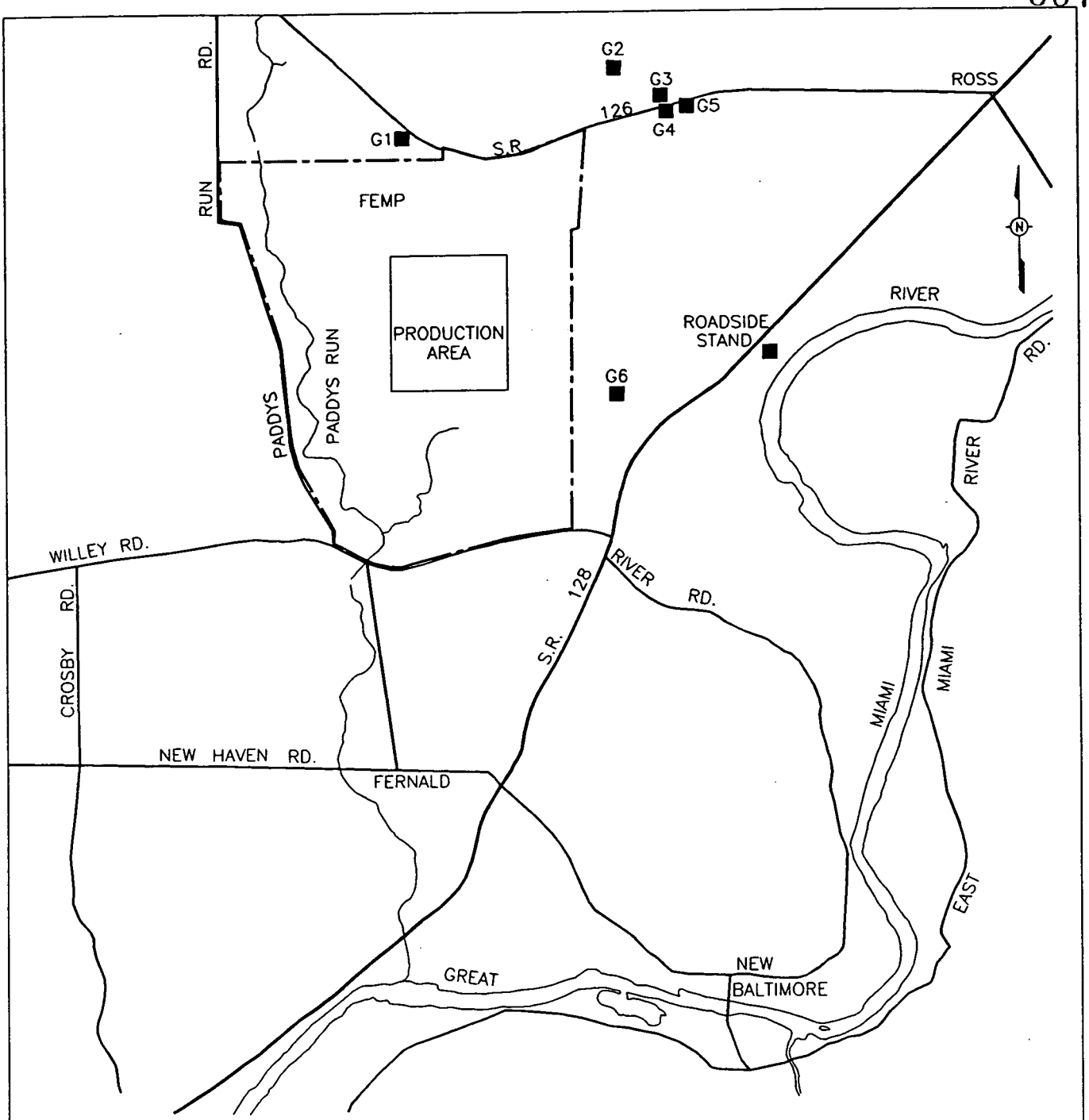


INDIANA CONTROL AREAS
(NOT SHOWN ON MAP)

| | |
|---|---|
| 11 | 5041 HIGHLAND COURT ROAD, BROOKVILLE, IN N580,923 E687,671 |
| 12 | SAME AS 11 |
| 13 | N672,048 E687,671 |
| 14 | N664,096 E689,594 |

SCALE

0 3000 6000 FEET

LEGEND:

| | |
|---|---|
| G1 | 3881 CINCINNATI–BROOKVILLE RD. |
| G2 | 4033 CHRISTIAN ROAD |
| G3 | 3418 CINCINNATI–BROOKVILLE ROAD |
| G4 | 3418 CINCINNATI–BROOKVILLE ROAD |
| G5 | 3133 CINCINNATI–BROOKVILLE ROAD |
| G6 | N479,398 E1,384,217 |
| ROADSIDE STAND | 0.8 MILES NORTH OF WILLEY ROAD ON STATE ROUTE 128, EAST SIDE |

602.A_AIRMONTR_SCR_CIN

FIGURE H.2–1. LOCATION OF SAMPLING SITES FOR GARDEN PRODUCE AND AGRICULTURAL CROPS IN THE FEMP VICINITY

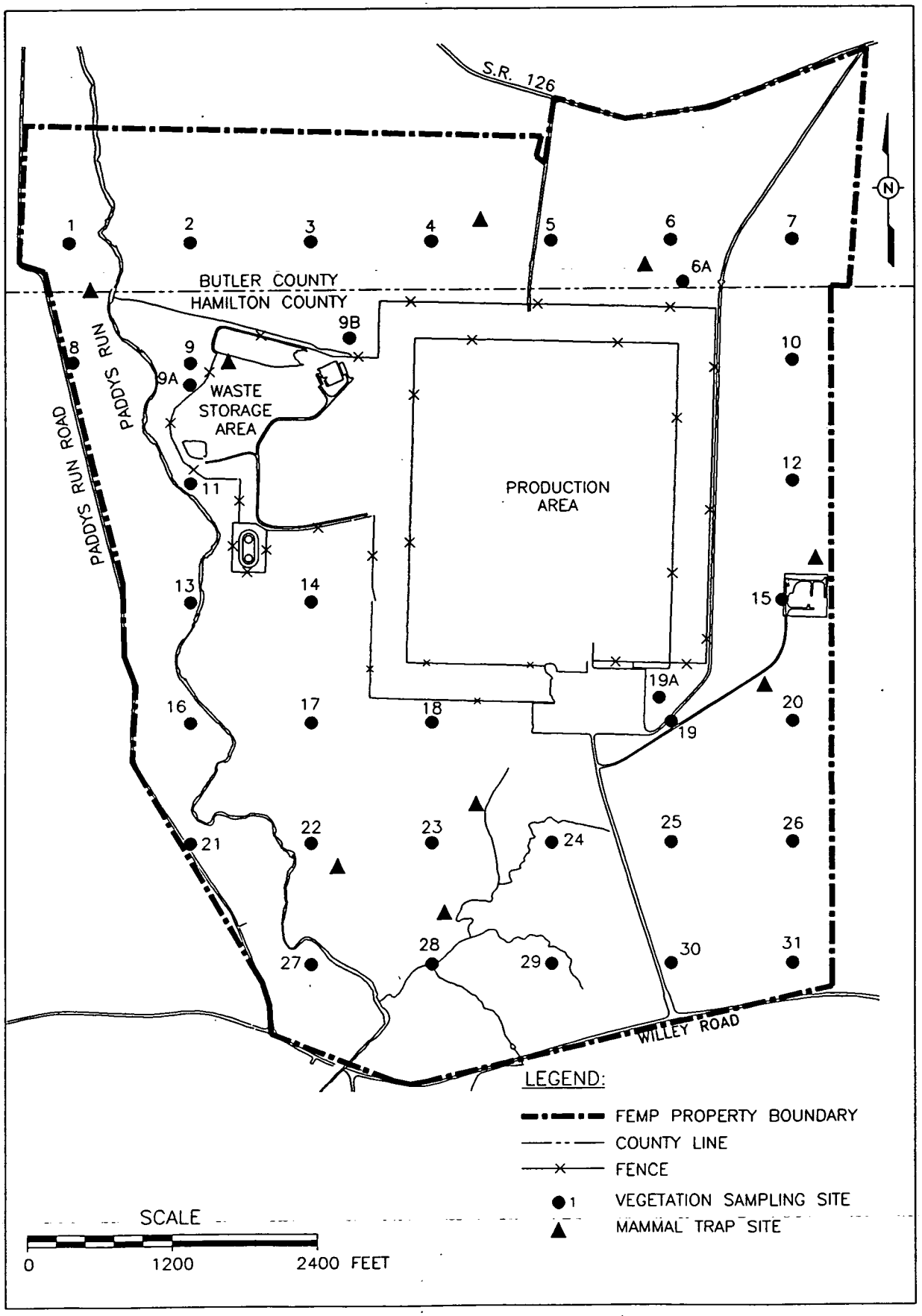


FIGURE H.2-2. LOCATION OF RI/FS VEGETATION/SOILS AND MAMMAL SAMPLING SITES ON THE FEMP

- Following placement of the 0.5 m x 0.5 m quadrat, a staging area (polyethylene sheet) was placed on the ground and sample utensils were laid out, including:
  - Shears
  - Trowel
  - Aluminum foil
  - Zip-loc bags
  - Site map
  - Polyethylene wash bottles
  - Paper towels
  - Wash receptacle
  - Sample labels
  - Cooler with blue ice
  - Marking pen
  - Field notebook
  - Deionized water
  - Methyl alcohol
  - Alcohol wipes

- Vegetation samples were collected by cutting shoots at ground level with the shears, dividing the materials into major groups (e.g., grass, forb, shrub, moss, pine needle), and placing the material on a sheet of aluminum foil. Samplers wore disposable latex gloves, which were changed after use at each site to prevent sample cross-contamination while clipping vegetative shoots and digging root samples.

- The plant material was wrapped in the aluminum foil sheet and placed in a zip-loc bag.

- Sample labels were put on each zip-loc bag indicating the sample location, date, time, sample type, sample collectors, analytical parameters, and a dedicated sample number. This information was also recorded on a sample collection log sheet and in the field notebook.

- This procedure was repeated for root samples to a depth of approximately 15 cm at each sample site. To the extent possible, earth was removed from root samples prior to packaging.

- The samples were stored in a cooler with blue ice while other sites were being sampled.

- Shears, trowels, and shovels were decontaminated by washing with biodegradable soap and deionized water, drying with methyl alcohol, alcohol wipes, and paper towels, and were then placed in a clean polyethylene bag.

- Used latex gloves, wipes, paper towels, and label backing were placed in a polyethylene trash bag for appropriate disposal by WEMCO.

- Sample bags were sealed with chain-of-custody tape and placed in a locked, dedicated freezer to await shipment to the analytical laboratory.

- Chain-of-custody forms and request-for-analysis forms were prepared to accompany samples to the analytical laboratory. Samples were shipped by the sample coordinator to the analytical laboratory in sealed coolers packed with blue ice.

Analytical parameters are presented in Section H.2.3.

Sampling of farm and garden produce was coordinated with sampling conducted by WEMCO Environmental Compliance personnel, with assistance from the Public Affairs Department. Under the grower's supervision, RI team representatives collected samples of the produce available, e.g., fruits,

leafy vegetables, grains, and root crops, and a representative soil sample. Sample collection and handling followed the procedures listed previously, except that a quadrat-bounded sample area was not used.

Four wetland sites were sampled (Figure H.2-2). Site 6A is a drainage ditch on the county line at the southeast corner of the northern pine plantation. Both cattail and sedge samples were collected from this site. Site 9A, a seep below the Waste Storage Area on the eastern bank of Paddys Run, was sampled for vegetation and soil. Site 9B, a pond and wetland system occupying the drainage ditch below the sanitary landfill and collecting drainage water from the north and northwest of the FEMP, provided samples of cattail. Site 19A, the drainage ditch near the main parking lot, was also sampled for cattails. Two algae samples were collected from Paddys Run in 1988 at sites PR-1 and PR-2A (Figure H.2-3). PR-1 was located at the northern property line of the FEMP, above the zone of potential FEMP influence, and PR-2A was located just downstream from the C & O Railroad bridge.

### H.2.2 FAUNA SAMPLING

On- and off-property faunal samples included mammals and fish. Sample locations were selected (1) in areas where the potential for contamination was high (i.e., near the fly ash pile, incinerator, and waste pits), (2) in a drainage pond below the sanitary landfill, (3) in Paddys Run (on and off property), and (4) in the Great Miami River (up- and downstream from the FEMP outfall). When available, samples were also taken from road-killed mammals. All faunal samples were collected under Scientific Collecting Permit No. 228 from the Ohio Department of Natural Resources, Division of Wildlife.

#### H.2.2.1 Mammals

Tissue from small mammals was collected from below the fly ash pile and near Waste Pit 5, as well as from the pine plantation just north and northeast of the Production Area (Figure H.2-2). Small mammal samples included deer mouse, shrew, and cottontail rabbit. Tissue from two opossum was also analyzed as well as the kidney and liver of a road-killed white-tailed deer, southwest of the Production Area near the pine plantation.

Mammals were captured using a combination of live and snap traps. Traps were baited with rolled oats, apple, carrot, or peanut butter, as appropriate, and set in likely habitat. Larger mammals constituted individual samples, while small mammals were composited for each trap site. Samples were prepared as follows:

- Animals were placed in appropriately labeled zip-loc bags and stored in a locked, dedicated freezer until shipment to the analytical laboratory. Frozen samples were shipped via overnight courier in a cooler packed with blue ice to maintain sample integrity.

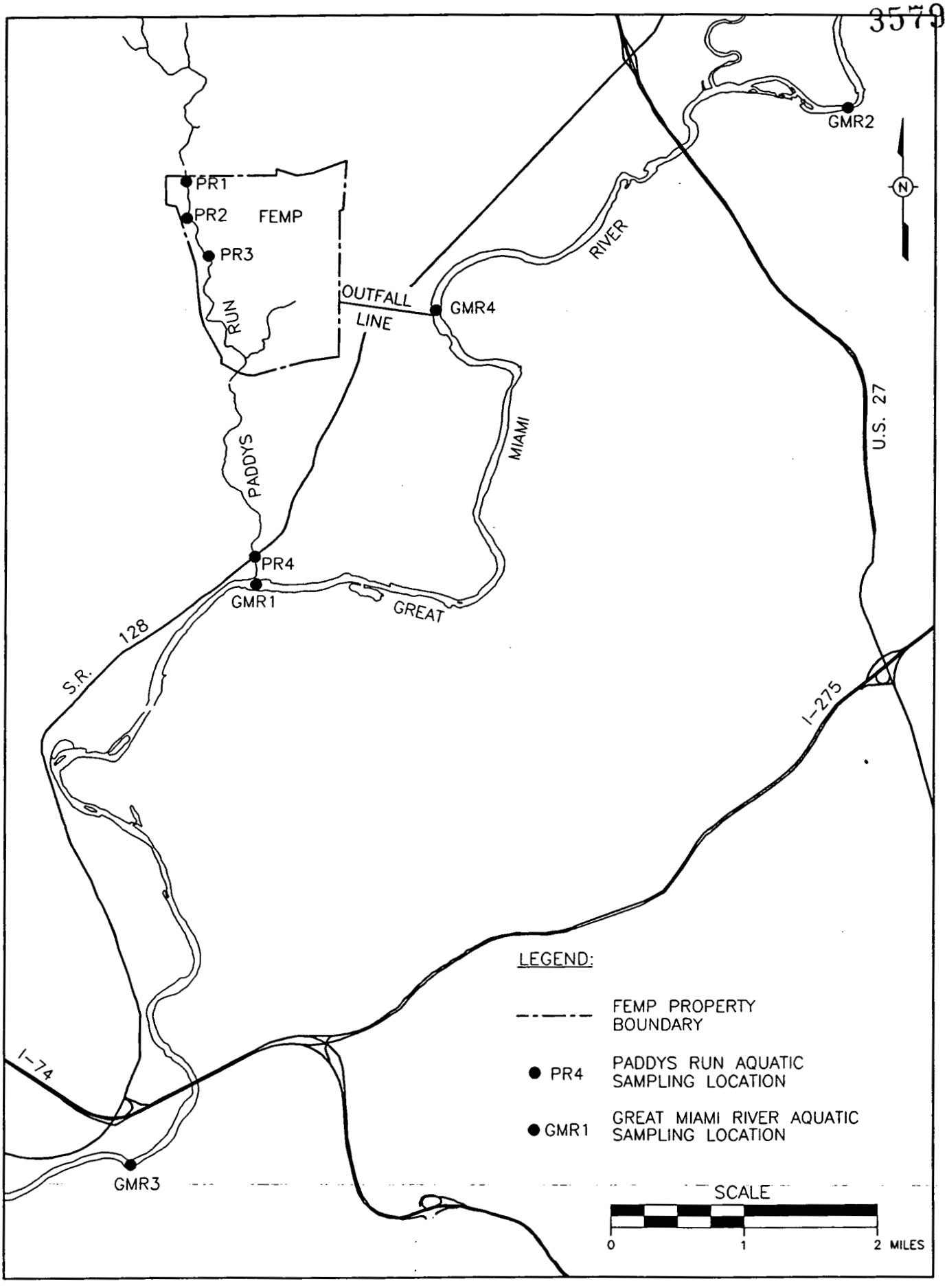


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FIGURE H.2-3. RI/FS AQUATIC BIOLOGICAL SAMPLING LOCATIONS ON AND NEAR THE FEMP

- All dissection of mammal tissue was performed in the laboratory to minimize the potential for cross-contamination.
- Decontaminated scalpel, forceps, and shears (decontaminated by washing in biodegradable soap, rinsing with deionized water, and wiping with an alcohol wipe) were used to excise tissues.
- Disposable latex gloves were worn to prevent contamination to workers and cross-contamination of samples. Gloves were disposed of after each use.
- Samples of muscle, internal organs (liver, kidney, and gonads), and/or bone were excised and placed on aluminum foil.
- Individual samples were wrapped in foil and placed in a zip-loc bag with the appropriate sample label.
- Each sample was recorded on chain-of-custody and request-for-analysis forms.

H.2.2.2 Fish

Fish were collected from four sites each on Paddys Run and the Great Miami River, and from a small drainage pond north of the Production Area in 1987 (Figure H.2-3). PR-1 was located at the northern property line of the FEMP. PR-2 was located where the C & O Railroad crosses Paddys Run. PR-3 was located downstream of PR-2, and PR-4 was just above the confluence of Paddys Run and the Great Miami River (Figure H.2-3).

The sites on the Great Miami River were located near the Bolton water treatment plant upstream from the FEMP effluent line (GMR-2); just below the discharge point of the FEMP effluent line (GMR-4); at the confluence with Paddys Run (GMR-1); and approximately one mile south of I-75 (GMR-3) (Figure H.2-3). Three samples of fish were collected and analyzed for radionuclides from a small pond at Site 9B (Figure H.2-2).

A combination of techniques, e.g., backpack shocker, seining, and dip netting was used to capture fish species for laboratory analyses. The small pond was sampled using a hand-held seine (1 m x 3 m). Two sweeps of the pond were sufficient to obtain specimens necessary for radionuclide analyses.

Paddys Run consisted of only a few small pools with short riffle areas at the time of sampling. A combination of electrofishing and seining was used to collect representative fish samples from each aquatic habitat. Each pool was sampled using a Coffelt Model BP-4 backpack shocking unit equipped with two five-foot electrode handles. Fish shocked to the surface were captured in a hand-held dip net and transferred to a collecting pail. After approximately a half-hour of use at each collection site, the backpack shocking technique was replaced by seining to adequately sample smaller fish species in the

shallower waters. Fish captured were identified, a sufficient number or mass retained for analyses, and the remainder returned to the water.

The Great Miami River was relatively low at the time of sampling. Therefore, fish collection was possible by wading and using both the Coffelt Model BP-4 backpack shocker and seines. Deeper pools were sampled from the shore using a baited hook and line. Sample stations along the Great Miami River were approximately 100-150 meters long. Electrofishing was used along the length of the sample station, followed by seining. Fish captured were identified, a sufficient number or mass retained for analyses, and the remainder returned to the water.

Following collection, fish samples were prepared as follows:

- Holding pails and pans, rubber gloves, and fillet knives were pre-washed at the decontamination facility, using biodegradable soap, rinsed thoroughly with deionized water, and dried using alcohol wipes and paper towels.

- Samplers wore textured rubber gloves to prevent sample cross-contamination and aid in handling fish specimens while sorting, measuring, and weighing the specimens.

- A staging area (polyethylene sheet) was prepared with the following sample utensils:
  - Field notebook
  - Site maps
  - Sample labels
  - Marking pens
  - Measuring board
  - Scales
  - Fillet knife
  - Aluminum foil
  - Zip-loc bags
  - Paper towels
  - Deionized water
  - Alcohol wipes
  - Cooler with blue ice

- Fish to be used for analysis were identified, measured, and weighed.

- Smaller fish were composited, larger fish were filleted, and sample tissue was placed on a dedicated sheet of aluminum foil.

- Fish tissue was wrapped in aluminum foil and placed in a zip-loc bag.

- Sample labels were put on each zip-loc bag indicating the sample location, date, time, sample type, sample collectors, and a dedicated sample number.

- The above information was recorded on a sample collection log sheet and in the field notebook.

- Samples were stored in a cooler packed with blue ice while other sites were being sampled.

- Equipment was decontaminated at the decontamination station by washing with biodegradable soap and deionized water, and drying with alcohol wipes and paper towels. All equipment was stored in plastic bags for transport to the next sampling location.

- Used wipes, paper towels, label backing and other refuse were placed in polyethylene trash bags for appropriate disposal by WEMCO.

- Following collection of fish samples, the sample bags were sealed with chain-of-custody tape and placed in a locked, dedicated freezer to await shipment to the analytical laboratory. At this time both chain-of-custody forms and request for analysis forms were prepared to accompany samples to the analytical laboratory.

H.2.2.3 Benthic Macroinvertebrates

Benthic macroinvertebrate (benthos) samples were collected from Paddys Run and the Great Miami River at the same time and locations that fish samples were collected (Figure H.2-3). A Surber sampler (0.09 $m^2$ area) was used to collect benthos samples, with organisms from three collections composited to produce the final sample for laboratory analysis. Crayfish caught while seining for smaller fish were also sent to the analytical laboratory as benthos samples, although analytical results were derived separately for crayfish and composite samples of other macroinvertebrates.

H.2.3 CONTAMINANT ANALYSES

Biological resource samples were analyzed for the uptake of various contaminants from the FEMP process materials and stored wastes. Analyses were conducted for three basic types of contaminants: radiological, organic, and HSL inorganics.

Radiological analyses in 1987 included the isotopes of uranium (U-234, U-235, U-236, U-238), strontium (Sr-90), and cesium (Cs-137). Samples collected from some of the sites used for collection of radiological samples were analyzed for organic and HSL inorganic constituents as well. These analyses were conducted in 1988 on samples from approximately eight percent of the initial sampling locations. Results are reported for 15 biological samples including five grass leaves, five grass roots, one composite minnow sample, two small mammal samples, and two deer organ samples. Analytical parameters were as follows:

- Organic
  - Anthracene
  - Butyl benzyl phthalate
  - Chlordane
  - Chrysene
  - DDT
  - Fluoranthene
  - Nitrophenol
  - PCBs
  - Phenanthrene
  - Pyrene

- Inorganics
  - Fluoride
  - Sulfate

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- Metals
  - Aluminum
  - Arsenic
  - Barium
  - Cadmium
  - Lead
  - Mercury
  - Silver
  - Vanadium
  - Zinc

These samples were also analyzed for isotopic uranium, Sr-90, Cs-137, and technetium-99 (Tc-99). Tc-99 was added due to its presence in FEMP waste streams and to its solubility.

## H.3.0 RESULTS

A total of 302 biological samples were collected for radionuclide analysis in 1987 and 1988. Sixty-three of these samples were archived, four contained insufficient mass for analysis, and 11 samples were not sent out for analysis. Therefore, a total of 224 samples was analyzed for radionuclides; of these, 15 samples were also analyzed for hazardous chemicals. Results of all analyses are reported in Tables H-1 through H-16. These data are summarized and their significance discussed in Section 4.5.5 of the EIS text and in Section 5.0, Summary of Current Site Risks.

## TABLE H-1A
## URANIUM-234 CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Uranium-234 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | 2.3 | <0.6[b] | <0.6 | c | c | c |
| 2 | 2.2 | c | c | <0.6 | 0.8 | c |
| 3 | 6.2 | <0.6[d] | <0.6[d] | c | c | c |
| 4 | 3.6 | 1.8 | 2.1 | 2.5 | 1.9 | c |
| | c | 3.2 | 2.2 | c | c | c |
| 5 | 11.0 | 4.0 | 10.7 | 2.5 | 2.7 | c |
| 6 | 16.5 | 2.4 | 3.4 | <0.6 | 3.4 | c |
| 7 | c | 1.6 | 3.6 | 1.1 | 2.2 | c |
| | c | c | 1.3 | c | c | c |
| 8 | 2.6 | <0.6 | 0.6 | 0.6 | <0.6 | c |
| 9 | 2.9 | <0.6 | 3.9 | c | c | c |
| | 2.6 | c | c | c | c | c |
| 10 | c | 2.0 | 12.9 | 3.0 | 0.8 | c |
| | c | <0.6[d] | 1.6[d] | c | c | c |
| 11 | 1.7 | c | c | <0.6 | 0.6 | c |
| 12 | 17.0 | <0.6 | 12.8 | 1.1 | 13.7 | c |
| 13 | 1.3 | c | c | <0.6 | <0.6 | 1.0[e] |
| | c | c | c | c | c | <0.6[f] |
| | c | c | c | c | c | 4.8[g] |
| 14 | c | c | c | 3.1 | 10.4 | <0.6[g] |
| 15 | c | <0.6 | 13.5 | 2.0 | 14.1 | c |
| | c | <0.6[d] | 9.7[d] | c | c | c |
| 16 | 4.3 | <0.6 | 1.2 | 0.9 | 2.3 | c |
| 17 | 16.0 | <0.6 | 2.8 | c | c | <0.6[h] |
| | c | c | c | c | c | <0.6[i] |
| 18 | 14.5 | 0.8 | 8.4 | 0.8 | 2.0 | c |
| 19 | 14.7 | 1.7 | 3.8 | c | c | c |
| | c | 1.6 | 4.4 | c | c | c |

See footnotes at end of Table H-1D.

**TABLE H-1A**
**(Continued)**

| | Uranium-234 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 5.9 | 1.3 | 2.2 | c | c | c |
| 21 | 6.0 | 2.3 | <0.6 | c | c | c |
| 22 | 5.1 | c | c | <0.6 | 0.8 | c |
| 23 | 2.6 | <0.6 | <0.6 | c | c | c |
| 24 | 4.4 | 1.0 | 1.6 | c | c | c |
| 25 | 3.2 | 0.6 | 2.9 | c | c | c |
| 26 | 3.7 | <0.6 | <0.6 | c | c | c |
| 27 | 1.0 | <0.6 | <0.6 | c | c | c |
| 28 | 14.5 | 1.2[d] | 2.1[d] | 1.0 | 16.1 | c |
| | c | c | c | 1.1 | 4.4 | c |
| 29 | 3.0 | <0.6 | <0.6 | c | c | c |
| 30 | 3.4 | <0.6 | <0.6 | c | c | c |
| 31 | 2.8 | <0.6 | <0.6 | <0.6 | <0.6 | c |

See footnotes at end of Table H-1D.

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# TABLE H-1B
## URANIUM-235/236 CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Uranium-235, -236 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | <0.6 | <0.6 | <0.6 | c | c | c |
| 2 | <0.6 | c | c | <0.6 | <0.6 | c |
| 3 | <0.6 | <0.6[d] | <0.6[d] | c | c | c |
| 4 | 1.6 | <0.6 | <0.6 | <0.6 | <0.6 | c |
| | c | <0.6 | <0.6 | c | c | c |
| 5 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | c |
| 6 | 1.7 | <0.6 | <0.6 | <0.6 | 0.9 | c |
| 7 | c | <0.6 | <0.6 | <0.6 | 0.8 | c |
| | c | c | <0.6 | c | c | c |
| 8 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | c |
| 9 | <0.6 | <0.6 | <0.6 | c | c | c |
| | <0.6 | c | c | c | c | c |
| 10 | c | <0.6 | <0.6 | <0.6 | <0.6 | c |
| | c | <0.6[d] | <0.6[d] | c | c | c |
| 11 | <0.6 | c | c | <0.6 | <0.6 | c |
| 12 | 1.3 | <0.6 | 1.2 | <0.6 | 0.9 | c |
| 13 | <0.6 | c | c | <0.6 | <0.6 | <0.6[e] |
| | c | c | c | c | c | <0.6[f] |
| | c | c | c | c | c | 0.8[g] |
| 14 | c | c | c | <0.6 | 1.2 | <0.6[g] |
| 15 | c | <0.6 | 1.2 | <0.6 | 0.9 | c |
| | c | <0.6[d] | 0.6[d] | c | c | c |
| 16 | <0.6 | <0.6 | <0.6 | c | c | c |
| 17 | 1.2 | <0.6 | <0.6 | c | c | <0.6[h] |
| | c | c | c | c | c | <0.6[i] |
| 18 | 1.4 | <0.6 | <0.6 | <0.6 | <0.6 | c |
| 19 | 0.9 | <0.6 | <0.6 | c | c | c |
| | c | <0.6 | <0.6 | c | c | c |

See footnotes at end of Table H-1D.

TABLE H-1B
(Continued)

| | Uranium-235, -236 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 0.8 | <0.6 | <0.6 | c | c | c |
| 21 | <0.6 | <0.6 | <0.6 | c | c | c |
| 22 | <0.6 | c | c | <0.6 | <0.6 | c |
| 23 | <0.6 | <0.6 | <0.6 | c | c | c |
| 24 | <0.6 | <0.6 | <0.6 | c | c | c |
| 25 | <0.6 | <0.6 | <0.6 | c | c | c |
| 26 | <0.6 | <0.6 | <0.6 | c | c | c |
| 27 | <0.6 | <0.6 | <0.6 | c | c | c |
| 28 | 1.8 | <0.6[d] | <0.6[d] | <0.6 | 1.6 | c |
| | c | c | c | <0.6 | <0.6 | c |
| 29 | <0.6 | <0.6 | <0.6 | c | c | c |
| 30 | <0.6 | <0.6 | <0.6 | c | c | c |
| 31 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | c |

See footnotes at end of Table H-1D.

# TABLE H-1C
## URANIUM-238 CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Uranium-238 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | 1.9 | <0.6 | <0.6 | c | c | c |
| 2 | 2.3 | c | c | <0.6 | 0.9 | c |
| 3 | 7.8 | <0.6[d] | <0.6[d] | c | c | c |
| 4 | 4.7 | <0.6 | 1.6 | 2.4 | 1.0 | c |
| | c | 0.9 | 2.0 | c | c | c |
| 5 | 10.9 | 1.7 | 6.6 | 1.4 | 1.4 | c |
| 6 | 17.4 | 1.2 | 3.4 | <0.6 | 5.0 | c |
| 7 | c | 0.9 | 2.6 | 1.0 | 2.9 | c |
| | c | c | 1.5 | c | c | c |
| 8 | 3.6 | <0.6 | 0.7 | <0.6 | <0.6 | c |
| 9 | 5.2 | <0.6 | 4.8 | c | c | c |
| | 4.2 | c | c | c | c | c |
| 10 | c | 13.7 | 13.7 | 1.1 | 0.7 | c |
| | c | <0.6[d] | 1.6[d] | c | c | c |
| 11 | 2.6 | c | c | <0.6 | 2.1 | c |
| 12 | 17.3 | 0.7 | 13.6 | 1.7 | 14.3 | c |
| 13 | 1.7 | c | c | <0.6 | <0.6 | 0.7[e] |
| | c | c | c | c | c | <0.6[f] |
| | c | c | c | c | c | 6.3[g] |
| 14 | c | c | c | 3.3 | 12.0 | <0.6[g] |
| 15 | c | <0.6 | 17.2 | 4.2 | 17.4 | c |
| | c | <0.6[d] | 9.8[d] | c | c | c |
| 16 | 3.3 | <0.6 | 1.6 | 0.7 | 1.7 | c |
| 17 | 15.2 | <0.6 | 2.8 | c | c | <0.6[h] |
| | c | c | c | c | c | <0.6[i] |
| 18 | 14.3 | <0.6 | 9.5 | <0.6 | 1.9 | c |
| 19 | 11.7 | 2.1 | 3.9 | c | c | c |
| | c | 1.8 | 4.5 | c | c | c |

See footnotes at end of Table H-1D.

