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LONG-TERM EFFECTS OF DREDGING
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INTERIM REPORT: COLLATION AND
INTERPRETATION OF DATA FOR TIMES BEACH
CONFINED DISPOSAL FACILITY
BUFFALO, NEW YORK

Compiled by

Elizabeth A. Stafford

Entomology Department

Rothamsted Experimental Station

Harpenden, Hartfordshire, United Kingdom

and

John W. Simmers, R. Glenn Rhett, Carole P. Brown

Environmental Laboratory

DEPARTMENT OF THE ARMY

Waterways Experiment Station, Corps of Engineers

3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

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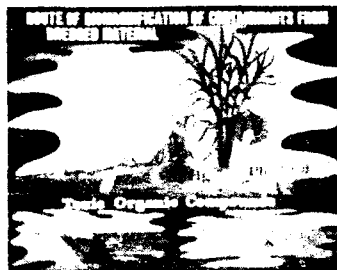


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13. ABSTRACT (Maximum 200 words) This interim report, prepared for the US Army Engineer District, Buffalo, collates all data gathered to date by scientists working at the Times Beach confined disposal facility (CDF), Buffalo, NY. The purpose of the studies at the CDF was to determine the mobility and potential hazard of contaminants known to be in the dredged material placed at Times Beach by sampling and analyzing various components of the developing ecosystems. Upland, wetland, and aquatic areas are represented within the CDF and, for each area, inventories of colonizing biota were made and samples collected for measurement of heavy metals and organic contaminants. Where sufficient data exist for conclusions to be drawn, the implications for management of Times Beach and CDFs in general are discussed. Where insufficient data are available, areas for future productive research are recommended. The major amount of information available is for the upland area, where detailed inventories of colonizing vegetation and soil-dwelling invertebrates have been made. Samples of dredged (Continued)				
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Aquatic	Contaminant mobility	Invertebrates
Bioaccumulation	Copper	PAHs
Bioassay	Dredged material	PCBs
Buffalo River	Earthworms	Plant
Cadmium	Food chain	Terrestrial
Contaminant cycling	Habitat development	Wetland

19. ABSTRACT (Continued).

material, vegetation, and soil-dwelling invertebrates, and vertebrates have been collected and heavy metal concentrations measured. The results suggest that the persistent contaminants, particularly cadmium, are concentrating in the leaf litter zone and moving into the detritivorous invertebrates. Highest concentrations of heavy metals were noted in the earthworms. Of the plant and animal species analyzed, earthworms, millipedes, woodlice, and spiders appeared to be target organisms for accumulation of heavy metals, and these groups contained higher concentrations of copper and cadmium than the other groups. For comparison with the Times Beach upland area, a reference site at Grand Island, Buffalo, NY, was selected; soil-dwelling invertebrates were collected for analysis. Earthworms collected at Times Beach generally had higher concentrations of zinc, copper, and cadmium compared with earthworms from Grand Island. Higher concentrations of the elements copper and cadmium were present in the millipedes and woodlice, respectively, collected at Times Beach compared with those from Grand Island.

Polychlorinated biphenyl (PCB) and polynuclear aromatic hydrocarbon contaminants in the dredged material were below machine detection limits in the vertebrate top-predators collected in the upland area at the CDF. However, further collection and analysis of vertebrates is required for statistical comparisons to be made.

In the wetland area, collection and analysis of heavy metal concentrations in the vegetation have been done; however, further sampling and analysis are necessary to conclusively demonstrate the effect of physical conditions (for example, frequency of inundation by water) on uptake of contaminants by the plants. Results of sampling and analysis of the sizable muskrat population cannot be interpreted at present due to the lack of comparable information from a reference site.

The least amount of data is available for the aquatic area. Contaminant concentrations in water collected in the aquatic area and from ground-water wells were below guidance limits as defined by the US Environmental Protection Agency; however, concentrations measured in fish suggested an elevation in concentrations of PCBs. Plankton, benthic, and fish species present at the CDF were examined with regard to their relative abundance and potential for future use as biomonitors.



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SUMMARY

The Times Beach Confined Disposal Facility (CDF), Buffalo, NY, was constructed in 1971 to contain contaminated dredged material from the Buffalo Harbor at the mouth of the Buffalo River. During the period 1972 to 1976, $7.2 \times 10^5 \text{ m}^3$ of material was pumped into the 46-acre (186,000-m²) facility. The CDF was rapidly colonized by plants and animals and provided an attractive habitat for resident and migratory birds (over 222 species). In response to a request by the Buffalo Ornithological Society through the City of Buffalo, the site was designated a nature preserve and left only partially filled. Consequently, the upland, wetland, and aquatic areas that appear either as an end product or transiently at all CDFs are permanently established features of the site. Times Beach offers a unique opportunity to observe the processes of dredged material consolidation and the establishment and development of ecosystems after disposal of dredged material and filling of CDFs. Thus, Times Beach has been the site of studies leading to 22 reports submitted to the Buffalo District since 1981, as well as numerous related papers in journals and conference proceedings.

The following report is intended to serve as an interim report collating the results of these studies, with interpretations where sufficient data are available. It is also intended to serve as a planning document for identifying research needs where additional studies will be productive. In addition, the report suggests where potential exists for utilizing the data accrued in the management of Times Beach and, most significantly, in the management of CDFs in general.

Studies of the upland, oxidized portion of Times Beach have yielded an assessment of the mobility of heavy metals from the dredged material through the plant community to the soil invertebrates. The studies have suggested the possible role of cottonwood trees in transporting cadmium from dredged material to the surface leaf litter and provided evidence for the movement of cadmium from the leaf litter to the detritivorous soil invertebrates. Preliminary data indicate that there is no appreciable movement of cadmium or other metals into the vertebrate animals indigenous to the upland portion of the CDF. Additional analysis of vertebrates is recommended to permit the statistical comparisons necessary to confirm these findings. Further sampling and analysis of leaf litter of various plant species is recommended to permit the

statistical comparisons necessary to confirm their role in the movement of contaminants from the dredged material into the ecosystem. This information is required to formulate guidelines for the management of contaminant mobility through selection of plant species colonizing filled CDFs.

Results of preliminary investigations at the Times Beach CDF suggest that the organic contaminants (PCBs and PAHs) appear to be decreasing in concentration in the oxidized upland area at Times Beach. The reasons for this are not known. Analysis of potential target organisms within the upland plant and animal communities is recommended as well as the application of laboratory procedures to document the fate of the organic contaminants.

Contaminant mobility within the wetland and aquatic communities has not been fully quantified. Analysis of specimens representative of the sizable muskrat population inhabiting the CDF cannot be interpreted at this time, as muskrats from a reference area have not been collected and the preliminary analysis for organic contaminants was unable to employ sufficiently low detection limits. The fledgling mallard ducks collected onsite, and known to have remained within the area, did have elevated cadmium and mercury levels in comparison to both contaminated and uncontaminated reference sites. A more extensive characterization of the wetland and aquatic areas is recommended. There is a need to formulate management practices for Times Beach as well as other CDFs that may have permanent or transient wetland and/or aquatic habitats during filling or when returned to the sponsor.

PREFACE

This interim report was prepared by Dr. Elizabeth A. Stafford of the Entomology Department, Rothamsted Experimental Station (RES), Harpenden, Hertfordshire, United Kingdom (UK), jointly with Dr. John W. Simmers, Mr. R. Glenn Rhett and Ms. Carole P. Brown of the Ecosystem Research and Simulation Division (ERSD), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES).

Financial support for the study was provided by the US Army Engineer District (USAED), Buffalo, through a cost-sharing contract (DAJA45-86-C-0023) established through the WES and RES. Contractual arrangements were made through the US Army Research, Development, and Standardization Group-UK. Funding for publication was provided by the Long-Term Effects of Dredging Operations (LEDO) Program, which is sponsored by the Headquarters, US Army Corps of Engineers (HQUSACE). LEDO is managed within the Environmental Effects of Dredging Programs, Dr. Robert M. Engler, Manager. Technical Monitors for the HQUSACE were Dr. Robert W. Pierce, Dr. William L. Klesch, and Mr. Charles W. Hummer.

General supervision was provided by Dr. Trevor Lewis and Dr. Brian Kerry, previous and current head of the Entomology Department, respectively, and by Mr. Donald L. Robey, Chief, ERSD, and Dr. John Harrison, Chief, EL. Review, valuable suggestions, and constructive comments were provided by Mr. R. P. Leonard, USAED, Buffalo; Dr. Steve P. McGrath, RES; Dr. Charles R. Lee, Dr. Douglas Gunnison, Ms. Joan U. Clarke, and Mr. Dennis L. Brandon, all of WES. Support in analytical chemistry (metals in soil invertebrates and earthworms) was provided by Messrs. Vincent Cosimini and Mike P. Fearnhead of RES and by the following personnel of The Netherlands Organization for Applied Scientific Research (TNO): Dr. Hans Compaan (PCBs), Dr. J. W. J. Gielen (PAHs), and Messrs. Peter De Jong and Jan Spyk (metals in soils and tissues). Field collection and identification of specimens were performed by the following individuals: plants - Richard P. Leonard and Len Bryniarski of the USAED, Buffalo; Dr. Gerould S. Wilhelm, The Morton Arboretum, Lisle, IL; and Prof. W. H. O. Ernst, Free University of Amsterdam, The Netherlands; soil microinvertebrates - Mr. John Bater, Ohio State University, Ohio; soil macroinvertebrates, including earthworms - Dr. Stafford, Dr. Wilf Powell, and Mr. James Ashby, RES; and Dr. Simmers and Mr. Rhett, WES; vertebrates in the

upland area - Dr. Robert Andrie, Buffalo Museum of Science, Buffalo;
Dr. Edward Neuhauser, Cornell University; Dr. Stafford, RES; and Dr. Simmers,
Mr. Rhett, and Ms. Brown, WES; and plankton, benthos, and fish - Dr. J. M.
Marquenie and Mr. Ben Shrieken, TNO, and Dr. Stratford Kay, WES. Statistical
analysis of the data was carried out by Mr. Brandon and Ms. Clarke, WES.

COL Larry B. Fulton, EN, was Commander and Director of WES.
Dr. Robert W. Whalin was Technical Director. Sir Leslie Fowden was Director
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INTERIM REPORT: COLLATION AND INTERPRETATION OF DATA
FOR TIMES BEACH CONFINED DISPOSAL FACILITY
BUFFALO, NEW YORK

PART I: INTRODUCTION

Times Beach Confining Disposal Facility:
Historical Perspective

1. The Times Beach confined disposal facility (CDF) was constructed in 1971 along the shore of Lake Erie to accommodate sediment generated by dredging operations carried out in the Buffalo Harbor. The 186,000-m² (46-acre) site, separated by a dike from the waters of Lake Erie, lies close to the mouth of the Buffalo River at Buffalo, NY (Figure 1). During a 4-year period (1972-1976), 7.2×10^5 m³ of sediment was pumped into the CDF.

2. This sediment contained contaminants as a result of the activities of industries situated along the waterfront, including an oil refinery, two steel plants, an aniline dye chemical plant, and milling facilities. Subsequent chemical analysis of dredged material collected from the CDF in 1981 indicated the presence of potentially toxic heavy metals and organic compounds (Marquenie, Simmers, and Kay 1987).

3. Dredging operations, up to 1976, only partially utilized the capacity of the site. Consequently, the elevation of the dredged material decreased from around the disposal pipe in the northeastern section toward the dike constructed around the site. As a result, part of the CDF lies above the water table and part below, and aquatic, wetland, and upland ecosystems have developed at the site (Figures 2 and 3). Rapid colonization of the CDF by flora and fauna provided an attractive habitat to migratory birds and other wildlife.

4. The diversity of species observed at the site (Appendix A), coupled with the paucity of nature preserves in the city area, led to a suggestion by the Buffalo Ornithological Society that the Times Beach CDF be designated a nature preserve and that no more dredged material disposal be allowed to occur in this CDF.