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## TABLE H-1C
(Continued)

| Site[a] | Uranium-238 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 6.6 | 1.6 | 2.1 | c | c | c |
| 21 | 5.4 | 3.2 | <0.6 | c | c | c |
| 22 | 4.9 | c | c | <0.6 | 1.5 | c |
| 23 | 2.7 | <0.6 | <0.6 | c | c | c |
| 24 | 4.7 | 0.9 | 1.5 | c | c | c |
| 25 | 2.7 | <0.6 | 2.8 | c | c | c |
| 26 | 3.2 | <0.6 | <0.6 | c | c | c |
| 27 | 1.7 | <0.6 | <0.6 | c | c | c |
| 28 | 16.2 | 1.4[d] | 2.5[d] | 1.2 | 17.8 | c |
| | c | c | c | 1.6 | 5.7 | c |
| 29 | 3.1 | <0.6 | <0.6 | c | c | c |
| 30 | 3.1 | <0.6 | <0.6 | c | c | c |
| 31 | 2.9 | <0.6 | <0.6 | <0.6 | <0.6 | c |

See footnotes at end of Table H-1D.

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## TABLE H-1D
## TOTAL ISOTOPIC URANIUM CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Total Isotopic Uranium (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | 4.2 | <d.l.[j] | <d.l. | c | c | c |
| 2 | 4.5 | c | c | <d.l. | 1.7 | c |
| 3 | 14.0 | <d.l.[d] | <d.l.[d] | c | c | c |
| 4 | 9.9 | 1.8 | 3.7 | 4.9 | 2.9 | c |
| | c | 4.1 | 4.2 | c | c | c |
| 5 | 21.9 | 5.7 | 17.3 | 3.9 | 4.1 | c |
| 6 | 35.6 | 3.6 | 6.8 | <d.l. | 9.3 | c |
| 7 | c | 2.5 | 6.2 | 2.1 | 5.9 | c |
| 8 | 6.2 | <d.l. | 1.3 | 0.6 | <d.l. | c |
| 9 | 8.1 | <d.l. | 8.7 | c | c | c |
| | 6.8 | c | c | c | c | c |
| 10 | c | 15.7 | 26.6 | 4.1 | 1.5 | c |
| | c | <d.l.[d] | 3.2[d] | c | c | c |
| 11 | 4.3 | c | c | <d.l. | 2.7 | c |
| 12 | 35.6 | 0.7 | 27.6 | 2.8 | 28.9 | c |
| 13 | 3.0 | c | c | <d.l. | <d.l. | 1.7[e] |
| | c | c | c | c | c | <d.l.[f] |
| | c | c | c | c | c | 11.9[g] |
| 14 | c | c | c | 6.4 | 23.6 | <d.l.[g] |
| 15 | c | <d.l. | 31.9 | 6.2 | 32.4 | c |
| | c | <d.l.[d] | 20.1[d] | c | c | c |
| 16 | 7.6 | <d.l. | 2.8 | 1.6 | 4.0 | c |
| 17 | 32.4 | <d.l. | 5.6 | c | c | 0.6[h] |
| | c | c | c | c | c | <d.l.[i] |
| 18 | 30.2 | 0.8 | 17.9 | 0.8 | 3.9 | c |
| 19 | 27.3 | 3.8 | 7.7 | c | c | c |
| | c | 3.4 | 8.9 | c | c | c |

See footnotes at end of next page.

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**TABLE H-1D**
**(Continued)**

| | Total Isotopic Uranium (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 13.3 | 2.9 | 4.3 | c | c | c |
| 21 | 11.4 | 5.5 | <d.l. | c | c | c |
| 22 | 10.0 | c | c | <d.l. | 2.3 | c |
| 23 | 5.3 | <d.l. | <d.l. | c | c | c |
| 24 | 9.1 | 1.9 | 3.1 | c | c | c |
| 25 | 5.9 | 0.6 | 5.7 | c | c | c |
| 26 | 6.9 | <d.l. | <d.l. | c | c | c |
| 27 | 2.7 | <d.l. | <d.l. | c | c | c |
| 28 | 32.5 | 2.6[d] | 4.6[d] | 2.2 | 35.5 | c |
| | c | c | c | 2.7 | 10.1 | c |
| 29 | 6.1 | <d.l. | <d.l. | c | c | c |
| 30 | 6.5 | <d.l. | <d.l. | c | c | c |
| 31 | 5.7 | <d.l. | 0.6 | <d.l. | <d.l. | c |

[a] See Figure H.2-2
[b] <, less than stated detection limit
[c] Not sampled at this site
[d] 1988 samples
[e] Onion leaves
[f] Onion bulbs
[g] Moss
[h] Mint leaves
[i] Pine needles
[j] <d.l., means that all isotopes of uranium were below detection limits.

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## TABLE H-2
## CESIUM-137 CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Cesium-137 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | 0.8 | <0.3[b] | 0.3 | c | c | c |
| 2 | 0.5 | c | c | <0.2 | <0.2 | c |
| 3 | 1.0 | <0.2[d] | 1.2[d] | c | c | c |
| 4 | 0.6 | <0.2 | <0.5 | 0.4 | <0.3 | c |
| | c | <0.3 | <0.3 | c | c | c |
| 5 | 0.8 | <0.3 | <0.2 | <0.2 | <0.4 | c |
| 6 | 1.6 | 0.4 | <0.5 | <0.2 | 0.2 | c |
| 7 | c | <0.5 | 0.8 | <0.2 | <0.6 | c |
| | c | c | 0.3 | c | c | c |
| 8 | 0.7 | <0.3 | 0.6 | <0.3 | <0.2 | c |
| 9 | <0.2 | <0.3 | <0.2 | c | c | c |
| | <0.2 | c | c | c | c | c |
| 10 | c | <0.2 | 1.4 | <0.2 | <0.7 | c |
| | c | <0.2[d] | 1.2[d] | c | c | c |
| 11 | <0.2 | c | c | <0.2 | <0.2 | c |
| 12 | 0.9 | <0.3 | 0.9 | <0.2 | 0.8 | c |
| 13 | <0.2 | c | c | <0.4 | <0.3 | <0.7[e] |
| | c | c | c | c | c | 0.3[f] |
| | c | c | c | c | c | <0.2[g] |
| 14 | c | c | c | <0.3 | <0.3 | 0.6[g] |
| 15 | c | <0.3 | <0.3 | <0.3 | 0.3 | c |
| | c | <0.2[d] | 1.2[d] | c | c | c |
| 16 | 0.4 | <0.2 | 0.3 | <0.2 | <0.3 | c |
| 17 | 1.0 | <0.2 | 0.6 | c | c | <0.2[h] |
| | c | c | c | c | c | <0.2[i] |
| 18 | 1.2 | <0.8 | 1.0 | <0.6 | <0.8 | c |
| 19 | 0.7 | <0.2 | 0.6 | c | c | c |
| | c | <0.3 | 0.4 | c | c | c |

See footnotes at end of table.

**TABLE H-2**
**(Continued)**

| | Cesium-137 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 0.8 | <0.4 | 0.5 | c | c | c |
| 21 | 0.9 | <0.4 | <0.2 | c | c | c |
| 22 | 0.7 | c | c | <0.3 | <0.3 | c |
| 23 | 0.3 | <0.2 | 0.3 | c | c | c |
| 24 | 1.1 | <0.3 | 0.6 | c | c | c |
| 25 | 0.7 | <0.2 | 0.8 | c | c | c |
| 26 | 0.8 | <0.3 | 0.3 | c | c | c |
| 27 | <0.2 | <0.3 | <0.2 | c | c | c |
| 28 | 0.8 | <0.2[d] | 0.9[d] | <0.2 | <0.4 | c |
| | c | c | c | <0.3 | <0.4 | c |
| 29 | 0.8 | <0.2 | 0.6 | c | c | c |
| 30 | 0.5 | <0.3 | 0.4 | c | c | c |
| 31 | 0.8 | <0.2 | 0.4 | <0.3 | <0.2 | c |

[a] See Figure H.2-2
[b] <, less than stated detection limit
[c] Not sampled
[d] 1988 samples
[e] Onion leaves
[f] Onion bulbs
[g] Moss
[h] Mint leaves
[i] Pine needles

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## TABLE H-3
## STRONTIUM-90 CONCENTRATIONS IN SOIL AND TERRESTRIAL VEGETATION ON THE FEMP

| | Strontium-90 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Site[a] | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 1 | <0.5[b] | <0.5 | <0.5 | c | c | c |
| 2 | 2.5 | c | c | <0.5 | <0.5 | c |
| 3 | d | <0.5[e] | <0.5[e] | c | c | c |
| 4 | d | <0.7 | <0.5 | <0.5 | <0.7 | c |
| | c | <0.7 | <0.5 | c | c | c |
| 5 | 1.4 | <1.5 | <0.8 | 0.7 | 0.6 | c |
| 6 | 0.9 | <0.8 | <0.7 | <0.5 | 0.7 | c |
| 7 | c | <0.7 | <0.5 | <0.5 | <1.4 | c |
| | c | c | 0.8 | c | c | c |
| 8 | 1.5 | <0.5 | <0.5 | <0.5 | <0.5 | c |
| 9 | 0.6 | <1.5 | <0.5 | c | c | c |
| | 0.5 | c | c | c | c | c |
| 10 | c | <0.5 | <0.5 | <0.6 | <0.5 | c |
| | c | <0.5[e] | <0.5[e] | c | c | c |
| 11 | <0.5 | c | c | <0.5 | <0.5 | c |
| 12 | 0.6 | <0.6 | <0.5 | 0.9 | <0.5 | c |
| 13 | <0.5 | c | c | <1.0 | <0.6 | <1.9[f] |
| | c | c | c | c | c | <0.5[g] |
| | c | c | c | c | c | <0.5[h] |
| 14 | c | c | c | <0.6 | <0.5 | <1.4[h] |
| 15 | c | <0.5 | <0.5 | <0.5 | <0.5 | c |
| | c | <0.5[e] | <0.5[e] | c | c | c |
| 16 | 1.3 | <0.5 | <0.2 | <0.6 | <0.6 | c |
| 17 | 0.6 | <0.5 | <0.5 | c | c | <0.5[i] |
| | c | c | c | c | c | <0.5[j] |
| 18 | 0.8 | 0.6 | <0.5 | <0.5 | <0.5 | c |
| 19 | 0.9 | <0.7 | <0.5 | c | c | c |
| | c | <0.9 | <0.5 | c | c | c |

See footnotes at end of table.

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TABLE H-3
(Continued)

| Site[a] | Strontium-90 (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| | Soil | Grass Leaves | Grass Roots | Forb Leaves | Forb Roots | Other |
| 20 | 1.5 | <0.6 | <0.5 | c | c | c |
| 21 | <0.5 | <1.2 | <0.5 | c | c | c |
| 22 | <0.5 | c | c | <0.5 | <0.5 | c |
| 23 | <0.5 | <0.5 | <0.5 | c | c | c |
| 24 | 1.1 | <0.5 | <0.5 | c | c | c |
| 25 | 0.8 | <0.5 | <0.5 | c | c | c |
| 26 | 0.8 | <0.7 | <0.5 | c | c | c |
| 27 | 1.6 | <0.5 | <0.5 | c | c | c |
| 28 | 0.6 | <0.5[e] | <0.5[e] | <0.5 | <0.5 | c |
| | c | c | c | 0.6 | <0.6 | c |
| 29 | 1.2 | <0.8 | <0.4 | c | c | c |
| 30 | 0.6 | <0.8 | <0.5 | c | c | c |
| 31 | 1.0 | <0.5 | <0.5 | <0.6 | <0.5 | c |

[a] See Figure H.2-2
[b] <, less than stated detection limit
[c] Not sampled at this site
[d] Lost in analysis
[e] 1988 samples
[f] Onion leaves
[g] Onion bulbs
[h] Moss
[i] Mint leaves
[j] Pine needles

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## TABLE H-4
## RADIONUCLIDE CONCENTRATIONS IN WETLAND PLANTS ON THE FEMP

| | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | Site[a] | Cs-137 | Sr-90 | Tc-99 | U-234 | U-235, -236 | U-238 | Total Isotopic Uranium |
| Algae[c] | PR-1 | <0.2[d] | 0.9 | <0.9 | <0.6 | <0.6 | <0.6 | e |
| Algae[c] | PR-2A | <0.2 | <0.5 | <0.9 | <0.6 | <0.6 | <0.6 | e |
| Cattail leaf | 6A | <0.6 | <0.9 | b | <0.6 | <0.6 | 0.8 | 0.8 |
| Cattail root | 6A | <0.2 | <0.9 | b | <0.6 | <0.6 | <0.6 | e |
| Sedge leaf | 6A | <0.2 | <0.7 | b | <0.6 | <0.6 | <0.6 | e |
| Sedge leaf | 6A | <0.2 | <1.3 | b | <0.6 | <0.6 | <0.6 | e |
| Soil | 9A | <0.2 | 0.6 | b | 3.9 | <0.6 | 12.4 | 16.3 |
| Cattail leaf | 9A | <0.3 | <0.5 | b | <0.6 | <0.6 | <0.6 | e |
| Cattail leaf | 9A | <0.2 | <0.5 | b | 0.7 | <0.6 | 0.7 | 1.4 |
| Cattail root | 9A | <0.3 | <0.5 | b | 2.6 | <0.6 | 3.8 | 6.4 |
| Grass leaf | 9A | <0.3 | <0.6 | b | <0.6 | <0.6 | <0.6 | e |
| Grass root | 9A | <0.2 | <0.5 | b | 7.7 | 1.3 | 22.3 | 31.3 |
| Grass leaves[c] | 9A | <0.2 | <0.5 | 1.9 | <0.6 | <0.6 | <0.6 | e |
| Grass roots[c] | 9A | <0.2 | <0.5 | <0.9 | 0.9 | <0.6 | 4.2 | 5.1 |
| Cattail leaf | 9B | <0.4 | <1.0 | b | 1.4 | <0.6 | 1.9 | 3.3 |
| Cattail root | 9B | <0.2 | <0.5 | b | <0.6 | <0.6 | <0.6 | e |
| Cattail leaf | 19A | <0.4 | <1.0 | b | <0.6 | <0.6 | <0.6 | e |
| Cattail root | 19A | <0.2 | <0.5 | b | 1.6 | <0.6 | 2.2 | 3.8 |

[a] See Figure H.2-2

[b] Technetium-99 analyzed for 1988 samples only.

[c] 1988 sample

[d] <, less than stated detection limit

[e] No uranium isotopes detected

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**TABLE H-5**
**INORGANIC CHEMICAL CONCENTRATIONS**
**IN VEGETATION AND WILDLIFE SAMPLES FROM THE FEMP (mg/kg)**

| | | Chemical | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Type | Site[a] | Aluminum | Arsenic | Barium | Cadmium | Fluoride | Lead | Mercury | Silver | Sulfate | Vanadium | Zinc |
| Grass leaves | 3 | 4950 | 12 | 9.0 | 0.5u[b] | 330 | 3u | 0.6 | 0.5u | 2400 | 1 | 13.0 |
| Grass roots | 3 | 4940 | 8 | 36.1 | 0.7 | 620 | 3 | 0.6 | 0.5u | 1300 | 10 | 35.7 |
| Grass leaves | 15 | 18 | 9 | 2.8 | 0.5u | 340 | 3u | 1.4 | 0.5u | 830 | 1u | 5.5 |
| Grass roots | 15 | 6350 | 10 | 47.2 | 0.8 | 15 | 12 | 3.6 | 0.5u | 80 | 1u | 115.0 |
| Grass leaves | 10 | 52 | 5 | 2.6 | 0.5u | 80 | 3u | 8.2 | 0.5u | 1600 | 1u | 9.5 |
| Grass roots | 10 | 10600 | 8 | 59.8 | 0.9 | 58 | 10 | 3.3 | 0.5u | 240 | 20 | 42.9 |
| Grass leaves | 9A | 25 | 13 | 3.2 | 0.5u | 210 | 3u | 0.5 | 0.5u | 320 | 1u | 4.4 |
| Grass roots | 9A | 2160 | 3u | 17.5 | 0.5u | 50u | 3u | 2.1 | 0.5u | 830 | 3 | 8.0 |
| Grass leaves | 28 | 2840 | 7 | 12.5 | 0.5u | 720 | 3u | 15.3 | 0.5u | 110 | 1u | 12.3 |
| Grass roots | 28 | 1680 | 11 | 24.9 | 0.5u | 15 | 4 | 67.1 | 0.5u | 67 | 4 | 20.6 |
| Minnows | PR-1 | 28 | 6 | 1.0 | 4.2 | 1400 | 3u | 0.3 | 0.5u | 830 | 1u | 33.2 |
| Small mammal (carcass) | 28 | 42 | 13 | 1.0 | 0.5u | 710 | 3u | 0.24 | 0.5u | 1700 | 1u | 38.3 |
| Cottontail (muscle) | 28 | 4u | 8 | 0.2u | 0.5u | 540 | 3u | 0.2 | 0.5u | 160 | 1u | 10.9 |
| Deer (kidney) | c | 4u | 17 | 0.2u | 0.5u | 160 | 3u | 0.1u | 0.5u | 60 | 1u | 32.3 |
| Deer (liver) | c | 8 | 20 | 0.2u | 0.5u | 2400 | 3u | 0.1u | 0.5u | 140 | 1u | 51.8 |

[a] See Figure H.2-2
[b] u indicates metal was not detected
[c] Roadkill on FEMP

## TABLE H-6

## ORGANIC CHEMICAL CONCENTRATIONS IN VEGETATION AND WILDLIFE COLLECTED FROM THE FEMP (µg/kg)

| | | Chemical | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample Type | Site[a] | Anthracene | Butylbenzyl-Phthalate | Chrysene | Fluoranthene | Phenanthrene | Pyrene | 2-Nitrophenol | 4-Nitrophenol |
| Grass leaves | 3 | 20000u[b] | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u | 100000u |
| Grass roots | 3 | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass leaves | 15 | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass roots | 15 | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass leaves | 10 | 10000u | 1800jb | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass roots. | 10 | 10000u | 1300jb | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass leaves | 9A | 10000u | 2000j | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass roots | 9A | 10000u | 1000j | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Grass leaves | 28 | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u | 100000u |
| Grass roots | 28 | 10000u | 1600j | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Minnows | PR-1 | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u | 20000u |
| Small mammal (carcass) | 28 | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Cottontail (muscle) | 28 | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |
| Deer (kidney) | c | 1000u | 1000u | 1000u | 1000u | 1000u | 1000u | 1000u | 5000u |
| Deer (liver) | c | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 10000u | 50000u |

[a] See Figure H.2-2

[b] u indicates compound was not detected
j indicates estimated detection level
B indicates compound found in blank sample

[c] Roadkill on the FEMP

TABLE H-7

PESTICIDE AND PCB CONCENTRATIONS
IN VEGETATION AND WILDLIFE COLLECTED FROM THE FEMP (µg/kg)

| | | PCB | | | | | | Pesticide | |
|---|---|---|---|---|---|---|---|---|---|
| Sample Type | Site[a] | Aroclor-1260 | Aroclor-1254 | Aroclor-1221 | Aroclor-1016 | Aroclor-1232 | Aroclor-1242 | Chlordane | 4,4-DDT |
| Grass leaves | 3 | 800u[b] | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass roots | 3 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass leaves | 15 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass roots | 15 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass leaves | 10 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass roots | 10 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass leaves | 9A | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass roots | 9A | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass leaves | 28 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Grass roots | 28 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Minnows | PR-1 | 800u | 800u | 1400u | 800u | 800u | 800u | 800u | 400u |
| Small mammal (carcass) | 28 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Cottontail (muscle) | 28 | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Deer (kidney) | c | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |
| Deer (liver) | c | 800u | 800u | 800u | 800u | 800u | 800u | 800u | 400u |

[a] See Figure H.2-2

[b] u indicates compound was not detected

[c] Roadkill on the FEMP

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## TABLE H-8
## RADIONUCLIDE CONCENTRATIONS IN GARDEN PRODUCE, AGRICULTURAL CROPS, AND SOIL SAMPLES INDIANA REFERENCE SITE

| | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Site[a] | Cs-137 | Sr-90 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| Soil (field) | I1 | 0.3 | <0.5[b] | 1.1 | <0.6 | 1.0 | 2.1 |
| Alfalfa | I1 | <0.5 | 0.5 | 2.4 | 0.6 | 1.1 | 4.1 |
| Field corn | I1 | 0.3 | <0.5 | 1.1 | <0.6 | 1.0 | 2.1 |
| Soil (garden) | I1 | 0.3 | <0.5 | 1.4 | <0.6 | 1.2 | 2.6 |
| Okra | I1 | <0.4 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Tomato | I1 | <0.2 | <0.5 | 2.5 | <0.6 | 0.8 | 3.3 |
| Green pepper | I1 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (flesh) | I1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (peel) | I1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soil | I2 | 0.2 | <0.5 | 2.4 | <0.6 | 3.2 | 5.6 |
| Tomato | I2 | <0.2 | <0.5 | 0.8 | <0.6 | <0.6 | 0.8 |
| Tomato | I2 | <0.4 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Green pepper | I2 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (flesh) | I2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (peel) | I2 | <0.3 | <0.5 | 2.7 | <1.4 | <1.4 | 2.7 |
| Soil | I3 | 0.3 | 1.2 | 1.0 | <0.6 | 1.3 | 2.3 |
| Soybean | I3 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soybean | I3 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soybean (husk) | I3 | <0.2 | 0.6 | 0.7 | <0.6 | <0.6 | 0.7 |
| Field corn | I3 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |

[a] See Figure H.2-2

[b] <, less than stated detection limit

[c] No uranium isotopes detected

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# TABLE H-9
## RADIONUCLIDE CONCENTRATIONS IN GARDEN PRODUCE, AGRICULTURAL CROPS, AND SOIL SAMPLES FROM THE FEMP VICINITY

| | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Site[a] | Cs-137 | Sr-90 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| Soil | G1 | 0.2 | <0.5[b] | 1.7 | <0.6 | 1.6 | 3.3 |
| Green pepper | G1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Okra | G1 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Tomato | G1 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Cucumber | G1 | <1.1 | <0.6 | 3.0 | <0.6 | 1.8 | 4.8 |
| Squash | G1 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soil | G2 | 0.3 | 0.8 | 1.3 | <0.6 | 1.5 | 2.8 |
| Cabbage | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Green pepper | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Okra | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (peel) | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Potato (flesh) | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Sweet potato | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Tomato | G2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soil | G3 | 0.3 | 0.7 | 0.8 | <0.6 | <0.6 | 0.8 |
| Tomato | G3 | <0.3 | <0.5 | 0.8 | <0.6 | <0.6 | 0.8 |
| Okra | G3 | <0.5 | <0.5 | 1.4 | <0.6 | 0.8 | 2.2 |
| Green pepper | G3 | <0.2 | <0.5 | 1.0 | <0.6 | <0.6 | 1.0 |
| Soil | G4 | 0.2 | <0.5 | 2.5 | <0.6 | 2.1 | 4.6 |
| Alfalfa | G4 | <0.4 | <0.5 | 1.2 | <0.6 | <0.6 | 1.2 |
| Soil (garden) | G5 | <0.2 | <0.5 | 1.3 | <0.6 | 1.3 | 2.6 |
| Soil (field) | G5 | <0.2 | 2.7 | 1.3 | <0.6 | 1.7 | 3.0 |
| Tomato | G5 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Field corn | G5 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Field corn | G5 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soil (soybean field) | G6 | <0.2 | <0.5 | 3.1 | <0.6 | 2.8 | 5.9 |
| Soybeans | G6 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Soil (pumpkin field) | G6 | 0.3 | 1.3 | 3.7 | <0.6 | 2.9 | 6.6 |
| Pumpkin | G6 | <0.3 | <0.5 | 1.5 | <0.6 | <0.6 | 1.5 |
| Pumpkin | G6 | <0.4 | <0.5 | 0.9 | <0.6 | 0.8 | 1.7 |

[a] See Figure H.2-2

[b] <, less than stated detection limit

[c] No uranium isotopes detected

## TABLE H-10
## RADIONUCLIDE CONCENTRATIONS IN GARDEN PRODUCE FROM A ROADSIDE STAND[a] NEAR THE FEMP

| | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Sample | Cs-137 | Sr-90 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| Sweet corn | <0.2[b] | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Sweet corn | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Tomato | <0.5 | <0.5 | 1.9 | <0.6 | 0.7 | 2.6 |
| Cantaloupe | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |

[a] See Figure H.2-1

[b] <, less than stated detection limit

[c] No uranium isotopes detected

## TABLE H-11
## RADIONUCLIDE CONCENTRATIONS IN MAMMAL TISSUE FROM THE FEMP

| | | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample | Type | Site[a] | Cs-137 | Sr-90 | Tc-99 | U-234 | U-235, U-236 | U-238 | Total Isotopic Uranium |
| Opossum | Muscle | N. Pine Plantation | <0.2[b] | <0.5 | c | <0.2 | <0.2 | <0.2 | d |
| Opossum | Muscle | N. Pine Plantation | <0.2 | <0.5 | c | <0.6 | <0.6 | <0.6 | d |
| Opossum | Muscle[e] | Paddys Run Railroad Bridge | <0.3 | <0.5 | <1.0 | <0.6 | <0.6 | <0.6 | d |
| Cottontail | Muscle[e] | Vegetation Site 28 | <0.7 | <0.5 | <0.9 | <0.6 | <0.6 | <0.6 | d |
| Small mammal[f] (Composite) | Carcasses | Waste Pit 5 | <0.2 | <0.1 | c | <0.6 | <0.6 | <0.6 | d |
| Small mammal[f] (Composite) | Organs | Waste Pit 5 | <1.1 | <2.5 | c | 8.3 | 1.1 | 8.6 | 18.0 |
| Small mammal[e,f] | Carcasses | Vegetation Site 28 | <0.2 | <0.5 | g | <0.6 | <0.6 | <0.6 | d |
| Deer | Kidney[e] | Roadkill, FEMP | <0.2 | <0.5 | <0.9 | <0.6 | <0.6 | <0.6 | d |
| Deer | Liver[e] | Roadkill, FEMP | <0.2 | <0.5 | <0.9 | <0.6 | <0.6 | <0.6 | d |

[a] See Figure H.2-2

[b] <, less than stated detection limit

[c] Technetium-99 analyzed for 1988 samples only

[d] No isotopes of uranium detected

[e] 1988 samples

[f] Composite small mammal samples of deer mouse and short-tailed shrew

[g] Insufficient sample for analysis

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## TABLE H-12
## RADIONUCLIDE CONCENTRATIONS IN FISH FROM THE GREAT MIAMI RIVER

| | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | Site[a] | Cesium-137 | Strontium-90 | U-234 | U-235, U-236 | U-238 | Total Isotopic Uranium |
| Gizzard shad | GMR-1 | <0.3[b] | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Gizzard shad | GMR-1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Channel catfish | GMR-1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Minnow | GMR-1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Catfish (fillets) | GMR-1 | <0.7 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Catfish (fillets) | GMR-1 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Catfish (bones and entrails) | GMR-1 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Gizzard shad | GMR-2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Freshwater drum | GMR-2 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Smallmouth bass | GMR-2 | <0.3 | d | d | d | d | c |
| Gizzard shad | GMR-3 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Green sunfish | GMR-3 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Longear sunfish | GMR-3 | <0.3 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Gizzard shad | GMR-4 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Gizzard shad | GMR-4 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |
| Minnow | GMR-4 | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | c |

[a] See Figure H.2-3

[b] <, less than stated detection limit

[c] No isotopes of uranium detected

[d] Lost in analysis

## TABLE H-13
## RADIONUCLIDE CONCENTRATIONS IN BENTHIC MACROINVERTEBRATES FROM THE GREAT MIAMI RIVER

| | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | | |
|---|---|---|---|---|---|---|---|
| Site[a] | Cs-137 | Sr-90 | Tc-99 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| GMR-2[b] | <0.2[c] | <1.1 | <0.9 | <0.6 | <0.6 | <0.6 | d |
| GMR-2 | <0.6 | <1.7 | e | 1.8 | <0.8 | 0.9 | 2.7 |
| GMR-4 | <2.1 | <4.7 | e | 3.4 | <2.2 | 3.1 | 6.5 |

[a] See Figure H.2-3

[b] 1988 sample

[c] <, less than stated detection limit

[d] No uranium isotopes detected

[e] Technetium-99 analyzed for 1988 samples only

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## TABLE H-14
## RADIONUCLIDE CONCENTRATIONS IN FISH FROM PADDYS RUN

| | | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample | Site[a] | Cs-137 | Sr-90 | Tc-99 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| Minnow[b] | PR-1 | <0.2[c] | <0.5 | <1.6 | <0.6 | <0.6 | <0.6 | d |
| Minnow | PR-2 | <0.42 | <0.5 | e | <0.6 | <0.6 | <0.6 | d |
| White sucker | PR-2 | 0.20 | <0.5 | e | f | f | f | d |
| Creek chub | PR-2 | <1.90 | <0.7 | e | 1.0 | <0.6 | 0.7 | 1.7 |
| Creek chub | PR-3 | <0.17 | <0.5 | e | <0.6 | <0.6 | <0.6 | d |
| White sucker | PR-3 | <0.22 | <0.5 | e | <0.6 | <0.6 | <0.6 | d |
| Bluegill | PR-3 | <0.19 | <0.5 | e | <0.6 | <0.6 | <0.6 | d |
| White sucker | PR-4 | <0.41 | <0.5 | e | 0.6 | <0.6 | <0.6 | 0.6 |
| Creek chub | PR-4 | <0.24 | <0.5 | e | <0.6 | <0.6 | <0.6 | d |
| Bluegill | PR-4 | <1.23 | <3.32 | e | 2.4 | <1.1 | 1.3 | 3.7 |

[a] See Figure H.2-3

[b] 1988 sample

[c] <, less than stated detection limit

[d] No isotopes of uranium detected

[e] Technetium-99 analyzed for 1988 samples only

[f] Lost in analysis

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## TABLE H-15
## RADIONUCLIDE CONCENTRATIONS IN BENTHIC MACROINVERTEBRATES FROM PADDYS RUN

| | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | | |
|---|---|---|---|---|---|---|---|
| Site[a] | Cs-137 | Sr-90 | Tc-99 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| PR-1[b] | <0.2[c] | <0.5 | <1.6 | <0.6 | <0.6 | <0.6 | d |
| PR-2 | <2.0 | <3.7 | e | 3.6 | <1.5 | 2.8 | 6.4 |
| PR-2 (Crayfish) | <1.94 | <1.2 | e | 3.5 | <0.9 | 0.9 | 4.4 |
| PR-3 (Crayfish) | <4.00 | <2.6 | e | 3.6 | <1.1 | 1.5 | 5.1 |
| PR-4 (Crayfish) | <0.24 | <1.8 | e | 1.5 | <0.6 | <0.6 | 1.5 |

[a] See Figure H.2-3
[b] 1988 sample
[c] <, less than stated detection limit
[d] No isotopes of uranium detected
[e] Technetium-99 analyzed for 1988 samples only

## TABLE H-16
## RADIONUCLIDE CONCENTRATIONS IN FISH FROM THE FEMP POND

| | Radionuclide Type and Concentration (pCi/g dry weight) | | | | | |
|---|---|---|---|---|---|---|
| Sample | Cesium-137 | Strontium-90 | U-234 | U-235,-236 | U-238 | Total Isotopic Uranium |
| Bluegill | <0.2[a] | <0.5 | <0.6 | <0.6 | <0.6 | b |
| White sucker | <0.2 | <0.5 | 0.7 | <0.6 | 1.0 | 1.7 |
| Creek chub | <0.2 | <0.5 | <0.6 | <0.6 | <0.6 | b |

[a] <, less than stated detection limit
[b] No isotopes of uranium detected

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# LIST OF REFERENCES

U.S. Environmental Protection Agency, 1989a, "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)," EPA/540/1-89/002, U.S. EPA, Washington, D.C.