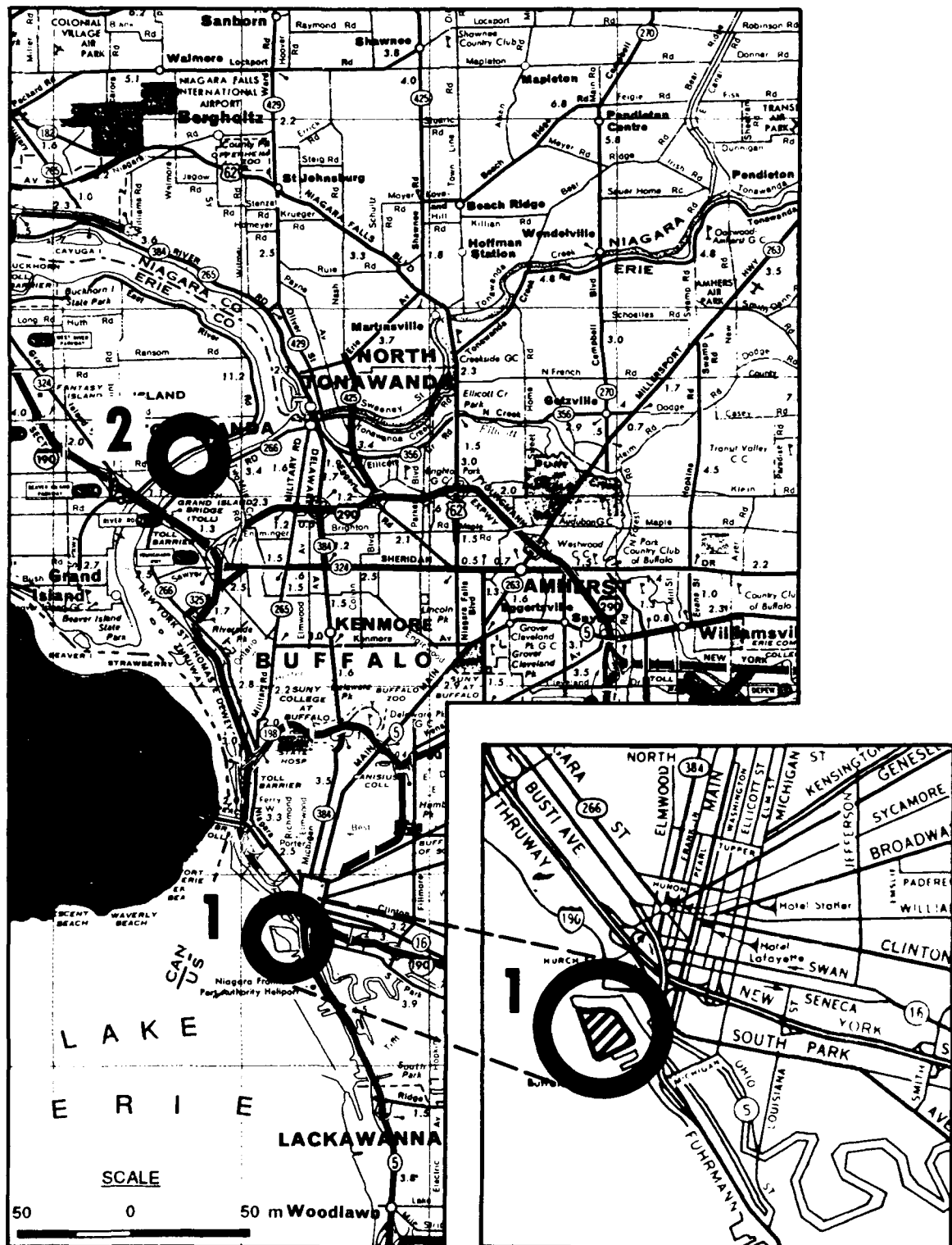


Figure 1. Location of Times Beach confined disposal facility (1) and the selected reference site, Grand Island (2)



Figure 2. Aerial photograph of Times Beach
CDF showing upland (1), wetland (2), and
aquatic (3) areas

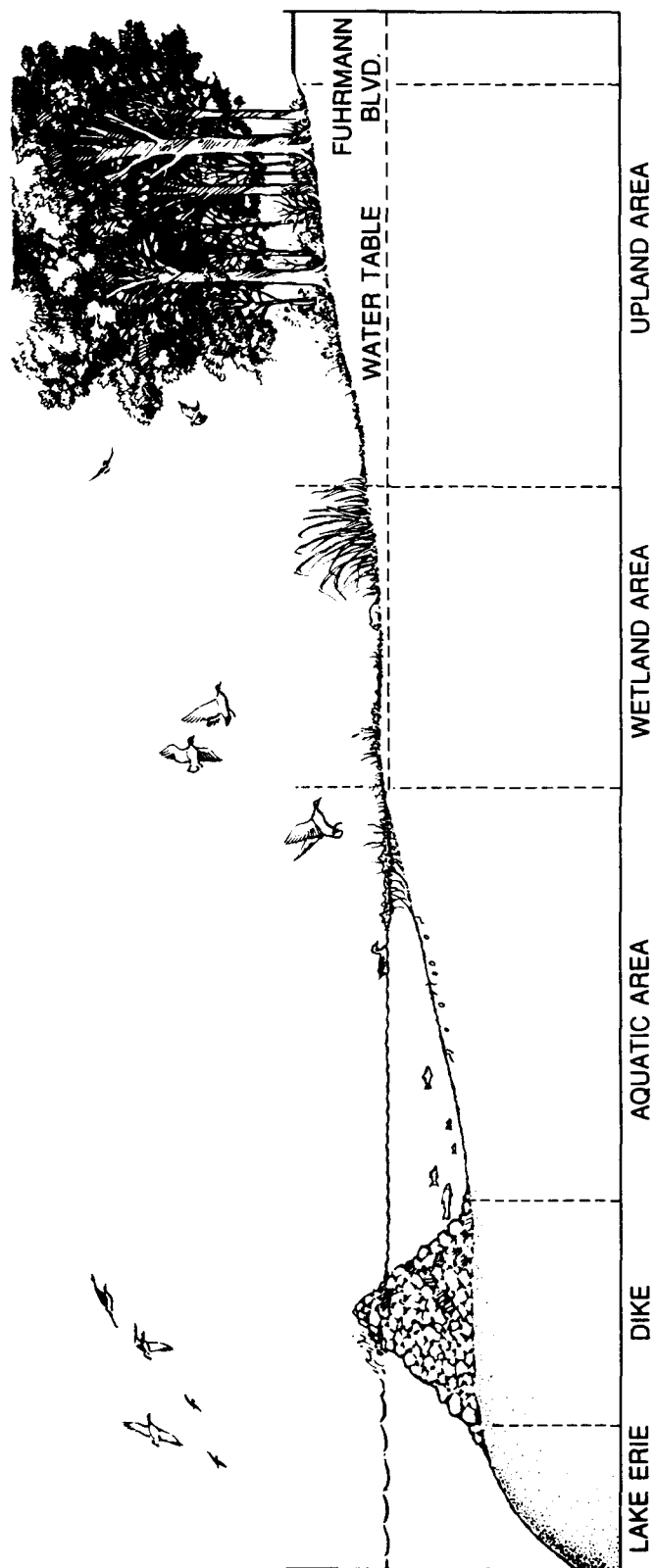


Figure 3. Diagram of ecosystems at Times Beach CDF

5. The US Army Engineer District, Buffalo, then raised the concern that contaminants known to be in the sediment may be potentially hazardous to people and wildlife using the site (Appendix B). To assess the potential hazard at Times Beach, a preliminary evaluation of the bioavailability of these contaminants was made. Samples of dredged material collected from the Times Beach CDF in 1981 were returned to the laboratory; plant and animal bioassay procedures were applied by US Army Engineer Waterways Experiment Station (WES) personnel to measure the potential contaminant uptake into plant and animal tissues. The results of these preliminary screening investigations suggested a potential for uptake of contaminants into plant and animal tissues from the samples of dredged material (Marquenie and Simmers 1984; Marquenie, Simmers, and Kay 1987; Marquenie et al., in preparation). Preliminary investigations made by Folsom (in 1982), Simmers and Rhett (in 1983), and Simmers (in 1984) are described in Appendix C to this report, and in the reports of Marquenie, Simmers, and Kay (1987) and Marquenie et al. (in preparation).

6. Results of these preliminary investigations led to an International Working Group of Scientists meeting (the fourth Contaminant Mobility Workshop) in May 1985, in Buffalo, NY, focusing entirely on the Times Beach CDF. The proceedings of this workshop are included as Appendix D. Based upon the suggestions of this group, a more comprehensive evaluation of the nature and extent of contamination was required, including inventories of various components of the ecosystems established at Times Beach and sampling of selected components for contaminant analysis. This interim report collates the data gathered to date (projects are listed in Table 1), provides a reference source for the research conducted at the site, and suggests directions for future relevant research.

Grand Island Reference Site

7. For comparative purposes, a reference area known to be relatively uncontaminated but otherwise similar to the Times Beach CDF was designated by the Buffalo District. This area, of about 1 acre (4,047 m²), is situated on the northeastern shore of Grand Island, near Buffalo, NY (Figure 1).

Table 1

Summary of Contaminant Mobility Studies Conducted to Date at Times Beach

<u>Contributor</u>	<u>Organization*</u>	<u>Description of Project</u>	<u>Date</u>
Folsom/Simmers	WES	Plant bioassays with <i>Cyperus</i> .	1981
Folsom/Simmers	WES	Assessment of water quality at Times Beach.	1982
Marquenie	TNO	Metal analysis of plant mate- rial collected at Times Beach.	1984
Marquenie/Crawley/ Schrieken	WES/TNO	Preliminary planktonic and benthic inventory at Times Beach.	Jun 84
Wilhelm	Morton Arboretum	Inventory of plant species and and assessment of abundance.	1983/ 1985
Stafford	RES/WES	Identification and metal analy- sis of soil macro- invertebrates collected by pitfall trapping.	May 85 Oct 85 May 86 Nov 86
Crawley	WES	Times Beach duck analysis.	Jun 85
Stafford	RES/WES	Assessment of metal variation between species and indivi- duals of the same species.	Jul 85
Wilhelm/Stafford	Morton Arboretum/ RES	Collection of dominant plant species, divided according to leaf, stem, and flower for metal analysis.	Jul - Sep 85
Andrle	Buffalo Museum of Science	Inventory of wildlife at Times Beach: songbirds, ducks, amphibians, and reptiles.	1975 1985 1986
Bryniarski	NCB	Estimation of age of trees at Times Beach by increment boring.	Oct 85

(Continued)

* Key to abbreviations:

- WES = US Army Engineer Waterways Experiment Station.
TNO = Technology for Society Division, The Netherlands.
RES = Rothamsted Experimental Station, England.
NCB = US Army Engineer District, Buffalo, Buffalo, NY.

Table 1 (Concluded)

<u>Contributor</u>	<u>Organization</u>	<u>Description of Project</u>	<u>Date</u>
Neuhauser	Cornell University	Trapping and metal analysis of mice and voles.	Fall 85
Simmers/Rhett	WES	Collection of dredged material in upland ecosystem. Laboratory bioassay with <i>E. foetida</i> .	Apr 86
Bater	Ohio State University	Collection of soil-dwelling microfauna. Identification and estimation of relative abundance.	May 86
Kay/Simmers/ Marquenie	WES/TNO	PCB content of fishes collected at Times Beach.	Sep 86
Simmers/Rhett/ Stafford	WES/RES	Collection of cottonwood leaf litter for metal analysis.	Nov 86
Stafford	RES/WES	Collection and metal analysis of dredged material collected in upland area.	Nov 86
Stafford	RES/WES	Collection and metal analysis of native earthworms in upland area.	Nov 86
Simmers/Rhett/ Brown/Stafford	WES/RES	Dissection of vertebrate fauna and analysis of tissues for metals.	Nov 86
Simmers/Rhett/ Brown/Stafford	WES/RES	Analysis of above vertebrate fauna tissues for content of organics.	Dec 86
Marquenie/Simmers/ Kay	WES/TNO	Preliminary Assessment of Bioaccumulation Report (Misc. Paper EL-87-6).	Apr 87
Marquenie/Simmers/ Rhett/Brandon	TNO/WES	Biomonitoring in the Buffalo River, Times Beach and Lake Erie (Miscellaneous Paper, Marquenie et al., in preparation).	Oct 87

Scope

8. The major objective of this interim report is to provide a collation of the data gathered to date as a result of research conducted at Times Beach. This research has been undertaken through a number of different investigations and by specialists in particular areas (projects are listed in Table 1). To maximize the benefit to be gained from these studies, collation of the data was necessary, so that where sufficient data exist, technically defensible conclusions could be drawn and applied to the management strategy for Times Beach. The report is also intended to identify where trends are suggested by the data but where, at present, insufficient data exist to substantiate conclusions. However, there is reason to believe that additional data would furnish valuable information in assessing contaminant mobility at Times Beach. In these cases, the report suggests the necessary additional research as well as the anticipated benefits. The data gathered at Times Beach are the most comprehensive available to date for assessing the fate of contaminants in an ecosystem developing at a CDF and should therefore be collated and made available for reference in future studies of contaminant mobility at CDFs. Results documented in this report will also provide valuable information for use in the planning of sampling programs at other CDFs so that maximum relevant information is obtained from the minimum number of samples at the lowest cost possible. Findings reported in this document will also facilitate the making of safer management decisions affecting CDFs in general.

9. Within the report, several conventions have been used in order to make the names of animals and plants more easily identifiable. The names of plant and animal species are italicized, other functional names are capitalized and underlined (such as Families, Orders, and Classes), and following the convention of Swink and Wilhelm (1979), common names are capitalized for ease of recognition. A listing of scientific and common names for plants and animals referred to in the text is given as Appendix E. Metric (SI) units of measure have been employed throughout the report with non-SI equivalents supplied where appropriate. In some situations, data sets were not originally in metric measurements, or non-SI units of measure are most commonly used (such as forestry). For these cases, metric conversion factors are supplied.

PART II: METHODOLOGY

10. Where feasible, documentation of the studies undertaken at Times Beach adopts the following pattern: descriptive inventories precede sections describing the collection of samples for analysis. Within each of these sections, characterization of the general physical appearance of the CDF is followed by descriptions of dredged material and soils, vegetation, soil-dwelling invertebrates, including earthworms, and finally, vertebrates.

11. Partial filling of the Times Beach CDF resulted in the creation of upland, wetland, and aquatic areas. An aerial photograph shows the physical layout of these areas at the site (Figure 2), and the diagrammatic representation of a cross section of the Times Beach CDF identifies major components of the ecosystem in each area (Figure 3). Initial samples of dredged material and water were collected and analyzed to ascertain the extent of contamination at the site (see preliminary assessments presented in Appendix C and the reports of Marquenie, Simmers, and Kay 1987 and Marquenie et al., in preparation). Summaries of the results of these initial investigations are given in Appendix B, Part I(1), Table 1 (dredged material), and Appendix B, Part III(1), Table 16 (water quality).

12. Descriptions of physical conditions at the site and vegetation colonizing each area were made by a number of scientists, each specializing in a particular field. Extracts from their reports are included in Part III of this report, and the full descriptive inventories comprise Appendix A to this report. For the purposes of their descriptions and based upon their observations, each investigator defined distinct zones within the upland, wetland, and aquatic areas at the site. Zones defined by Bryniarski, Andrle, and Wilhelm are shown in Figures 4-7, respectively. The physical appearance of Times Beach was described initially by Bryniarski in 1975, and subsequently by Andrle in 1975, 1985, and 1986. The vegetation at Times Beach was described in detail by Wilhelm in 1983 and 1985. These descriptive inventories led to the definition of distinct vegetation zones within the site, and those zones delineated by Wilhelm in his 1985 survey were used to select plots for the collection of dredged material, vegetation, and soil-dwelling invertebrates, including native earthworms. Details of the sampling procedures are described in a later part of this report.

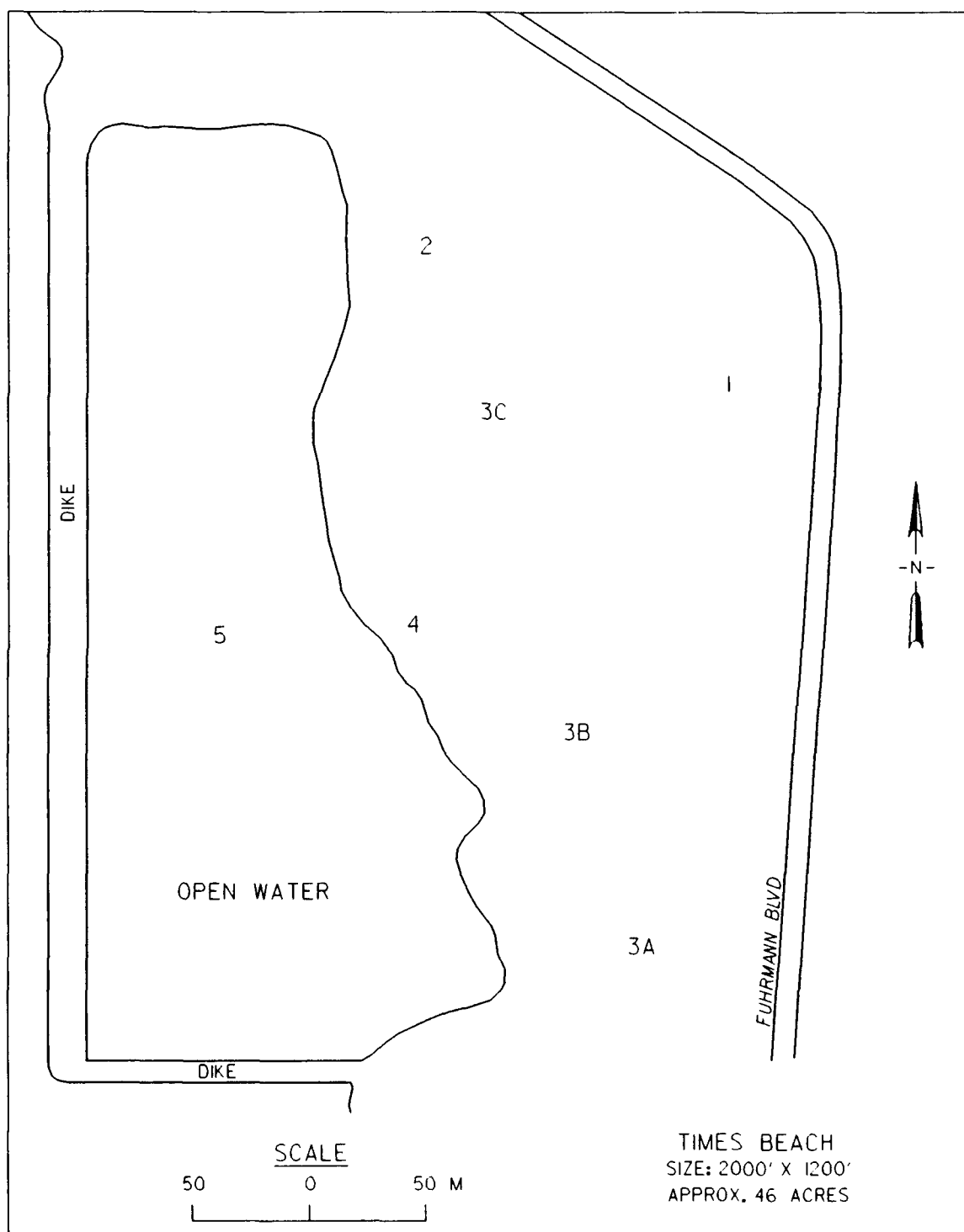


Figure 4. Times Beach CDF showing vegetation areas as defined by Bryniarski, 1975. (For key, see Table 2)

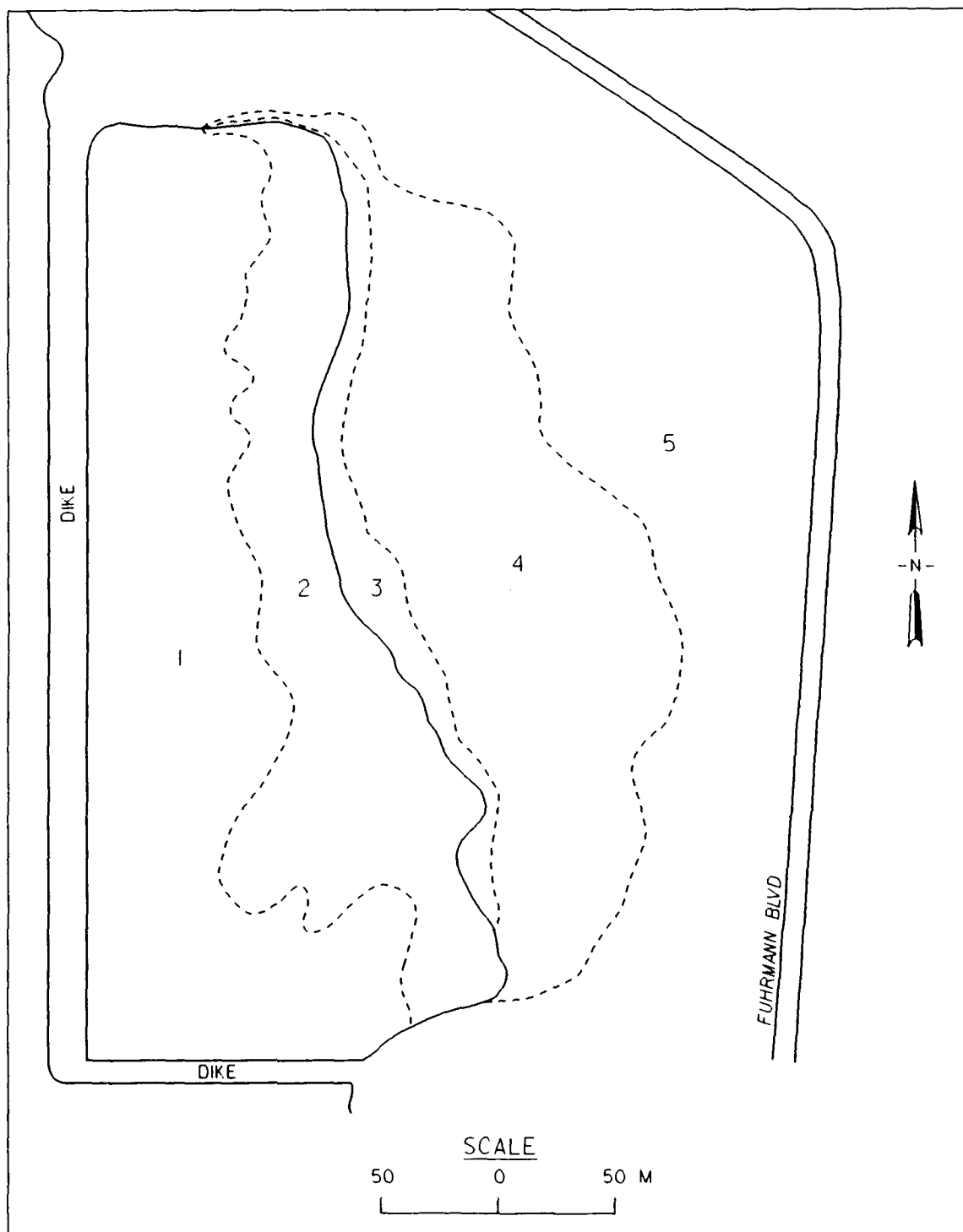


Figure 5. Times Beach CDF showing physical zones as defined by Andrie, 1975 (1 = deep water, 2 = shallow water, 3 = littoral, 4 = silt flat, 5 = upland).
(For more details see Appendix A)

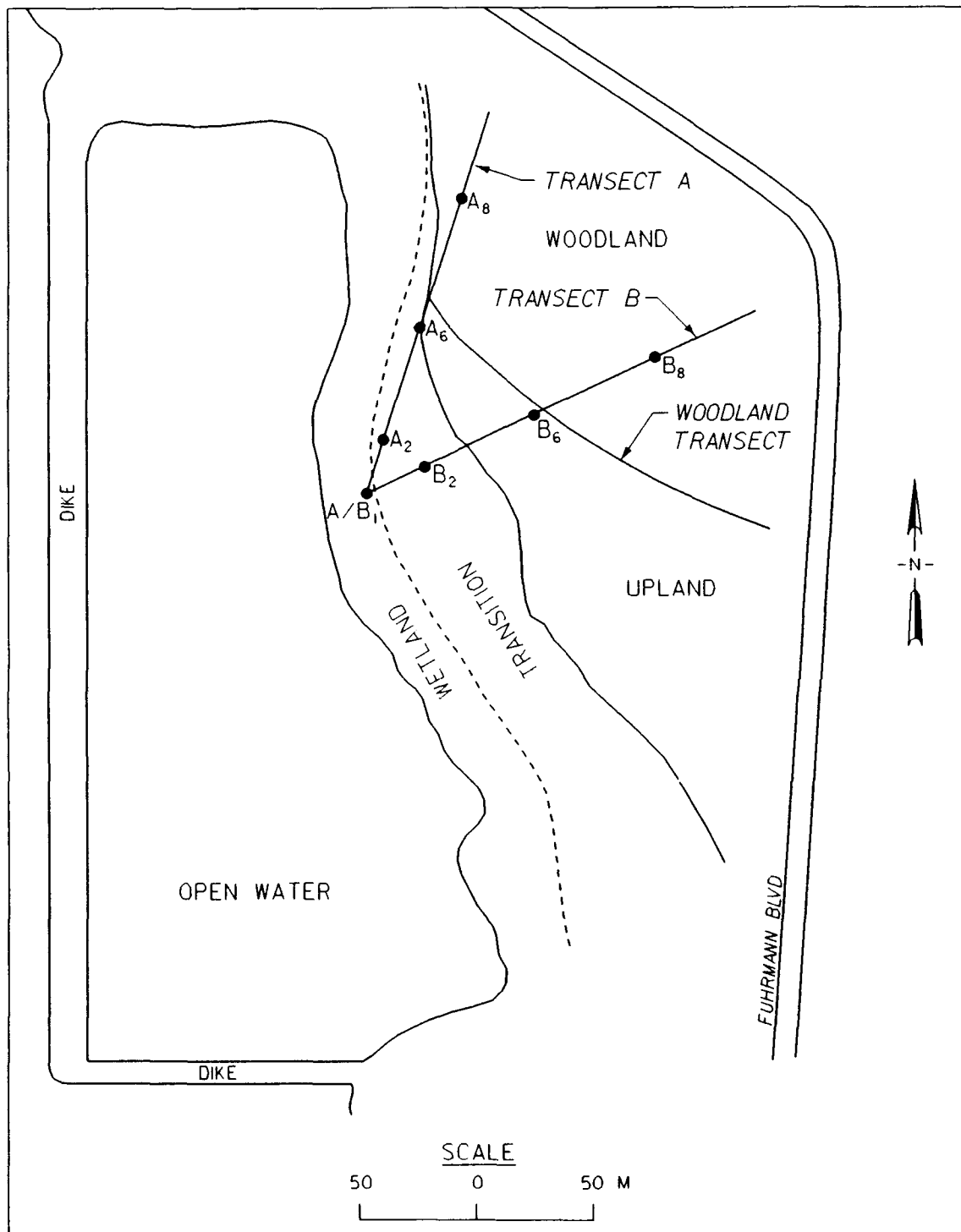


Figure 6. Times Beach CDF showing Transects A and B and the woodland transect used for identification of vegetation by Wilhelm, 1983 (see Tables 3a, 3b, and 4a)