U.S. Environmental Protection Agency, 1989b, "Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual," EPA/540/1-89/001, U.S. EPA, Washington, D.C.

APPENDIX I

# APPENDIX I

## ANNOTATED BIBLIOGRAPHY OF ADDITIONAL FEMP DATA SOURCES

ASI/IT (Advanced Sciences, Inc./International Technology Corporation), 1989, "Geochemical Program Issues 3 and 5 Report," prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Surface water and subsurface soil samples were analyzed for chemicals and radionuclides. In addition, Eh, pH, dissolved oxygen, conductivity, temperature and alkalinity were measured during the collection of samples. Samples were collected above and below the confluence of Paddys Run and the storm sewer outfall ditch. The purpose of the report was to examine the likelihood that surface water in this area might contribute uranium to the aquifer by vertical infiltration.

Battelle, 1981, "Environmental Report of the Feed Materials Production Center," prepared for NLO, Inc., Battelle Columbus Laboratories, Columbus, OH.

This report addressed all environmental media at the FEMP. The purpose of the study was to describe the FEMP, the surrounding environment, and existing and potential environmental impacts of plant operations. The report provides species lists, summaries of air, water quality and radiation data from other references and limited analyses of potential environmental impacts of the operations at the time.

Bauer, B.H., B.A. Branson and S.T. Colwell, 1978, "Fishes of Paddys Run Creek and the Dry Fork of the Whitewater River, Southwestern Ohio," Ohio J. Science Vol. 78, No. 3, pp. 144-148.

This paper characterizes the fish species of Paddys Run.

Dames and Moore, 1985, "Groundwater Study Task A Report," prepared for National Lead Company of Ohio, Cincinnati, OH.

This report summarizes NLO data on sediment and groundwater. The sources of these data included NLO in-house files, permits, memos, and consulting reports; data available from state and federal agency files; and published literature.

Dames and Moore, 1986, "Addendum Report," prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

The media examined in this report were surface water and sediment within the storm sewer system at the FEMP. The purpose was to characterize storm water quality under a variety of discharge conditions. Surface water sample locations were not stated in the report. Sediment sampling was conducted over the length of the storm sewer outfall ditch from its confluence with Paddys Run to the where storm water runoff entered the ditch. Three rounds of surface water samples were analyzed for uranium, and a number of sediment samples were analyzed for gamma and alpha emissions and uranium.

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International Technology Corp., 1986, "Final Interim Report - Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC, Fernald, Ohio," Report and Data Package prepared for the U.S. Dept. of Energy in support of the Fernald litigation, Oak Ridge Operations Office, Oak Ridge, TN.

The media examined in this report were air, soil, surface and groundwater. Data on the last three are summarized in Section 4. The report also assessed health risks from airborne uranium based on estimates of uranium emissions from 1951 through 1984.

International Technology Corp., 1988, "Final Report, Hydrogeologic Study of the FMPC Discharge to the Great Miami River (Zone of Influence Report)," prepared for Westinghouse Materials Company of Ohio, U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Surface water samples were taken from 11 locations on the Great Miami River during September 1987 to evaluate the distribution of uranium and its potential impact on the Southwest Ohio Water Company (SOWC) well field. Samples were taken upstream from, adjacent to, and downstream from the FEMP effluent discharge. Three sediment samples were taken at three locations upstream from the discharge and at three locations downstream. Sediment samples analyzed for grain size to evaluate stream bed hydraulic properties.

International Technology Corp., 1989, "Assessment of Radiation Dose and Cancer Risk for Emissions from 1951 through 1984, Feed Materials Production Center, Fernald, Ohio," prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

The medium examined in this report was air. The report was prepared under the direction of the Centers for Disease Control (CDC) to aid the CDC in assessing the feasibility of conducting an epidemiology study in communities near the FEMP. The investigation was similar in scope to the IT (1986) study, but was based on revised estimates of radionuclide emissions.

National Oceanic and Atmospheric Administration, 1987, "Meteorological Site Survey of the Feed Materials Production Center, Fernald, Ohio," draft prepared by the Atmospheric Turbulence and Diffusion Division, Air Resources Laboratory, NOAA, Oak Ridge, TN.

This investigation was conducted to obtain information about meteorological monitoring that would be required to characterize local wind fields in the event of an emergency episode.

Ohio Dept. of Health, 1988, "Ohio Department of Health Study of Radioactivity in Drinking Water and Other Environmental Media in the Vicinity of the U.S. Department of Energy's Feed Materials Production Center and Portsmouth Gaseous Diffusion Plant," ODH, Columbus, OH.

The media examined in this study were air, surface and ground water, and soil. The primary objective was to sample drinking water supplies used by residents in the immediate vicinity. Approximately 309 water samples from residential wells and cisterns were analyzed for gross alpha, gross beta, and uranium. Surface waters from six locations were analyzed for these variables, and water samples from 9 homes were analyzed for radon. Thirty-four soil samples were collected in the vicinity of the FEMP and analyzed for uranium. ODH also installed dosimeters to measure environmental radiation levels and monitored airborne radon at several locations in the vicinity.

Trautman, M.B., 1957, The Fishes of Ohio, Ohio State University Press, Columbus, OH. 3579

Trautman, M.B., 1981, The Fishes of Ohio, 2nd. ed., Ohio State University Press, Columbus, OH.

These two studies provide lists of fish species observed in the Great Miami River.

U.S. Dept. of Energy, 1988, "FMPC Sampling and Analysis Report," Vols. 1 and 2, Draft, DOE Oak Ridge Operations, Oak Ridge, TN.

The media examined in this report were stored wastes, soil, surface and groundwater. Data on the first three are summarized in Part I, Section 4.0. Single groundwater samples were collected from six on-property and 12 off-property wells. The samples were analyzed for several volatile organics and RCRA metals, uranium, neptunium, plutonium, thorium, and bismuth-214. These limited samples do not significantly augment the groundwater data reported in Part I, Section 4.0.

U.S. Dept. of Energy, 1989, "Draft 4; Environmental Impact Statement, Feed Materials Production Center Renovation and Site Evaluation", DOE/EIS-0142D, Oak Ridge National Laboratory, Oak Ridge, TN.

This report addressed all environmental media at the FEMP. During 1989, renovation of the FEMP was under consideration. This EIS assessed the impacts of approximately 125 renovation projects that were under consideration at that time, and provided summary information on FEMP contaminants based on data extant at that time.

U.S. Dept. of Energy, 1989 to 1991, "Annual Reports of Highest Off-Site Dose From Airborne Radionuclides, as Required by 40CFR61, Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPS)," prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

These reports are concerned with air emissions. Using dispersion modeling and a current emission inventory, these reports estimate the highest dose of radiation from airborne radionuclides that an off-site person could theoretically receive during the year, and compares it to the amount permitted under 40CFR61, Subpart H. Recent reports include DOE-1187-89: "DOE Feed Materials Production Center (FMPC) Fernald, Ohio 1988 Compliance with 40CFR61, Subpart H, NESHAP for Radionuclides," DOE-1392-90: "Supplemental Information for the Annual Radionuclide Air Emission Report for Calendar Year 1989 - National Emission Standards for Hazardous Air Pollutants (NESHAPS), 40CFR61, Subpart H - Feed Materials Production Center," and DOE-1537-91: "1990 National Emission Standards for Hazardous Air Pollutants Annual Report for Feed Materials Production Center, 40CFR61, Subpart H."

U.S. Dept. of Energy, "Annual Reports of Toxic Chemical Releases to Air and Other Media, as Required by Section 313 of Title III: Emergency Planning and Community Right-To-Know Act of 1986, Public Law 99-499," prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

These reports provide information primarily on air emissions, although other media would be covered if releases occurred to them. Recent reports include DOE-1275-89, June 30, 1989: "Toxic Chemical Release Inventory," DOE-1332-90, June 27, 1990: "Toxic Chemical Release Inventory Feed Materials Production Center," and U.S. Dept. of Energy, Feed Materials Production Center, June, 1991: "Supporting Documentation for Toxic Chemical Releases, Report Form R, Calendar Year 1990."

Webster, C. D., H. J. Serazin, and M. J. Knapp, 1988, "A Report on the Acute Toxicity of U.S. Department of Energy Feed Materials Production Center at Fernald Outfall 001 Effluents to Pimephales promelas and Ceriodaphnia affinis/dubia," Bioassay Report No. 88-565-SW, Surface Water Monitoring Section, Div. Water Quality Monitoring and Assessment, Ohio EPA, Dayton, OH.

This study was conducted by Ohio EPA in 1988. The objective was to screen FEMP effluent for acute aquatic toxicity, as part of a toxics evaluation related to renewal of the NPDES permit for the outfall. Forty-eight hour acute toxicity tests were run on undiluted FEMP effluent and on control water collected from the Great Miami River upstream of the outfall. Details of methods are provided in the report. Acute toxicity was not observed.

Westinghouse Materials Company of Ohio, 1988, "Fugitive Dust Emissions from FMPC Waste Pits," Ref. WMCO:EVP:88-153, "Air Emission Update," WMCO, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

The medium examined in this report was air. The objective of this internal investigation was to obtain order-of-magnitude estimates of fugitive emissions of airborne uranium and thorium from six waste pits during the period 1952 through 1987. Emission estimates for 1988 and 1989 are addressed in supplementary reports.

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Weston, R.F., 1987, "Characterization Investigation Study, Volume 2: Chemical and Radiological Analysis of the Waste Pits," prepared for Westinghouse Materials Company of Ohio, U.S. Department of Energy Feed Materials Production Center, Fernald, OH.

This report examined surface and subsurface soils, as described in Part I, Section 4.0. In addition, ten water samples were collected from the waste pit storage areas, (one from Pit 4, two from Pit 5, five from Pit 6, and two from the Clearwell, and analyzed for radionuclides.

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APPENDIX J

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# APPENDIX J

## CHANGES IN WELL NAMES THROUGH TIME

# APPENDIX J

| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| AL | 18 | EMR-6 |
| Argon-A-D | | 3053 |
| Argon-A-S | | 1053 |
| Argon-B-D | | 3054 |
| Argon-B-S | | 1054 |
| Argon-C-D | | 3055 |
| Argon-C-S | | 1055 |
| AW | 10, 18 | EMR-17, OS-3, MW-OS3, 3062 |
| BHMHP-D | 18 | EMR-16 |
| BLK | 18 | EMR-14 |
| BPH | 18 | EMR-10, 2104 |
| BU-11 | 18 | |
| BU-13 | | 4023 |
| BU-80 | 18 | |
| BU-91 | | 2121 |
| BU-92 | | 2122 |
| BU-93 | 18 | |
| BU-94 | 18 | |
| BU-101 | | 2026 |
| B-1 | 18 | |
| B-2 | 18 | |
| B-3 | 18 | |
| B-4 | 18 | |
| Ch. Young | | 3100 |
| Cone House | | TCH, FMPC-CH, 1124 |
| COLL 1 | 18 | EMR-9 |
| COLL 2 | 18 | EMR-8, SW-2 |
| CW | 18 | EMR-5 |
| DE | 18 | EMR-18 |
| DG | 18 | EMR-22 |
| DH | 18 | EMR-1, 1058 |
| DS | 10, 18 | EMR-15, OS-2, MW-OS2, 2061 |
| EL-1 | 18 | |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| EMR-1 | 1, 2, 3, 4, 5, 6, 7, 8 | DH, 1058 |
| EMR-2 | 1, 2 | |
| EMR-3 | 1, 2, 3, 4, 5, 6, 7, 8 | RB, 1040 |
| EMR-4 | 1, 2, 3, 4, 5, 6, 7, 8 | |
| EMR-5 | 1, 2, 3, 4, 5, 6, 7, 8 | CW |
| EMR-6 | 1, 2, 3, 4, 5 | AL |
| EMR-7 | 1, 2, 3, 4, 5, 6, 7, 8 | S |
| EMR-8 | 1, 2, 3, 4, 5, 6, 7, 8 | COLL 2, SW-2 |
| EMR-9 | 1, 2, 3, 4, 5, 6, 7, 8 | COLL1 |
| EMR-10 | 1, 2, 3, 4, 5, 6, 7, 8 | BPH, 2104 |
| EMR-11 | 1, 2, 3, 4, 5, 6, 7, 8 | KY |
| EMR-12 | 1, 2, 3, 4, 5, 6, 7, 8 | HK-S, OS-1, MW-OS1, 2060 |
| EMR-13 | 1, 2, 3, 4, 5, 6, 7, 8 | WK |
| EMR-14 | 1, 2, 3, 4, 5, 6, 7, 8 | BLK |
| EMR-15 | 1, 2, 3, 4, 5, 6, 7, 8 | DS, OS-2, MW-OS2, 2061 |
| EMR-16 | 1, 2, 3, 4, 5, 6, 7, 8 | BHMHP-D |
| EMR-17 | 1, 2, 3, 4, 5, 6, 7, 8 | OS-3, MW-OS3, AW, 3062 |
| EMR-18 | 1, 2, 3, 4, 5, 6, 7, 8 | DE |
| EMR-19 | 1, 2, 3, 4, 5, 6, 7, 8 | RE |
| EMR-20 | 1, 2, 3, 4, 5 | |
| EMR-21 | 1, 2, 3, 4, 5, 6, 7, 8 | MVRM |
| EMR-22 | 2, 3, 4, 5, 6, 7, 8 | DG |
| EMR-23 | 3, 4, 5, 6, 7, 8 | |
| EMR-24 | 3, 4, 5, 6, 7, 8 | |
| EMR-25 | 3, 4, 5, 6, 7, 8 | |
| EMR-26 | 3, 4, 5, 6, 7, 8 | 15D, W-15D, HK-15D, MW-15D, HK-D, FMPC-15D, 415, 4015 |
| EMR-27 | 4, 5, 6, 7, 8 | |
| EMR-28 | 6, 7, 8 | |
| EMR-29 | 5, 6, 7, 8 | |
| EMR-30 | 5, 6, 7, 8 | |
| EMR-31 | 6 | |
| EMR-32 | 7, 8 | |
| EMR-34 | 7, 8 | |
| EMR-35 | 7, 8 | |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| EMR-36 | 8 | |
| EMR-37 | 8 | |
| EMR-38 | 8 | |
| ER-1 | 18 | |
| FMPC-CH | 18 | TCH, 1124 |
| FMPC-P1 | 18 | P-1, P1, 4101 |
| FMPC-P2 | 18 | P-2, P2, 4102 |
| FMPC-P3 | 18 | P-3, P3, 4103 |
| FMPC-1D | 18 | T1D, 1D, W-1D, MW-1D, 401, 4001 |
| FMPC-3 | 18 | T3, 3, W-3, MW-3, 303, 3003 |
| FMPC-5 | 18 | T5, 5, W-5, MW-5, 305, 3005 |
| FMPC-8D | 18 | T8D, 8D, W-8D, MW-8D, 408, 4008 |
| FMPC-8S | 18 | T8S, 8S, W-8S, MW-8S, 308, 3008 |
| FMPC-9 | 18 | T9, 9, W-9, MW-9, 309, 3009 |
| FMPC-10 | 18 | T10, 10, W-10, MW-10, 310, 3010 |
| FMPC-11 | 18 | T11, 11, MW-11, W-11, 211, 2011 |
| FMPC-12 | 18 | 12, W-12, MW-12, 112, 1012 |
| FMPC-13D | 18 | 13D, MW-13D, W-13D, 313, 3013 |
| FMPC-13S | 18 | 13S, MW-13S, W-13S, 213, 2013 |
| FMPC-14D | 18 | 14D, W-14D, MW-14D, 314, 3014 |
| FMPC-14S | 18 | 14S, W-14S, MW-14S, 214, 2014 |
| FMPC-15D | 18 | 15D, EMR-26, W-15D, MW-15D, HK-15D, HK-D, 415, 4015 |
| FMPC-15S | 18 | 15S, W-15S, MW-15S, 215, 2015 |
| FMPC-16D | 18 | 16D, W-16D, MW-16D, 316, 3016 |
| FMPC-16S | 18 | 16S, W-16S, MW-16S, 216, 2016 |
| FMPC-17D | 18 | 17D, W-17D, MW-17D, 317, 3017 |
| FMPC-17S | 18 | 17S, W-17S, MW-17S, 217, 2017 |
| FMPC-18D | 18 | 18D, MW-18D, W-18D, 318, 3018 |
| FMPC-18S | 18 | 18S, MW-18S, W-18S, 218, 2018 |
| HK-DG | 10 | |
| HK-D | 18 | 15D, EMR-26, W-15D, MW-15D, HK-15D, FMPC-15D, 415, 4015 |
| HK-S | 10, 18 | OS-1, MW-OS1, EMR-12, 2060 |
| HK-15D | 10, 11, 12 | 15D, EMR-26, W-15D, MW-15D, HK-D, FMPC-15D, 415, 4015 |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| H-4 | 18 | |
| H-105 | 18 | |
| H-112 | 18 | |
| H-113 | 18 | |
| H-115 | 18 | |
| H-120 | 18 | |
| H-122 | 18 | |
| H-122A | 18 | |
| H-123 | 18 | |
| H-124 | 18 | |
| H-125 | 18 | |
| H-126 | 18 | |
| H-127 | 18 | |
| H-128 | 18 | |
| H-129 | 18 | |
| INH | 18 | |
| IT-1 | 4, 10, 11, 12, 13, 14, 18 | 268, 2068 |
| IT-2 | 4, 10, 11, 12, 13, 14, 18 | 267, 2067 |
| IT-3 | 18 | |
| IT-4 | 18 | 271, 2071 |
| IT-5 | 18 | |
| IT-5A | 4, 10, 11, 12, 13, 14 | 270, 2070 |
| IT-6 | 4, 10, 11, 12, 13, 14, 18 | 369, 3069 |
| James Dill | | 3063 |
| KY | 18 | EMR-11 |
| K-1 | 18 | |
| K-2 | 18 | |
| K-3 | 18 | |
| K-4 | 18 | |
| LB-1 | 18 | |
| LO-1 | 18 | |
| LO-2 | 18 | |
| MVRM | 18 | EMR-21 |
| MW-OS1 | 12 | OS-1, EMR-12, HK-S, 2060 |
| MW-OS-1A | 12 | OS-1A, 1060 |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| MW-OS2 | 12 | OS-2, EMR-15, DS, 2061 |
| MW-OS3 | 12 | OS-3, EMR-17, AW, 3062 |
| MW-TP19 | 9 | TP-19/TP19, 19TP, W-19TP, MW-19TP, 119, 1019 |
| MW-TP20 | 9 | TP-20, 20TP, W-20TP, MW-20TP, 120, 1020 |
| MW-TP21 | 9 | TP-21/TP21, 21TP, W-21TP, MW-21TP, 121, 1021 |
| MW-TP22 | 9 | TP-22/TP22, 22TP, W-22TP, MW-22TP, 122, 1022 |
| MW-1D | 9, 10, 11, 12, 13, 14 | T1D, 1D, W-1D, FMPC-1D, 401, 4001 |
| MW-1S | 9, 10, 11, 12, 13, 14 | T1S, 1S, W-1S, 301, 3001 |
| MW-3 | 9, 10, 11, 12, 13, 14 | T3, 3, W-3, MW-3, FMPC-3, 303, 3003 |
| MW-4 | 9, 10, 11, 12, 13, 14 | T4, 4, W-4, 204, 2004 |
| MW-5 | 9, 10, 11, 12, 13, 14 | T5, 5, W-5, FMPC-5, 305, 3005 |
| MW-8D | 9, 10, 11, 12, 13, 14 | T8D, 8D, W-8D, FMPC-8D, 408, 4008 |
| MW-8S | 9, 10, 11, 12, 13, 14 | T8S, 8S, W-8S, FMPC-8S, 308, 3008 |
| MW-9 | 9, 10, 11, 12, 13, 14 | T9, 9, W-9, FMPC-9, 309, 3009 |
| MW-10 | 9, 10, 11, 12, 13, 14 | T10, 10, W-10, FMPC-10, 310, 3010 |
| MW-11 | 9, 10, 11, 12, 13, 14 | T11, 11, W-11, FMPC-11, 211, 2011 |
| MW-12 | 9, 10, 11, 12, 13, 14 | 12, W-12, FMPC-12, 112, 1012 |
| MW-13D | 9, 10, 11, 12, 13, 14 | 13D, W-13D, 313, 3013 |
| MW-13S | 9, 10, 11, 12, 13, 14 | 13S, W-13S, 213, 2013 |
| MW-14D | 9, 10, 11, 12, 13, 14 | 14D, W-14D, FMPC-14D, 314, 3014 |
| MW-14S | 9, 10, 11, 12, 13 | 14S, W-14S, FMPC-14S, 214, 2014 |
| MW-15D | 13, 14 | 15D, EMR-26, W-15D, HK-15D, HK-D, FMPC-15D, 415, 4015 |
| MW-15S | 9, 10, 11, 12, 13, 14 | 15S, W-15S, FMPC-15S, 215, 2015 |
| MW-16D | 9, 10, 11, 12, 13, 14 | 16D, W-16D, FMPC-16D, 316, 3016 |
| MW-16S | 9, 10, 11, 12, 13, 14 | 16S, W-16S, FMPC-16S, 216, 2016 |
| MW-17D | 9, 10, 11, 12, 13, 14 | 17D, W-17D, FMPC-17D, 317, 3017 |
| MW-17S | 9, 10, 11, 12, 13, 14 | 17S, W-17S, FMPC-17S, 217, 2017 |
| MW-18D | 9, 10, 11, 12, 13, 14 | 18D, W-18D, FMPC-18D, 318, 3018 |
| MW-18S | 9, 10, 11, 12, 13, 14 | 18S, W-18S, FMPC-18S, 218, 2018 |
| MW-19D | 9, 10, 11, 12, 13, 14 | 19D, W-19D, 319, 3019 |
| MW-19S | 9, 10, 11, 12, 13, 14 | 19S, W-19S, 219, 2019 |
| MW-19TP | 10, 11, 12, 13, 14 | TP-19/TP19, 19TP, W-19TP, MW-TP19, 119, 1019 |
| MW-20D | 9, 10, 11, 12, 13, 14 | 20D, W-20D, 320, 3020 |
| MW-20S | 9, 10, 11, 12, 13, 14 | 20S, W-20S, 220, 2020 |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| MW-20TP | 10, 11, 12, 13, 14 | TP-20, 20TP, W-20TP, MW-TP20, 120, 1020 |
| MW-21S | 9, 10, 11, 12, 13, 14 | 21S, W-21S, 221, 2021 |
| MW-21TP | 10, 11, 12, 13, 14 | TP-21/TP21, 21TP, W-21TP, MW-TP21, 121, 1021 |
| MW-22S | 9, 10, 11, 12, 13, 14 | 22S, W-22S, 222, 2022 |
| MW-22TP | 10, 11, 12, 13, 14 | TP-22/TP22, 22TP, W-22TP, MW-TP22, 122, 1022 |
| M-30 | 18 | |
| N | 18 | |
| OAB | 18 | TOAB |
| OB-1 | 18 | |
| OS-1 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | EMR-12, MW-OS1, HK-S, 2060 |
| OS-1A | 4, 5, 6, 9, 10, 11, 12, 13, 14 | MW-OS-1A, 1060 |
| OS-2 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | EMR-15, MW-OS2, DS, 2061 |
| OS-3 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | EMR-17, MW-OS3, AW, 3062 |
| O2E | 18 | |
| O2W | 18 | |
| O-3 | 18 | |
| PALLET CO. | 18 | 2050 |
| P1 | 1, 2, 3, 4, 5, 6 | P-1, FMPC-P1, 4101 |
| P2 | 1, 2, 3, 4, 5, 6 | P-2, FMPC-P2, 4102 |
| P3 | 1, 2, 3, 4, 5, 6 | P-3, FMPC-P3, 4103 |
| P-1 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | P1, FMPC-P1, 4101 |
| P-2 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | P2, FMPC-P2, 4102 |
| P-3 | 4, 5, 6, 9, 10, 11, 12, 13, 14, 18 | P3, FMPC-P3, 4103 |
| RB | 18 | EMR-3, 1040 |
| RE | 18 | EMR-19 |
| RIVER | 18 | |
| Robert James | | WW-1, 3099 |
| R-1 | 18 | |
| R-7 | 18 | |
| R-59 | 18 | |
| R-69 | 18 | |
| S | 18 | EMR-7 |
| STATE 4 | 18 | |
| STATE 5 | 18 | |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| STATE 8 | 18 | 2056 |
| STATE 10 | 18 | 2105 |
| STATE 16 | 18 | 2057 |
| STATE 25 | 18 | |
| STATE 41 | 18 | |
| STATE 42 | 18 | |
| STATE 134 | 18 | |
| STATE 137 | 18 | |
| STATE 150 | 18 | |
| SW-1 | 18 | |
| SW-2 | 4, 5, 6, 9, 10, 11, 12, 13, 14 | EMR-8, COLL2 |
| SW-3A | 18 | |
| SW-4A | 18 | |
| TCH | 2 | Cone House, FMPC-CH, 1124 |
| TOAB | 2 | OAB |
| TP-19/TP19 | 4, 9, 10, 11, 12, 13, 14 | 19TP, W-19TP, MW-TP19, MW-19TP, 119, 1019 |
| TP-20 | 4, 9, 10, 11, 12, 13, 14 | 20TP, W-20TP, MW-TP20, MW-20TP, 120, 1020 |
| TP-21/TP21 | 4, 9, 10, 11, 12, 13, 14 | 21TP, W-21TP, MW-TP21, MW-21TP, 121, 1021 |
| TP-22/TP22 | 4, 9, 10, 11, 12, 13, 14 | 22TP, W-22TP, MW-TP22, MW-22TP, 122, 1022 |
| T1D | 1, 2, 3, 4 | 1D, W-1D, MW-1D, FMPC-1D, 401, 4001 |
| T1S | 1, 2, 3, 4 | 1S, W-1S, MW-1S, 301, 3001 |
| T3 | 1, 2, 3, 4 | 3, W-3, MW-3, FMPC-3, 303, 3003 |
| T4 | 1, 2, 3, 4 | 4, W-4, MW-4, 204, 2004 |
| T5 | 1, 2, 3, 4 | 5, W-5, MW-5, FMPC-5, 305, 3005 |
| T8D | 1, 2, 3, 4 | 8D, W-8D, MW-8D, FMPC-8D, 408, 4008 |
| T8S | 1, 2, 3, 4 | 8S, W-8S, MW-8S, FMPC-8S, 308, 3008 |
| T9 | 1, 2, 3, 4 | 9, W-9, MW-9, FMPC-9, 309, 3009 |
| T10 | 1, 2, 3, 4 | 10, W-10, MW-10, FMPC-10, 310, 3010 |
| T11 | 1, 2, 3, 4 | 11, W-11, MW-11, FMPC-11, 211, 2011 |
| WK | 18 | EMR-13 |
| WK-1 | 18 | |
| WW-1 | 18 | Robert James, 3099 |
| W-1D | 4 | T1D, 1D, MW-1D, FMPC-1D, 401, 4001 |
| W-1S | 4 | T1S, 1S, MW-1S, 301, 3001 |
| W-3 | 4 | T3, 3, W-3, MW-3, FMPC-3, 303, 3003 |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| W-4 | 4 | T4, 4, MW-4, 204, 2004 |
| W-5 | 4 | T5, 5, MW-5, FMPC-5, 305, 3005 |
| W-8D | 4 | T8D, 8D, MW-8D, FMPC-8D, 408, 4008 |
| W-8S | 4 | T8S, 8S, MW-8S, FMPC-8S, 308, 3008 |
| W-9 | 4 | T9, 9, MW-9, FMPC-9, 309, 3009 |
| W-10 | 4 | T10, 10, MW-10, FMPC-10, 310, 3010 |
| W-11 | 4 | T11, 11, MW-11, FMPC-11, 211, 2010 |
| W-12 | 4 | 12, MW-12, FMPC-12, 112, 1012 |
| W-13D | 4 | 13D, MW-13D, FMPC-13D, 313, 3013 |
| W-13S | 4 | 13S, MW-13S, FMPC-13S, 213, 2013 |
| W-14D | 4 | 14D, MW-14D, FMPC-14D, 314, 3014 |
| W-14S | 4 | 14S, MW-14S, FMPC-14S, 214, 2014 |
| W-15D | 4 | 15D, EMR-26, HK-15D, MW-15D, HK-D, FMPC-15D, 415, 4015 |
| W-15S | 4 | 15S, MW-15S, FMPC-15S, 215, 2015 |
| W-16D | 4 | 16D, MW-16D, FMPC-16D, 316, 3016 |
| W-16S | 4 | 16S, MW-16S, FMPC-16S, 216, 2016 |
| W-17D | 4 | 17D, MW-17D, FMPC-17D, 317, 3017 |
| W-17S | 4 | 17S, MW-17S, FMPC-17S, 217, 2017 |
| W-18D | 4 | 18D, MW-18D, FMPC-18D, 318, 3018 |
| W-18S | 4 | 18S, MW-18S, FMPC-18S, 218, 2018 |
| W-19D | 4 | 19D, MW-19D, 319, 3019 |
| W-19S | 4 | 19S, MW-19S, 219, 2019 |
| W-19TP | 4 | 19TP, TP-19/TP19, MW-TP19, MW-19TP, 119, 1019 |
| W-20D | 4 | 20D, MW-20D, 320, 3020 |
| W-20S | 4 | 20S, MW-20S, 220, 2020 |
| W-20TP | 4 | 20TP, TP-20, MW-TP20, MW-20TP, 121, 1021 |
| W-21S | 4 | 21S, MW-21S, 221, 2021 |
| W-21TP | 4 | 21TP, TP-21/TP21, MW-TP21, MW-21TP, 121, 1021 |
| W-22S | 4 | 22S, MW-22S, 222, 2022 |
| W-22TP | 4 | 22TP, TP-22/TP22, MW-TP22, MW-22TP, 122, 1022 |
| 1A | 16, 18 | 1059 |
| 1D | 4, 9, 10, 11, 12, 13, 14 | T1D, W-1D, MW-1D, FMPC-1D, 401, 4001 |
| 1NH | 18 | |
| 1S | 4, 9, 10, 11, 12, 13, 14 | T1S, W-1S, MW-1S, 301, 3001 |