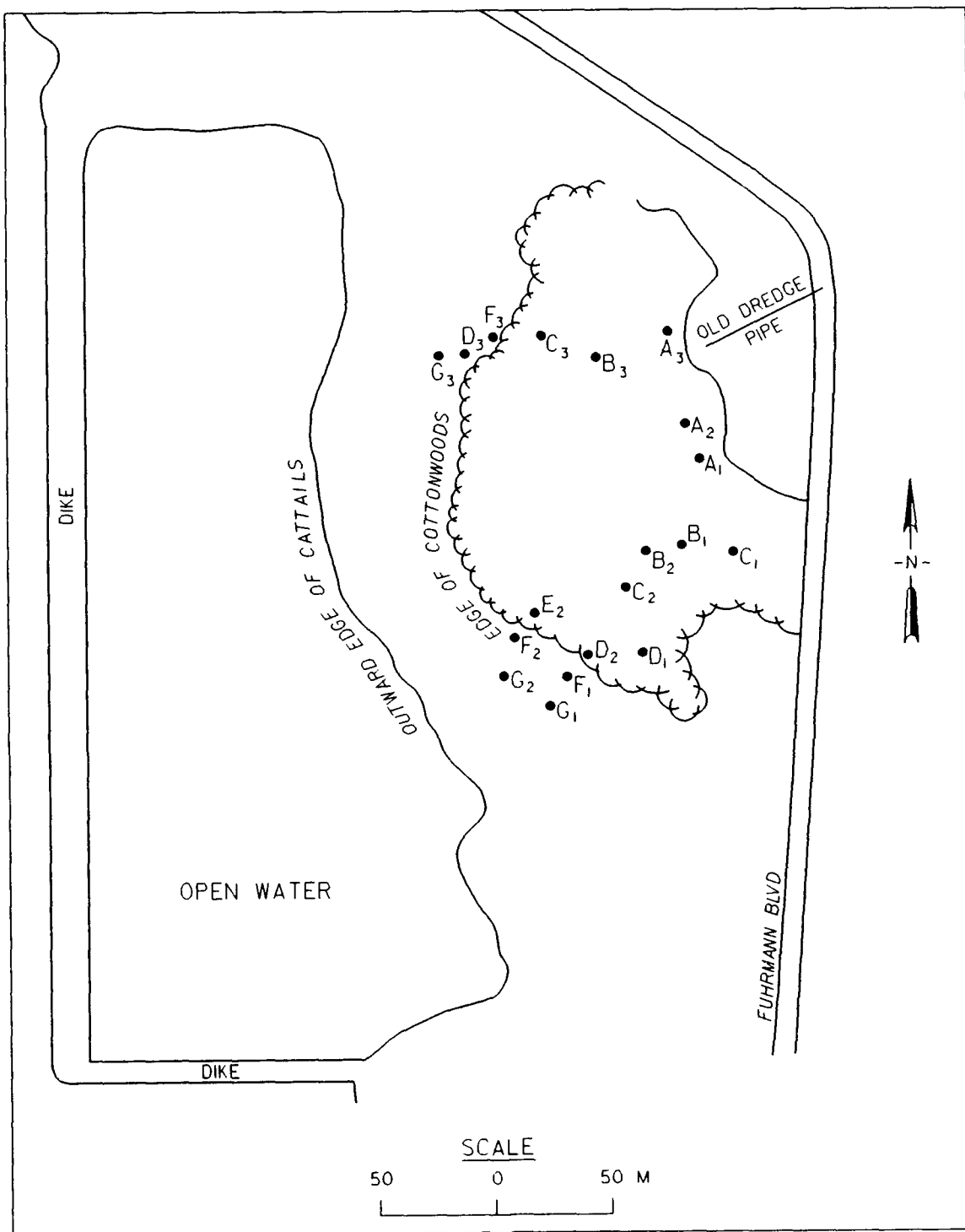


Figure 7. Times Beach CDF showing vegetation types as defined by Wilhelm, 1985, and used for the collection of vegetation samples for chemical analysis. Codes are: A = Upper Cottonwood, B = Dogwood/Cottonwood, C = Lower Cottonwood, D = Giant Reed Grass, E = Reed Canary Grass, F = Purple Loosestrife Marsh, G = Cattail. (For more detail, see paragraph 17)

Descriptive Inventories - Vegetation

13. Vegetation was surveyed, qualitatively recorded, and evaluated quantitatively by Wilhelm (The Morton Arboretum, Lisle, IL) using the technique described by Swink and Wilhelm (1979). This technique has predominantly been employed in the evaluation of vegetation within the 22-county Chicago, IL, region. However, the remarkably close resemblance between the Times Beach CDF and similar sites in the Chicago region made the technique useful for making comparisons among floristic areas within the CDF.

14. Three inventories of vegetation at Times Beach were made by Wilhelm: one in 1983 (summer) and two in 1985 (in July and September). For the 1983 survey, two linear transects, A and B, were established, starting in the marsh area and extending to include lower portions of the wooded area (Figure 6). These transects are also described by Marquenie, Simmers, and Kay (1987). Each transect consisted of eight sample plots approximately 7.5 m in diameter, with their centers about 20 m apart. Transects A and B shared plot 1 (AB). For each plot, estimates were made (subjectively by Wilhelm) regarding the percent phytomass for each vascular plant taxon noted within the plot. This was termed the "perceived relative phytomass." The percent phytomass is likely to change somewhat from season to season with respect to species composition, but midsummer (7 July) was considered to be a good point of reference. Also within each plot, all living trees were counted and their trunk diameters, if 2.5 cm (1 in.) or greater at 1.4 m (4.5 ft) above the ground (diameter at body height, DBH), were recorded. In this case, all of the trees sampled were *Populus deltoides*.

15. Also in 1983, in conjunction with Transects A and B above, a 125-m transect was laid out through the upland wooded area, beginning at the "No Trespassing" sign at the east edge of the fill (this was the third such sign from the North along Fuhrmann Boulevard). This transect consisted of nine sample plots, each approximately 15 m apart. It extended perpendicular to the road in a westerly direction (Figure 6). The vegetation was recorded in the manner described for Transects A and B, as was the circumscription of the plots. All botanical nomenclature follows Fernald (1950), while common names are those employed by Swink and Wilhelm (1979).

Sampling Plots in the Upland and Wetland Areas

16. In 1985, as a result of further observations of vegetation at Times Beach, a detailed classification of vegetation into seven zones, termed Transects A-G, was made by Wilhelm, in collaboration with Ernst, of the Free University, Amsterdam, The Netherlands. This classification into vegetation zones was derived from observations made by Wilhelm in 1983. Each zone was marked by a distinct association of vascular plants, and each zone has its own physiognomic characteristics. These zones were later used in the selection of transects for collection of vegetation samples for chemical analysis and in the selection of plots for placement of pitfall traps and collection of invertebrate samples. Therefore, a brief description of each of the zones has been extracted from an unpublished report compiled by Wilhelm in 1985 and is given here. Seven sampling transects (A-G) were laid out across elevation gradients at the Times Beach CDF. With the exception of Transect E, each transect consisted of three permanent quadrats 5 m square; Transect E had only one. Quadrats were designated A1, A2, A3, B1, etc. The position of each of these quadrats is shown in Figure 7. Transects A-C were in the upland area, and Transects D-G were in the wetland area. It should also be pointed out that the definition of upland and wetland areas at the Times Beach CDF is influenced by fluctuating water levels in Lake Erie (as a result of rainfall, etc.), and the transition zone between upland and aquatic areas will vary with season.

Transect A is the highest and driest of the transects. It is wooded, almost entirely by Cottonwood (*P. deltoides*). These trees average 10.6 cm (4.2 in.) $\pm$ 5.4 cm (2.2 in.) DBH, and have a density of about 1,100 trees per acre. It is dominated beneath by the perennial Tall Goldenrod (*Solidago altissima*). The incipient "A" horizon here is the deepest and most oxidized of all the transects; inundation even for short periods is rare. There is probably a loss of nutrients each year due to leaching, though decomposition of the nonligneous annual productivity does not appear to be complete.

Transect B is, on the whole, 0.6 to 0.9 m lower in elevation than Transect A; it is also dominated in the canopy by Cottonwood, but there is a lower story characterized by the Red-Osier Dogwood (*Cornus stolonifera*) along with a few Willows (*Salix* spp.). The ground cover is relatively diverse and is variously populated by the Common Jewel Weed (*Impatiens capensis*), Purple Loosestrife (*Lythrum salicaria*), Goldenrods (*Solidago* spp.), and others. Here the Cottonwoods average 8.1 cm (3.2 in.) $\pm$ 4.8 cm (1.9 in.) and

have a density of about 1,500 trees per acre. While the upper 0.3 m or so of soil is fairly well oxidized, this transect is evidently inundated for short periods every year. Decomposition of the nonligneous annual productivity appears to be more complete than in Transect A, but the annual yield is not as high.

Transect C is the lowest of the transects in the upland area. It is characterized by a canopy of Cottonwoods which average 8.9 cm (3.5 in.) $\pm$ 3.3 cm (1.3 in.) DBH; there are about 1,400 trees per acre. There is no significant middle shrub story. The ground cover is nearly everywhere dominated by *I. capensis*. The decomposition of seasonally produced phytomass is nearly or quite complete, though nonligneous productivity is much reduced when compared with the other six transects. Only the top few inches are fully oxidized, and it is evident that the transect area is subjected to frequent inundations, vulnerable to the vagaries of water-level fluctuations in Lake Erie.

Transect D is dominated by Giant Reed (*Phragmites australis*). Only random stems of Cattail (*Typha* spp.) and *L. salicaria* are apparent. This transect is under the influence of regular inundation. Decomposition of the annual phytomass production is poor, though much of it appears to be broken mechanically and spread as flotsam to accumulate in shallow ridges along high water lines.

Transect E is dominated by Reed Canary Grass (*Phalaris arundinacea*). Though it is not a significant plant at this particular CDF, this small stand was selected for analysis only because elsewhere in the Great Lakes region it is a very abundant and aggressive component in disturbed wetlands. Analysis of this species in the context of the Times Beach CDF would seem to be useful. It represents a clone-like stand within an area that is transitional between Transects C and F.

Transect F comprises most of the paludal zones below the "upland" wooded area and above the Cattail marsh. It is fairly diverse, though until midsummer there is very little productivity because of lingering levels of high water. Later, however, it becomes dominated by *L. salicaria*, and later yet by Rice Cutgrass (*Leersia oryzoides*). Productivity late in the year is fairly high, and decomposition appears to be high as well; alternatively, the dead plant parts are washed out into the deeper marshes. The caudices of the *Lythrum* in many instances are thick and quite ensconced, evidently unperturbed by fluctuating water levels. Young seedlings of this perennial are also abundant.

Transect G is the lowest in elevation, inundated nearly or quite all of the time. It is dominated by two Cattail species: *Typha latifolia* and *Typha angustifolia*. Productivity here appears to be high, although accumulations of duff seem not to be as great as in some other Cattail marshes. Fluctuating water levels, ice, and wave action appear to break up the leaves and distribute them as flotsam, not only throughout the littoral zones, but probably also in the deeper portions of the marsh and diked area as well.

Beyond Transect G lies the aquatic area, with surface and submergent aquatic flora.

Sample Collection for Chemical Analysis

Upland and wetland areas

17. Dredged material. Samples of the dredged material pumped into the Times Beach CDF were collected in 1981 from the upland area for use in conducting plant and later (1982) animal uptake studies. Subsequently, in 1983, samples were collected in the upland area and separated into oxidized, surface-layer material (top 20 cm) and unconsolidated, deep-layer material (taken from below the water table, at least 1-m depth) for separate analysis. The layer of dredged material below the water table remained unconsolidated and in a reduced condition. Contaminant concentrations in this layer were considered to be essentially the same as those in the original dredged material. From each of the plots along transects A and B, as defined by Wilhelm in 1983, dredged material samples (surface layer = top 20 cm) were collected and subjected to analysis for heavy metal and organic contaminant concentrations. Methods of collection and chemical analysis of these samples are fully described in the report by Marquenie, Simmers, and Kay (1987) and in the preliminary assessments prepared by Folsom in 1982, Simmers and Rhett in 1984, and Simmers in 1984, which are included in Appendix C. In 1986, dredged material was collected from each of the transects (A-C) within the upland area of Times Beach as defined by Wilhelm in 1985 and from additional plots corresponding to those used for the collection of soil-dwelling invertebrates. Dredged material collected using a soil corer (5-cm diameter by 15 cm) at each plot was placed in a polyethylene zipper-lock bag, mixed, air-dried, and passed through a 2-mm sieve. A subsample was then removed and oven-dried in preparation for metal analysis.

18. Vegetation. In 1985, following the recommendations of the International Working Group that met at Buffalo and focused on the Times Beach CDF, collections of phytomass were made in early July and in late September. Leaves, stems, roots, rhizomes, and fruits were sampled from the dominant phytomass producer in each plot. Roots and rhizomes were bagged together and later separated and cleaned in the laboratory. These samples were stored at -20° C but not used for chemical analysis. Leaves, stems, and fruits were

bagged separately in the field. Leaves and stems of *Impatiens* were cut away at the root and bagged together for analysis. A record of plant parts collected in July and later used for determination of heavy metal concentrations is given in Appendix B, Part I(2), Table 3. In addition to the living phytomass collected, grab samples of leaf litter (*Populus deltoides*) were collected in November 1986, and samples from Transects A, B, and C were composited for analysis of heavy metal concentrations.

19. Plant parts were handled and treated according to the following method of Ernst: after collection, the plants were put immediately into polyethylene, zipper-lock bags and placed on ice to avoid biomass consumption by respiration. The aboveground parts, with the exception of the flowers and fruits, were washed three times for 1 min in distilled water, then blotted between filter paper and dried at 80° C for 48 hr. Belowground parts were cleaned roughly and washed three times for 5 min in 0.1 M KCl solution. This was followed by three washings, for 5, 3, and 1 min, in distilled water. Exterior layers of tubers (dead material) and rhizomes (periderm) were removed. Inasmuch as the roots remained contaminated by dredged material, the dredged material (silica fraction) could be collected after wet ashing. After drying and weighing, the contamination could be calculated.

20. For each species, a perceived relative phytomass coefficient was assigned in July. This was a subjective assessment of the standing crop of vegetation made by Wilhelm and based on his observations. This coefficient ranged from 0 to 100 percent and was given subjectively in increments of 5. Estimates were made on the plants in each plot relative only to other plants in that plot. A species with a coefficient of 100 percent indicates the whole plot contains only that species. Species preceded by a "-" symbol were present but comprised less than 3 percent of the total phytomass in July. Net productivity, as measured by the standing crop of four dominant nonligneous species, was sampled 25 September 1985.

21. Soil-dwelling macroinvertebrates. Invertebrate fauna were collected from plots within each of the vegetation zones (A-C) as defined by Wilhelm in 1985, in the upland area at Times Beach (Figure 8). Samples were collected in the spring and fall of 1985 and 1986. All samples were returned to the Entomology Department of Rothamsted Experimental Station, Harpenden, UK, for identification and analysis.

22. Soil-dwelling invertebrate fauna were sampled using pitfall traps

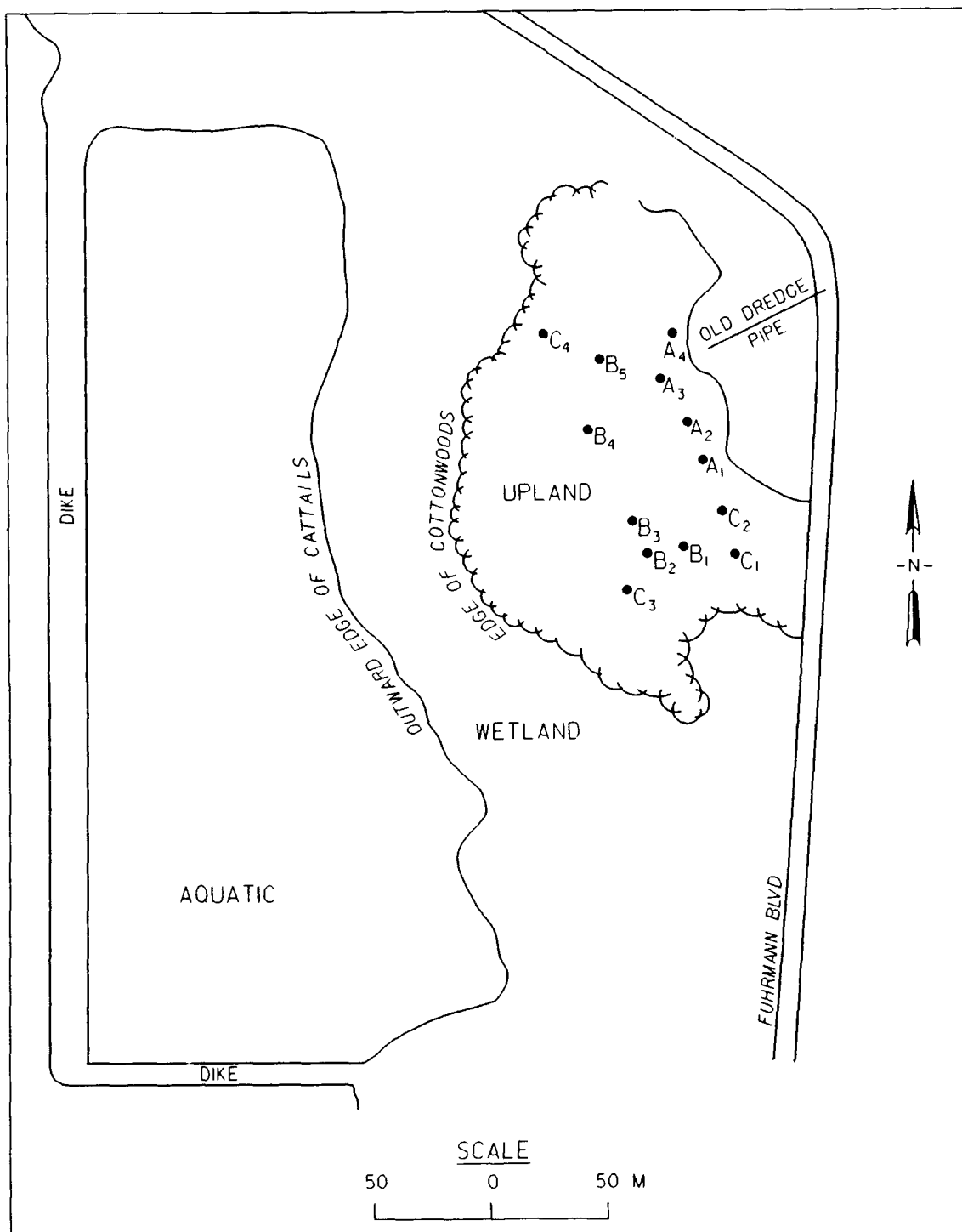


Figure 8. Times Beach CDF showing sites used for collection of soil-dwelling invertebrates by Stafford and Bater, 1985 and 1986

containing 20 ml of 5-percent formalin solution. Four pitfall traps, placed in the dredged material at each corner of a 1-m² plot, were situated within each of Transects A1, A2, A3, B1, B2, B3, C1, C2, and C3, as described by Wilhelm in 1985 (see paragraph 12). Four additional plots at Times Beach were also used: one each in vegetation zones A and C, and two in vegetation zone B (Figure 8), making a total of 13 plots. The upper rim of the pitfall trap was placed level with the surface of the humus layer of the soil as shown in Figure 9. In May 1985, for the initial investigation, 7 of the 13 possible plots were used, and pitfall traps were left in position for 3 days before the contents were collected. In subsequent seasons (September 1985, May 1986, and November 1986), pitfall traps were left in position at all 13 of the plots for 10 days. After each sampling period, fauna collected in the four traps from each plot were pooled, rinsed free of debris, and stored in 5-percent formalin solution for later identification and analysis. Formalin preservation has been shown to be a suitable method of storing samples prior to metal analysis (Wiemeyer, Moore, and Mulhern 1984). The period of storage between collection and preparation for analysis did not exceed 4 weeks.

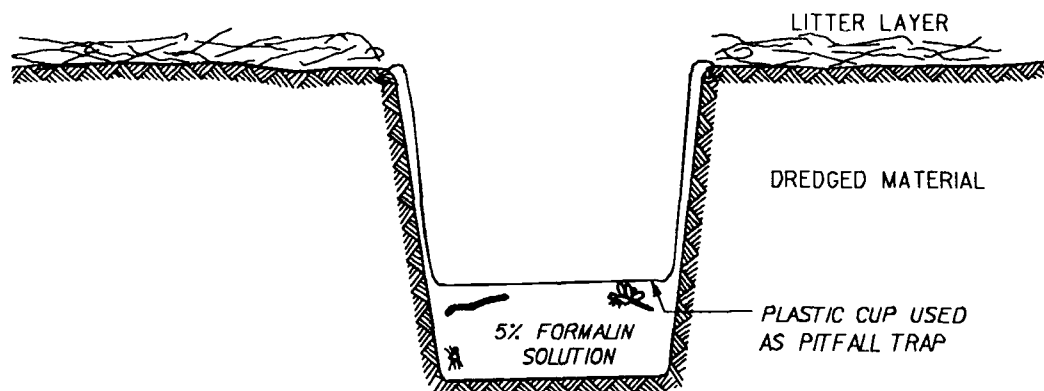


Figure 9. Pitfall trap used to collect soil invertebrates

23. Fauna collected in each of the pitfall traps were sorted into major taxonomic groups and counted. The following taxonomic groupings were used to evaluate the fauna in the pitfall traps: Diplopoda (Millipedes) and Chilopoda (Centipedes) were grouped according to Class; the Class Arachnida was further divided into the Orders Araneida (Spiders) and Opliolones (Harvestmen). The Class Insecta was further divided into the Orders Orthoptera (Grasshoppers) and Coleoptera (Beetles), and the Isopoda (Woodlice) were grouped together as an Order within the Class Crustacea. These groupings were chosen on the basis of biomass and numerical abundance of specimens collected

in the traps and the diversity of species within the group. Within each group, further identification was carried out where expertise was available. To obtain sufficient biomass for chemical analysis, individuals of the same taxonomic group from the four traps at each plot were pooled. Invertebrates of each taxonomic group from each plot were oven-dried at 80° C to constant weight and their dry-weight biomass was recorded.

24. Soil-dwelling microinvertebrates. In May 1986, a soil corer (15 by 5 cm) was used to provide holes for the placement of pitfall traps; the dredged material thus excavated was returned to the laboratory and placed in a Tulgren funnel apparatus for the extraction of soil-dwelling microinvertebrates. Specimens collected from the dredged material were sorted and identified by Mr. John Bater of the Entomology Department of Ohio State University (OH).

25. Earthworms. Native earthworms colonizing the Times Beach CDF were obtained by application of 0.5-percent formaldehyde solution to the dredged material (Raw 1959). The formaldehyde solution, termed a "vermifuge," caused minor irritation to the earthworms in the dredged material, resulting in their emergence on the surface. This vermifuge was applied within each of the plots shown in Figure 8. Earthworms emerging as a result of the vermifuge were immediately rinsed free of the chemical in tap water and held in a sample of dredged material collected before application of the formaldehyde. Earthworms could then be returned to the laboratory for identification and preparation for chemical analysis. Earthworms were not allowed to purge their gut contents before analysis, since interspecific differences in rates of gut evacuation may have influenced the results of metal analysis. Instead, the method of Stafford and McGrath (1986) using acid-insoluble residue concentration was used to apply a correction factor which eliminated the effect of substrate present in the earthworm gut on the results of metal analysis. A preliminary assessment of the earthworm population at Times Beach was made in May 1985, and a more comprehensive collection from each of the plots shown in Figure 8 was made in November 1986.

26. Bioassay procedures. Details of bioassay procedures applied at the Waterways Experiment Station, using plants (Yellow Nut Sedge, *Cyperus esculentus*) and animals (Red Wiggler Earthworms, *Eisenia foetida*) to measure contaminant uptake by biota exposed to the dredged materials from Times Beach, are given in the preliminary assessment reports included as Appendix C to this

report and in Simmers et al. (1986). Dredged material from each of the plots shown in Figure 8 was collected in April 1986 and returned to the laboratory at WES. A 28-day earthworm bioassay was conducted under controlled temperature and light conditions. Earthworm samples are currently being stored at -20° C awaiting analysis.

27. Vertebrate fauna. Toads, identified as *Bufo americanas*, were also caught in several of the pitfall traps placed at Times Beach for the collection of invertebrates. These were either dried whole or (if large enough) dissected to remove the liver, kidney, and bone (femur, tibia, and fibula) tissues that were dried in preparation for analysis.

28. Observations of mammals and birds were made by Dr. Robert Andrie (Buffalo Museum of Science, Buffalo, NY) on frequent visits to the site (e.g., 37 visits between 12 May 1985 through 31 May 1986). These visits were conducted on foot during diurnal, crepuscular, and nocturnal time periods. Based upon information on life cycles and behavior of the vertebrates present, it was possible to identify resident and visitant vertebrates and to determine as far as possible their occurrence, distribution and abundance, and position in the food web. Investigations were based on a north/south-oriented 100-yd (92.3-m) scale grid superimposed on an outline map (topographic and general terrestrial-aquatic) constructed by the Buffalo District (included in Andrie's report, Appendix A). During each visit, observations were conducted systematically in all existing habitats and were concentrated on mammals, birds, reptiles, and amphibians. Selected resident species were collected for chemical analysis. Specimens from designated reference areas were also collected for comparative purposes. Species collected and the tissues dissected and removed for analysis of heavy metal and organic contaminant concentrations are listed in Appendix B, Part I(5), Table 12(a).

29. To sample the small mammals colonizing the Times Beach CDF, trap lines were placed across the site by Neuhauser in 1985 (see Table 1). In order to make an estimate of the populations of these small mammals, a mark and recapture technique was used, and only animals which died in the traps were used for making the measurements of heavy metal concentrations that are included in this report. Liver, kidney, muscle, and bone tissues were dissected from these specimens for metal analysis.

Aquatic area

30. Water quality. Assessment of water quality at Times Beach was made in 1982 and 1985. In 1982, samples of water from the aquatic area at Times Beach were collected by Buffalo District personnel and shipped to the WES for chemical analysis. Samples of water were collected in glass containers (filtered and unfiltered) and in plastic containers (unfiltered) for measurement of heavy metal and organic contaminant concentrations.

31. In 1985, ground water at the Times Beach CDF was collected using ground-water monitoring wells. A model 51453 depth gage was used to measure well depth and calculate the amount of water contained in each well. Three well volumes were evacuated with an ISCO Model 2600 well sampling pump. After evacuation, each well was allowed to stand undisturbed for 5 min to allow any sediments to settle. The water samples were then taken using a Teflon bailer. Field conductivity and pH were also measured. Water samples were filtered through a 0.45-mm filter utilizing a Nucleopore 425900 pressure filtration device. The filtered and unfiltered samples were then split and preserved in containers as follows:

- a. One-quart (0.948-l) glass for extractable organics.
- b. One 250-ml glass with septum top for volatile organics.
- c. One-quart (0.948-l) plastic with nitric acid for metal analyses.