See footnotes at end of table

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 2CW | 18 | |
| 3 | 9, 10, 11, 12, 13, 14 | T3, W-3, MW-3, FMPC-3, 303, 3003 |
| 4 | 9, 10, 11, 12, 13, 14 | T4, W-4, MW-4, 204, 2004 |
| 5 | 9, 10, 11, 12, 13, 14 | T5, W-5, MW-5, FMPC-5, 305, 3005 |
| 7-8A | 18 | |
| 8D | 9, 10, 11, 12, 13, 14 | T8D, W-8D, MW-8D, FMPC-8D, 408, 4008 |
| 8S | 9, 10, 11, 12, 13, 14 | T8S, W-8S, MW-8S, FMPC-8S, 308, 3008 |
| 9 | 9, 10, 11, 12, 13, 14 | T9, W-9, MW-9, FMPC-9, 309, 3009 |
| 9-2 | 18 | |
| 10 | 9, 10, 11, 12, 13, 14 | T10, 10, W-10, FMPC-10, 310, 3010 |
| 11 | 9, 10, 11, 12, 13, 14 | T11, W-11, MW-11, FMPC-11, 211, 2011 |
| 12 | 9, 10, 11, 12, 13, 14 | W-12, MW-12, FMPC-12, 112, 1012 |
| 12-3 | 18 | 2123 |
| 12-5 | 18 | 2036 |
| 12-7 | 18 | |
| 12-7A | 18 | |
| 13D | 9, 10, 11, 12, 13, 14 | W-13D, MW-13D, FMPC-13D, 313, 3013 |
| 13S | 9, 10, 11, 12, 13, 14 | W-13S, MW-13S, FMPC-13S, 213, 2013 |
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| 14D | 9, 10, 11, 12, 13, 14 | W-14D, MW-14D, FMPC-14D, 314, 3014 |
| 14S | 9, 10, 11, 12, 13, 14 | W-14S, MW-14S, FMPC-14S, 214, 2014 |
| 15D | 9, 10, 11, 12, 13, 14 | EMR-26, W-15D, HK-15D, MW-15D, HK-D, FMPC-15D, 415, 4015 |
| 15S | 9, 10, 11, 12, 13, 14 | W-15S, MW-15S, FMPC-15S, 215, 2015 |
| 16D | 9, 10, 11, 12, 13, 14 | W-16D, MW-16D, FMPC-16D, 316, 3016 |
| 16S | 9, 10, 11, 12, 13, 14 | W-16S, MW-16S, FMPC-16S, 216, 2016 |
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| 16-2 | 18 | |
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| 17D | 9, 10, 11, 12, 13, 14 | W-17D, MW-17D, FMPC-17D, 317, 3017 |
| 17S | 9, 10, 11, 12, 13, 14 | W-17S, MW-17S, FMPC-17S, 217, 2017 |
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| 18S | 9, 10, 11, 12, 13, 14 | W-18S, MW-18S, FMPC-18S, 218, 2018 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
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| 19D | 9, 10, 11, 12, 13, 14 | W-19D, MW-19D, 319, 3019 |
| 19S | 9, 10, 11, 12, 13, 14 | W-19S, MW-19S, 219, 2019 |
| 19TP | 9 | TP-19/TP19, W-19TP, MW-TP19, MW-19TP, 119, 1019 |
| 20D | 9, 10, 11, 12, 13, 14 | W-20, MW-20D, 320, 3020 |
| 20S | 9, 10, 11, 12, 13, 14 | W-20S, MW-20S, 220, 2020 |
| 20TP | 9 | TP-20, W-20TP, MW-TP20, MW-20TP, 121, 1021 |
| 21S | 9, 10, 11, 12, 13, 14 | W-21S, MW-21S, 221, 2021 |
| 21TP | 9 | TP-21/TP21, W-21TP, MW-TP21, MW-21TP, 121, 1021 |
| 22S | 9, 10, 11, 12, 13, 14 | W-22S, MW-22S, 222, 2022 |
| 22TP | 9 | TP-22/TP22, W-22TP, MW-TP22, MW-22TP, 122, 1022 |
| 104 | 16 | 1004 |
| 108 | 16 | 1008 |
| 109 | 16 | 1009 |
| 110 | 16 | 1010 |
| 111 | 16 | 1011 |
| 112 | 5, 6, 16 | 12, W-12, MW-12, FMPC-12, 1012 |
| 113D | 16 | 1013 |
| 113S | 16 | 1913 |
| 114 | 16 | 1014 |
| 115D | 16 | 1015 |
| 115S | 16 | 1915 |
| 116 | 16 | 1016 |
| 118 | 16 | 1018 |
| 119 | 5, 6, 16 | TP-19/TP19, W-19TP, MW-TP19, 19TP, MW-19TP, 1019 |
| 120 | 5, 6, 16 | TP-20, 20TP, W-20TP, MW-TP20, MW-20TP, 1020 |
| 121 | 5, 6, 16 | TP-21/TP21, 21TP, W-21TP, MW-TP21, MW-21TP, 1021 |
| 122 | 5, 6, 16 | TP-22/TP22, 22TP, W-22TP, MW-TP22, MW-22TP, 1022 |
| 124 | 16 | 1024 |
| 125 | 16 | 1025 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 127 | 16 | 1027 |
| 128 | 16 | 1028 |
| 129 | 16 | 1029 |
| 130 | 16 | 1030 |
| 131 | 16 | 1031 |
| 132 | 16 | 1032 |
| 133 | 16 | 1033 |
| 134 | 16 | 1034 |
| 135 | 16 | 1035 |
| 137 | 16 | 1037 |
| 138 | 16 | 1038 |
| 139 | 16 | 1039 |
| 141 | 16 | 1041 |
| 142 | 16 | 1042 |
| 145 | 16 | 1045 |
| 146 | 16 | 1046 |
| 147 | 16 | 1047 |
| 148 | 16 | 1048 |
| 152 | 16 | 1052 |
| 165 | 16 | 1065 |
| 172 | 16 | 1072 |
| 173 | 16 | 1073 |
| 174 | 16 | 1074 |
| 175 | 16 | 1075 |
| 176 | 16 | 1076 |
| 177 | 16 | 1077 |
| 178 | 16 | 1078 |
| 179 | 16 | 1079 |
| 180 | 16 | 1080 |
| 181 | 16 | 1081 |
| 182 | 16 | 1082 |
| 183 | 16 | 1083 |
| 184 | 16 | 1084 |
| 204 | 5, 6, 16 | T4, 4, W-4, MW-4, 2004 |
| 208 | 16 | 2008 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 209 | 16 | 2009 |
| 210 | 16 | 2010 |
| 211 | 5, 6, 16 | T11, 11, W-11, MW-11, FMPC-11, 2011 |
| 213 | 5, 6, 16 | 13S, W-13S, MW-13S, FMPC-13S, 2013 |
| 214 | 5, 6, 16 | 14S, W-14S, MW-14S, FMPC-14S, 2014 |
| 215 | 5, 6, 16 | 15S, W-15S, MW-15S, FMPC-15S, 2015 |
| 216 | 5, 6, 16 | 16S, W-16S, MW-16S, FMPC-16S, 2016 |
| 217 | 5, 6, 16 | 17S, W-17S, MW-17S, FMPC-17S, 2017 |
| 218 | 5, 6, 16 | 18S, W-18S, MW-18S, FMPC-18S, 2018 |
| 219 | 5, 6, 16 | 19S, W-19S, MW-19S, 2019 |
| 220 | 5, 6, 16 | 20S, W-20S, MW-20S, 2020 |
| 221 | 5, 6, 16 | 21S, W-21S, MW-21S, 2021 |
| 222 | 5, 6, 16 | 22S, W-22S, MW-22S, 2022 |
| 224 | 16 | 2024 |
| 227 | 16 | 2027 |
| 234 | 16 | 2034 |
| 237 | 16 | 2037 |
| 242 | 16 | 2042 |
| 243 | 16 | 2043 |
| 244 | 16 | 2044 |
| 249 | 16 | 2049 |
| 251 | 16 | 2051 |
| 252 | 16 | 2052 |
| 264 | 16 | 2064 |
| 265 | 16 | 2065 |
| 266 | 16 | 2066 |
| 267 | 6, 16 | IT-2, 2067 |
| 268 | 6, 16 | IT-1, 2068 |
| 269 | 16 | 2069 |
| 270 | 6, 16 | IT-5A, 2070 |
| 271 | 16 | IT-4, 2071 |
| 284 | 16 | 2084 |
| 291 | 16 | 2091 |
| 292 | 16 | 2092 |
| 293 | 16 | 2093 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 294 | 16 | 2094 |
| 295 | 16 | 2095 |
| 296 | 16 | 2096 |
| 297 | 16 | 2097 |
| 298 | 16 | 2098 |
| 301 | 5, 6, 16 | T1S, 1S, W-1S, MW-1S, 3001 |
| 303 | 5, 6, 16 | T3, 3, W-3, MW-3, FMPC-3, 3003 |
| 304 | 16 | 3004 |
| 305 | 5, 6, 16 | T5, 5, W-5, MW-5, FMPC-5, 3005 |
| 308 | 5, 6, 16 | T8S, 8S, W-8S, MW-8S, FMPC-8S, 3008 |
| 309 | 5, 6, 16 | T9, 9, W-9, MW-9, FMPC-9, 3009 |
| 310 | 5, 6, 16 | T10, 10, W-10, MW-10, FMPC-10, 3010 |
| 311 | 16 | 3011 |
| 313 | 5, 6, 16 | 13D, MW-13D, W-13D, FMPC-13D, 3013 |
| 314 | 5, 6, 16 | 14D, MW-14D, W-14D, FMPC-14D, 3014 |
| 315 | 16 | 3015 |
| 316 | 5, 6, 16 | 16D, MW-16D, W-16D, FMPC-16D, 3016 |
| 317 | 5, 6, 16 | 17D, MW-17D, W-17D, FMPC-17D, 3017 |
| 318 | 5, 6, 16 | 18D, MW-18D, W-18D, FMPC-18D, 3018 |
| 319 | 5, 6, 16 | 19D, MW-19D, W-19D, 3019 |
| 320 | 5, 6, 16 | 20D, MW-20D, W-20D, 3020 |
| 324 | 16 | 3024 |
| 334 | 16 | 3034 |
| 337 | 16 | 3037 |
| 344 | 16 | 3044 |
| 351 | 16 | 3051 |
| 364 | 16 | 3064 |
| 367 | 16 | 3067 |
| 368 | 16 | 3068 |
| 369 | 5, 6, 16 | IT-6, 3069 |
| 370 | 16 | 3070 |
| 384 | 16 | 3084 |
| 391 | 16 | 3091 |
| 392 | 16 | 3092 |
| 393 | 16 | 3093 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 394 | 16 | 3094 |
| 395 | 16 | 3095 |
| 396 | 16 | 3096 |
| 397 | 16 | 3097 |
| 398 | 16 | 3098 |
| 401 | 5, 6, 16 | T1D, 1D, W-1D, MW-1D, FMPC-1D, 4001 |
| 408 | 5, 6, 16 | T8D, 8D, W-8D, MW-8D, FMPC-8D, 4008 |
| 415 | 5, 6, 16 | 15D, EMR-26, HK-15D, W-15D, MW-15D, HK-D, FMPC-15D, 4015 |
| 491 | 16 | 4091 |
| 496 | 16 | 4096 |
| 497 | 16 | 4097 |
| 1004 | 7, 17 | 104 |
| 1008 | 17 | 108 |
| 1009 | 17 | 109 |
| 1010 | 17 | 110 |
| 1011 | 17 | 111 |
| 1012 | 17 | 12, MW-12, W-12, FMPC-12, 112 |
| 1013 | 17 | 113D |
| 1014 | 17 | 114 |
| 1015 | 17 | 115D |
| 1016 | 17 | 116 |
| 1018 | 17 | 118 |
| 1019 | 8, 17 | TP-19/TP19, MW-TP19, 19TP, MW-19TP, 119 |
| 1020 | 17 | TP-20, 20TP, MW-TP20, MW-20TP, 120 |
| 1021 | 8, 17 | TP-21/TP21, 21TP, MW-TP21, MW-21TP, 121 |
| 1022 | 8, 17 | TP-22/TP22, 22TP, MW-TP22, MW-22TP, 122 |
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| 1029 | 17 | 129 |
| 1030 | 7, 17 | 130 |
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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
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| 1040 | 17 | EMR-3, RB |
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| 1045 | 17 | 145 |
| 1046 | 17 | 146 |
| 1047 | 8, 17 | 147 |
| 1048 | 8, 17 | 148 |
| 1052 | 7, 17 | 152 |
| 1053 | 8, 17 | Argon-A-S |
| 1054 | 8, 17 | Argon-B-S |
| 1055 | 17 | Argon-C-S |
| 1058 | 17 | EMR-1, DH |
| 1059 | 17 | 1A |
| 1060 | 17 | OS-1A, MW-OS-1A |
| 1065 | 17 | 165 |
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| 1074 | 7, 8, 17 | 174 |
| 1075 | 8, 17 | 175 |
| 1076 | 8, 17 | 176 |
| 1077 | 17 | 177 |
| 1078 | 8, 17 | 178 |
| 1079 | 7, 8, 17 | 179 |
| 1080 | 7, 8, 17 | 180 |
| 1081 | 7, 8, 17 | 181 |
| 1082 | 7, 8, 17 | 182 |
| 1083 | 7, 8, 17 | 183 |
| 1084 | 8, 17 | 184 |
| 1124 | 17 | TCH, FMPC-CH, Cone House |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 1913 | 17 | 113S |
| 1915 | 17 | 115S |
| 2004 | 7, 8, 17 | T4, 4, MW-4, 204 |
| 2008 | 17 | 208 |
| 2009 | 17 | 209 |
| 2010 | 7, 8, 17 | 210 |
| 2011 | 7, 8, 17 | T11, 11, MW-11, W-11, FMPC-11, 211 |
| 2013 | 7, 8, 17 | 13S, MW-13S, W-13S, FMPC-13S, 213 |
| 2014 | 17 | 14S, MW-14S, W-14S, FMPC-14S, 214 |
| 2015 | 8, 17 | 15S, MW-15S, W-15S, FMPC-15S, 215 |
| 2016 | 17 | 16S, MW-16S, W-16S, FMPC-16S, 216 |
| 2017 | 17 | 17S, MW-17S, W-17S, FMPC-17S, 217 |
| 2018 | 17 | 18S, MW-18S, W-18S, FMPC-18S, 218 |
| 2019 | 7, 8, 17 | 19S, MW-19S, W-19S, 219 |
| 2020 | 17 | 20S, MW-20S, W-20S, 220 |
| 2021 | 7, 8, 17 | 21S, MW-21S, W-21S, 221 |
| 2022 | 8, 17 | 22S, MW-22S, W-22S, 222 |
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| 2026 | 17 | BU-101 |
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| 2034 | 17 | 234 |
| 2036 | 17 | 12-5 |
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| 2042 | 17 | 242 |
| 2043 | 7, 17 | 243 |
| 2044 | 17 | 244 |
| 2049 | 17 | 249 |
| 2050 | 17 | Pallet Co. |
| 2051 | 7, 8, 17 | 251 |
| 2052 | 17 | 252 |
| 2056 | 17 | State 8 |
| 2057 | 17 | STATE 16 |
| 2060 | 8, 17 | OS-1, EMR-12, MW-OS1, HK-S |
| 2061 | 8, 17 | OS-2, EMR-15, MW-OS2, DS |
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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
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| 2105 | 17 | State 10 |
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| 2122 | 17 | BU-92 |
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| 3003 | 7, 8, 17 | T3, 3, W-3, MW-3, FMPC-3, 303 |
| 3004 | 8, 17 | 304 |
| 3005 | 7, 8, 17 | T5, 5, W-5, MW-5, FMPC-5, 305 |
| 3008 | 7, 8, 17 | T8S, 8S, W-8S, MW-8S, FMPC-8S, 308 |
| 3009 | 7, 8, 17 | T9, 9, W-9, MW-9, FMPC-9, 309 |
| 3010 | 7, 8, 17 | T10, 10, W-10, MW-10, FMPC-10, 310 |
| 3011 | 17 | 311 |
| 3013 | 7, 8, 17 | 13D, W-13D, MW-13D, FMPC-13D, 313 |
| 3014 | 17 | 14D, W-14D, MW-14D, FMPC-14D, 314 |
| 3015 | 17 | 315 |
| 3016 | 17 | 16D, W-16D, MW-16D, FMPC-16D, 316 |
| 3017 | 17 | 17D, W-17D, MW-17D, FMPC-17D, 317 |
| 3018 | 17 | 18D, W-18D, MW-18D, FMPC-18D, 318 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 3019 | 7, 8, 17 | 19D, W-19D, MW-19D, 319 |
| 3020 | 17 | 20D, W-20D, MW-20D, 320 |
| 3024 | 8, 17 | 324 |
| 3034 | 17 | 334 |
| 3037 | 7, 8, 17 | 337 |
| 3044 | 17 | 344 |
| 3051 | 7, 8, 17 | 351 |
| 3053 | 17 | Argon-A-D |
| 3054 | 17 | Argon-B-D |
| 3055 | 7, 8, 17 | Argon-C-D |
| 3062 | 8, 17 | OS-3, MW-OS3, AW, EMR-17 |
| 3063 | 17 | James Dill |
| 3064 | 17 | 364 |
| 3064 | 17 | 364 |
| 3066 | 7, 17 | 366 |
| 3067 | 17 | 367 |
| 3068 | 17 | 368 |
| 3069 | 17 | IT-6, 369 |
| 3070 | 17 | 370 |
| 3084 | 7, 8, 17 | 384 |
| 3091 | 17 | 391 |
| 3092 | 17 | 392 |
| 3093 | 17 | 393 |
| 3094 | 17 | 394 |
| 3095 | 17 | 395 |
| 3096 | 17 | 396 |
| 3097 | 17 | 397 |
| 3098 | 17 | 398 |
| 3099 | 17 | Robert James, WW-1 |
| 3100 | 17 | Ch. Young |
| 4001 | 7, 8, 17 | T1D, 1D, W-1D, MW-1D, FMPC-1D, 401 |
| 4008 | 7, 8, 17 | T8D, 8D, W-8D, MW-8D, FMPC-8D, 408 |
| 4015 | 17 | 15D, EMR-26, W-15D, HK-15D, MW-15D, HK-D, FMPC-15D, 415 |
| 4023 | 17 | BU-13 |

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| Well I.D. | Sampling Program[a] | Synonym I.D. |
|---|---|---|
| 4091 | 17 | 491 |
| 4096 | 17 | 496 |
| 4097 | 17 | 497 |
| 4101 | 7, 8, 17 | P1, P-1, FMPC-P1 |
| 4102 | 7, 8, 17 | P2, P-2, FMPC-P2 |
| 4103 | 7, 8, 17 | P3, P-3, FMPC-P3 |

[a]Only wells sampled in the following programs and installed prior to the fourth quarter of 1988 were listed.

[b] 1: FMPC Environmental Monitoring Annual Report for 1983, NLO, 1984. Twenty-one off-property sampling points are noted as EMR wells. See Figures 3-15 and 3-16 for on-porperty and off-property well locations, respectively.

2: FMPC Environmental Monitoring Annual Report for 1984, NLO, 1985. Twenty-two off-property sampling points are noted as EMR wells. See Figures 3-15 and 3-16 for on-property and off-property well locations, respectively.

3: FMPC Environmental Monitoring Annual Report for 1985, WMCO, 1986. Twenty-five off-property sampling points are noted as EMR wells. See Figures 3-15 and 3-16 for on-property and off-property well locations, respectively.

4: FMPC Environmental Monitoring Annual Report for 1986, WMCO, 1987. Twenty-six off-property sampling points are noted as EMR wells. See Figures 3-15 and 3-16 for on-property and off-property well locations, respectively.

5: FMPC Environmental Monitoring Annual Report for 1987, WMCO, 1988. Twenty-eight off-property sampling points are noted as EMR wells. See Figures 3-17 and 3-16 for on-property and off-property well locations, respectively.

6: FMPC Environmental Monitoring Annual Report for 1988, WMCO, 1989. Twenty-eight off-property sampling points are noted as EMR wells. See Figures 3-17 and 3-16 for on-property and off-property well locations, respectively.

7: FMPC Environmental Monitoring Annual Report for 1989, WMCO, 1990. Thirty off-property sampling points are noted as EMR wells. See Figures 3-17 and 3-16 for on-property and off-property well locations, respectively.

8: FMPC Environmental Monitoring Annual Report for 1990, WMCO, 1991. Thirty-four off-property sampling points are noted as EMR wells. See Figures 3-17 and 3-16 for on-property and off-property well locations, respectively.

9: Round One RCRA (1985/1986), Dames and Moore, 1986. See Figure 3-18 for well locations.

10: Round Two RCRA (2nd Quarter 1986), Dames and Moore, 1986. See Figure 3-18 for well locations.

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11: Round Three RCRA (3rd Quarter 1986), Dames and Moore, 1986. See Figure 3-18 for well locations.

12: Round Four RCRA (4th Quarter 1986), Dames and Moore, 1987. See Figure 3-18 for well locations.

13: Round Five RCRA (2nd Quarter 1987), Dames and Moore, 1987. See Figure 3-18 for well locations.

14: Round Six RCRA (4th Quarter 1987), ASI/IT, 1988. See Figure 3-18 for well locations.

15: Third Quarter 1988 through Fourth Quarter 1991 RI/FS, ASI/IT

16: July 1986 through third Quarter 1988 RI/FS, ASI/IT

17: Fourth Quarter 1988 to present RI/FS, ASI/IT

18: Interim Report, IT, 1986. See Figure 3-14 for well locations.

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# APPENDIX K

## ANNUAL ENVIRONMENTAL MONITORING REPORT DATA FOR GROUNDWATER

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**TABLE K-1**
**ANNUAL AVERAGE CONCENTRATIONS OF SILVER, ARSENIC, BARIUM AND CALCIUM IN GROUNDWATER SAMPLES FROM OFF-PROPERTY WELLS**

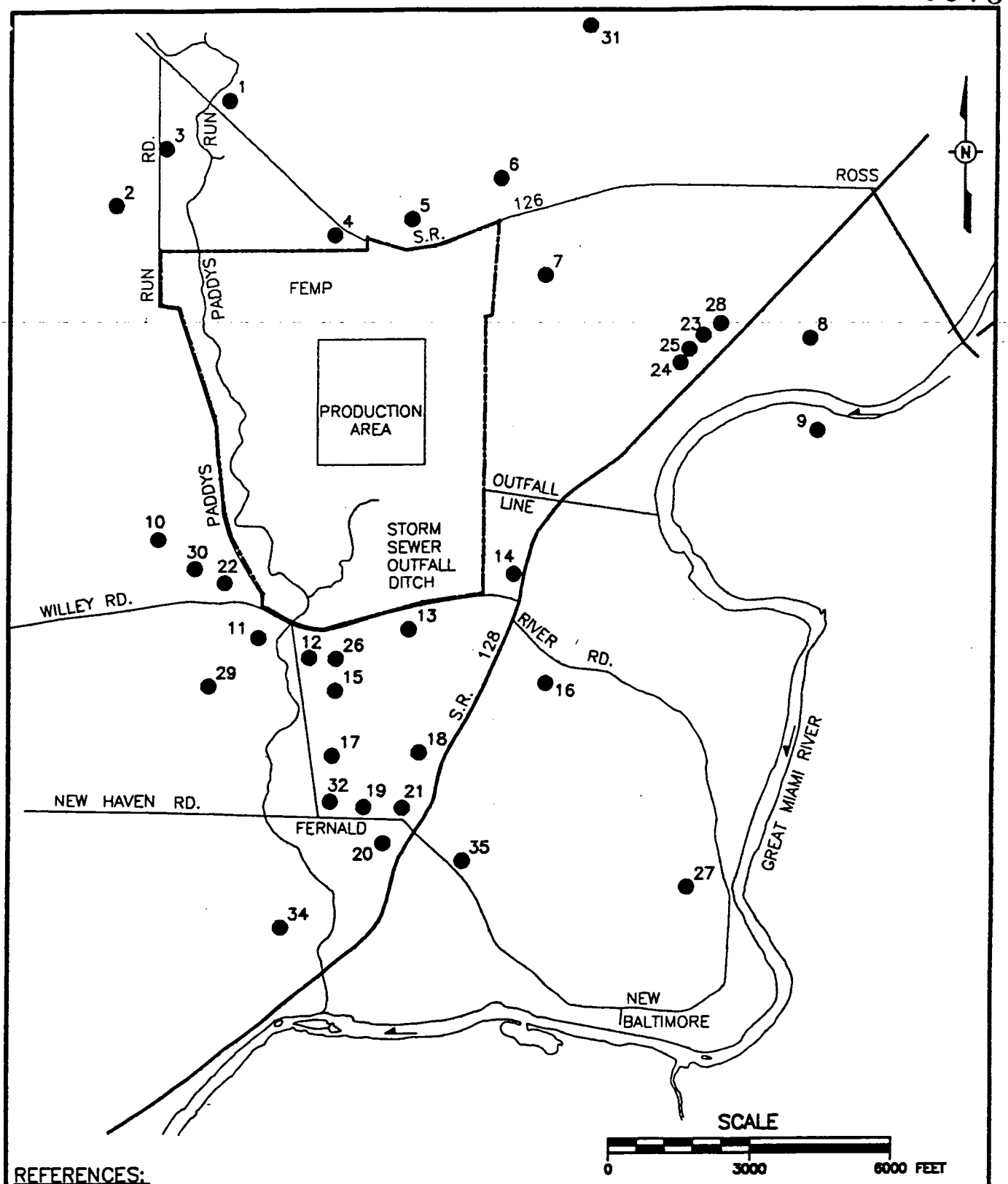
| Well Location[a] | Silver Average (mg/ℓ) Range[b] (mg/ℓ) | Arsenic Average (mg/ℓ) Range (mg/ℓ) | Barium Average (mg/ℓ) Range (mg/ℓ) | Calcium Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 1 | 0.007<br>< 0.001 - < 0.030 | 0.016<br>< 0.010 - 0.024 | 0.375<br>0.280 - 0.451 | 74.1<br>52.0 - 87.4 |
| 3 | 0.006<br>< 0.001 - < 0.030 | 0.013<br>< 0.010 - 0.018 | 0.456<br>0.390 - 0.491 | 75.8<br>62.0 - 85.3 |
| 4 | 0.006<br>< 0.001 - 0.001 | 0.003<br>< 0.002 - 0.004 | 0.053<br>< 0.030 - 0.068 | 132.0<br>88.0 - 158.0 |
| 5 | 0.013<br>< 0.001 - 0.039 | 0.003<br>0.001 - 0.003 | 0.059<br>0.040 - 0.059 | 160.6<br>150.0 - 170.0 |
| 6 | < 0.030[e] | < 0.005[c] | 0.074<br>0.048 - NA[d] | 84.3[c] |
| 7 | 0.006<br>< 0.001 - < 0.030 | 0.006<br>< 0.002 - 0.016 | 0.090<br>0.070 - 0.141 | 109.6<br>81.0 - 120.0 |
| 8 | 0.006<br>< 0.001 - < 0.030 | 0.002<br>0.001 - 0.002 | 0.067<br>0.047 - 0.068 | 91.6<br>79.0 - 98.0 |
| 9 | 0.006<br>< 0.001 - < 0.030 | 0.002<br>< 0.001 - 0.002 | 0.085<br>0.063 - 0.095 | 77.3<br>67.0 - 86.0 |
| 10 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>< 0.002 - 0.004 | 0.075<br>0.050 - 0.121 | 102.7<br>83.6 - 112.0 |
| 11 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>0.001 - 0.005 | 0.054<br>0.001 - 0.071 | 82.3<br>74.8 - 87.5 |
| 12 | 0.007<br>< 0.001 - < 0.030 | 0.003<br>0.002 - 0.004 | 0.058<br>0.041 - 0.050 | 82.2<br>60.3 - 96.2 |
| 13 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>< 0.002 - 0.002 | 0.048<br>0.034 - 0.050 | 89.8<br>66.0 - 101.0 |
| 14 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>< 0.002 - 0.004 | 0.122<br>0.100 - 0.198 | 91.5<br>11.7 - 121.0 |
| 15 | 0.006<br>< 0.001 - < 0.030 | 0.004<br>< 0.002 - 0.006 | 0.060<br>0.041 - 0.076 | 85.4<br>77.0 - 90.7 |
| 16 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>< 0.001 - 0.004 | 0.089<br>0.048 - 0.120 | 103.8<br>93.0 - 120.0 |
| 17 | 0.006<br>< 0.001 - 0.001 | 0.003<br>0.002 - 0.004 | 0.061<br>0.023 - 0.072 | 91.3<br>70.0 - 97.1 |
| 18 | 0.006<br>< 0.001 - 0.001 | 0.003<br>< 0.002 - 0.006 | 0.076<br>0.058 - 0.083 | 104.2<br>84.0 - 120.0 |
| 19 | 0.006<br>< 0.001 - 0.001 | 0.058<br>0.035 - 0.094 | 0.035<br>0.013 - 0.039 | 92.7<br>49.0 - 167.0 |
| 20 | 0.005[e] | 0.038[e] | 0.069<br>< 0.050 - 0.113 | < 1.0[e] |

**TABLE K-1**
**(Continued)**

| Well Location[a] | Silver Average (mg/ℓ) Range[b] (mg/ℓ) | Arsenic Average (mg/ℓ) Range (mg/ℓ) | Barium Average (mg/ℓ) Range (mg/ℓ) | Calcium Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 21 | 0.006<br>< 0.001 - < 0.030 | 0.004<br>0.002 - 0.006 | 0.084<br>0.074 - 0.086 | 103.6<br>91.0 - 110.0 |
| 22 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>0.001 - 0.007 | 0.064<br>0.036 - 0.120 | 84.6<br>67.0 - 96.0 |
| 23 | 0.006<br>< 0.001 - 0.001 | 0.002<br>< 0.001 - 0.002 | 0.041<br>< 0.030 - 0.049 | 41.6<br>1.0 - 88.8 |
| 24 | 0.004<br>0.001 - NA | 0.002<br>< 0.001 - < 0.002 | 0.051<br>0.046 - 0.056 | 112.0<br>98.0 - 120.0 |
| 25 | 0.006<br>< 0.001 - < 0.030 | 0.003<br>< 0.001 - NA | 0.055<br>< 0.030 - 0.050 | 75.0<br>87.0 - 114.0 |
| 26 | 0.006<br>< 0.001 - < 0.030 | 0.005<br>0.004 - 0.007 | 0.074<br>0.053 - 0.081 | 99.6<br>79.0 - 110.0 |
| 27 | 0.001<br>< 0.001 - < 0.003 | 0.003<br>< 0.001 - 0.002 | 0.053<br>0.027 - 0.073 | 86.7<br>35.0 - 120.0 |
| 28 | 0.008<br>< 0.003 - < 0.030 | 0.004<br>< 0.005 - 0.010 | 0.058<br>< 0.030 - < 0.200 | 58.1<br>28.0 - 88.1 |
| 29 | 0.003<br>< 0.001 - < 0.020 | 0.004<br>< 0.002 - 0.005 | 0.068<br>0.052 - 0.080 | 93.8<br>78.0 - 111.0 |
| 30 | 0.003<br>< 0.001 - < 0.020 | 0.002<br>< 0.010 - 0.010 | 0.155<br>0.044 - 0.500 | 83.5<br>63.0 - 99.8 |
| 31 | < 0.001[f] | 0.003[f] | 0.005[f] | 34.8[f] |
| 32 | 0.006<br>< 0.003 - < 0.020 | 0.018<br>0.014 - 0.021 | < 0.030<br>NA | 78.5<br>75.0 - 82.0 |
| 33 | < 0.003[h] | < 0.010[h] | 0.069[h] | 72.0[h] |
| 34 | < 0.003[h] | < 0.010[h] | < 0.030[h] | 85.0[h] |
| 35 | < 0.003[h] | < 0.010[h] | 0.031[h] | 75.0[h] |
| 36 | < 0.003[h] | < 0.010[h] | 0.037[h] | 110.0[h] |
| 37 | < 0.003[h] | < 0.010[h] | 0.077[h] | 55.0[h] |

[a] See Figure K-1 for well locations.
[b] Ranges listed were based on annual averages. The minimum concentration shown for each well is either the lowest detection limit or the lowest positively detected concentration, whichever is smaller. The maximum concentration shown for each well is the highest positively detected concentration or, when the parameter has never been detected in groundwater collected from the specific well, the highest detection limit ever applied.
[c] Data were collected only during 1986.
[d] The constituent has only been detected once at the indicated concentration. However, one or more detection limits of greater than this value were applied during previous or subsequent sampling rounds.
[e] Data were collected only during 1987.
[f] Data collected only in 1988.
[g] Concentrations at which detected were <0.030 in both 1989 and 1990.
[h] Data collected only in 1990.

SOURCE: Westinghouse Materials Company of Ohio (WMCO), 1987-1991, "Feed Materials Production Center (FMPC) Environmental Monitoring Annual Reports for 1986 to 1990."

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2. WESTINGHOUSE MATERIALS COMPANY OF OHIO, 1986–1991, "FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR CALENDAR YEAR 1989."

LEGEND:

FEMP PROPERTY BOUNDARY

FLOW DIRECTION

1 SAMPLING LOCATION

313327-B53 (SWCR) (PGH.)