32. Planktonic and benthic inventory. In June 1984, samples of plankton were collected at four stations in the aquatic area at Times Beach. Two stations were situated in Lake Erie at the outside of the dike enclosing Times Beach; two stations were situated on the inside of the dike. Each sample was composed of three equal hauls of approximately 5 m, made with a regular plankton net (50 μ , 30-cm diameter). Plankton were preserved in 4-percent formalin. Samples were diluted to 10 ml, and a 1-ml subsample was counted. Sediment samples from the *Typha* marsh were sieved over 0.5-mm screen, and animals were hand collected and stored in 4-percent formalin.

33. "Mussel watch." An assessment of the mobility of contaminants within the aquatic area of the Times Beach CDF was made using the "mussel watch" technique, based on the procedure of active biomonitoring with mussels initially developed by Goldberg (1976). Mussels of the species *Elliptio dilatata* were collected from a pristine lake and exposed to the sediment and water column at Times Beach, in Lake Erie, and in the Buffalo River. Full

details of the methods employed, results obtained, and implications for contaminant mobility at Times Beach are provided in a separate report (Marquenie et al., in preparation).

34. Vertebrates. Of the bird species collected by Andrie during his observations at the site, the duck specimens were considered most relevant to the assessment of contaminant mobility in the aquatic area of Times Beach. Several species of duck were known to nest at the site, and immature ducks born and raised at the site would feed entirely within the confines of the CDF, thus representing a potential pathway for the movement of contaminants out of the CDF. Specimens of mature and immature Mallard Ducks were collected by Andrie and by WES personnel and returned to the laboratory. These were dissected to remove liver, kidneys, muscle, and bone tissue and were prepared for analysis of heavy metal and organic contaminants.

35. Fish species naturally colonizing the aquatic area of the Times Beach CDF were collected primarily by seining and, to a lesser extent, by hook and line. Similar sized individuals of the same species were pooled, packed in polyethylene bags, and frozen at -20° C until analyzed. Fish of the species Yellow Perch (*Perca flavescens*), Pumpkinseed (*Lepomis gibbosus*), Rock Bass (*Ambloplites rupestris*), and Carp (*Cyprinus carpio*) were collected in sufficient quantity for analysis. Livers and fillets of the lateral musculature were removed, homogenized, and stored frozen at -20° C in preparation for chemical analysis.

Grand Island reference site

36. Five plots of similar size to those delineated at Times Beach were selected for the collection of samples at the Grand Island reference site. Soil samples were collected for analysis of heavy metal concentrations from within each of these plots, for determination of the soil-dwelling microfauna by means of the Tullgren funnel apparatus, and for conducting laboratory earthworm bioassays using the earthworm species *Eisenia foetida*. In each case, the methods of collection and treatment in the laboratory were as described for those samples collected at Times Beach.

37. Due to the different species composition of the vegetation at the Grand Island site compared with the Times Beach CDF, vegetation samples were not collected for heavy metal analysis.

38. From within each of the Grand Island plots, native earthworms were collected in November 1986 using the formalin vermifuge. Four pitfall traps

were placed in each of the five plots for collection of soil-dwelling macro-invertebrates. Pitfall traps were left in position for 10 days in May 1986 and November 1986. Treatment of the soil-dwelling macroinvertebrate samples followed the same procedure as described for the Times Beach samples. At the Grand Island site, frogs, salamanders, and shrews were caught in some of the pitfall traps, and these were the only vertebrate samples collected from this site. These specimens were either dried whole or, where size permitted, dissected to remove liver, muscle, and bone tissue for metal analysis.

39. To place the results obtained at Times Beach in perspective, investigators collecting vertebrate samples at Times Beach selected "reference" areas known to be either highly contaminated or uncontaminated. From these areas, vertebrate samples were collected that would provide information on the range of metal concentrations which may be expected. Andrle selected the Amherst site near Buffalo, NY, for the collection of Red-winged Blackbirds; he also collected Mallard Ducks from a site known to be relatively uncontaminated. Neuhauser used information gathered at contaminated and uncontaminated sites in Binghamton, NY, for comparison of mice and vole tissue metal concentrations, and Marquenie furnished information gathered from contaminated and uncontaminated lakes in The Netherlands for comparison of Mallard Duck metal concentrations.

Chemical Analysis

40. Total concentrations of 36 elements in dredged material collected at Times Beach in 1981 were measured by instrumental neutron activation analysis (INAA) at the laboratories of The Netherlands Organization for Applied Scientific Research (TNO) and also, for some elements, were measured by atomic absorption spectrophotometry after digestion in concentrated HNO_3 . Full details of the methods used are included in the report by Marquenie, Simmers, and Kay (1987).

41. Unless stated otherwise, metal concentrations in samples were determined as follows. In preparation for metal analysis, samples were oven-dried at 80°C to constant weight. Total metal concentrations in the dredged material, flora, and fauna samples were determined after a wet-ashing digestion procedure. Sample weights of less than or equal to 0.5 g (dry weight) were digested in "AnalaR" grade concentrated HNO_3 (5 ml) at room temperature

for 48 hr and then refluxed at 125° C for 5 hr. After cooling, AnalaR grade 70-percent HClO₄ was added before reheating to 200° C, taking samples almost to dryness. Samples were then reextracted in hot 25-percent HCl and made up to final volume (5-percent HCl). The final volume available for metal determinations depended upon the sample weight initially available from collection. Concentrations of zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), chromium (Cr), and lead (Pb) were determined using inductively coupled plasma (ICP) emission spectrometry (ARL 34000 instrument). Standard solutions of these elements were prepared using the same extractant solution, and reagent blanks were also run. In some cases (mostly invertebrates), insufficient biomass was available for analysis. In all circumstances, due care was taken to avoid contamination by metals in the analytical procedures.

42. When making an assessment of the bioavailability of heavy metals, it is essential to distinguish between metal within the animal tissue and metal present as a result of soil in the sample, for example soil within the earthworm gut. For the purposes of preliminary investigations and earthworm bioassays, earthworms were held on moist filter paper for 48 hr to allow time for gut evacuation. As this was not practicable in the field, a new method was developed in response to these needs, which utilizes acid-insoluble residue as an inert marker to enable the quantity of soil present in any earthworm sample to be calculated. A correction factor can then be applied which eliminates the heavy metal concentrations resulting from soil within the earthworm gut, leaving only the concentrations of heavy metals in the earthworm tissue. Full details of this method have been published elsewhere (Stafford and McGrath 1986). For similar reasons, concentrations of metals in other samples, for example Mussels, have been expressed in terms of ash-free dry weight (Marquenie et al., in preparation).

43. Analysis of samples to determine concentrations of organic contaminants, such as polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs), was carried out as described in the reports by Marquenie, Simmers, and Kay (1987) and Marquenie et al. (in preparation). All samples were homogenized and stored frozen (-20° C) until analyzed.

44. Subsamples of each sediment and fish tissue homogenate collected in the aquatic area of the Times Beach CDF (Kay, Simmers, and Marquenie 1986) were dried and ashed to allow the expression of concentrations of contaminants on the basis of either dry weight for the sediment collected from the edge of

the open water, or ash-free dry weight for the fish tissue samples. The PCBs were extracted and analyzed for nine congeners by electron capture gas chromatography. Full details of this study are provided by Kay, Simmers, and Marquenie (1986).

Statistical Analysis

45. Prior to the statistical comparison of data, the homogeneity of variance between the plots was tested using Cochran's test for homogeneity of variance. Where necessary, data transformations were carried out until valid comparisons could be made using analysis of variance. Statistical comparisons between the means were achieved using the Waller-Duncan k-ratio t-test. Where homogeneity of variance was not achieved by data transformation, comparisons between the means were carried out using nonparametric tests. Two nonparametric tests were applied as appropriate; if $k = 2$, the Mann-Whitney U test was applied, and if $k > 2$, the Kruskal-Wallis test was employed (Winer 1971, Sokal and Rohlf 1981). Where relevant, the method of comparison between means is indicated for tables presented in this report.

PART III: RESULTS OF DESCRIPTIVE INVENTORIES

46. Dredged material was discharged into the Times Beach CDF from a point source disposal pipe (see Figure 7); as a result, some gradation of physical and chemical characteristics of the sediment is likely to occur, as well as the obvious topographical changes with increasing distance from the pipe. Three distinct areas have been described: upland, wetland, and aquatic (Figure 3). The drier, higher disposal area, termed "upland," is roughly semicircular around the disposal pipe and occupies the northern and northeastern extremities of the fill area, comprising about a quarter of the total CDF. Approximately half of the site lies below the level of the water table (to a water depth of up to 2 m) and has been defined as the "aquatic" area. The low-lying silt or mud-flat section between the upland and aquatic areas, of similar elevation to the water table, is defined as the "wetland" area and, although of variable width, comprises approximately a quarter of the site. Delineation between the three areas is somewhat arbitrary since it varies with the season and the changing stages of Lake Erie. Descriptions of the species colonizing each of the designated areas and the CDF in general have been provided by a variety of specialists (see Table 1). Their detailed reports, summarized here, are included as Appendix A to this report.

Upland and Wetland Areas

Vegetation

47. Vegetation at the CDF was initially described by Bryniarski in July 1975. Bryniarski defined five vegetation zones at Times Beach (Figure 4) and recorded common, uncommon, and rare plant species (by common names) within each locale (Table 2).

48. This classification was subsequently updated with a more detailed account made by Wilhelm in the summer of 1983. Wilhelm conducted a vegetation survey along two transects (A and B) through the wetland and lower areas of the upland and on one transect that traversed the drier, wooded, upland area in the northeast portion of the fill (Figure 6). The results of this 1983 survey and the percent biomass per species at the time of survey are given in Table 3a (Transect A, Transect B, and the Woodland Transect). Vegetation of

Table 2
Results of Field Inspection of Vegetation at Times Beach
Bryniarski, July 1975*

<u>Locale</u>	<u>General Description</u>	<u>Herbaceous spp.</u>	<u>Abundance</u>
1	Woody vegetation dominant (trees) with scattered openings of some terrestrial herbaceous vegetation on somewhat drier, higher, filled portions of the terrain. The woody plant overstory contains Eastern Cottonwood (C) and Willow (C).	Goldenrod Buckhorn Plantain Cocklebur Smartweed Sedges Rice Cutgrass Softstem Bulrush Johnsongrass Bouncing Bet Broadleaf Cattail	C UC C UC UC C UC UC UC UC+
2	Infestation of softstem bulrush dominant (estimated 98% of this locale); remaining 2% of locale in slender spikerush, sedges, and smartweed.		
3A	Southern half of this locale contains established invasions of young Eastern Cottonwood and Willow. Northern half of locale is basically open and invaded with herbaceous species.	Rice Cutgrass Purple Loosestrife Smartweed Cocklebur Slender Spikerush Narrowleaf Cattail Broadleaf Cattail Buckhorn Plantain Curled Dock Reed Canarygrass Giant Reed Squirrel Tail	C C C C C R+ C+ UC R R+ R+ R
3B	Herbaceous species predominant on 100% of this locale, with Rice Cutgrass most dominant followed by scattered invasions of Purple Loosestrife. Subdominant species included consist of sedges, slender spikerush, and cocklebur with some interspersions of small exposed mud flat areas.		
3C	Somewhat similar in herbaceous vegetation species to locale 3A but with more interspersions of open mud flat areas, and some scattered growths of young Eastern Cottonwood and Willow extending into herbaceous vegetation.		
4	Principally an open mud flat zone with conspicuous scattered colonial establishment of slender spikerush, sedges, and softstem bulrush.		
5	Principally an open aquatic zone. Submerged shoreline gradually slopes westward and southwestward toward deeper water. Water depth measurements were not taken during field inspection. Existing submerged aquatic plants include hornwort; however, some other species may be present in addition to planktonic organisms such as diatoms, flagellates, rotifers, and miscellaneous planktonic organisms.		

Note: C = common; UC = uncommon; R = rare; + = clumped.

* See Figure 4.

Table 3a

Inventory of Vegetation Observed at Times Beach - Wilhelm, 1983

Plant Species	% Phytomass Estimated in Midsummer/Species TRANSECT A,* 1983 SURVEY								
	AA	AB	A2	A3	A4	A5	A6	A7	A8
<i>Achillea millefolium</i>					-**				
<i>Carex cristatella</i>			-	-		-	-	5	5
<i>Carex scoparia</i>					-				
<i>Carex stipata</i>			-	-					-
<i>Carex vulpinoidea</i>			-						
<i>Cirsium vulgare</i>						-			
<i>Cornus stolonifera</i>						-	-		
<i>Eleocharis calva</i>				-	-				
<i>Erigeron philadelphicus</i>									-
<i>Eupatorium perfoliatum</i>					-				
<i>Impatiens capensis</i>		-	-	-			-	-	10
<i>Juncus effusus</i>			-		5				
<i>Leersia oryzoides</i>	-	5	45	80	5				
<i>Lythrum salicaria</i>		-	20	10	50	5	-	-	10
<i>Phalaris arundinacea</i>			-		10				
<i>Phragmites australis</i>		-				75			
<i>Poa compressa</i>								-	-
<i>Poa palustris</i>			-		-	-	5		-
<i>Poa pratensis</i>									-
<i>Populus deltoides</i>					-			15	
<i>Rumex crispus</i>						-			
<i>Sagittaria latifolia</i>									-
<i>Salix interior</i>				-	-	5			
<i>Scirpus atrovirens</i>									-
<i>Solidago altissima</i>									35
<i>Solidago gigantea</i>					-	5	85	75	30
<i>Sphenopholis intermedia</i>						-			
<i>Typha latifolia</i>	100	95	5						
<i>Verbena hastata</i>					-				

(Continued)

* See Figure 6.

** Species was present in the plot but comprised less than 1% of the phytomass at the time of sampling.

(Sheet 1 of 3)

Table 3a (Continued)

Plant Species	% Phytomass Estimated in Midsummer/Species TRANSECT B, 1983 SURVEY						
	B2	B3	B4	B5	B6	B7	B8
<i>Carex cristatella</i>		-*	-	15			
<i>Carex hystricina</i>		-					
<i>Carex scoparia</i>			-				
<i>Carex stipata</i>		-					
<i>Carex tenera</i>				-			
<i>Eleocharis calva</i>		5			-		
<i>Geum laciniatum trichocarpum</i>				5			
<i>Impatiens capensis</i>	-	-	-	15	10	-	-
<i>Leersia oryzoides</i>	-	40	-	5	-		
<i>Lythrum salicaria</i>	5	45	10	50	80	-	
<i>Phragmites australis</i>			20	-	-	100	100
<i>Salix interior</i>			40				
<i>Solidago gigantea</i>					-		
<i>Typha angustifolia</i>			20				
<i>Typha latifolia</i>	-				5		
<i>Urtica procera</i>				-			

(Continued)

* Species was present but represented less than 1% of the phytomass at the time of sampling.

(Sheet 2 of 3)

Table 3a (Concluded)

Plant Species	% Phytomass Estimated in Midsummer/Species WOODLAND TRANSECT, 1983 SURVEY								
	I	II	III	IV	V	VI	VII	VIII	IX
<i>Agropyron repens</i>	.*								
<i>Agrostis alba</i>	-	-		-	-				
<i>Aster pilosus</i>	-								
<i>Carex</i> sp.							-		
<i>Convovulus sepium</i>						-			
<i>Cornus stolonifera</i>		5	-	-	-	5			-
<i>Cynanchum nigrum</i>	-						-		
<i>Daucus carota</i>	-							-	
<i>Epipactis helleborine</i>			-						
<i>Equisetum arvense</i>						-			
<i>Lythrum salicaria</i>									-
<i>Nepeta cataria</i>	-								
<i>Oenothera biennis</i>	-								
<i>Petasites hybridus</i>									-
<i>Phragmites australis</i>									-
<i>Poa compressa</i>	-			-				-	-
<i>Poa pratensis</i>	-	-	-	5	5	-		-	-
<i>Rhamnus cathartica</i>						-			
<i>Salix rigida</i>									-
<i>Solidago altissima</i>	90	90	95	80	85	90	100	95	95
<i>Verbena hastata</i>						-			
<i>Vicia cracca</i>					-				
<i>Vitis riparia</i>				5					

* Species was present but represented less than 1% of the phytomass at the time of sampling.

(Sheet 3 of 3)

the stone rubble dike area, which encloses the marsh and open water on the north, west, and south, was also recorded (for details see Appendix A).

49. Based on the 1983 survey and observations made in 1985, seven vegetation zones were defined at Times Beach in the upland (Transects A-C) and wetland (Transects D-G) areas (Figure 7). In 1985, a full inventory of the species recorded by Wilhelm and Ernst was conducted, and the relative abundance of each species, as a "perceived relative biomass" within each of the quadrats shown in Figure 7, was estimated. The perceived relative biomass was a subjective estimate, made by Wilhelm and based on his personal observations, of the standing crop of each species relative to the whole quadrat. A summary of these results is given in Table 3b, and further details can be found in Appendix A.

50. For the most part, the perceived relative phytomass did not change significantly from July to September. In Transect F, however, *Leersia* was scarcely evident in July, whereas in September, it comprised as much as half the phytomass in some areas. Likewise, in Transects B and C, the relative amounts of *Impatiens* increased sharply from July to September. However, a frost on the night of 24 September literally demolished the sensitive *Impatiens*, which completely changed its perceived relative phytomass overnight.

51. In 1983 and 1985, Wilhelm recorded all living trees within the designated plots at the Times Beach CDF and measured diameter at body height (DBH) for each tree having a diameter greater than 1 in. (2.54 cm). Table 4a gives results for 1983, and Table 4b gives results for 1985. Also in 1985, Bryniarski estimated the age of a random selection of Eastern Cottonwood trees (*Populus deltoides*). Results of this study are given in Table 5.

52. The trees sampled by Bryniarski were between 3 and 11 years old with a mean age of 7 years. Wilhelm noted that all trees were infested with canker and were without lichen growth. In his assessment, trees were heavily overstocked (about 1,300 per acre) and were therefore under severe competition stress. Rapid growth seemed to have ceased. In his opinion, under the present conditions of high stocking density, vulnerability to water-level fluctuations, and incapacity to outgrow the canker, most trees would be dead within a few years. He noted that a number of the trees were already dead and that, despite evidence of seed production in the area, no seedlings of Cottonwood were developing.

Table 3b

Inventory of Vegetation Observed at Times Beach - Wilhelm, 1985(Transects A-C, Upland Area, Figure 7)

Plant Species	% Phytomass Estimated in Midsummer/Species								
	A1	A2	A3	B1	B2	B3	C1	C2	C3
<i>Achillea millefolium</i>				-**					
<i>Asclepias incarnata</i>		-							
<i>Aster lateriflorus</i>	*								
<i>Aster novae-angliae</i>					-				
<i>Calamagrostis canadensis</i>						-			
<i>Carex brevior</i>								-	
<i>Carex cristatella</i>	-	-		-	5	-		-	-
<i>Carex stipata</i>								-	-
<i>Convovulus sepium</i>		-							
<i>Cornus stolonifera</i>		-		80	40	50		-	
<i>Epilobium hirsutum</i>					-				
<i>Eupatorium maculatum</i>						-			
<i>Eupatorium perfoliatum</i>					-				
<i>Geum laciniatum trichocarpum</i>	-	-		-	-	-	-	-	-
<i>Glyceria striata</i>				-					
<i>Impatiens capensis</i>	-			5	-	-	95	80	10
<i>Juncus dudleyi</i>					-				
<i>Lysimachia ciliata</i>						5			
<i>Lythrum salicaria</i>				-	30	-		5	5
<i>Phalaris arundinacea</i>	-							-	
<i>Poa compressa</i>			-						
<i>Poa palustris</i>									-
<i>Poa pratensis</i>		-	-	-	5				
<i>Rhus typhina</i>			-						
<i>Rumex obtusifolius</i>	-							-	
<i>Salix bebbiana</i>					(1)†				
<i>Salix fragilis</i>		-							
<i>Salix rigida</i>					(1,2)		(5)		-
<i>Solanum dulcamara</i>	-		-						
<i>Solidago altissima</i>	95	95	95	-	5	5	-	-	80
<i>Solidago graminifolia nuttallii</i>					-				-
<i>Taraxacum officinale</i>		-							
<i>Viburnum opulus</i>								*	
<i>Vitis riparia</i>	*								

(Continued)

* Species was present in September but not July.

** Species was present but represented less than 1% of the phytomass at the time of sampling.

† Values in parentheses give the DBH, in inches (1 in. = 2.54 cm) for tree species at the time of sampling.

Table 3b (Concluded)

Plant Species	% Phytomass Estimated in Midsummer/Species									
	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>E2</u>	<u>F1</u>	<u>F2</u>	<u>F3</u>	<u>G1</u>	<u>G2</u>	<u>G3</u>
<i>Carex cristatella</i>							-	5		
<i>Carex lurida</i>							-	-		
<i>Carex stipata</i>							-	-		
<i>Eleocharis calva</i>					-	-	-	5		
<i>Eupatorium perfoliatum</i>							-	-		
<i>Juncus effusus</i>							-	-		
<i>Leersia oryzoides</i>					-	-	*			
<i>Lythrum salicaria</i>		-	5		95		40			5
<i>Phalaris arundinacea</i>				95						
<i>Phragmites australis</i>	95	100	80				-			
<i>Salix interior</i>				-			20			
<i>Scirpus atrovirens</i>							-			
<i>Scirpus validus creber</i>							-			
<i>Typha angustifolia</i>							20			
<i>Typha latifolia</i>	-		15					100	100	95

Table 4a

Inventory of Cottonwood Trees at Times Beach - Wilhelm, 1983
(Recorded on Transects A, B, and the Woodland Transect in 1983*)

<u>Plot</u>	<u>Number of Trees</u>	<u>Mean(sd)</u>	<u>Diameter at Body Height (DBH) (inches)</u>
A5	6	2.1(1.2)	1, 1, 1.5, 2, 3, 4
A6	8	1.8(0.70)	1, 1, 1.5, 1.5, 2, 2, 2.5, 3
A7	9	1.4(0.68)	1, 1, 1, 1, 1, 1.5, 1.5, 2, 3
A8	8	1.8(0.60)	1, 1, 1.5, 1.5, 2, 2, 2.5, 2.5
B5	14	2.0(0.91)	1, 1, 1, 1, 1.5, 1.5, 1.5, 2, 2, 2.5 2.5, 3, 3.5, 3.5
B6	6	2.9(1.2)	1.5, 2, 2.5, 3, 4, 4.5
III	2	12(14)	2, 22
IV	1	2.5	2.5
VI	3	4.7(2.1)	3, 4, 7
VII	9	3.8(0.94)	3, 3, 3, 3.5, 3.5, 4, 4, 4, 6
VIII	8	1.7(0.65)	1, 1, 1, 1.5, 2, 2, 2.5, 2.5
IX	11	1.5(0.61)	1, 1, 1, 1, 1, 1.5, 1.5, 2, 2, 2.5, 2.5

Note: 1 in. = 2.54 cm.

* See Figure 6.

Table 4b

Inventory of Cottonwood Trees at Times Beach - Wilhelm, 1985
(Recorded in the Upland Transects A, B, and C*)

<u>Plot</u>	<u>Number of Trees</u>	<u>Mean(sd)</u>	<u>Diameter at Body Height (DBH) (inches)</u>
A1	4	7.3(2.8)	4, 6, 9, 10
A2	8	2.4(1.4)	1, 1, 1, 2, 3, 3, 3, 5
A3	7	4.4(2.3)	2, 3, 3, 4, 5, 5, 9
B1	8	2.3(1.7)	1, 1, 1, 2, 2, 2, 3, 6
B2	10	2.7(0.68)	2, 2, 2, 2, 3, 3, 3, 3, 3, 4
B3	10	4.5(2.3)	2, 2, 3, 4, 4, 4, 5, 5, 6, 10
C1	7	2.9(1.2)	2, 2, 2, 2, 3, 4, 5
C2	9	3.8(1.4)	2, 2, 3, 3, 4, 4, 5, 5, 6
C3	9	3.9(1.2)	3, 3, 3, 3, 3, 4, 5, 5, 6

Note: 1 in. = 2.54 cm.

* See Figure 7.

Table 5
Increment Borings Made on Cottonwood Trees at Times Beach
and Estimation of Tree Age - Bryniarski, 1985

<u>Location</u>	<u>Diameter (inches)*</u>	<u>Age (years)</u>
C125 (NW corner of <i>Phragmites</i>)	5.5	8
	5.0	6
	3.0	5
D75 (Blue flag)	5.0	8
	6.0	10
	1.5	3
	3.5	6
D125 (Blue flag)	3.5	6
	5.0	10
	2.0	4
	7.0	11
E125 (Yellow flag)	5.0	9
	2.5	5
	3.5	7
	5.0	9

* 1 in. = 2.54 cm.

Invertebrates

53. Invertebrates collected at the site were identified by John Bater of the Entomology Department, Ohio State University, and James Ashby of the Entomology Department, Rothamsted Experimental Station, Harpenden, England. Individuals from most of the major invertebrate taxa were represented in the pitfall traps. Specimens of Coleoptera (Beetles), Araneida (Spiders), Opiolones (Harvestmen), Chilopoda (Centipedes), Diplopoda (Millipedes), Isopoda (Woodlice), and Orthoptera (Grasshoppers) collected in the pitfall traps were identified and counted. Even families of Coleoptera were represented, dominated numerically by the Carabidae (Tiger Beetles); four families of Isopoda were present, dominated numerically by *Trichoniscus* (Woodlice); two families of Diplopoda and one family each of Chilopoda and Araneida were recorded in the samples collected at each sampling time. A full record of species collected and identified is included in Appendix B, Part 1(3). In

composition, the invertebrate fauna collected in the pitfall traps was dominated both numerically and in terms of dry matter contribution to the total biomass by Coleoptera, Diplopoda, and Isopoda. Relative percent biomass of each group in the pitfall traps is given in Appendix B, Part 1(3), Tables 5C, 6C, 7B, and 8B. Pitfall trapping as a sampling technique is likely to collect proportionally more of the active groups such as predatory species, actively seeking prey, and detritivores moving about in the litter and on the soil surface. Herbivorous invertebrates are commonly poorly represented in the samples collected. Pitfall trapping is not intended to provide a means of estimating absolute invertebrate populations.