FIGURE K-1. OFF-PROPERTY GROUNDWATER MONITORING WELL LOCATIONS FOR THE ENVIRONMENTAL MONITORING PROGRAM, 1983-1991

TABLE K-2
ANNUAL AVERAGE CONCENTRATIONS OF CADMIUM, CHROMIUM, COPPER, AND IRON IN GROUNDWATER SAMPLES FROM OFF-PROPERTY WELLS

| Well Location[a] | Cadmium Average (mg/ℓ) Range[b] (mg/ℓ) | Chromium Average (mg/ℓ) Range (mg/ℓ) | Copper Average (mg/ℓ) Range (mg/ℓ) | Iron Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 1 | 0.001 | 0.002 | 0.010 | 3.538 |
| 3 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.011<br>0.004 - 0.026 | 3.375<br>2.950 - 3.995 |
| 4 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - 0.001 | 0.021<br>0.012 - 0.028 | 0.151<br>0.033 - 0.486 |
| 5 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.016<br>0.003 - 0.041 | 0.551<br>0.078 - 0.939 |
| 6 | < 0.002[c] | < 0.005[c] | 0.039[c] | < 0.050[c] |
| 7 | 0.002<br>< 0.001 - 0.009 | 0.002<br>< 0.001 - < 0.006 | 0.011<br>0.003 - 0.022 | 1.452<br>0.690 - 2.200 |
| 8 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.008<br>0.003 - 0.011 | 0.113<br>0.040 - 0.219 |
| 9 | 0.002<br>< 0.001 - 0.007 | 0.002<br>< 0.001 - < 0.006 | 0.009<br>0.003 - 0.014 | 0.159<br>0.084 - 0.379 |
| 10 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.052<br>0.002 - 0.234 | 2.767<br>1.850 - 3.845 |
| 11 | 0.002<br>< 0.001 - 0.007 | 0.002<br>< 0.001 - < 0.006 | 0.045<br>< 0.014 - 0.082 | 0.123<br>0.036 - 0.213 |
| 12 | 0.001<br>< 0.001 - 0.001 | 0.001<br>< 0.001 - < 0.005 | 0.013<br>0.007 - 0.016 | 0.104<br>< 0.050 - 0.181 |
| 13 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.028<br>< 0.014 - 0.065 | 0.091<br>< 0.025 - 0.212 |
| 14 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.008<br>0.003 - 0.011 | 0.861<br>0.730 - 1.080 |
| 15 | 0.001<br>< 0.001 - < 0.006 | 0.006<br>< 0.001 - 0.026 | 0.103<br>0.036 - 0.31 | 3.506<br>< 0.025 - 17.000 |
| 16 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.008<br>0.002 - 0.010 | 1.226<br>0.160 - 2.040 |
| 17 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.006<br>< 0.001 - < 0.025 | 1.556<br>0.740 - 2.500 |
| 18 | 0.002<br>< 0.001 - 0.008 | 0.002<br>< 0.001 - < 0.006 | 0.008<br>< 0.001 - 0.016 | 2.964<br>2.220 - 3.390 |
| 19 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.008<br>0.002 - 0.013 | 1.472<br>0.810 - 2.940 |
| 20 | 0.002[d] | 0.004[d] | 0.003[d] | 0.120[d] |

TABLE K-2
(Continued)

| Well Location[a] | Cadmium Average (mg/ℓ) Range[b] (mg/ℓ) | Chromium Average (mg/ℓ) Range (mg/ℓ) | Copper Average (mg/ℓ) Range (mg/ℓ) | Iron Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 21 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.009<br>0.002 - 0.013 | 2.097<br>1.500 - 2.655 |
| 22 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.009<br>0.003 - 0.013 | 0.125<br>< 0.025 - 0.227 |
| 23 | 0.001<br>< 0.001 - 0.001 | 0.002<br>< 0.001 - < 0.006 | 0.016<br>0.007 - 0.026 | 0.134<br>< 0.050 - 0.342 |
| 24 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.007<br>< 0.001 - 0.014 | 0.114<br>< 0.025 - 0.246 |
| 25 | 0.002<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.013<br>0.006 - 0.026 | 0.088<br>< 0.050 - 0.120 |
| 26 | 0.001<br>< 0.001 - < 0.006 | 0.002<br>< 0.001 - < 0.006 | 0.009<br>0.001 - 0.011 | 2.912<br>2.100 - 3.500 |
| 27 | 0.001<br>< 0.001 - < 0.006 | 0.001<br>< 0.001 - < 0.006 | 0.101<br>0.036 - 0.176 | 0.173<br>0.120 - 0.239 |
| 28 | 0.002<br>< 0.002 - < 0.006 | 0.003<br>< 0.005 - < 0.006 | 0.013<br>0.014 - NA[e] | 0.261<br>0.130 - 0.392 |
| 29 | 0.001<br>< 0.001 - < 0.006 | 0.001<br>< 0.001 - < 0.006 | 0.006<br>0.002 - 0.007 | 2.913<br>1.400 - 6.090 |
| 30 | 0.002<br>< 0.001 - 0.007 | 0.001<br>< 0.001 - < 0.006 | 0.024<br>0.015 - 0.033 | 0.121<br>0.025 - 0.210 |
| 31 | < 0.001[f] | < 0.001[f] | < 0.001[f] | 0.271[f] |
| 32 | 0.002<br>< 0.001 - < 0.006 | 0.002<br>< 0.002 - < 0.006 | 0.008<br>0.008 - NA[f] | 1.400<br>1.300 - 1.500 |
| 33 | < 0.006[g] | < 0.006[g] | < 0.048[g] | 0.100[g] |
| 34 | < 0.006[g] | < 0.006[g] | < 0.014[g] | 0.630[g] |
| 35 | < 0.006[g] | < 0.006[g] | < 0.014[g] | 0.062[g] |
| 36 | < 0.006[g] | < 0.006[g] | < 0.014[g] | 0.054[g] |
| 37 | 0.008[g] | < 0.006[g] | < 0.014[g] | 0.038[g] |

[a] See Figure K-1 for well locations.
[b] Ranges listed were based on annual averages as discussed in Table K-1.
[c] Data were collected only during 1986.
[d] Data were collected only during 1987.
[e] The constituent has only been detected once at the indicated concentration. However, one or more detection limits of greater than this value were applied during previous or subsequent sampling rounds.
[f] Data collected only in 1988.
[g] Data collected only in 1990.

SOURCE: Westinghouse Materials Company of Ohio (WMCO), 1987-1991, "Feed Materials Production Center (FMPC) Environmental Monitoring Annual Reports for 1986 to 1990."

**TABLE K-3**
**ANNUAL AVERAGE CONCENTRATIONS OF POTASSIUM, MAGNESIUM, MANGANESE, AND SODIUM IN GROUNDWATER SAMPLES FROM OFF-PROPERTY WELLS**

| Well Location[a] | Potassium Average (mg/ℓ) Range[b] (mg/ℓ) | Magnesium Average (mg/ℓ) Range (mg/ℓ) | Manganese Average (mg/ℓ) Range (mg/ℓ) | Sodium Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 1 | 1.006<br>0.780 - 1.300 | 21.5<br>18.0 - 24.2 | 0.019<br>0.016 - 0.021 | 14.6<br>10.0 - 1704 |
| 3 | 1.258<br>0.900 - 1.800 | 24.4<br>20.0 - 29.1 | 0.020<br>0.014 - 0.031 | 30.2<br>27.0 - 32.2 |
| 4 | 2.250<br>1.470 - 3.440 | 62.0<br>43.0 - 72.2 | 0.005<br>0.001 - 0.004 | 46.1<br>31.0 - 53.0 |
| 5 | 2.050<br>1.300 - 3.070 | 57.6<br>51.0 - 67.3 | 0.045<br>< 0.006 - 0.083 | 31.6<br>24.0 - 40.0 |
| 6 | 12.800[c] | 29.6[c] | < 0.020[c] | 11.6[c] |
| 7 | 2.006<br>1.600 - 2.570 | 31.7<br>23.0 - 37.5 | 0.149<br>0.120 - 0.180 | 8.5<br>6.8 - 9.5 |
| 8 | 2.716<br>2.228 - 3.460 | 28.4<br>25.0 - 33.3 | 0.145<br>0.120 - 0.176 | 16.4<br>14.2 - 19.2 |
| 9 | 3.292<br>2.910 - 4.100 | 27.7<br>23.0 - 32.0 | 0.384<br>0.210 - 0.560 | 29.1<br>25.2 - 36.8 |
| 10 | 2.106<br>1.590 - 2.820 | 28.0<br>26.0 - 30.2 | 0.249<br>0.230 - 0.270 | 11.1<br>10.1 - 12.0 |
| 11 | 2.474<br>1.700 - 3.150 | 25.4<br>22.0 - 28.9 | 0.004<br>0.001 - 0.003 | 28.3<br>10.9 - 52.0 |
| 12 | 3.178<br>2.300 - 3.700 | 23.0<br>18.9 - 28.6 | 0.024<br>0.001 - 0.080 | 13.7<br>11.4 - 17.8 |
| 13 | 2.530<br>2.220 - 2.800 | 27.5<br>19.0 - 33.7 | 0.033<br>0.010 - 0.070 | 14.2<br>10.3 - 19.0 |
| 14 | 5.704<br>4.400 - 8.300 | 32.7<br>27.0 - 38.9 | 0.263<br>0.110 - 0.350 | 19.4<br>14.2 - 23.8 |
| 15 | 3.276<br>2.700 - 4.990 | 23.0<br>20.0 - 26.6 | 0.382<br>0.008 - 1.800 | 12.0<br>10.7 - 13.0 |
| 16 | 2.318<br>1.760 - 2.700 | 29.6<br>25.0 - 33.0 | 0.214<br>0.001 - 0.370 | 28.9<br>10.7 - 40.0 |
| 17 | 2.518<br>2.200 - 3.000 | 22.8<br>18.0 - 26.9 | 0.386<br>0.310 - 0.450 | 12.1<br>11.0 - 13.4 |
| 18 | 2.352<br>1.980 - 3.100 | 28.3<br>23.0 - 32.0 | 0.221<br>0.140 - 0.280 | 9.8<br>8.5 - 12.0 |
| 19 | 124.328<br>15.400 - 370.000 | 37.9<br>19.0 - 58.8 | 0.235<br>0.120 - 0.320 | 24.9<br>12.0 - 51.0 |
| 20 | 401.000[d] | 0.6[d] | < 0.010[d] | 231.0[d] |
| 21 | 2.300<br>1.850 - 2.700 | 27.7<br>24.0 - 31.4 | 0.264<br>0.220 - 0.320 | 10.0<br>8.4 - 11.0 |
| 22 | 2.746<br>2.300 - 3.580 | 22.7<br>19.0 - 26.1 | 0.064<br>0.043 - 0.090 | 11.2<br>10.1 - 13.0 |

TABLE K-3
(Continued)

| Well Location[a] | Potassium Average (mg/ℓ) Range[b] (mg/ℓ) | Magnesium Average (mg/ℓ) Range (mg/ℓ) | Manganese Average (mg/ℓ) Range (mg/ℓ) | Sodium Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 23 | 1.154<br>0.750 - 1.510 | 12.4<br>< 0.10 - 27.0 | 0.028<br>< 0.002 - 0.070 | 80.2<br>4.75 - 160.0 |
| 24 | 2.217<br>1.800 - 2.950 | 32.5<br>30.0 - 35.5 | 0.074<br>0.057 - 0.088 | 7.0<br>6.2 - 7.7 |
| 25 | 1.263<br>0.170 - 1.830 | 23.8<br>0.17 - 38.8 | 0.038<br>< 0.006 - 0.100 | 71.4<br>7.0 - 200.0 |
| 26 | 1.720<br>1.410 - 2.200 | 26.4<br>21.0 - 29.0 | 0.325<br>0.270 - 0.390 | 6.8<br>5.8 - 7.6 |
| 27 | 3.107<br>2.110 - 3.810 | 20.5<br>7.8 - 27.2 | 0.004<br>0.003 - NA[e] | 14.6<br>6.9 - 19.8 |
| 28 | 1.200<br>0.76 - 1.640 | 17.6<br>8.3 - 26.9 | 0.052<br>0.022 - 0.082 | 39.7<br>4.4 - 75.0 |
| 29 | 2.813<br>2.100 - 4.150 | 27.8<br>22.0 - 37.0 | 0.220<br>0.170 - 0.261 | 9.7<br>8.7 - 11.2 |
| 30 | 2.735<br>2.120 - 3.820 | 23.3<br>18.0 - 27.5 | 0.003<br>< 0.001 - 0.002 | 14.9<br>10.9 - 22.6 |
| 31 | 1.310[f] | 12.8[f] | 0.047[f] | 8.8[f] |
| 32 | 60.000<br>49.000 - 71.000 | 27.5<br>27.0 - 28.0 | 0.460<br>0.440 - 0.480 | 13.0<br>10.0 - 16.0 |
| 33 | 1.600[g] | 21.0[g] | < 0.006[g] | 16.0[g] |
| 34 | 2.000[g] | 22.0[g] | 0.046[g] | 8.5[g] |
| 35 | 1.900[g] | 22.0[g] | < 0.006[g] | 20.0[g] |
| 36 | 3.400[g] | 21.0[g] | < 0.006[g] | 12.0[g] |
| 37 | 2.900[g] | 21.0[g] | 0.023[g] | 10.0[g] |

[a] See Figure K-1 for well locations.
[b] Ranges listed were based on annual averages. The minimum concentration shown for each well is either the lowest detection limit or the lowest positively detected concentration, whichever is smaller. The maximum concentration shown for each well is the highest positively detected concentration or, when the parameter has never been detected in groundwater collected from the specific well, the highest detection limit ever applied.
[c] Data were collected only during 1986.
[d] Data were collected only during 1987.
[e] The constituent has only been detected once at the indicated concentration. However, one or more detection limits of greater than this value were applied during previous or subsequent sampling rounds.
[f] Data collected only in 1988.
[g] Data collected only in 1990.

SOURCE: Westinghouse Materials Company of Ohio (WMCO), 1987-1991, "Feed Materials Production Center (FMPC) Environmental Monitoring Annual Reports for 1986 to 1990."

**TABLE K-4**
**ANNUAL AVERAGE CONCENTRATIONS OF NICKEL, LEAD, SELENIUM, AND ZINC IN GROUNDWATER SAMPLES FROM OFF-PROPERTY WELLS**

| Well Location[a] | Nickel Average (mg/ℓ) Range[b] (mg/ℓ) | Lead Average (mg/ℓ) Range (mg/ℓ) | Selenium Average (mg/ℓ) Range (mg/ℓ) | Zinc Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 1 | 0.002<br>< 0.001 - < 0.009 | 0.002<br>< 0.001 - < 0.006 | 0.0048<br>0.0020 - 0.0110 | 0.260<br>0.016 - 0.740 |
| 3 | 0.003<br>< 0.001 - 0.008 | 0.002<br>< 0.001 - 0.002 | 0.0033<br>0.0010 - 0.0080 | 0.062<br>0.008 - 0.270 |
| 4 | 0.002<br>< 0.001 - 0.002 | 0.002<br>< 0.001 - 0.003 | 0.0081<br>< 0.0025 - 0.0140 | 0.137<br>0.020 - 0.560 |
| 5 | 0.003<br>< 0.001 - 0.005 | 0.002<br>< 0.001 - 0.003 | 0.0049<br>< 0.0025 - 0.0100 | 0.092<br>0.020 - 0.142 |
| 6 | < 0.005[c] | < 0.005[c] | < 0.0025[c] | 0.494[c] |
| 7 | 0.002<br>< 0.001 - < 0.009 | 0.002<br>< 0.001 - 0.003 | 0.0059<br>< 0.0025 - 0.0140 | 0.178<br>0.038 - 0.620 |
| 8 | 0.002<br>< 0.001 - 0.002 | 0.001<br>< 0.001 - < 0.006 | 0.0044<br>< 0.0025 - 0.0110 | 0.122<br>0.009 - 0.560 |
| 9 | 0.002<br>< 0.001 - 0.002 | 0.001<br>< 0.001 - < 0.006 | 0.0055<br>< 0.0025 - 0.0110 | 0.080<br>0.009 - 0.360 |
| 10 | 0.002<br>< 0.001 - 0.001 | 0.002<br>< 0.001 - 0.007 | 0.0043<br>< 0.0025 - 0.0100 | 0.117<br>0.007 - 0.500 |
| 11 | 0.003<br>0.002 - 0.006 | 0.002<br>< 0.001 - 0.004 | 0.0051<br>< 0.0025 - 0.0110 | 0.235<br>0.106 - 0.500 |
| 12 | 0.002<br>< 0.001 - 0.002 | 0.002<br>< 0.001 - 0.003 | 0.0043<br>< 0.0025 - 0.0100 | 0.177<br>0.138 - 0.260 |
| 13 | 0.002<br>< 0.001 - 0.001 | 0.002<br>< 0.001 - 0.002 | 0.0056<br>0.0030 - 0.0090 | 0.095<br>0.008 - 0.370 |
| 14 | 0.003<br>0.002 - NA[d] | 0.002<br>< 0.001 - 0.002 | 0.0063<br>< 0.0025 - 0.0120 | 0.047<br>0.010 - 0.170 |
| 15 | 0.002<br>< 0.001 - 0.001 | 0.009<br>< 0.001 - 0.038 | 0.0051<br>< 0.0025 - 0.0090 | 0.330<br>0.042 - 1.400 |
| 16 | 0.002<br>< 0.001 - 0.002 | 0.001<br>< 0.001 - < 0.006 | 0.0059<br>< 0.0025 - 0.0120 | 0.105<br>0.008 - 0.490 |
| 17 | 0.002<br>< 0.001 - < 0.009 | 0.002<br>< 0.001 - 0.001 | 0.0049<br>< 0.0025 - 0.0100 | 0.129<br>< 0.010 - 0.600 |
| 18 | 0.002<br>< 0.001 - 0.001 | 0.001<br>< 0.001 - < 0.006 | 0.0053<br>< 0.0025 - 0.0110 | 0.136<br>< 0.010 - 0.650 |
| 19 | 0.004<br>0.001 - 0.009 | 0.002<br>< 0.001 - 0.002 | 0.0129<br>< 0.0025 - 0.0340 | 0.175<br>< 0.010 - 0.820 |
| 20 | 0.002[e] | 0.052[e] | 0.0340[e] | < 0.010[e] |
| 21 | 0.003<br>< 0.001 - 0.005 | 0.001<br>< 0.001 - < 0.006 | 0.0057<br>< 0.0025 - 0.0100 | 0.145<br>0.020 - 0.580 |
| 22 | 0.003<br>0.001 - 0.006 | 0.001<br>< 0.001 - < 0.006 | 0.0049<br>< 0.0025 - 0.0100 | 0.098<br>< 0.010 - 0.410 |

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**TABLE K-4**
**(Continued)**

| Well Location[a] | Nickel Average (mg/ℓ) Range[b] (mg/ℓ) | Lead Average (mg/ℓ) Range (mg/ℓ) | Selenium Average (mg/ℓ) Range (mg/ℓ) | Zinc Average (mg/ℓ) Range (mg/ℓ) |
|---|---|---|---|---|
| 23 | 0.003<br>< 0.001 - 0.006 | 0.002<br>< 0.001 - 0.002 | 0.0061<br>< 0.0025 - 0.0160 | 0.098<br>< 0.004 - 0.380 |
| 24 | 0.002<br>< 0.001 - < 0.009 | 0.001<br>< 0.001 - < 0.006 | 0.0077<br>0.0090 - NA[d] | 0.137<br>0.020 - 0.360 |
| 25 | 0.003<br>0.002 - NA[d] | 0.003<br>0.001 - NA[d] | 0.0038<br>< 0.0025 - 0.0050 | 0.104<br>< 0.025 - 0.260 |
| 26 | 0.003<br>< 0.001 - 0.007 | 0.002<br>< 0.001 - 0.002 | 0.0053<br>< 0.0025 - 0.0100 | 0.135<br>0.052 - 0.380 |
| 27 | 0.002<br>< 0.001 - 0.002 | 0.002<br>< 0.001 - 0.001 | 0.0050<br>0.0030 - 0.0080 | 0.267<br>0.060 - 0.480 |
| 28 | 0.004<br>< 0.005 - < 0.009 | 0.003<br>< 0.005 - < 0.006 | 0.0031<br>< 0.0025 - < 0.010 | 0.201<br>< 0.025 - 0.390 |
| 29 | 0.002<br>< 0.001 - 0.002 | 0.001<br>< 0.001 - < 0.006 | 0.0075<br>0.0050 - 0.0110 | 0.091<br>0.005 - 0.310 |
| 30 | 0.002<br>< 0.001 - 0.001 | 0.003<br>0.001 - 0.004 | 0.0049<br>< 0.0010 - 0.0110 | 0.096<br>0.005 - 0.360 |
| 31 | < 0.001[f] | < 0.001[f] | < 0.0010[f] | 0.011[f] |
| 32 | 0.003<br>< 0.003 - < 0.009 | 0.002<br>< 0.001 - < 0.006 | 0.0095<br>< 0.0100 - 0.0140 | 0.297<br>0.004 - 0.590 |
| 33 | < 0.009[g] | < 0.006[g] | < 0.0100[g] | 0.290[g] |
| 34 | < 0.009[g] | < 0.006[g] | < 0.0100[j] | 0.440[g] |
| 35 | < 0.009[g] | < 0.006[g] | < 0.0100[g] | 0.470[g] |
| 36 | < 0.009[g] | < 0.006[g] | < 0.0100[g] | 0.850[g] |
| 37 | < 0.009[g] | < 0.006[g] | < 0.0100[g] | 0.320[g] |

[a] See Figure K-1 for well locations.
[b] Ranges listed were based on annual averages. The minimum concentration shown for each well is either the lowest detection limit or the lowest positively detected concentration, whichever is smaller. The maximum concentration shown for each well is the highest positively detected concentration or, when the parameter has never been detected in groundwater collected from the specific well, the highest detection limit ever applied.
[c] Data were collected only during 1986.
[d] The constituent has only been detected once at the indicated concentration. However, one or more detection limits of greater than this value were applied during previous or subsequent sampling rounds.
[e] Data were collected only during 1987.
[f] Data collected only in 1988.
[g] Data collected only in 1990.

SOURCE: Westinghouse Materials Company of Ohio (WMCO), 1987-1991, "Feed Materials Production Center (FMPC) Environmental Monitoring Annual Reports for 1986 to 1990."

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# APPENDIX L

## ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES DURING RCRA SAMPLING

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**TABLE L-1**
**TOTAL URANIUM, TOTAL RADIUM, GROSS ALPHA, AND GROSS BETA IN GROUNDWATER SAMPLES COLLECTED FROM THE GLACIAL OVERBURDEN DURING THE RCRA DETECTION PROGRAM**

| Well Location[a] | Total Uranium Average (µg/ℓ) Range[b] (µg/ℓ) | Total Radium Average (pCi/ℓ) Range (pCi/ℓ) | Gross Alpha Average (pCi/ℓ) Range (pCi/ℓ) | Gross Beta Average (pCi/ℓ) Range (pCi/ℓ) |
|---|---|---|---|---|
| Background (1012) | 1.6<br>< 0.1 - 1.5 | 1.8<br>< 1.0 - < 5.0 | 8.5<br>0.5 - 21 | 19<br>5.0 - 78 |
| 1019 | 495<br>< 14.9 - 900 | 3.2<br>< 1.0 - 5.8 | 16.6<br>2.0 - 43 | 74.2<br>45.4 -102 |
| 1020 | 16<br>< 1.5 - 31 | 1.8<br>< 1.0 - < 5.0 | 4.1<br>< 1.0 - 5.0 | 18<br>3.0 - 77 |
| 1021 | 3970<br>< 14.9 - 9612 | 10.8<br>< 1.0 - 21.1 | 281<br>16.3 - 964 | 862<br>250 - 3310 |
| 1022 | 4244<br>< 74.6 - 6269 | 1.5<br>< 1.0 - < 5.0 | 412<br>37 - 1370 | 753<br>143 - 1340 |
| 1060 | 1.5<br>1.1 - 2.2 | 1.8<br>< 1.0 - < 5.0 | < 2.8<br>< 1.0 - < 15.0 | 23<br>< 5.0 - 33 |

[a] See Appendix J for historical well identification names.
[b] The minimum concentration shown for each well is either the lowest detection limit or the lowest positively detected concentration, whichever is smaller. The maximum concentration shown for each well is the highest positively detected concentration or, when the parameter has never been detected in groundwater collected from the specific well, the highest detection limit ever applied.

SOURCE: RCRA Round 1 to Round 6 Reports. Dames and Moore, 1985a; 1985b; 1986; 1987a; 1987b; 1988.

TABLE L-2
TOTAL URANIUM, TOTAL RADIUM, GROSS ALPHA, AND GROSS BETA
IN GROUNDWATER SAMPLES COLLECTED FROM THE SAND AND GRAVEL AQUIFER
DURING THE RCRA DETECTION PROGRAM

| Well Location[a] | Total Uranium Average (µg/ℓ) Range[b] (µg/ℓ) | Total Radium Average (pCi/ℓ) Range (pCi/ℓ) | Gross Alpha Average (pCi/ℓ) Ranged (pCi/ℓ) | Gross Beta Average (pCi/ℓ) Range (pCi/ℓ) |
|---|---|---|---|---|
| Background (Coll 2) | 1.6<br>< 0.6 - 0.8 | 3.6<br>< 1.0 - 7.7 | 2.7<br>< 1.0 - 6.3 | 8.2<br>2.5 - 17 |
| 2004 | 6.1<br>< 1.5 - 8.7 | 1.8<br>< 1.0 - < 5.0 | 3.4<br>< 1.0 - 1.3 | 7.5<br>< 1.0 - 18 |
| 2011 | 0.4<br>< 0.1 - 0.6 | 1.8<br>< 1.0 - < 5.0 | 2.8<br>< 1.0 - < 15 | 5.0<br>2.0 - 9.0 |
| 2013 | 1.3<br>0.8 - 2.1 | 1.8<br>< 1.0 - 15 | 3.2<br>< 0.5 - 2.9 | 5.1<br>1.3 - 15 |
| 2014 | 33.1<br>< 14.9 - 85 | 1.5<br>< 1.0 - < 5.0 | 15<br>< 1.0 - 47 | 25<br>< 1.0 - 57 |
| 2015 | 220<br>154 - 402 | 3.4<br>< 1.0 - 7.14 | 30<br>< 15.0 - 70 | 39<br>< 5.0 - 95 |
| 2016 | 13.6<br>< 1.5 - 20 | 1.8<br>< 1.0 - < 5.0 | 5.6<br>1.4 - 8 | 6.8<br>< 1.0 - 12 |
| 2017 | 3.3<br>< 1.5 - 5.1 | 1.9<br>< 1.0 - < 5.0 | 3.1<br>< 1.0 - 2.1 | 2.9<br>2.0 - 6.0 |
| 2018 | 2.6<br>1.0 - 2.7 | 1.5<br>< 1.0 - 5.0 | 5.1<br>< 1.0 - 21 | 11<br>< 1.0 - 44 |
| 2019 | 5.8<br>1.1 - 10.4 | 65<br>< 1.0 - 130 | 14.0<br>3.47 - 36 | 755<br>209 - 1290 |
| 2020 | 0.6<br>0.5 - 0.8 | 3.7<br>< 1.0 - 8 | 2.8<br>< 1.0 - < 15.0 | 10.1<br>3.0 - 21.0 |
| 2021 | 5.3<br>1.8 - 13.4 | 11<br>< 2.0 - 29 | 24.8<br>11.4 - 51 | 1109<br>400 - 2270 |
| 2022 | 3.2<br>< 1.5 - 4.3 | 1.8<br>< 1.0 - < 5.0 | 4.2<br>< 1.0 - 3.8 | 256<br>42 - 1220 |
| 2060 | 320<br>200 - 591 | 13<br>< 1.0 - 36 | 32.1<br>< 15.0 - 59 | 46.8<br>28 - 104 |
| 2061 | 326<br>260 - 476 | 3.2<br>< 1.0 - 6.6 | 40<br>16 - 59 | 55<br>19 - 99 |
| 3001 | 23.4<br>< 1.5 - 83 | 1.8<br>< 1.0 - < 5.0 | 4.2<br>< 1.0 - 5.0 | 7.7<br>4.0 - 15 |
| 3003 | 3495<br>2.2 - 17462 | 1.8<br>< 1.0 - < 5.0 | 499<br>< 1.0 - 2980 | 2359<br>2.0 - 14100 |
| 3005 | 3.6<br>< 1.5 - 6.2 | 1.8<br>< 1.0 - < 5.0 | 3.1<br>< 1.0 - 2.0 | 5.5<br>3.0 - 12 |
| 3008 | 1.4<br>0.6 - 3.2 | 1.8<br>< 1.0 - < 5.0 | 3.6<br>< 1.0 - 5 | 7.8<br>1.66 - 18 |
| 3009 | 1.3<br>1.1 - 2.1 | 1.8<br>< 1.0 - < 5.0 | 3.1<br>< 1.0 - 2.0 | 8.7<br>< 5.0 - 18 |

**TABLE L-2**
**(continued)**

| Well Location[a] | Total Uranium Average (µg/ℓ) Range[b] (µg/ℓ) | Total Radium Average (pCi/ℓ) Range (pCi/ℓ) | Gross Alpha Average (pCi/ℓ) Ranged (pCi/ℓ) | Gross Beta Average (pCi/ℓ) Range (pCi/ℓ) |
|---|---|---|---|---|
| 3010 | 14.1<br>< 1.5 - 19 | 1.5<br>< 1.0 - < 5.0 | 4.2<br>< 1.0 - 8.9 | 19.5<br>1.88 - 62 |
| 3013 | 15.2<br>< 1.5 - 21 | 1.9<br>< 1.0 - < 5.0 | 3.1<br>< 1.0 - 2.0 | 5.2<br>< 3.23 - 10 |
| 3014 | 23<br>< 14.9 - 38 | 1.5<br>< 1.0 - < 5.0 | 6.7<br>5.0 - 9.0 | 9.2<br>< 5.0 - 17 |
| 3016 | 7.3<br>< 1.5 - 10 | 1.8<br>< 1.0 - < 5.0 | 3.8<br>< 1.0 - 3.0 | 5.7<br>< 1.0 - 17 |
| 3017 | 0.8<br>0.6 - 0.9 | 1.8<br>< 1.0 - < 5.0 | 2.8<br>< 1.0 - < 15.0 | 2.7<br>< 1.0 - 6.03 |
| 3018 | 1.7<br>0.75 - 2.9 | 1.8<br>< 1.0 - < 5.0 | 6.4<br>0.5 - 22 | 7.97<br>4.0 - 13.8 |
| 3019 | 29<br>< 1.5 - 67 | 1.8<br>< 1.0 - < 5.0 | 4.1<br>1.7 - 4 | 9.5<br>< 1.0 - 17 |
| 3020 | 0.9<br>0.7 - 1.3 | 3.0<br>< 1.0 - 5.9 | 2.95<br>< 1.0 - 1.21 | 3.6<br>4.0 - 4.77 |
| 3062 | 94<br>31 - 304 | 1.8<br>< 1.0 - < 5.0 | 6.1<br>< 1.0 - 10 | 9.4<br>2.0 - 23 |
| 4001 | 1.5<br>0.1 - 0.2 | 1.5<br>< 1.0 - < 5.0 | 6.1<br>< 1.0 - 13 | 3.0<br>< 1.0 - 7.0 |
| 4008 | 0.7<br>0.3 - 1.1 | 1.8<br>< 1.0 - < 5.0 | 4.4<br>< 1.0 - 10 | 12<br>< 1.0 - 29 |
| 4015 | 0.3<br>0.1 - 0.3 | 1.8<br>< 1.0 - < 5.0 | 2.8<br>< 1.0 - < 15.0 | 2.7<br>1.0 - 4.0 |
| 4101 | 0.8<br>0.1 - 2.3 | 1.8<br>< 1.0 - < 5.0 | 3.3<br>< 1.0 - 3.5 | 7.4<br>1.0 - 24.3 |
| 4102 | 0.5<br>0.1 - 1.1 | 1.8<br>< 1.0 - < 5.0 | < 2.8<br>< 1.0 - < 15.0 | 3.1<br>< 1.0 - 5.25 |
| 4103 | 0.4<br>0.2 - 0.75 | 1.8<br>< 1.0 - < 5.0 | 4.0<br>0.5 - NA[c] | 2.0<br>1.5 - NA |

[a] See Appendix J for historical well identification names.
[b] The minimum concentration shown for each well is either the lowest detection limit or the lowest positively detected concentration, whichever is smaller. The maximum concentration shown for each well is the highest positively detected concentration or, when the parameter has never been detected in groundwater collected from the specific well, the highest detection limit ever applied.
[c] Not applicable. The constituent has only been detected once at the indicated concentration. However, one or more detection limits that are greater than this value were applied during previous or sebsequent sampling rounds.

SOURCE: RCRA Round 1 to Round 6 Reports, Dames and Moore, 1985a; 1985b; 1986; 1987a; 1987b; 1988.

APPENDIX M

# APPENDIX M

## ONGOING RI/FS AND RCRA GROUNDWATER SAMPLING DATA

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TABLE M-1
RADIOLOGICAL CONSTITUENTS IN BACKGROUND PERCHED GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| RA-228 | 1 /19 | 5.200^f | 5.200 - 5.200 | | N | 1.713 | 2.050 | 0.846 | 0.716 |
| TH-228 | 3 /27 | 1.241 | 1.040 - 1.600 | | N | 0.597 | 0.690 | 0.281 | 0.079 |
| TH-230 | 2 /27 | 2.503 | 2.000 -34.800 | | L | 0.620 | 0.819 | 2.335 | 5.454 |
| TH-TOTAL^g | 1 /13 | 0.003^f | 0.003 - 0.003 | | N | 0.002 | 0.003 | 0.001 | 0.000 |
| U-234 | 11 /27 | 2.885 | 1.060 - 6.200 | | L | 0.854 | 1.089 | 2.096 | 4.393 |
| U-238 | 5 /27 | 2.047 | 1.070 - 3.100 | | N | 0.725 | 0.914 | 0.577 | 0.333 |
| U-TOTAL^g | 19 /27 | 0.006 | 0.001 - 0.011 | | L | 0.002 | 0.003 | 0.002 | 0.000 |

^a If blank data are available.
^b Upper 95% tolerance level for background data with a 95% level of confidence.
^c Distribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^d If the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^e If the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^f When background sample size is one, this concentration is given instead of a UTL.
^g Units are reported in mg/L.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Vanadium | 4 /4 | [illegible] | 0.100 - 0.580 | L | [illegible] | | | | |
| Zinc | 7 /10 | 0.362 | | | | | | | |

TABLE M-2
NONRADIOLOGICAL CONSTITUENTS IN BACKGROUND PERCHED GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 4 /4 | | 0.720 | 0.121 - 0.337 | N^f | 0.180 | 0.304 | 0.105 | 0.011 |
| Arsenic | 1 /20 | | 0.003^g | 0.003 - 0.003 | N^f | 0.036 | 0.003^h | 0.048 | 0.002 |
| Barium | 20 /23 | | 0.132 | 0.034 - 0.112 | N | 0.074 | 0.083 | 0.025 | 0.001 |
| Beryllium | 3 /4 | | 0.004 | 0.001 - 0.002 | N^f | 0.001 | 0.002 | 0.001 | 0.000 |
| Cadmium | 4 /20 | | 0.009 | 0.003 - 0.007 | N | 0.003 | 0.004 | 0.002 | 0.000 |
| Calcium | 23 /23 | | 128.017 | 74.400 -130.00 | L | 98.904 | 105.280 | 16.615 | 276.049 |
| Chromium | 10 /23 | | 0.076 | 0.020 - 0.120 | N | 0.021 | 0.029 | 0.024 | 0.001 |
| Cobalt | 1 /4 | | 0.013^g | 0.013 - 0.013 | N | 0.007 | 0.012 | 0.004 | 0.000 |
| Copper | 7 /23 | | 0.046 | 0.013 - 0.190 | L | 0.010 | 0.014 | 2.538 | 6.439 |
| Iron | 17 /23 | | 1.810 | 0.005 - 4.900 | L | 0.443 | 2.541 | 1.081 | 1.169 |
| Lead | 7 /23 | | 0.054 | 0.002 - 0.006 | L | 0.005 | 0.006^h | 4.216 | 17.777 |
| Magnesium | 23 /23 | | 56.792 | 20.400 -47.800 | N | 35.674 | 38.921 | 9.068 | 82.222 |
| Manganese | 17 /20 | | 0.202 | 0.003 - 0.220 | L | 0.051 | 0.130 | 0.054 | 0.003 |
| Mercury | 3 /20 | | 0.001 | 0.000 - 0.004 | L | 0.000 | 0.000 | 2.334 | 5.450 |
| Molybdenum | 1 /19 | | 0.020^g | 0.020 - 0.020 | N | 0.013 | 0.015 | 0.006 | 0.000 |
| Nickel | 7 /23 | | 0.103 | 0.013 - 0.180 | N | 0.022 | 0.034 | 0.035 | 0.001 |
| Potassium | 18 /20 | | 25.931 | 0.891 -31.500 | N^f | 6.824 | 9.907 | 7.975 | 63.593 |
| Silver | 6 /23 | | 0.050 | 0.011 - 0.052 | L | 0.005 | 0.009 | 3.950 | 15.600 |
| Sodium | 20 /20 | | 59.615 | 5.710 -84.000 | L | 23.090 | 34.227 | 20.717 | 429.174 |
| Vanadium | 4 /4 | | 0.058 | 0.018 - 0.033 | N | 0.023 | 0.031 | 0.007 | 0.000 |
| Zinc | 4 /4 | | 0.064 | 0.032 - 0.042 | N | 0.039 | 0.042^h | 0.005 | 0.000 |
| Ammonia | 7 /19 | | 0.362 | 0.100 - 0.580 | L | 0.088 | 0.123 | 2.369 | 5.613 |
| Chloride | 21 /23 | | 40.144 | 1.400 -35.700 | L | 8.809 | 24.717 | 9.923 | 98.475 |
| Fluoride | 23 /23 | | 1.624 | 0.200 - 1.350 | L | 0.713 | 0.948 | 0.371 | 0.137 |
| Nitrate | 14 /23 | | 0.341 | 0.037 - 0.300 | N | 0.128 | 0.161 | 0.092 | 0.008 |
| Phosphorus (black, white, red | 13 /19 | | 0.488 | 0.026 - 0.640 | N | 0.107 | 0.169 | 0.158 | 0.025 |
| Sulfate | 21 /22 | | 211.217 | 3.240 -239.00 | N | 72.897 | 94.491 | 58.859 | 3464.44 |
| Total Kjeldahl Nitrogen | 8 /9 | | 0.959 | 0.150 - 0.700 | L | 0.323 | 0.700^h | 0.230 | 0.053 |
| Total Organic Carbon | 2 /4 | | 12.995 | 3.266 - 4.690 | N | 2.239 | 4.690^h | 2.090 | 4.370 |
| Total Organic Halides | 2 /13 | | 0.066 | 0.008 - 0.067 | N^f | 0.021 | 0.029 | 0.017 | 0.000 |
| Total Organic Nitrogen | 11 /19 | | 0.403 | 0.100 - 0.400 | L | 0.148 | 0.233 | 0.113 | 0.013 |
| Acetone | 3 /3 | | 0.130 | 0.002 - 0.029 | N^f | 0.011 | 0.029^h | 0.016 | 0.000 |
| Carbon disulfide | 1 /1 | | -1.000^g | 0.004 - 0.004 | ^i | ^i | 0.004^h | . | . |
| Methylene chloride | 2 /3 | | 0.041 | 0.010 - 0.010 | N^f | 0.008 | 0.010^h | 0.004 | 0.000 |
| N-Nitrosodiphenylamine | 1 /1 | | -1.000^g | 0.002 - 0.002 | ^i | ^i | 0.002^h | . | . |
| Phenol | 1 /1 | | -1.000^g | 0.002 - 0.002 | ^i | ^i | 0.002^h | . | . |
| Phenols | 11 /19 | | 0.049 | 0.005 - 0.040 | L | 0.016 | 0.029 | 0.013 | 0.000 |

^a If blank data are available.
^b Upper 95% tolerance level for background data with a 95% level of confidence.

TABLE M-2
(continued)

^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.

^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.

^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.

^fDistribution could not be determined from available data; therefore, a normal distribution was assumed.

^gWhen backgound sample size is one, this concentration is given instead of a UTL. The mean site-related value will be compared with the single background value.

^hIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.

^iNot applicable if sample size ≤ 2.

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TABLE M-3
RADIOLOGICAL CONSTITUENTS IN PERCHED GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) |
|---|---|---|---|---|---|---|---|
| NP-237 | 1 /239 | ^f | | 1.000 - 1.000 | N^g | 0.544 | 0.580 |
| RA-226 | 53 /242 | ^f | | 0.300 - 7.340 | L | 0.678 | 0.727 |
| RA-228 | 23 /241 | 5.200 | | 0.930 -219.00 | L | 1.760 | 1.882 |
| SR-90 | 7 /239 | ^f | | 5.300 -27.200 | L | 2.599 | 2.665 |
| TC-99 | 56 /287 | ^f | | 13.800 - 13230 | L | 29.686 | 34.514 |
| TH-228 | 60 /285 | 1.241 | | 1.000 -49.700 | L | 0.676 | 0.720 |
| TH-230 | 72 /285 | 2.503 | | 1.000 -23.300 | L | 0.755 | 0.815 |
| TH-232 | 46 /241 | ^f | | 1.000 -40.800 | L | 0.703 | 0.763 |
| Thorium^h | 63 /192 | 0.003 | | 0.002 - 0.368 | N^g | 0.009 | 0.012 |
| U-234 | 248 /283 | 2.885 | | 1.100 -127982 | L | 610.65 | 1230.78 |
| U-235 | 1 /18 | ^f | | 4.290 - 4.290 | L | 0.563 | 0.694 |
| U-235/236 | 94 /265 | ^f | | 0.913 -7494.0 | L | 1.948 | 2.461 |
| U-238 | 242 /282 | 2.047 | | 1.000 -121642 | L | 1166.3 | 2599.26 |
| Uranium^h | 532 /554 | 0.006 | | 0.001 -696.00 | L | 11.508 | 20.911 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hUnits are reported in mg/L.

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TABLE M-4
NONRADIOLOGICAL CONSTITUENTS IN PERCHED GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| Aluminum | 77 /89 | | 0.720 | 0.014 - 8.570 | N | 0.473 | 0.705 |
| Antimony | 17 /70 | | ^f | 0.001 - 0.310 | L | 0.010 | 0.015 |
| Arsenic | 34 /189 | | ^f | 0.002 - 0.440 | L | 0.002 | 0.002 |
| Barium | 235 /251 | | 0.132 | 0.025 - 2.000 | L | 0.121 | 0.132 |
| Beryllium | 32 /89 | | 0.004 | 0.001 - 0.076 | L | 0.001 | 0.002 |
| Cadmium | 92 /231 | | 0.009 | 0.002 - 0.050 | L | 0.003 | 0.003 |
| Calcium | 248 /248 | | 128.017 | 12.900 -4000.0 | L | 170.28 | 185.322 |
| Chromium | 115 /251 | | 0.076 | 0.003 - 2.140 | L | 0.017 | 0.019 |
| Cobalt | 22 /89 | | ^f | 0.009 - 0.486 | L | 0.007 | 0.009 |
| Copper | 82 /251 | | 0.046 | 0.010 - 0.409 | L | 0.008 | 0.009 |
| Iron | 215 /251 | | 1.810 | 0.005 -27.000 | L | 0.668 | 0.996 |
| Lead | 61 /204 | | 0.054 | 0.002 - 0.118 | L | 0.002 | 0.002 |
| Magnesium | 248 /248 | | 56.792 | 5.680 -698.00 | L | 65.834 | 72.192 |
| Manganese | 223 /232 | | 0.202 | 0.003 -38.000 | L | 0.576 | 0.824 |
| Mercury | 45 /233 | | 0.001 | 0.000 -30.200 | L | 0.000 | 0.000 |
| Nickel | 97 /251 | | 0.103 | 0.000 - 0.981 | L | 0.019 | 0.021 |
| Osmium | 3 /7 | | ^f | 0.059 - 0.469 | N^g | 0.108 | 0.228 |
| Potassium | 217 /230 | | 25.931 | 0.001 -455.00 | L | 5.220 | 6.405 |
| Selenium | 18 /192 | | ^f | 0.002 - 0.019 | L | 0.001 | 0.002 |
| Silicon | 2 /2 | | ^f | 7.330 - 7.750 | ^h | ^h | 7.750^i |
| Silver | 76 /251 | | 0.050 | 0.010 - 0.847 | L | 0.004 | 0.005 |
| Sodium | 232 /232 | | 59.615 | 1.600 -1300.0 | L | 50.145 | 60.438 |
| Thallium | 4 /69 | | ^f | 0.001 - 0.003 | N | 0.001 | 0.001 |
| Vanadium | 70 /89 | | 0.058 | 0.004 - 0.691 | L | 0.039 | 0.054 |
| Zinc | 73 /89 | | 0.064 | 0.005 - 0.501 | L | 0.030 | 0.038 |
| Alkalinity as CaCO3 | 1 /1 | | ^f | 481.00 -481.00 | ^h | ^h | 481.000^i |
| Ammonia | 98 /182 | | 0.362 | 0.100 -253.00 | L | 1.222 | 1.953 |
| Chloride | 206 /209 | | 40.144 | 0.500 -6300.0 | L | 205.11 | 352.801 |
| Cyanide | 11 /63 | | ^f | 0.002 - 0.248 | L | 0.003 | 0.004 |
| Fluoride | 206 /209 | | 1.624 | 0.100 - 7.250 | L | 0.871 | 0.962 |
| Nitrate | 333 /565 | | 0.341 | 0.012 -843.00 | L | 9.140 | 13.859 |
| Phosphate | 3 /4 | | ^f | 0.100 - 5.600 | N^g | 1.501 | 4.720 |
| Phosphorus | 138 /161 | | ^f | 0.020 -39.800 | L | 0.583 | 0.819 |
| Sulfate | 198 /208 | | 211.217 | 2.000 -1180.0 | L | 287.73 | 382.625 |
| Sulfide | 1 /10 | | ^f | 4.260 - 4.260 | L | 0.283 | 0.528 |
| Total Dissolved Solids | 1 /1 | | ^f | 939.00 -939.00 | ^h | ^h | 939.000^i |
| Total Kjeldahl Nitrogen | 85 /100 | | 0.959 | 0.100 -260.00 | L | 4.560 | 8.523 |
| Total Organic Carbon | 23 /30 | | 12.995 | 1.250 -39.900 | L | 4.842 | 8.780 |
| Total Organic Halides | 40 /132 | | 0.066 | 0.004 - 0.896 | L | 0.025 | 0.029 |
| Total Organic Nitrogen | 123 /166 | | 0.403 | 0.024 -40.000 | L | 0.658 | 0.882 |
| 1,1,1-Trichloroethane | 22 /68 | | ^f | 0.002 - 2.900 | L | 0.005 | 0.008 |
| 1,1,2-Trichloroethane | 1 /68 | | ^f | 0.002 - 0.002 | N | 0.002 | 0.002^i |
| 1,1-Dichloroethane | 31 /85 | | ^f | 0.001 - 2.500 | L | 0.005 | 0.006 |
| 1,1-Dichloroethene | 15 /69 | | ^f | 0.001 - 0.490 | L | 0.004 | 0.005 |
| 1,2-Dichlorobenzene | 1 /64 | | ^f | 0.004 - 0.004 | N^g | 0.005 | 0.004^i |
| 1,2-Dichloroethane | 7 /69 | | ^f | 0.001 - 0.086 | L | 0.003 | 0.003 |
| 1,2-Dichloroethylene | 19 /61 | | ^f | 0.001 - 1.500 | L | 0.005 | 0.007 |
| 2,3,4,6-Tetrachlorophenol | 1 /7 | | ^f | 0.004 - 0.004 | N^g | 0.005 | 0.004^i |
| 2,4-Dimethylphenol | 1 /64 | | ^f | 0.040 - 0.040 | N^g | 0.006 | 0.007 |
| 2,6-Dinitrotoluene | 1 /63 | | ^f | 0.006 - 0.006 | N | 0.005 | 0.005 |
| 2-Butanone | 26 /69 | | ^f | 0.001 - 0.067 | L | 0.005 | 0.005 |
| 2-Nitrophenol | 1 /64 | | ^f | 0.012 - 0.012 | N | 0.005 | 0.006 |
| 4,6-Dinitro-2-methylphenol | 1 /61 | | ^f | 0.006 - 0.006 | N | 0.024 | 0.006^i |
| 4-Methyl-2-pentanone | 5 /68 | | ^f | 0.002 - 0.010 | N^g | 0.005 | 0.005 |
| 4-Methylphenol | 1 /64 | | ^f | 0.015 - 0.015 | N | 0.005 | 0.006 |
| 4-Nitrophenol | 1 /61 | | ^f | 0.011 - 0.011 | N^g | 0.025 | 0.011^i |
| Acetone | 57 /85 | | 0.130 | 0.002 - 0.059 | L | 0.005 | 0.006 |
| Benzene | 5 /69 | | ^f | 0.001 - 0.014 | N | 0.003 | 0.003 |
| Benzoic acid | 1 /57 | | ^f | 0.025 - 0.025 | N | 0.025 | 0.025^i |
| Benzyl alcohol | 1 /64 | | ^f | 0.005 - 0.005 | N | 0.005 | 0.005^i |
| Bromochloromethane | 1 /1 | | ^f | 0.050 - 0.050 | ^h | ^h | 0.050^i |
| Butyl benzyl phthalate | 3 /64 | | ^f | 0.001 - 0.003 | L | 0.005 | 0.003^i |
| Carbon Tetrachloride | 1 /69 | | ^f | 0.005 - 0.005 | N | 0.003 | 0.003 |
| Carbon disulfide | 9 /68 | | ^f | 0.002 - 0.130 | L | 0.003 | 0.003 |

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TABLE M-4
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| Chloroethane | 2 /68 | | ^f | 0.025 - 0.110 | L | 0.005 | 0.006 |
| Chloroform | 3 /69 | | ^f | 0.001 - 0.026 | L | 0.003 | 0.003 |
| Di-n-butyl phthalate | 8 /64 | | ^f | 0.003 - 0.012 | L | 0.005 | 0.005 |
| Diethyl phthalate | 3 /64 | | ^f | 0.002 - 0.004 | N | 0.005 | 0.004^i |
| Ethylbenzene | 2 /68 | | ^f | 0.013 - 0.038 | L | 0.003 | 0.003 |
| Heptachlor epoxide | 1 /60 | | ^f | 0.000 - 0.000 | N | 0.000 | 0.000 |
| Methylene chloride | 61 /85 | | 0.041 | 0.001 - 0.028 | L | 0.006 | 0.008 |
| Molybdenum | 72 /210 | | ^f | 0.008 - 0.678 | L | 0.016 | 0.017 |
| N-Nitrosodiethylamine | 1 /7 | | ^f | 0.004 - 0.004 | N^g | 0.005 | 0.004^i |
| N-Nitrosodiphenylamine | 6 /56 | | ^f | 0.002 - 0.003 | N | 0.005 | 0.003^i |
| Naphthalene | 1 /64 | | ^f | 0.002 - 0.002 | N^g | 0.005 | 0.002^i |
| Oil and Grease | 8 /8 | | ^f | 1.440 - 6.400 | L | 2.958 | 4.632 |
| Pentachlorophenol | 1 /1 | | ^f | 0.003 - 0.003 | ^h | ^h | 0.003^i |
| Phenol | 5 /64 | | ^f | 0.001 - 0.002 | N^g | 0.005 | 0.002^i |
| Phenols | 87 /184 | | 0.049 | 0.005 - 0.240 | L | 0.010 | 0.011 |
| Tetrachloroethene | 15 /86 | | ^f | 0.001 - 0.350 | L | 0.004 | 0.004 |
| Toluene | 10 /85 | | ^f | 0.001 - 0.260 | L | 0.003 | 0.003 |
| Total xylenes | 4 /68 | | ^f | 0.002 - 0.400 | L | 0.003 | 0.004 |
| Tributyl phosphate | 2 /4 | | ^f | 0.410 - 0.450 | N | 0.218 | 0.450^i |
| Trichloroethene | 21 /86 | | ^f | 0.001 - 6.400 | L | 0.005 | 0.006 |
| Vinyl Acetate | 2 /68 | | ^f | 0.001 - 0.002 | N | 0.005 | 0.002^i |
| Vinyl chloride | 6 /69 | | ^f | 0.002 - 0.016 | N | 0.005 | 0.005 |
| bis(2-Ethylhexyl) phthalate | 4 /62 | | ^f | 0.003 - 0.006 | N | 0.005 | 0.005 |
| trans-1,2-Dichloroethene | 1 /7 | | ^f | 0.018 - 0.018 | N | 0.005 | 0.009 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hNot applicable if sample size ≤ 2.
^iIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.

TABLE M-5
RADIOLOGICAL CONSTITUENTS IN BACKGROUND GROUNDWATER
OF THE GREAT MIAMI AQUIFER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Dry Fork Background | | | | | |
| TH-230 | 1 /13 | | 2.100^f | 2.100 - 2.100 | N | 0.623 | 0.842 | 0.444 | 0.197 |
| U-TOTAL^g | 7 /13 | | 0.001 | 0.000 - 0.000 | N | 0.000 | 0.000^h | 0.000 | 0.000 |
| | | | | Shandon Background | | | | | |
| RA-226 | 3 /21 | | 1.749 | 1.400 - 2.000 | N | 0.676 | 0.847 | 0.453 | 0.205 |
| RA-228 | 1 /21 | | 4.800^f | 4.800 - 4.800 | N | 1.657 | 1.928 | 0.720 | 0.519 |
| TC-99 | 1 /28 | | 36.000^f | 36.000 -36.000 | N | 15.750 | 17.027 | 3.969 | 15.750 |
| TH-228 | 2 /28 | | 1.804 | 1.990 - 2.900 | N | 0.639 | 0.808 | 0.525 | 0.276 |
| TH-230 | 1 /28 | | 2.500^f | 2.500 - 2.500 | N | 0.571 | 0.693 | 0.378 | 0.143 |
| U-TOTAL^g | 6 /28 | | 0.002 | 0.000 - 0.003 | N | 0.001 | 0.001 | 0.001 | 0.000 |
| | | | | Dry Fork - Shandon Divide Background | | | | | |
| RA-226 | 2 /30 | | 1.384 | 1.800 - 2.000 | N | 0.593 | 0.704 | 0.356 | 0.127 |
| TH-228 | 1 /33 | | 1.990^f | 1.990 - 1.990 | N | 0.545 | 0.622 | 0.259 | 0.067 |
| TH-230 | 1 /33 | | 2.100^f | 2.100 - 2.100 | N | 0.548 | 0.631 | 0.279 | 0.078 |
| U-TOTAL^g | 11 /33 | | 0.002 | 0.000 - 0.003 | N^i | 0.001 | 0.001 | 0.001 | 0.000 |
| | | | | Ross Background | | | | | |
| RA-226 | 1 /28 | | 1.100^f | 1.100 - 1.100 | N | 0.521 | 0.558 | 0.113 | 0.013 |
| RA-228 | 5 /28 | | 4.593 | 3.100 - 5.500 | N | 2.007 | 2.382 | 1.165 | 1.356 |
| TH-228 | 1 /27 | | 1.400^f | 1.400 - 1.400 | N | 0.533 | 0.590 | 0.173 | 0.030 |
| TH-230 | 4 /28 | | 1.378 | 1.000 - 1.700 | N | 0.629 | 0.737 | 0.338 | 0.114 |
| TH-TOTAL^g | 2 /18 | | 0.005 | 0.002 - 0.002 | N | 0.002 | 0.002^h | 0.001 | 0.000 |
| U-TOTAL^g | 14 /28 | | 0.001 | 0.000 - 0.002 | L | 0.001 | 0.001 | 0.000 | 0.000 |

^a If blank data are available.
^b Upper 95% tolerance level for background data with a 95% level of confidence.
^c Distribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^d If the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.

TABLE M-5
(continued)

^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fWhen background sample size is one, this concentration is given instead of a UTL. The mean site-related value will be compared with the single background value.
^gUnits are reported in mg/L.
^hIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.
^iDistribution could not be determined from available data; therefore, a normal distribution was assumed.

TABLE M-6
NONRADIOLOGICAL CONSTITUENTS IN BACKGROUND GROUNDWATER
OF THE GREAT MIAMI AQUIFER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| **Dry Fork Background** | | | | | | | | | |
| Arsenic | 3 /13 | | 0.280 | 0.004 - 0.300 | N^f | 0.050 | 0.093 | 0.086 | 0.007 |
| Barium | 10 /13 | | 0.051 | 0.034 - 0.045 | N^f | 0.035 | 0.038 | 0.006 | 0.000 |
| Calcium | 13 /13 | | 103.701 | 81.700 -110.00 | L | 91.023 | 96.595 | 7.643 | 58.420 |
| Chromium | 3 /13 | | 0.030 | 0.020 - 0.030 | N | 0.013 | 0.016 | 0.006 | 0.000 |
| Copper | 7 /13 | | 0.090 | 0.012 - 0.270 | L | 0.033 | 0.080 | 0.072 | 0.005 |
| Iron | 8 /13 | | 0.602 | 0.009 - 1.380 | L | 0.216 | 1.380^g | 0.489 | 0.239 |
| Lead | 2 /13 | | 0.037 | 0.003 - 0.004 | L | 0.003 | 0.004^g | 4.410 | 19.450 |
| Magnesium | 13 /13 | | 27.957 | 20.700 -26.200 | N | 23.346 | 24.200 | 1.727 | 2.983 |
| Manganese | 6 /13 | | 1.029 | 0.002 - 0.480 | L | 0.011 | 0.043 | 15.846 | 251.080 |
| Molybdenum | 1 /13 | | 0.010^h | 0.010 - 0.010 | N | 0.009 | 0.010^g | 0.002 | 0.000 |
| Potassium | 13 /13 | | 2.044 | 0.801 - 1.700 | N | 1.270 | 1.413 | 0.290 | 0.084 |
| Silver | 2 /13 | | 0.061 | 0.034 - 0.110 | L | 0.006 | 0.013 | 3.906 | 15.256 |
| Sodium | 13 /13 | | 4.765 | 1.960 - 3.990 | N | 3.243 | 3.525 | 0.570 | 0.325 |
| Ammonia | 4 /13 | | 0.368 | 0.100 - 0.400 | N | 0.098 | 0.148 | 0.101 | 0.010 |
| Chloride | 13 /13 | | 30.061 | 1.000 -20.100 | L | 9.062 | 20.100^g | 5.621 | 31.601 |
| Fluoride | 13 /13 | | 0.467 | 0.100 - 0.380 | N | 0.253 | 0.293 | 0.080 | 0.006 |
| Nitrate | 10 /13 | | 19.415 | 0.030 -14.400 | N^f | 5.343 | 7.948 | 5.270 | 27.776 |
| Phosphorus (black, white, red | 10 /13 | | 0.163 | 0.018 - 0.195 | L | 0.062 | 0.108 | 0.057 | 0.003 |
| Phenols | 9 /13 | | 0.034 | 0.007 - 0.030 | N | 0.012 | 0.016 | 0.008 | 0.000 |
| Sulfate | 13 /13 | | 60.159 | 3.240 -43.700 | N | 27.988 | 33.944 | 12.049 | 145.180 |
| Total Kjeldahl Nitrogen | 6 /6 | | 0.578 | 0.110 - 0.400 | N | 0.225 | 0.303 | 0.095 | 0.009 |
| Total Organic Nitrogen | 9 /12 | | 0.312 | 0.100 - 0.300 | N^f | 0.115 | 0.152 | 0.072 | 0.005 |
| **Shandon Background** | | | | | | | | | |
| Aluminum | 5 /5 | | 0.303 | 0.082 - 0.182 | N^f | 0.137 | 0.175 | 0.040 | 0.002 |
| Arsenic | 12 /23 | | 0.385 | 0.004 - 0.260 | L | 0.058 | 0.260^g | 0.074 | 0.006 |
| Barium | 25 /26 | | 1.047 | 0.040 - 0.800 | N | 0.477 | 0.560 | 0.249 | 0.062 |
| Beryllium | 3 /5 | | 0.004 | 0.001 - 0.002 | N^f | 0.001 | 0.002 | 0.001 | 0.000 |
| Cadmium | 5 /23 | | 0.007 | 0.002 - 0.007 | N^f | 0.003 | 0.003 | 0.002 | 0.000 |
| Calcium | 25 /26 | | 136.363 | 30.400 -121.00 | N | 79.643 | 87.933 | 24.747 | 612.427 |
| Chromium | 11 /26 | | 0.039 | 0.020 - 0.042 | N | 0.017 | 0.020 | 0.010 | 0.000 |
| Copper | 1 /26 | | 0.022^h | 0.022 - 0.022 | N | 0.006 | 0.008 | 0.004 | 0.000 |
| Iron | 26 /26 | | 4.131 | 0.017 - 3.600 | N | 1.756 | 2.103 | 1.036 | 1.074 |
| Lead | 10 /26 | | 0.051 | 0.002 - 0.056 | L | 0.005 | 0.008 | 4.098 | 16.791 |
| Magnesium | 25 /26 | | 47.038 | 15.800 -41.000 | N | 27.917 | 30.712 | 8.342 | 69.594 |
| Manganese | 23 /23 | | 0.265 | 0.014 - 0.376 | L | 0.083 | 0.145 | 0.084 | 0.007 |
| Mercury | 4 /23 | | 0.001 | 0.000 - 0.006 | L | 0.000 | 0.000 | 2.684 | 7.204 |

TABLE M-6
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Shandon Background (continued) | | | | | |
| Molybdenum | 6 /21 | | 0.029 | 0.010 - 0.030 | N | 0.014 | 0.016 | 0.007 | 0.000 |
| Nickel | 4 /26 | | 0.026 | 0.021 - 0.026 | N | 0.014 | 0.016 | 0.005 | 0.000 |
| Potassium | 21 /23 | | 5.068 | 0.169 -13.400 | L | 2.072 | 2.802 | 2.541 | 6.455 |
| Selenium | 2 /23 | | 0.130 | 0.006 - 0.016 | N^f | 0.028 | 0.016^g | 0.044 | 0.002 |
| Silver | 5 /26 | | 0.014 | 0.010 - 0.014 | N | 0.006 | 0.007 | 0.004 | 0.000 |
| Sodium | 23 /23 | | 100.309 | 7.600 -179.00 | L | 47.797 | 60.025 | 32.722 | 1070.70 |
| Vanadium | 5 /5 | | 0.034 | 0.016 - 0.023 | N | 0.020 | 0.023 | 0.003 | 0.000 |
| Zinc | 5 /5 | | 0.109 | 0.020 - 0.057 | N | 0.045 | 0.057^g | 0.015 | 0.000 |
| Ammonia | 19 /21 | | 7.125 | 0.300 - 8.000 | N | 2.810 | 3.495 | 1.820 | 3.312 |
| Chloride | 25 /25 | | 110.026 | 2.750 -100.00 | N | 55.474 | 63.618 | 23.801 | 566.497 |
| Fluoride | 26 /26 | | 1.328 | 0.280 - 1.250 | N | 0.760 | 0.843 | 0.248 | 0.062 |
| Nitrate | 6 /26 | | 1.527 | 0.016 - 2.500 | N^f | 0.248 | 0.435 | 0.558 | 0.311 |
| Phosphate | 2 /2 | | -1.000 | 0.100 - 0.560 | ^i | ^i | 0.560^g | . | . |
| Phosphorus | 17 /19 | | 0.728 | 0.040 - 1.070 | L | 0.203 | 0.483 | 0.293 | 0.086 |
| Sulfate | 16 /26 | | 129.779 | 2.790 -197.00 | L | 28.755 | 126.631 | 52.997 | 2808.64 |
| Total Kjeldahl Nitrogen | 11 /12 | | 6.630 | 0.530 - 4.740 | N | 2.526 | 3.303 | 1.500 | 2.250 |
| Total Organic Carbon | 5 /5 | | 11.924 | 1.650 - 6.362 | N | 3.682 | 5.552 | 1.961 | 3.847 |
| Total Organic Halides | 2 /19 | | 0.096 | 0.023 - 0.324 | L | 0.020 | 0.030 | 2.575 | 6.632 |
| Total Organic Nitrogen | 13 /17 | | 2.123 | 0.130 - 2.750 | L | 0.572 | 1.525 | 0.743 | 0.552 |
| Acetone | 3 /5 | | 0.011 | 0.002 - 0.006 | N^f | 0.004 | 0.006 | 0.002 | 0.000 |
| Methylene chloride | 3 /5 | | 0.018 | 0.007 - 0.008 | N^f | 0.006 | 0.008^g | 0.003 | 0.000 |
| N-Nitrosodiphenylamine | 2 /3 | | 0.013 | 0.003 - 0.003 | N^f | 0.004 | 0.003^g | 0.001 | 0.000 |
| Phenol | 1 /3 | | 0.002^h | 0.002 - 0.002 | N | 0.004 | 0.002^g | 0.002 | 0.000 |
| Phenols | 9 /21 | | 0.061 | 0.008 - 0.090 | N^f | 0.014 | 0.021 | 0.020 | 0.000 |
| Toluene | 1 /5 | | 0.005^h | 0.005 - 0.005 | N | 0.003 | 0.004 | 0.001 | 0.000 |
| bis(2-Ethylhexyl) phthalate | 2 /3 | | 0.015 | 0.002 - 0.003 | N | 0.003 | 0.003^g | 0.002 | 0.000 |
| | | | | Dry Fork - Shandon Divide Background | | | | | |
| Aluminum | 2 /2 | | -1.000 | 0.082 - 0.143 | ^i | ^i | 0.143^g | . | . |
| Arsenic | 15 /30 | | 0.426 | 0.004 - 0.300 | L | 0.063 | 0.300^g | 0.082 | 0.007 |
| Barium | 28 /32 | | 1.056 | 0.034 - 0.800 | N^f | 0.357 | 0.451 | 0.315 | 0.099 |
| Beryllium | 1 /2 | | -1.000^h | 0.001 - 0.001 | ^i | ^i | 0.001^g | . | . |
| Cadmium | 2 /30 | | 0.004 | 0.002 - 0.006 | N | 0.002 | 0.002 | 0.001 | 0.000 |
| Calcium | 31 /32 | | 122.960 | 30.400 -110.00 | N | 78.988 | 84.924 | 19.807 | 392.325 |
| Chromium | 10 /32 | | 0.030 | 0.020 - 0.030 | N | 0.014 | 0.016 | 0.007 | 0.000 |
| Copper | 7 /32 | | 0.032 | 0.012 - 0.270 | L | 0.008 | 0.010 | 2.407 | 5.795 |
| Iron | 27 /32 | | 4.088 | 0.009 - 3.600 | N | 1.351 | 1.721 | 1.233 | 1.521 |
| Lead | 8 /32 | | 0.042 | 0.003 - 0.056 | N^f | 0.012 | 0.016 | 0.014 | 0.000 |
| Magnesium | 31 /32 | | 36.035 | 15.800 -31.300 | N | 24.127 | 25.734 | 5.364 | 28.772 |

TABLE M-6
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Dry Fork - Shandon Divide Background (continued) | | | | | |
| Manganese | 23 /30 | | 0.521 | 0.002 - 0.480 | L | 0.087 | 0.480^g | 0.149 | 0.022 |
| Mercury | 3 /30 | | 0.001 | 0.000 - 0.001 | N | 0.000 | 0.000 | 0.000 | 0.000 |
| Molybdenum | 7 /30 | | 0.024 | 0.010 - 0.030 | N | 0.012 | 0.014 | 0.005 | 0.000 |
| Potassium | 29 /30 | | 6.816 | 0.169 -13.400 | N^f | 1.829 | 2.526 | 2.246 | 5.046 |
| Selenium | 1 /30 | | 0.016^h | 0.016 - 0.016 | N^f | 0.032 | 0.016^g | 0.046 | 0.002 |
| Silver | 4 /32 | | 0.052 | 0.010 - 0.110 | N | 0.010 | 0.016 | 0.019 | 0.000 |
| Sodium | 30 /30 | | 148.483 | 1.960 -179.00 | L | 31.693 | 88.667 | 36.818 | 1355.59 |
| Vanadium | 2 /2 | | -1.000 | 0.016 - 0.017 | ^i | ^i | 0.017^g | . | . |
| Zinc | 2 /2 | | -1.000 | 0.020 - 0.052 | ^i | ^i | 0.052^g | . | . |
| Ammonia | 20 /30 | | 6.343 | 0.100 - 8.000 | N | 1.799 | 2.434 | 2.047 | 4.191 |
| Chloride | 32 /32 | | 178.454 | 1.000 -100.00 | L | 49.517 | 92.195 | 76.718 | 5885.66 |
| Fluoride | 32 /32 | | 1.560 | 0.100 - 1.250 | L | 0.634 | 0.823 | 0.479 | 0.230 |
| Nitrate | 15 /32 | | 12.663 | 0.016 -14.400 | L | 0.199 | 0.424 | 12.499 | 156.218 |
| Phosphate | 2 /2 | | -1.000 | 0.100 - 0.560 | ^i | ^i | 0.560^g | . | . |
| Phosphorus | 24 /28 | | 0.366 | 0.018 - 0.902 | L | 0.123 | 0.188 | 0.176 | 0.031 |
| Sulfate | 22 /32 | | 134.828 | 2.790 -197.00 | L | 34.932 | 100.285 | 107.293 | 11511.9 |
| Total Kjeldahl Nitrogen | 15 /16 | | 7.737 | 0.110 - 4.740 | L | 1.696 | 4.740^g | 1.724 | 2.973 |
| Total Organic Carbon | 2 /2 | | -1.000 | 1.650 - 6.362 | ^i | ^i | 6.362^g | . | . |
| Total Organic Nitrogen | 20 /25 | | 1.043 | 0.100 - 2.750 | L | 0.354 | 0.552 | 0.558 | 0.311 |
| Acetone | 2 /2 | | -1.000 | 0.003 - 0.006 | ^i | ^i | 0.006^g | . | . |
| Methylene chloride | 2 /2 | | -1.000 | 0.007 - 0.008 | ^i | ^i | 0.008^g | . | . |
| Phenols | 15 /30 | | 0.026 | 0.007 - 0.040 | L | 0.010 | 0.014 | 0.009 | 0.000 |
| Toluene | 1 /2 | | -1.000^h | 0.005 - 0.005 | ^i | ^i | 0.005^g | . | . |
| | | | | Ross Background | | | | | |
| Arsenic | 4 /28 | | 0.376 | 0.300 - 0.550 | N^f | 0.088 | 0.130 | 0.130 | 0.017 |
| Barium | 24 /28 | | 0.079 | 0.035 - 0.073 | N | 0.048 | 0.052 | 0.014 | 0.000 |
| Cadmium | 1 /28 | | 0.010^h | 0.010 - 0.010 | N | 0.002 | 0.003 | 0.002 | 0.000 |
| Calcium | 28 /28 | | 111.731 | 70.200 -110.00 | N | 92.714 | 95.472 | 8.566 | 73.376 |
| Chromium | 6 /28 | | 0.025 | 0.010 - 0.030 | N | 0.013 | 0.014 | 0.006 | 0.000 |
| Copper | 16 /28 | | 0.154 | 0.010 - 0.176 | N | 0.040 | 0.057 | 0.051 | 0.003 |
| Iron | 11 /28 | | 0.126 | 0.007 - 0.210 | L | 0.013 | 0.021 | 3.896 | 15.182 |
| Lead | 4 /28 | | 0.059 | 0.003 - 0.080 | N^f | 0.016 | 0.023 | 0.019 | 0.000 |
| Magnesium | 28 /28 | | 37.968 | 15.700 -33.000 | N | 25.734 | 27.508 | 5.511 | 30.373 |
| Manganese | 12 /28 | | 0.035 | 0.002 - 0.073 | L | 0.004 | 0.006 | 3.774 | 14.245 |
| Mercury | 2 /28 | | 0.000 | 0.000 - 0.000 | N | 0.000 | 0.000 | 0.000 | 0.000 |
| Molybdenum | 10 /28 | | 0.055 | 0.010 - 0.092 | N | 0.016 | 0.022 | 0.017 | 0.000 |
| Nickel | 3 /28 | | 0.022 | 0.021 - 0.026 | N | 0.013 | 0.014 | 0.004 | 0.000 |
| Potassium | 28 /28 | | 3.086 | 2.070 - 3.280 | L | 2.596 | 2.691 | 0.285 | 0.081 |
| Silver | 1 /28 | | 0.033^h | 0.033 - 0.033 | N | 0.007 | 0.009 | 0.006 | 0.000 |

TABLE M-6
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Ross Background (continued) | | | | | |
| Sodium | 28 /28 | | 28.720 | 9.410 -55.000 | L | 17.303 | 19.431 | 8.594 | 73.857 |
| Ammonia | 9 /28 | | 0.184 | 0.100 - 0.200 | N | 0.077 | 0.092 | 0.048 | 0.002 |
| Chloride | 28 /28 | | 105.261 | 1.500 -120.00 | L | 27.836 | 53.412 | 23.466 | 550.633 |
| Fluoride | 28 /28 | | 0.370 | 0.180 - 0.370 | L | 0.262 | 0.283 | 0.060 | 0.004 |
| Nitrate | 28 /28 | | 21.662 | 0.280 -24.900 | L | 5.347 | 11.799 | 5.672 | 32.169 |
| Phosphorus | 13 /28 | | 0.126 | 0.010 - 0.299 | L | 0.029 | 0.038 | 2.466 | 6.079 |
| Sulfate | 28 /28 | | 131.387 | 3.080 -202.00 | N^f | 50.091 | 61.879 | 36.620 | 1340.99 |
| Total Kjeldahl Nitrogen | 11 /12 | | 0.625 | 0.200 - 0.600 | L | 0.268 | 0.420 | 0.144 | 0.021 |
| Total Organic Nitrogen | 18 /28 | | 0.396 | 0.100 - 0.480 | N | 0.141 | 0.178 | 0.115 | 0.013 |
| Phenols | 19 /28 | | 0.032 | 0.009 - 0.030 | N | 0.014 | 0.016 | 0.008 | 0.000 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^gIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.
^hWhen background sample size is one, this concentration is given instead of a UTL. The mean site-related value will be compared with the single background value.
^iNot applicable if sample size ≤ 2.

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TABLE M-7
RADIOLOGICAL CONSTITUENTS IN 2000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) |
|---|---|---|---|---|---|---|---|
| **Dry Fork Downgradient Wells** | | | | | | | |
| RA-226 | 22 /157 | | ^f | 1.000 - 7.720 | L | 0.609 | 0.654 |
| RA-228 | 13 /156 | | ^f | 3.020 - 8.020 | N^g | 1.766 | 1.893 |
| SR-90 | 6 /158 | | ^f | 5.320 -17.400 | N^g | 2.768 | 2.974 |
| TC-99 | 2 /159 | | ^f | 40.800 -100.00 | N^g | 15.747 | 16.670 |
| TH-228 | 37 /159 | | ^f | 1.000 - 4.200 | N^g | 0.797 | 0.883 |
| TH-230 | 13 /159 | | 2.100 | 1.100 - 4.530 | N^g | 0.588 | 0.639 |
| TH-232 | 5 /158 | | ^f | 1.050 - 2.300 | N^g | 0.534 | 0.561 |
| TH-TOTAL^h | 7 /147 | | ^f | 0.001 - 0.021 | N^g | 0.002 | 0.002 |
| U-234 | 107 /157 | | ^f | 1.000 -104.00 | N | 18.546 | 22.309 |
| U-235/236 | 48 /156 | | ^f | 1.080 - 5.540 | N^g | 1.236 | 1.403 |
| U-238 | 100 /157 | | ^f | 1.060 -119.00 | N | 19.601 | 23.598 |
| U-TOTAL^h | 135 /162 | | 0.741 | 0.000 - 0.462 | L | 0.125 | 0.240 |
| **Shandon Downgradient Wells** | | | | | | | |
| NP-237 | 1 /138 | | ^f | 1.000 - 1.000 | N | 0.504 | 0.510 |
| RA-226 | 13 /138 | | 1.749 | 1.060 - 3.300 | N | 0.608 | 0.664 |
| RA-228 | 4 /138 | | 4.800 | 3.360 - 5.900 | N | 1.586 | 1.661 |
| SR-90 | 10 /142 | | ^f | 6.510 -38.500 | L | 2.756 | 2.951 |
| TC-99 | 22 /178 | | 36.000 | 32.400 -5510.0 | L | 23.276 | 27.348 |
| TH-228 | 15 /180 | | 1.804 | 1.000 - 4.920 | N^g | 0.645 | 0.719 |
| TH-230 | 18 /180 | | 2.500 | 1.000 -14.700 | L | 0.572 | 0.605 |
| TH-232 | 2 /141 | | ^f | 1.100 - 2.730 | N | 0.523 | 0.550 |
| TH-TOTAL^h | 4 /115 | | ^f | 0.003 - 0.025 | N^g | 0.002 | 0.003 |
| U-234 | 106 /179 | | ^f | 1.000 -20.800 | L | 2.960 | 3.644 |
| U-235/236 | 4 /159 | | ^f | 1.100 - 2.400 | N | 0.531 | 0.558 |
| U-238 | 100 /180 | | ^f | 1.000 -24.800 | L | 2.941 | 3.630 |
| U-TOTAL^h | 142 /180 | | 0.002 | 0.001 - 0.120 | L | 0.010 | 0.014 |
| **Dry Fork - Shandon Divide Downgradient Wells** | | | | | | | |
| GROSS ALPHA | 2 /2 | | ^f | 3.530 -72.300 | ^i | ^i | 72.300^j |
| GROSS BETA | 1 /2 | | ^f | 52.900 -52.900 | ^i | ^i | 52.900^j |
| RA-226 | 2 /66 | | 1.384 | 1.720 - 1.840 | N | 0.526 | 0.574 |
| RA-228 | 1 /66 | | ^f | 4.300 - 4.300 | N | 1.533 | 1.605 |
| TC-99 | 1 /68 | | ^f | 39.600 -39.600 | N | 15.515 | 16.131 |
| TH-228 | 14 /68 | | 1.990 | 1.100 - 2.250 | N | 0.716 | 0.808 |
| TH-230 | 13 /68 | | 2.100 | 1.040 - 3.440 | N | 0.716 | 0.820 |
| TH-232 | 2 /66 | | ^f | 1.020 - 1.480 | N | 0.527 | 0.555 |
| TH-TOTAL^h | 6 /61 | | ^f | 0.002 - 0.013 | N^g | 0.002 | 0.003 |
| U-234 | 43 /67 | | ^f | 1.100 -219.00 | L | 14.926 | 30.024 |
| U-235/236 | 10 /65 | | ^f | 1.810 -11.500 | L | 0.731 | 0.885 |
| U-238 | 42 /67 | | ^f | 1.120 -231.00 | L | 15.395 | 31.328 |
| U-TOTAL^h | 56 /68 | | 0.002 | 0.001 - 0.907 | L | 0.060 | 0.146 |
| **Ross Downgradient Wells** | | | | | | | |
| U-234 | 1 /4 | | ^f | 1.200 - 1.200 | N^g | 0.675 | 1.087 |
| U-TOTAL^h | 4 /4 | | 0.001 | 0.002 - 0.003 | N^g | 0.002 | 0.003 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given.

TABLE M-7
(continued)

If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hUnits are reported in mg/L.
^iNot applicable if sample size ≤ 2.
^jIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.

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TABLE M-8
RADIOLOGICAL CONSTITUENTS IN 3000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) |
|---|---|---|---|---|---|---|---|
| **Dry Fork Downgradient Wells** | | | | | | | |
| RA-226 | 6 /90 | ^f | | 1.000 -39.800 | L | 0.579 | 0.645 |
| RA-228 | 3 /90 | ^f | | 4.500 - 7.100 | N | 1.639 | 1.772 |
| SR-90 | 1 /90 | ^f | | 6.210 - 6.210 | N | 2.541 | 2.610 |
| TC-99 | 1 /91 | ^f | | 25.200 -25.200 | N | 15.129 | 15.317 |
| TH-228 | 13 /91 | ^f | | 1.000 - 2.500 | N | 0.682 | 0.761 |
| TH-230 | 10 /91 | | 2.100 | 1.120 - 5.310 | N^g | 0.657 | 0.761 |
| TH-232 | 1 /90 | ^f | | 1.100 - 1.100 | N | 0.513 | 0.526 |
| TH-TOTAL^h | 4 /83 | ^f | | 0.005 - 0.007 | N | 0.002 | 0.002 |
| U-234 | 41 /91 | ^f | | 1.030 -32.000 | L | 1.469 | 1.864 |
| U-235/236 | 5 /91 | ^f | | 1.260 - 1.960 | N | 0.555 | 0.596 |
| U-238 | 37 /91 | ^f | | 1.260 -31.600 | L | 1.390 | 1.769 |
| U-TOTAL^h | 56 /92 | | 0.001 | 0.000 - 0.108 | L | 0.011 | 0.019 |
| **Shandon Downgradient Wells** | | | | | | | |
| RA-226 | 11 /119 | | 1.749 | 1.100 - 8.500 | L | 0.561 | 0.595 |
| RA-228 | 3 /119 | | 4.800 | 3.000 - 4.000 | N | 1.554 | 1.606 |
| TC-99 | 1 /148 | | 36.000 | 36.400 -36.400 | N | 15.218 | 15.467 |
| TH-228 | 4 /147 | | 1.804 | 1.000 - 3.100 | N^g | 0.538 | 0.571 |
| TH-230 | 6 /148 | | 2.500 | 1.000 - 7.270 | L | 0.530 | 0.551 |
| TH-TOTAL^h | 5 /94 | ^f | | 0.002 - 0.003 | N | 0.002 | 0.002 |
| U-234 | 63 /148 | ^f | | 1.030 -203.00 | L | 1.240 | 1.465 |
| U-235/236 | 4 /133 | ^f | | 1.000 - 8.600 | L | 0.525 | 0.548 |
| U-238 | 60 /148 | ^f | | 1.000 -213.00 | L | 1.212 | 1.442 |
| U-TOTAL^h | 83 /148 | | 0.002 | 0.000 - 0.490 | L | 0.009 | 0.013 |
| **Dry Fork - Shandon Divide Downgradient Wells** | | | | | | | |
| RA-226 | 2 /41 | | 1.384 | 1.600 - 2.400 | N | 0.573 | 0.662 |
| RA-228 | 1 /41 | ^f | | 3.800 - 3.800 | N | 1.559 | 1.653 |
| SR-90 | 1 /41 | ^f | | 16.500 -16.500 | N^g | 2.841 | 3.416 |
| TC-99 | 2 /41 | ^f | | 44.500 -46.900 | N | 16.617 | 18.377 |
| TH-228 | 3 /42 | | 1.990 | 1.210 - 3.290 | N | 0.622 | 0.745 |
| TH-230 | 4 /42 | | 2.100 | 1.090 - 2.210 | N | 0.622 | 0.722 |
| TH-232 | 1 /42 | ^f | | 1.040 - 1.040 | N | 0.526 | 0.556 |
| TH-TOTAL^h | 2 /38 | ^f | | 0.003 - 0.009 | N | 0.002 | 0.002 |
| U-234 | 19 /42 | ^f | | 1.100 -24.300 | L | 0.970 | 1.242 |
| U-235/236 | 1 /42 | ^f | | 1.090 - 1.090 | N | 0.514 | 0.538 |
| U-238 | 12 /42 | ^f | | 1.000 -25.300 | L | 0.794 | 1.010 |
| U-TOTAL^h | 28 /42 | | 0.002 | 0.001 - 0.082 | L | 0.003 | 0.006 |
| **Ross Downgradient Wells** | | | | | | | |
| U-TOTAL^h | 3 /4 | | 0.001 | 0.001 - 0.001 | N | 0.001 | 0.001^i |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.

TABLE M-8
(continued)

^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hUnits reported in mg/L.
^iIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.

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TABLE M-9
RADIOLOGICAL CONSTITUENTS IN 4000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Radionuclide | Frequency of Detection | Highest Blank^a (pCi/L) | Upper 95% TL for BKG^b (pCi/L) | Range of Detection | Dist^c | Mean^d (pCi/L) | Upper 95% CI on Mean^e (pCi/L) |
|---|---|---|---|---|---|---|---|
| RA-226 | 4 /70 | | ^f | 1.400 - 2.500 | N | 0.579 | 0.645 |
| RA-228 | 5 /70 | | ^f | 3.000 - 5.600 | N | 1.676 | 1.810 |
| TC-99 | 1 /86 | | ^f | 77.700 -77.700 | N | 15.876 | 17.091 |
| TH-228 | 4 /86 | | ^f | 1.190 - 2.100 | N | 0.555 | 0.601 |
| TH-230 | 5 /86 | | 2.100 | 1.000 - 3.200 | N^g | 0.588 | 0.662 |
| TH-232 | 1 /72 | | ^f | 1.670 - 1.670 | N | 0.518 | 0.546 |
| U-234 | 14 /86 | | ^f | 1.000 -29.700 | L | 0.651 | 0.743 |
| U-235/236 | 1 /81 | | ^f | 1.050 - 1.050 | L | 0.505 | 0.512 |
| U-238 | 10 /86 | | ^f | 1.000 -31.500 | L | 0.622 | 0.707 |
| U-TOTAL^h | 27 /86 | | 0.001 | 0.000 - 0.086 | L | 0.001 | 0.001 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hUnits are reported in mg/L.

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TABLE M-10
NONRADIOLOGICAL CONSTITUENTS IN 2000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| **Dry Fork Downgradient Wells** | | | | | | | |
| Barium | 113 /124 | | 0.051 | 0.003 - 1.250 | N^f | 0.095 | 0.125 |
| Cadmium | 76 /123 | | ^g | 0.002 - 0.012 | L | 0.004 | 0.004 |
| Calcium | 124 /124 | | 103.701 | 67.100 -181.00 | L | 100.89 | 103.944 |
| Chromium | 80 /125 | | 0.030 | 0.002 - 0.127 | L | 0.021 | 0.024 |
| Copper | 55 /125 | | 0.090 | 0.009 - 0.048 | L | 0.009 | 0.009 |
| Iron | 109 /124 | | 0.602 | 0.010 -21.200 | L | 0.612 | 1.094 |
| Lead | 42 /110 | | 0.037 | 0.002 - 0.259 | L | 0.002 | 0.003 |
| Magnesium | 124 /124 | | 27.957 | 18.000 -55.800 | L | 26.720 | 27.665 |
| Manganese | 111 /125 | | 1.029 | 0.001 - 2.450 | L | 0.108 | 0.171 |
| Mercury | 22 /123 | | ^g | 0.000 - 0.012 | N^f | 0.000 | 0.001 |
| Potassium | 114 /123 | | 2.044 | 1.310 -2390.0 | L | 8.173 | 10.792 |
| Selenium | 9 /114 | | ^g | 0.002 - 0.005 | N^f | 0.001 | 0.002 |
| Silver | 41 /125 | | 0.061 | 0.007 - 0.033 | L | 0.004 | 0.005 |
| Sodium | 124 /124 | | 4.765 | 3.400 -109.00 | L | 17.751 | 20.061 |
| Chloride | 121 /121 | | 30.061 | 0.750 -185.00 | L | 28.139 | 33.431 |
| Fluoride | 115 /123 | | 0.467 | 0.050 - 1.800 | L | 0.319 | 0.366 |
| Nitrate | 104 /123 | | 19.415 | 0.014 -397.00 | L | 7.548 | 13.613 |
| Phosphorus | 105 /117 | | ^g | 0.010 -38.600 | L | 2.453 | 4.651 |
| Sulfate | 123 /123 | | 60.159 | 0.380 -5431.0 | L | 92.917 | 110.706 |
| Sulfide | 5 /60 | | ^g | 0.629 -23.800 | N^f | 0.901 | 1.623 |
| Total Kjeldahl Nitrogen | 42 /51 | | 0.578 | 0.110 - 2.140 | L | 0.635 | 0.896 |
| Total Organic Halides | 23 /99 | | ^g | 0.010 -45.100 | L | 0.016 | 0.022 |
| Total Organic Nitrogen | 86 /121 | | 0.312 | 0.100 - 1.960 | L | 0.359 | 0.445 |
| Phenols | 47 /123 | | 0.034 | 0.006 - 0.078 | L | 0.009 | 0.010 |
| **Shandon Downgradient Wells** | | | | | | | |
| Aluminum | 52 /67 | | 0.303 | 0.012 - 0.375 | N | 0.126 | 0.144 |
| Antimony | 3 /26 | | ^g | 0.001 - 0.003 | N^f | 0.015 | 0.003^h |
| Arsenic | 11 /123 | | 0.385 | 0.002 - 0.400 | N^f | 0.008 | 0.014 |
| Barium | 135 /152 | | 1.047 | 0.014 - 0.969 | L | 0.087 | 0.093 |
| Beryllium | 14 /42 | | 0.004 | 0.001 - 0.003 | N^f | 0.001 | 0.002 |
| Cadmium | 49 /137 | | 0.007 | 0.002 - 0.045 | N^f | 0.003 | 0.004 |
| Calcium | 151 /151 | | 136.363 | 10.100 -519.00 | N^f | 149.97 | 160.788 |
| Chromium | 71 /152 | | 0.039 | 0.010 - 0.095 | N^f | 0.020 | 0.023 |
| Cobalt | 4 /42 | | ^g | 0.011 - 0.014 | N^f | 0.005 | 0.006 |
| Copper | 34 /152 | | ^g | 0.004 - 0.384 | L | 0.007 | 0.007 |
| Iron | 142 /152 | | 4.131 | 0.007 -14.800 | L | 5.561 | 10.499 |
| Lead | 45 /135 | | 0.051 | 0.002 - 0.100 | L | 0.002 | 0.002 |
| Magnesium | 151 /151 | | 47.038 | 2.270 -234.00 | L | 36.982 | 39.971 |
| Manganese | 128 /137 | | 0.265 | 0.002 -1062.0 | L | 0.595 | 1.045 |
| Mercury | 19 /136 | | 0.001 | 0.000 - 0.005 | N | 0.000 | 0.000 |
| Molybdenum | 27 /131 | | 0.029 | 0.003 - 0.051 | N | 0.014 | 0.015 |
| Nickel | 36 /152 | | 0.026 | 0.016 - 0.218 | N | 0.017 | 0.020 |
| Potassium | 121 /135 | | 5.068 | 0.917 -31.000 | L | 3.687 | 4.126 |
| Selenium | 9 /121 | | 0.130 | 0.002 - 0.022 | L | 0.001 | 0.001 |
| Silicon | 26 /26 | | ^g | 0.613 -63.400 | L | 6.893 | 8.255 |
| Silver | 39 /151 | | 0.014 | 0.010 - 0.024 | N^f | 0.006 | 0.007 |
| Sodium | 137 /137 | | 100.309 | 4.140 -280.00 | L | 21.448 | 23.731 |
| Thallium | 1 /26 | | ^g | 0.001 - 0.001 | N | 0.001 | 0.001^h |
| Vanadium | 45 /67 | | 0.034 | 0.003 - 0.058 | N | 0.018 | 0.021 |
| Zinc | 39 /42 | | 0.109 | 0.012 - 0.268 | L | 0.057 | 0.079 |
| Ammonia | 73 /132 | | 7.125 | 0.029 -11.700 | L | 0.454 | 0.638 |
| Chloride | 150 /151 | | 110.026 | 2.800 -265.00 | L | 47.747 | 54.657 |
| Cyanide | 1 /28 | | ^g | 0.001 - 0.001 | N^f | 0.006 | 0.001^h |
| Fluoride | 147 /151 | | 1.328 | 0.070 - 1.800 | L | 0.285 | 0.311 |
| Phosphate | 8 /8 | | ^g | 0.020 - 7.200 | L | 1.264 | 7.200^h |
| Phosphorus | 89 /115 | | 0.728 | 0.010 -541.00 | L | 2.231 | 4.868 |
| Sulfate | 148 /149 | | 129.779 | 14.000 -1320.0 | L | 185.95 | 218.006 |
| Sulfide | 11 /35 | | ^g | 1.400 -178.00 | L | 1.056 | 1.989 |
| Total Kjeldahl Nitrogen | 69 /80 | | 6.630 | 0.000 - 8.500 | N^f | 1.315 | 1.696 |

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TABLE M-10
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| **Shandon Downgradient Wells (continued)** | | | | | | | |
| Total Organic Carbon | 34 /48 | | 11.924 | 0.448 -52.800 | L | 3.121 | 5.130 |
| Total Organic Halides | 39 /109 | | 0.096 | 0.002 - 0.081 | N | 0.024 | 0.032 |
| Total Organic Nitrogen | 88 /120 | | 2.123 | 0.064 - 5.700 | L | 0.559 | 0.741 |
| 2-Butanone | 5 /26 | | ^g | 0.001 - 0.004 | N^f | 0.004 | 0.004^h |
| 3-Nitroaniline | 1 /25 | | ^g | 0.050 - 0.050 | N | 0.026 | 0.028 |
| 4-Nitrophenol | 1 /25 | | ^g | 0.003 - 0.003 | N^f | 0.024 | 0.003^h |
| Acetone | 24 /39 | | 0.011 | 0.002 - 0.037 | L | 0.007 | 0.009 |
| Aldrin | 1 /25 | | ^g | 0.000 - 0.000 | N | 0.000 | 0.000 |
| Benzene | 2 /26 | | ^g | 0.001 - 0.001 | N^f | 0.002 | 0.001^h |
| Butyl benzyl phthalate | 2 /25 | | ^g | 0.001 - 0.001 | N^f | 0.005 | 0.001^h |
| Carbon disulfide | 4 /26 | | ^g | 0.001 - 0.011 | N | 0.003 | 0.004 |
| Di-n-butyl phthalate | 10 /25 | | ^g | 0.003 - 0.010 | N^f | 0.005 | 0.006 |
| Diethyl phthalate | 2 /25 | | ^g | 0.001 - 0.007 | N^f | 0.005 | 0.005 |
| Ethylbenzene | 1 /26 | | ^g | 0.002 - 0.002 | N^f | 0.002 | 0.002^h |
| Heptachlor | 1 /25 | | ^g | 0.000 - 0.000 | N | 0.000 | 0.000 |
| Isophorone | 1 /25 | | ^g | 0.002 - 0.002 | N^f | 0.005 | 0.002^h |
| Methylene chloride | 26 /40 | | 0.018 | 0.001 - 0.022 | L | 0.006 | 0.008 |
| N-Nitrosodiphenylamine | 5 /20 | | 0.013 | 0.002 - 0.010 | L | 0.004 | 0.005 |
| Nitrate | 80 /152 | | 1.527 | 0.030 -79.400 | L | 4.940 | 9.841 |
| Phenol | 2 /25 | | ^g | 0.002 - 0.014 | L | 0.005 | 0.006 |
| Phenols | 55 /133 | | 0.061 | 0.006 - 0.227 | L | 0.010 | 0.011 |
| Toluene | 7 /40 | | ^g | 0.002 - 0.005 | N | 0.003 | 0.003 |
| Total xylenes | 1 /26 | | ^g | 0.003 - 0.003 | N | 0.003 | 0.003 |
| Trichlorofluoromethane | 1 /5 | | ^g | 0.066 - 0.066 | N^f | 0.015 | 0.042 |
| alpha-BHC | 1 /25 | | ^g | 0.000 - 0.000 | N | 0.000 | 0.000 |
| bis(2-Ethylhexyl) phthalate | 10 /25 | | 0.015 | 0.001 - 0.050 | L | 0.006 | 0.008 |
| **Dry Fork - Shandon Divide Downgradient Wells** | | | | | | | |
| Aluminum | 30 /37 | | ^g | 0.011 - 0.185 | N | 0.091 | 0.104 |
| Arsenic | 1 /62 | | 48.988 | 0.280 - 0.280 | N^f | 0.006 | 0.013 |
| Barium | 59 /66 | | . | 0.030 - 0.109 | L | 0.057 | 0.062 |
| Cadmium | 43 /66 | | 0.009 | 0.002 - 0.020 | L | 0.004 | 0.005 |
| Calcium | 66 /66 | | 158.216 | 42.000 -185.00 | L | 109.29 | 116.127 |
| Chromium | 41 /66 | | 0.036 | 0.009 - 0.052 | N | 0.021 | 0.024 |
| Hexavalent Chromium | 1 /2 | | ^g | 0.020 - 0.020 | ^i | ^i | 0.020^h |
| Copper | 32 /66 | | . | 0.005 - 0.085 | N^f | 0.011 | 0.014 |
| Iron | 57 /66 | | 5.050 | 0.012 - 2.440 | L | 0.362 | 0.627 |
| Lead | 24 /59 | | 0.052 | 0.002 - 0.015 | N^f | 0.003 | 0.003 |
| Magnesium | 65 /65 | | 40.218 | 10.710 -58.200 | L | 30.356 | 32.491 |
| Manganese | 62 /66 | | 0.533 | 0.002 - 0.517 | L | 0.116 | 0.200 |
| Mercury | 12 /64 | | 0.001 | 0.000 - 0.006 | N^f | 0.000 | 0.001 |
| Molybdenum | 5 /66 | | 0.028 | 0.008 - 0.030 | N | 0.009 | 0.011 |
| Nickel | 16 /66 | | ^g | 0.011 - 0.050 | N | 0.015 | 0.017 |
| Potassium | 59 /66 | | 8.568 | 1.180 -40.600 | N^f | 3.165 | 4.140 |
| Selenium | 6 /63 | | ^g | 0.003 - 0.006 | N | 0.002 | 0.002 |
| Silicon | 35 /35 | | ^g | 1.900 - 6.140 | N | 4.153 | 4.497 |
| Silver | 24 /66 | | 0.067 | 0.010 - 0.027 | N | 0.009 | 0.011 |
| Sodium | 66 /66 | | 142.148 | 2.710 -53.000 | L | 16.240 | 18.753 |
| Vanadium | 29 /37 | | ^g | 0.010 - 0.031 | L | 0.015 | 0.018 |
| Zinc | 1 /2 | | ^g | 0.050 - 0.050 | ^i | ^i | 0.050^h |
| Ammonia | 8 /66 | | . | 0.066 - 0.400 | N | 0.066 | 0.078 |
| Chloride | 63 /63 | | 255.007 | 1.000 -101.00 | L | 24.058 | 30.090 |
| Fluoride | 60 /66 | | 1.648 | 0.050 - 1.000 | L | 0.241 | 0.297 |
| Nitrate | 56 /66 | | 14.839 | 0.030 - 7.060 | L | 1.750 | 2.947 |
| Phosphate | 2 /2 | | ^g | 0.010 - 0.300 | ^i | ^i | 0.300^h |
| Phosphorus | 45 /61 | | 0.651 | 0.010 -45.400 | L | 0.898 | 2.207 |
| Sulfate | 66 /66 | | 147.653 | 4.000 -292.00 | N^f | 97.741 | 111.711 |
| Sulfide | 6 /35 | | ^g | 0.020 -44.200 | L | 0.459 | 0.779 |
| Total Kjeldahl Nitrogen | 26 /29 | | 6.868 | 0.100 - 3.230 | L | 0.543 | 0.906 |
| Total Organic Carbon | 26 /33 | | ^g | 0.234 -62.000 | L | 2.960 | 5.128 |

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TABLE M-10
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| **Dry Fork - Shandon Divide Downgradient Wells (continued)** | | | | | | | |
| Total Organic Halides | 12 /51 | | ^g | 0.010 - 0.181 | L | 0.010 | 0.013 |
| Total Organic Nitrogen | 45 /66 | | 2.026 | 0.100 - 2.920 | L | 0.309 | 0.419 |
| Diethyl phthalate | 1 /2 | | ^g | 0.020 - 0.020 | ^i | ^i | 0.020^h |
| N-Nitrosodiphenylamine | 1 /2 | | ^g | 0.021 - 0.021 | ^i | ^i | 0.021^h |
| Phenols | 27 /66 | | 0.037 | 0.008 - 0.340 | L | 0.010 | 0.013 |
| **Ross Downgradient Wells** | | | | | | | |
| Aluminum | 1 /1 | | ^g | 0.098 - 0.098 | ^i | ^i | 0.098^h |
| Barium | 4 /4 | | 0.079 | 0.034 - 0.052 | N^f | 0.045 | 0.052^h |
| Cadmium | 2 /4 | | ^g | 0.004 - 0.006 | N^f | 0.003 | 0.006 |
| Calcium | 4 /4 | | 111.731 | 92.600 -120.00 | N^f | 109.90 | 120.000^h |
| Chromium | 2 /4 | | 0.025 | 0.030 - 0.036 | N^f | 0.021 | 0.036^h |
| Copper | 3 /4 | | 0.154 | 0.011 - 0.050 | N^f | 0.020 | 0.044 |
| Iron | 4 /4 | | 0.126 | 0.048 - 0.400 | N^f | 0.166 | 0.353 |
| Lead | 1 /4 | | 0.059 | 0.066 - 0.066 | N^f | 0.017 | 0.055 |
| Magnesium | 4 /4 | | 37.968 | 25.800 -34.700 | N^f | 31.150 | 34.700^h |
| Manganese | 4 /4 | | 0.035 | 0.009 - 0.020 | N^f | 0.014 | 0.019 |
| Mercury | 1 /4 | | 0.000 | 0.001 - 0.001 | N^f | 0.000 | 0.000 |
| Molybdenum | 1 /4 | | 0.055 | 0.057 - 0.057 | N^f | 0.021 | 0.049 |
| Potassium | 4 /4 | | 3.086 | 1.370 - 1.840 | N^f | 1.603 | 1.829 |
| Selenium | 2 /4 | | ^g | 0.005 - 0.006 | N^f | 0.003 | 0.006^h |
| Silicon | 1 /1 | | ^g | 3.460 - 3.460 | ^i | ^i | 3.460^h |
| Silver | 1 /4 | | ^g | 0.013 - 0.013 | N^f | 0.005 | 0.012 |
| Sodium | 4 /4 | | 28.720 | 9.400 -17.200 | N^f | 12.253 | 16.479 |
| Vanadium | 1 /1 | | ^g | 0.018 - 0.018 | ^i | ^i | 0.018^h |
| Ammonia | 1 /4 | | 0.184 | 0.331 - 0.331 | N^f | 0.120 | 0.286 |
| Chloride | 4 /4 | | 105.261 | 9.000 -33.000 | N^f | 21.625 | 33.000^h |
| Fluoride | 4 /4 | | 0.370 | 0.170 - 0.280 | N^f | 0.248 | 0.280^h |
| Nitrate | 3 /4 | | 21.662 | 1.740 -11.100 | N^f | 3.713 | 9.594 |
| Phosphorus | 3 /4 | | 0.126 | 0.200 - 3.080 | N^f | 0.941 | 2.634 |
| Sulfate | 4 /4 | | 131.387 | 27.000 -132.00 | N^f | 80.375 | 130.830 |
| Sulfide | 1 /1 | | ^g | 30.400 -30.400 | ^i | ^i | 30.400^h |
| Total Kjeldahl Nitrogen | 3 /3 | | 0.625 | 0.170 - 0.459 | N^f | 0.287 | 0.459^h |
| Total Organic Halides | 2 /4 | | ^g | 0.011 - 0.013 | N^f | 0.014 | 0.013^h |
| Total Organic Nitrogen | 2 /4 | | 0.396 | 0.170 - 0.459 | N^f | 0.182 | 0.409 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^gBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^hIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.
^iNot applicable if sample size ≤ 2.

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TABLE M-11
NONRADIOLOGICAL CONSTITUENTS IN 3000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| **Dry Fork Downgradient Wells** | | | | | | | |
| Aluminum | 30 /35 | ^f | | 0.062 -103.00 | N^g | 3.195 | 8.166 |
| Arsenic | 8 /73 | | 0.280 | 0.002 - 0.014 | N^g | 0.002 | 0.002 |
| Barium | 74 /81 | | 0.051 | 0.008 -26.000 | N^g | 0.390 | 0.923 |
| Beryllium | 1 /1 | ^f | | 0.002 - 0.002 | ^h | ^h | 0.002^i |
| Cadmium | 50 /80 | ^f | | 0.003 - 3.200 | N^g | 0.044 | 0.110 |
| Calcium | 81 /81 | | 103.701 | 41.100 - 94700 | N^g | 1259.8 | 3203.49 |
| Chromium | 53 /81 | | 0.030 | 0.009 -23.800 | N^g | 0.341 | 0.830 |
| Copper | 32 /80 | | 0.090 | 0.009 - 0.100 | L | 0.008 | 0.009 |
| Iron | 73 /81 | | 0.602 | 0.019 -102.00 | L | 3.065 | 7.460 |
| Lead | 30 /73 | | 0.037 | 0.002 - 3.600 | L | 0.003 | 0.004 |
| Magnesium | 81 /81 | | 27.957 | 17.100 - 24300 | N^g | 325.16 | 823.880 |
| Manganese | 77 /81 | | 1.029 | 0.004 -76.100 | L | 0.405 | 0.670 |
| Mercury | 16 /80 | ^f | | 0.000 - 0.012 | L | 0.000 | 0.000 |
| Molybdenum | 11 /80 | ^f | | 0.007 - 0.037 | L | 0.009 | 0.010 |
| Nickel | 16 /80 | ^f | | 0.011 - 0.480 | L | 0.013 | 0.015 |
| Potassium | 75 /81 | | 2.044 | 0.811 -2300.0 | N^g | 64.056 | 124.301 |
| Selenium | 7 /74 | ^f | | 0.002 - 0.011 | N^g | 0.001 | 0.002 |
| Silicon | 34 /34 | ^f | | 2.000 -6140.0 | N^g | 185.03 | 490.422 |
| Silver | 21 /81 | | 0.061 | 0.011 -19.400 | N^g | 0.246 | 0.645 |
| Sodium | 81 /81 | | 4.765 | 2.750 -6310.0 | L | 21.694 | 27.764 |
| Thallium | 1 /1 | ^f | | 0.002 - 0.002 | ^h | ^h | 0.002^i |
| Vanadium | 31 /35 | ^f | | 0.010 -10.400 | N^g | 0.311 | 0.813 |
| Zinc | 1 /1 | ^f | | 0.030 - 0.030 | ^h | ^h | 0.030^i |
| Toluene | 1 /1 | ^f | | 0.005 - 0.005 | ^h | ^h | 0.005^i |
| Ammonia | 22 /81 | | 0.368 | 0.018 - 3.500 | L | 0.078 | 0.093 |
| Chloride | 81 /81 | | 30.061 | 0.750 -140.00 | L | 27.746 | 33.647 |
| Fluoride | 80 /81 | | 0.467 | 0.070 - 1.600 | L | 0.262 | 0.304 |
| Nitrate | 42 /81 | | 19.415 | 0.023 -445.00 | N^g | 6.282 | 15.414 |
| Phosphate | 1 /1 | ^f | | 0.010 - 0.010 | ^h | ^h | 0.010^i |
| Phosphorus | 62 /79 | ^f | | 0.010 -552.00 | L | 0.521 | 1.098 |
| Sulfate | 81 /81 | | 60.159 | 0.350 -951.00 | L | 93.516 | 114.942 |
| Sulfide | 3 /35 | ^f | | 0.500 -26.300 | N^g | 1.038 | 2.296 |
| Total Kjeldahl Nitrogen | 30 /37 | | 0.578 | 0.063 - 8.110 | L | 0.442 | 0.766 |
| Total Organic Carbon | 22 /30 | ^f | | 1.000 -11.500 | L | 2.185 | 3.198 |
| Total Organic Halides | 20 /61 | ^f | | 0.003 - 9.300 | L | 0.021 | 0.030 |
| Total Organic Nitrogen | 44 /79 | | 0.312 | 0.100 - 8.110 | L | 0.177 | 0.227 |
| 2-Butanone | 1 /1 | ^f | | 0.004 - 0.004 | ^h | ^h | 0.004^i |
| Acetone | 1 /1 | ^f | | 0.007 - 0.007 | ^h | ^h | 0.007^i |
| Benzene | 1 /1 | ^f | | 0.001 - 0.001 | ^h | ^h | 0.001^i |
| Methylene chloride | 1 /1 | ^f | | 0.002 - 0.002 | ^h | ^h | 0.002^i |
| Phenols | 33 /81 | | 0.034 | 0.010 -11.500 | L | 0.011 | 0.014 |
| **Shandon Downgradient Wells** | | | | | | | |
| Aluminum | 33 /36 | | 0.303 | 0.020 - 0.224 | N | 0.136 | 0.153 |
| Arsenic | 19 /91 | | 0.385 | 0.002 - 0.310 | N^g | 0.016 | 0.025 |
| Barium | 118 /139 | | 1.047 | 0.006 - 0.538 | L | 0.099 | 0.113 |
| Beryllium | 19 /28 | | 0.004 | 0.001 - 0.003 | N | 0.001 | 0.002 |
| Cadmium | 30 /116 | | 0.007 | 0.002 - 0.032 | N | 0.003 | 0.004 |
| Calcium | 139 /139 | | 136.363 | 7.900 -337.00 | N^g | 137.08 | 147.224 |
| Chromium | 59 /139 | | 0.039 | 0.007 - 0.560 | N^g | 0.022 | 0.029 |
| Copper | 22 /139 | ^f | | 0.007 - 0.037 | N | 0.007 | 0.008 |
| Iron | 132 /139 | | 4.131 | 0.030 -19.300 | L | 6.318 | 10.108 |
| Lead | 36 /110 | | 0.051 | 0.002 - 0.043 | N^g | 0.004 | 0.005 |
| Magnesium | 139 /139 | | 47.038 | 0.500 -85.800 | N | 32.690 | 34.785 |
| Manganese | 115 /116 | | 0.265 | 0.016 - 4.320 | L | 0.626 | 0.829 |
| Mercury | 11 /116 | | 0.001 | 0.000 - 0.009 | N^g | 0.000 | 0.000 |
| Molybdenum | 27 /112 | | 0.029 | 0.010 - 0.200 | N | 0.017 | 0.020 |
| Nickel | 30 /139 | | 0.026 | 0.020 - 0.780 | L | 0.014 | 0.015 |
| Osmium | 1 /4 | ^f | | 0.094 - 0.094 | N^g | 0.042 | 0.083 |
| Potassium | 108 /116 | | 5.068 | 0.652 -121.00 | L | 6.124 | 7.542 |

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TABLE M-11
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| **Shandon Downgradient Wells (continued)** | | | | | | | |
| Selenium | 9 /88 | | 0.130 | 0.002 - 0.025 | N^g | 0.002 | 0.003 |
| Silicon | 8 /8 | | ^f | 2.800 - 5.530 | L | 4.057 | 5.233 |
| Silver | 30 /139 | | 0.014 | 0.010 - 0.024 | N^g | 0.006 | 0.007 |
| Sodium | 116 /116 | | 100.309 | 8.600 -320.00 | L | 33.104 | 39.460 |
| Thallium | 1 /5 | | ^f | 0.002 - 0.002 | N^g | 0.001 | 0.002^i |
| Vanadium | 30 /36 | | 0.034 | 0.011 - 0.049 | N | 0.021 | 0.024 |
| Zinc | 28 /28 | | 0.109 | 0.017 - 0.267 | L | 0.057 | 0.070 |
| Ammonia | 76 /116 | | 7.125 | 0.035 -28.600 | N^g | 1.529 | 2.225 |
| Chloride | 142 /142 | | 110.026 | 2.750 -826.00 | L | 67.274 | 82.061 |
| Fluoride | 127 /143 | | 1.328 | 0.050 -23.000 | L | 0.261 | 0.300 |
| Nitrate | 64 /143 | | 1.527 | 0.020 -36.400 | L | 0.167 | 0.220 |
| Phosphate | 9 /9 | | ^f | 0.030 - 1.200 | N | 0.594 | 0.853 |
| Phosphorus | 65 /103 | | 0.728 | 0.010 -568.00 | L | 0.737 | 1.601 |
| Sulfate | 137 /141 | | 129.779 | 4.750 -800.00 | L | 208.21 | 266.806 |
| Sulfide | 1 /12 | | ^f | 3.400 - 3.400 | L | 0.329 | 0.489 |
| Total Kjeldahl Nitrogen | 55 /64 | | 6.630 | 0.100 -28.600 | L | 1.540 | 2.618 |
| Total Organic Carbon | 27 /33 | | 11.924 | 1.000 -14.513 | L | 3.241 | 4.711 |
| Total Organic Halides | 25 /96 | | 0.096 | 0.006 - 0.200 | N^g | 0.022 | 0.026 |
| Total Organic Nitrogen | 67 /114 | | 2.123 | 0.000 -12.000 | L | 0.420 | 0.575 |
| bis(2-Ethylhexyl) phthalate | 4 /6 | | 0.015 | 0.002 - 0.015 | N^g | 0.006 | 0.010 |
| 2-Butanone | 1 /5 | | ^f | 0.003 - 0.003 | N^g | 0.005 | 0.003^i |
| 4-Methyl-2-pentanone | 1 /5 | | ^f | 0.003 - 0.003 | N^g | 0.005 | 0.003^i |
| Acetone | 23 /26 | | 0.011 | 0.003 - 0.084 | L | 0.012 | 0.014 |
| Benzene | 1 /5 | | ^f | 0.004 - 0.004 | N^g | 0.003 | 0.003 |
| Butyl benzyl phthalate | 1 /6 | | ^f | 0.003 - 0.003 | N^g | 0.005 | 0.003^i |
| Carbon disulfide | 1 /5 | | ^f | 0.003 - 0.003 | N^g | 0.003 | 0.003 |
| Di-n-butyl phthalate | 3 /6 | | ^f | 0.002 - 0.010 | N^g | 0.005 | 0.007 |
| Diethyl phthalate | 1 /6 | | ^f | 0.002 - 0.002 | N^g | 0.005 | 0.002^i |
| Ethylbenzene | 1 /5 | | ^f | 0.002 - 0.002 | N^g | 0.002 | 0.002^i |
| Methylene chloride | 24 /26 | | 0.018 | 0.001 - 0.011 | N | 0.006 | 0.007 |
| N-Nitrosodiphenylamine | 2 /5 | | 0.013 | 0.002 - 0.003 | N^g | 0.004 | 0.003^i |
| Phenol | 1 /6 | | ^f | 0.017 - 0.017 | N^g | 0.007 | 0.011 |
| Phenols | 45 /116 | | 0.061 | 0.006 - 1.200 | N^g | 0.026 | 0.043 |
| Toluene | 14 /26 | | ^f | 0.002 - 0.010 | N^g | 0.003 | 0.004 |
| Total xylenes | 1 /5 | | ^f | 0.003 - 0.003 | N^g | 0.003 | 0.003 |
| Trichloroethene | 4 /26 | | ^f | 0.002 - 0.009 | N | 0.003 | 0.003 |
| Trichlorofluoromethane | 1 /4 | | ^f | 0.072 - 0.072 | N^g | 0.020 | 0.061 |
| **Dry Fork - Shandon Divide Downgradient Wells** | | | | | | | |
| Aluminum | 9 /17 | | ^f | 0.060 - 0.128 | L | 0.059 | 0.078 |
| Barium | 37 /41 | | . | 0.016 - 0.075 | N | 0.058 | 0.063 |
| Cadmium | 20 /41 | | 0.009 | 0.002 - 0.008 | N^g | 0.003 | 0.003 |
| Calcium | 41 /41 | | 158.216 | 34.400 -117.00 | N | 87.462 | 90.716 |
| Chromium | 18 /41 | | 0.036 | 0.007 - 0.160 | N^g | 0.018 | 0.025 |
| Copper | 8 /41 | | . | 0.006 - 0.090 | N^g | 0.009 | 0.013 |
| Iron | 39 /41 | | 5.050 | 0.020 -19.200 | L | 1.695 | 4.092 |
| Lead | 9 /33 | | 0.052 | 0.003 - 0.009 | N^g | 0.002 | 0.003 |
| Magnesium | 41 /41 | | 40.218 | 10.200 -232.00 | N^g | 29.527 | 38.132 |
| Manganese | 40 /41 | | 0.533 | 0.005 - 0.490 | N | 0.200 | 0.235 |
| Mercury | 7 /41 | | 0.001 | 0.000 - 0.008 | N^g | 0.000 | 0.001 |
| Molybdenum | 2 /41 | | 0.028 | 0.010 - 0.011 | N^g | 0.009 | 0.010 |
| Nickel | 7 /41 | | ^f | 0.018 - 0.260 | L | 0.013 | 0.016 |
| Potassium | 36 /41 | | 8.568 | 0.479 -18.700 | L | 2.705 | 3.301 |
| Selenium | 3 /39 | | ^f | 0.002 - 0.004 | N^g | 0.002 | 0.003 |
| Silicon | 17 /17 | | ^f | 0.402 - 4.240 | N | 2.968 | 3.411 |
| Silver | 8 /41 | | 0.067 | 0.011 - 0.018 | N^g | 0.006 | 0.008 |
| Sodium | 41 /41 | | 142.148 | 4.450 -90.600 | L | 10.771 | 12.223 |
| Vanadium | 3 /17 | | ^f | 0.016 - 0.018 | N | 0.007 | 0.009 |
| Ammonia | 10 /41 | | . | 0.100 - 4.100 | L | 0.070 | 0.087 |
| Chloride | 41 /41 | | 255.007 | 1.510 -37.990 | N | 17.713 | 19.553 |

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TABLE M-11
(continued)

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| | | | Dry Fork - Shandon Divide Downgradient Wells | | | | |
| Fluoride | 36 /41 | | 1.648 | 0.060 - 0.980 | L | 0.223 | 0.281 |
| Nitrate | 17 /41 | | 14.839 | 0.012 - 2.480 | N^g | 0.529 | 0.759 |
| Phosphate | 3 /3 | | ^f | 0.200 - 0.430 | N^g | 0.320 | 0.430^i |
| Phosphorus | 24 /36 | | 0.651 | 0.010 -50.000 | L | 0.304 | 0.869 |
| Sulfate | 41 /41 | | 147.653 | 7.980 -139.00 | N | 74.606 | 81.771 |
| Sulfide | 3 /17 | | ^f | 0.720 -44.700 | L | 0.496 | 0.991 |
| Total Kjeldahl Nitrogen | 15 /18 | | 6.868 | 0.100 - 0.561 | N | 0.224 | 0.288 |
| Total Organic Carbon | 10 /16 | | ^f | 1.000 - 9.820 | L | 2.360 | 4.951 |
| Total Organic Halides | 9 /29 | | ^f | 0.010 - 0.164 | N^g | 0.027 | 0.039 |
| Total Organic Nitrogen | 24 /41 | | 2.026 | 0.051 - 1.200 | L | 0.148 | 0.196 |
| Phenols | 18 /41 | | 0.037 | 0.006 - 0.068 | N^g | 0.014 | 0.017 |
| | | | Ross Downgradient Wells | | | | |
| Barium | 4 /4 | | 0.079 | 0.040 - 0.051 | N | 0.047 | 0.051^i |
| Cadmium | 2 /4 | | ^f | 0.005 - 0.006 | N | 0.003 | 0.006^i |
| Calcium | 4 /4 | | 111.731 | 103.00 -114.00 | N | 107.75 | 113.217 |
| Chromium | 2 /4 | | 0.025 | 0.026 - 0.041 | N | 0.022 | 0.039 |
| Copper | 1 /4 | | 0.154 | 0.011 - 0.011 | N | 0.007 | 0.010 |
| Iron | 3 /4 | | 0.126 | 0.022 - 0.057 | N | 0.027 | 0.054 |
| Lead | 2 /4 | | 0.059 | 0.005 - 0.008 | N | 0.004 | 0.008 |
| Magnesium | 4 /4 | | 37.968 | 29.800 -32.900 | N | 31.250 | 32.765 |
| Manganese | 4 /4 | | 0.035 | 0.019 - 0.021 | N | 0.020 | 0.021^i |
| Mercury | 1 /4 | | 0.000 | 0.001 - 0.001 | N^g | 0.000 | 0.000 |
| Potassium | 4 /4 | | 3.086 | 1.700 - 2.420 | N | 1.938 | 2.325 |
| Selenium | 1 /4 | | ^f | 0.004 - 0.004 | N | 0.002 | 0.004 |
| Silver | 1 /3 | | ^f | 0.014 - 0.014 | N | 0.006 | 0.014^i |
| Sodium | 4 /4 | | 28.720 | 6.440 - 8.200 | N | 7.500 | 8.200^i |
| Chloride | 4 /4 | | 105.261 | 8.000 -26.000 | N | 16.875 | 25.553 |
| Fluoride | 3 /4 | | 0.370 | 0.120 - 0.190 | N | 0.130 | 0.190^i |
| Nitrate | 4 /4 | | 21.662 | 1.740 - 4.610 | N | 2.733 | 4.287 |
| Phosphorus | 2 /4 | | 0.126 | 0.113 - 0.130 | N^g | 0.065 | 0.130^i |
| Sulfate | 4 /4 | | 131.387 | 62.700 -116.00 | L | 76.388 | 106.732 |
| Sulfide | 1 /1 | | ^f | 28.040 -28.040 | ^h | ^h | 28.040^i |
| Total Kjeldahl Nitrogen | 3 /3 | | 0.625 | 0.138 - 1.370 | N^g | 0.590 | 1.370^i |
| Total Organic Halides | 1 /4 | | ^f | 0.018 - 0.018 | N | 0.013 | 0.018^i |
| Total Organic Nitrogen | 3 /4 | | 0.396 | 0.138 - 1.370 | L | 0.223 | 1.144 |
| Phenols | 1 /4 | | 0.032 | 0.020 - 0.020 | N | 0.009 | 0.018 |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gDistribution could not be determined from available data; therefore, a normal distribution was assumed.
^hNot applicable if sample size ≤ 2.
^iIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.

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TABLE M-12
NONRADIOLOGICAL CONSTITUENTS IN 4000 SERIES WELL GROUNDWATER
ONGOING RI/FS AND RCRA SAMPLING

| Chemical | Frequency of Detection | Highest Blank^a (mg/L) | Upper 95% TL for BKG^b (mg/L) | Range of Detection | Dist^c | Mean^d (mg/L) | Upper 95% CI on Mean^e (mg/L) |
|---|---|---|---|---|---|---|---|
| 2,6-Dinitrotoluene | 1 /2 | | ^f | 0.002 - 0.002 | ^g | ^g | 0.002^h |
| 2-Hexanone | 1 /2 | | ^f | 0.003 - 0.003 | ^g | ^g | 0.003^h |
| 4-Methyl-2-pentanone | 1 /2 | | ^f | 0.003 - 0.003 | ^g | ^g | 0.003^h |
| Acetone | 12 /12 | | ^f | 0.001 - 0.035 | L | 0.008 | 0.021 |
| Aluminum | 21 /23 | | ^f | 0.040 - 0.238 | N | 0.101 | 0.119 |
| Ammonia | 46 /66 | | 0.368 | 0.100 - 6.630 | L | 0.595 | 0.917 |
| Arsenic | 17 /53 | | 0.280 | 0.002 - 0.015 | N^i | 0.003 | 0.004 |
| Barium | 64 /76 | | 0.051 | 0.028 - 0.450 | L | 0.097 | 0.114 |
| Beryllium | 9 /12 | | ^f | 0.001 - 0.002 | N^i | 0.001 | 0.002 |
| Cadmium | 23 /64 | | ^f | 0.002 - 0.012 | N | 0.003 | 0.004 |
| Calcium | 75 /75 | | 103.701 | 68.500 -270.00 | N^i | 102.53 | 109.127 |
| Chloride | 78 /78 | | 30.061 | 3.000 -472.00 | L | 36.090 | 45.246 |
| Chromium | 37 /76 | | 0.030 | 0.007 - 0.062 | N^i | 0.017 | 0.020 |
| Cobalt | 1 /12 | | ^f | 0.005 - 0.005 | N | 0.005 | 0.005^h |
| Copper | 19 /76 | | 0.090 | 0.005 - 0.104 | N | 0.010 | 0.013 |
| Fluoride | 76 /78 | | 0.467 | 0.062 - 1.100 | L | 0.260 | 0.296 |
| Iron | 74 /74 | | 0.602 | 0.030 - 9.640 | N | 2.944 | 3.331 |
| Lead | 25 /65 | | 0.037 | 0.002 - 0.152 | N^i | 0.006 | 0.010 |
| Magnesium | 75 /75 | | 27.957 | 18.000 -91.700 | N^i | 28.492 | 31.073 |
| Manganese | 64 /65 | | 1.029 | 0.009 -42.000 | L | 0.680 | 0.979 |
| Mercury | 11 /65 | | ^f | 0.000 - 0.006 | L | 0.000 | 0.000 |
| Methylene chloride | 10 /12 | | ^f | 0.001 - 0.012 | L | 0.006 | 0.011 |
| Molybdenum | 15 /65 | | ^f | 0.004 - 0.060 | L | 0.011 | 0.013 |
| Nickel | 14 /76 | | ^f | 0.014 -13.400 | N^i | 0.190 | 0.483 |
| Nitrate | 33 /79 | | 19.415 | 0.100 -12.400 | L | 0.105 | 0.140 |
| Phenols | 30 /67 | | 0.034 | 0.007 - 0.172 | L | 0.009 | 0.012 |
| Phosphate | 6 /6 | | ^f | 0.150 - 0.680 | N | 0.257 | 0.428 |
| Phosphorus | 46 /58 | | ^f | 0.020 - 1.330 | L | 0.190 | 0.297 |
| Potassium | 56 /64 | | 2.044 | 0.850 - 8.750 | L | 2.249 | 2.528 |
| Selenium | 4 /53 | | ^f | 0.002 - 0.003 | N | 0.001 | 0.002 |
| Silicon | 11 /11 | | ^f | 3.000 - 6.430 | N | 5.602 | 6.234 |
| Silver | 23 /76 | | 0.061 | 0.010 - 0.140 | N | 0.008 | 0.012 |
| Sodium | 65 /65 | | 4.765 | 3.930 -70.700 | L | 15.916 | 18.887 |
| Sulfate | 75 /77 | | 60.159 | 5.000 -355.00 | L | 79.717 | 105.984 |
| Sulfide | 4 /10 | | ^f | 17.400 -40.000 | L | 1.560 | 6.177 |
| Toluene | 6 /12 | | ^f | 0.002 - 0.005 | N | 0.003 | 0.003 |
| Total Kjeldahl Nitrogen | 32 /38 | | 0.578 | 0.103 - 6.790 | L | 1.027 | 1.841 |
| Total Organic Carbon | 16 /21 | | ^f | 1.240 -20.630 | L | 3.463 | 6.120 |
| Total Organic Halides | 13 /56 | | ^f | 0.014 - 0.074 | N | 0.018 | 0.021 |
| Total Organic Nitrogen | 41 /65 | | 0.312 | 0.000 - 3.500 | L | 0.260 | 0.355 |
| Vanadium | 18 /23 | | ^f | 0.011 - 0.038 | L | 0.017 | 0.022 |
| Zinc | 12 /12 | | ^f | 0.009 - 0.108 | L | 0.030 | 0.045 |
| bis(2-Ethylhexyl) phthalate | 1 /2 | | ^f | 0.005 - 0.005 | ^g | ^g | 0.005^h |

^aIf blank data are available.
^bUpper 95% tolerance level for background data with a 95% level of confidence.
^cDistribution: N = Normal; L = Lognormal.
If the number of detects ≥ 7 and the frequency of detection ≥ 50%, a probability plot that handles censored data is used in determining the distribution. Otherwise, the distribution is estimated by visual inspection of the raw data, a histogram, and a standard probability plot.
^dIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and frequency of detection ≥ 50%, an arithmetic mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric mean is given.
^eIf the distribution is normal or if the distribution is log-normal, the number of detects ≥ 7, and the frequency of detection ≥ 50%, an arithmetic upper 95% confidence interval (CI) on the mean is given. If the distribution is log-normal and either the number of detects < 7 or the frequency of detection is < 50%, a geometric upper 95% CI on the mean is given.
^fBackground data are either not available or are inappropriate if the constituent is not naturally-occuring.
^gNot applicable if sample size ≤ 2.
^hIf the upper 95% CI on the mean exceeds the maximum detected concentration or if the sample size ≤ 2, the maximum detected concentration is substituted.
^iDistribution could not be determined from available data; therefore, a normal distribution was assumed.