54. Invertebrates were sampled by pitfall trapping in spring and fall for two consecutive years. Seasonal differences between samples in terms of species abundance and composition were evident for some taxonomic groups; for example, Opiolones and Orthoptera were collected in far greater abundance in the pitfall traps collected in the fall compared with the spring. Snails were present in larger numbers in the sample collected in November compared to other samples. Within taxonomic groups (where further identification to genus level was possible), some differences between seasons were also observed. For example, in the May 1985 sample there were no Nitidulidae (Sap Beetles) or Chrysomelidae (Leaf Beetles) among the Coleoptera, while in the October 1985 sample the Elateridae (Click Beetles), Tachyporidae (Carrion Beetles), and Oxytelinidae (Carrion Beetles) that had been present in May were absent. These differences in composition between the samples are most likely due to seasonal breeding cycles of the invertebrates.

55. The greatest numbers and percentage biomass by weight collected in the traps were for the Coleoptera, followed by the Isopoda. A similar total dry weight biomass was collected in all the pitfall traps across the site. The composition of invertebrate fauna in the traps was then examined for changes in taxonomic composition which could be related to vegetation type. A similar relative biomass of Coleoptera was collected from all plots across the upland area at the site. There is some indication that an increase in relative percent by weight of Araneida and a decrease in relative percent by weight of Diplopoda and Isopoda in the pitfall traps may have occurred with increasing proximity to the water edge (Appendix B, Part I(3)). This may be related to the changing vegetation type, or may be directly due to higher moisture levels in the substrate. Changes in biomass of soil-dwelling

microinvertebrates collected in the Tulgren funnel apparatus suggested a positive relationship between biomass and the proximity of the plot to the water's edge (Table 6).

Table 6a
Microfauna Extracted from Dredged Material and Soil Cores
Taken at Times Beach* and Grand Island, May 1986

Plot	Taxonomic Group**										
	A	B	C	D	E	F	G	H	I	J	K
<u>Times Beach</u>											
A1	1	3	14	18	4	1	9	0	0	0	29
A2	4	9	14	38	0	0	1	4	0	0	39
A3	25	103	40	171	20	88	110	5	1	0	291
A4	2	42	34	81	90	29	122	3	3	4	226
B1	1	25	26	54	16	0	26	0	0	0	112
B2	3	1	9	9	4	9	13	0	1	1	28
B3	3	25	14	42	3	1	13	0	1	0	58
B4	1	0	10	11	14	0	14	0	1	1	31
B5	5	15	16	37	21	3	25	0	1	4	68
C1	0	0	0	0	0	0	0	1	1	0	3
C2	5	0	6	12	7	0	7	0	3	0	36
C4	0	0	4	4	0	2	3	0	0	0	7
<u>Grand Island</u>											
R1	4	0	45	49	5	0	5	0	2	0	67
R2	4	0	27	31	9	0	9	0	0	0	40
R3	6	1	131	141	43	3	47	1	1	1	192
R4	9	17	98	130	1	2	19	1	0	2	155
R5	1	0	76	79	2	2	5	2	1	1	89

Note: Core size: 5-cm diameter by 15-cm depth. Values are total numbers of invertebrates in all four cores per transect.

* See Figure 8.

** Taxonomic groups are as follows:

A = *Gamasina*

B = *Rhodacaidae*

C = *Oribatidae*

D = *Acarina* (total of groups A, B, and C and all mites)

E = *Onchiuridae*

F = *Isotomidae*

G = *Collembola* (total of groups E and F and all springtails)

H = *Myriapoda* (total of all centipedes and millipedes)

I = *Diptera* (total of all fly larvae)

J = *Coleoptera* (total of all beetles and beetle larvae)

K = Invertebrates (total)

Table 6b
Total Dredged Material and Soil Microfaunal Counts
Times Beach* and Grand Island, May 1986

<u>Plot</u>	<u>$\bar{x}$ Number Soil Invertebrates per Core, per Plot</u>	<u>$\bar{x}$ Number Soil Invertebrates per Core, per Zone</u>
<u>Times Beach</u>		
A1	7.25	36.56
A2	9.75	
A3	72.75	
A4	56.50	
B1	28.00	14.85
B2	7.00	
B3	14.50	
B4	7.75	
B5	17.00	
C1	0.75	3.83
C2	9.00	
C4	1.75	
<u>Grand Island</u>		
R1	16.75	27.15
R2	10.00	
R3	48.00	
R4	38.75	
R5	22.25	

Note: Soil cores, 5-cm diameter by 15-cm depth. Values are means of four replicate samples.

* See Figure 8.

56. Pitfall traps placed at the Grand Island site collected a similar taxonomic composition of soil-dwelling invertebrates to those identified from the Times Beach traps (Appendix B, Part IV, Tables 22 and 23). In similarity to the Times Beach results, numbers and biomass of invertebrates were dominated by the Coleoptera and Isopoda, and similar seasonal differences were noted; for example, Opiolones and Orthoptera were present in the November sample and not in the May sample.

57. Bater collected soil-dwelling microfauna from within dredged material and soil samples and recorded the species present (Tables 6a and 6b). Based on these collections, he determined that all species expected to be

present under the prevailing conditions at Times Beach were recorded. Similar numbers of soil microinvertebrates were collected at the Grand Island reference site compared with the drier plots at Times Beach (plots become progressively drier from Transects C to B and B to A). However, where the substrate was likely to become water-logged, numbers of soil microinvertebrates declined. This was considered most likely to be directly related to changes in the substrate moisture content.

58. Earthworms naturally colonizing the sites were extracted from their substrate and returned to the laboratory for identification by J. Reece Lofty of the Entomology Department, Rothamsted Experimental Station. Earthworms of the species *Lumbricus terrestris*, *Allolobophora caliginosa*, *Allolobophora chlorotica*, and *Lumbricus rubellus* were present at the Times Beach and Grand Island sites. At Times Beach, the deep burrowing species *L. terrestris* was found only in the higher, drier plots, where the top soil-like layer had developed to sufficient depth for burrowing. The lower, wetter plots were dominated by *L. rubellus*. Lists of the earthworm species collected at both the Times Beach and Grand Island sites are included in Appendix B, Part I(4) and Part IV(4).

Vertebrates

59. In 1975, a survey of vertebrate wildlife observed at the Times Beach CDF was initiated. Since this time a record of wildlife, and in particular bird species visiting the site, has been made by Andrle. Full inventories of the amphibians, reptiles, mammals, and birds identified and recorded at the site by Andrle through 1986 are included in Appendix A.

60. In general, Andrle noted that relatively few species and individuals of mammals, reptiles, and amphibians were recorded on the site despite careful observations and intensive efforts to investigate likely habitats for them. This he attributed to the relatively small size of the Times Beach CDF, the rather simple association of plant communities established at the site, and the isolation of the site from areas already colonized by wildlife, from which migration may occur. An oily substance, observed by Andrle within the dredged material both in and on the water, may be responsible for unfavorable conditions for some species. No further investigations of this substance have been carried out; however, it would be particularly relevant to ascertain the effects of this substance on the wildlife at Times Beach to determine its impact on their colonization and behavior.

61. The apparent paucity of mammalian species colonizing the CDF may have been due to their nocturnal habits, and this, together with the dense vegetation in some parts of the site, would preclude the observation of many individuals and/or species. Climatic conditions and frequent water-level fluctuations will also influence the abundance of reptiles and amphibians. Andrle also suggested that the lack of natural or other types of exposed objects in the water, for frogs and turtles to use as sunning places isolated from shore disturbances, would affect the numbers of these species.

62. Of the mammal species recorded, Muskrats, *Ondatra zibethicus* were observed frequently, mostly among the Cattails. On the basis of observations made, the population of Muskrats at the site was estimated at 75 to 125 individuals, and they were identified as the most numerous and important mammals in the food web. Other mammals recorded at the site included Eastern Cottontails (*Sylvilagus floridanus*), Raccoons (*Procyon lotor*), and Meadow Voles (*Microtus pennsylvanicus*). As a result of the trapping program conducted by Neuhauser in 1985, White Footed Mice (*Peromyscus leucopus*) and Meadow Voles were confirmed as present at the site though their populations could only be estimated at between 40 and 80 individuals. Garter Snakes (*Thamnophis sirtalis*) were the only reptiles recorded, and Bullfrogs (*Rana catesbeiana*) and American Toads (*Bufo americanas*) were the only amphibians identified as present. It was surprising, considering the conditions at Times Beach, that neither the Northern Water Snake (*Natrix sipedon*) nor any newts or salamanders were seen.

63. Birds were the most conspicuous animals onsite both in numbers and variety. A total of 222 species have been recorded since initiation of the disposal operations, mostly migrants and visitants. Listings of all species recorded at the site during a period when Andrle regularly visited the site (12 May 1985 to 31 May 1986), along with an indication of where on the site they were seen, are included in Appendix A. An estimated 117 pairs of birds nested on the site during 1985, based upon the incidence of singing males, pairs and nests located, and fledged precocial young. The avifauna has been compared favorably with numbers and species of avifauna observed at the nearby Tift Farm Nature Preserve. A brief indication of the nesting and feeding habits of some of the more commonly observed bird species at the site is given by Andrle (see Appendix A).

Aquatic Area

64. In the aquatic area of the Times Beach CDF, an inventory of the planktonic and benthic species observed was made with an estimation of their relative abundance (Tables 7a and 7b). Times Beach appeared to be richer in diversity and biomass than adjacent portions of Lake Erie, although more detailed studies than those conducted by Marquenie and Simmers (1984) will be necessary to confirm this. These surveys were conducted in an extremely general manner. They had no other purpose than to make an initial effort in documenting the occurrence and abundance of species.

Table 7a

Results of Preliminary Planktonic Hauls at Times Beach and Lake Erie, June 1984

<u>Taxonomic Group</u>	<u>Lake Erie</u>		<u>Times Beach</u>	
	<u>Station 1</u>	<u>Station 2</u>	<u>Station 1</u>	<u>Station 2</u>
CHLOROPHYTA				
<i>Ulotrichales</i>	+	+	+	-
<i>Zygenamles</i>	^	-	-	-
<i>Paediastrum</i> spp.	^	-	-(1)	-(8)
CHRYSTOPHYTA				
<i>Tabellaria</i> spp.	^	-	-	*(18)
<i>Asterionella</i> spp.	^	-	-(4)	*(39)
DINOFLAGELLATA				
<i>Ceratium</i> spp.	-(1)	-	*(35)	*(317)
ROTATORIA				
Several spp.	-(8)	-(3-8)	-(1-7)	*(25)
CLADOCERA				
<i>Ceriodaphnia</i> spp.	-(3)	*(11)	-(8)	-
<i>Bosmina</i> spp.	-(6)	-(3)	*(33)	-(3)
COPEPODA				
<i>Harpacticoids</i>	*(214)	*(51)	*(440)	*(63)
<i>Clyclopoids</i>	*(10)	-(4)	-(1)	*(28)
OSTRACODA				
Several spp.	-(2)	-(4)	-(2)	-(1)

Note: ^ = absent; - = some; + = several species; * = abundant.
Numbers in parentheses represent total number of organisms, where counted.

Table 7b
Results of Preliminary Benthic Surveys at Times Beach
June 1984

ANNELIDA	AMPHIPODA
Oligochaeta	1 species
Hirudinea*	
	DECAPODA
GASTROPODA	1 species
Lymnaea*	
Several spp.*	INSECTA
	Ephemeroptera
BIVALVA	Diptera*
Sphaeridae	
COPEPODA	
Larneaeopodoida*	

Note: Listing represents the taxonomic groups that were present. Those marked with asterisk were sufficiently abundant to be considered for use as possible biomonitor organisms.

65. Many of the bird species recorded by Andrle were frequently associated with the aquatic habitat at Times Beach as indicated in the reports by Andrle (see Appendix A).

66. A qualitative estimation of the fish species present in the aquatic area at Times Beach in 1983, as captured both by seining and hook and line, furnished the following species: *Ambloplites rupestris* (Rock Bass), *Cyprinus carpio* (Carp), *Lepomis gibbosus* (Pumpkinseed), and *Perca flavescens* (Yellow Perch). Concurrent with this collection, fish were sampled using the same methods from the Buffalo River. Yellow Perch and Pumpkinseed were captured, as well as *Moxostoma macrolepidotum* (Northern Rednose), *Morone americana* (White Perch), and *Notomigonus crysoleucus* (Golden Shiner).

PART IV: RESULTS OF CHEMICAL ANALYSIS

67. Detailed results of chemical analysis of samples relating to the Times Beach CDF are included in the appendixes to this report. The results of preliminary assessments of contaminant mobility from the Times Beach dredged material are included in Appendix C and in Marquenie, Simmers, and Kay (1987) and Marquenie et al. (in preparation). Measurements of the uptake of contaminants into tissues of the bioassay plants and animals are given in these reports. Samples collected at the Times Beach CDF (dredged material and naturally colonizing flora and fauna) were analyzed; the results are included in Appendix B. These results have been divided according to whether the samples were collected in the upland, wetland, or aquatic areas (Parts I, II, and III, respectively). Analytical results for soil and fauna collected at the Grand Island reference site (classified as an "upland" area) are also included in Appendix B, Part IV.

Upland and Wetland Areas

Dredged material and soil

68. Concentrations of elements present in the deep layer of unconsolidated dredged material (sampled at transect station A3, Figure 6) as well as the oxidized surface layer material (sampled at transect station B8, Figure 6) are given in Appendix B, Part I(1), Table 1. Elevated concentrations of a number of metals were observed (Marquenie, Simmers, and Kay 1987).

69. Subsequently, in 1986, oxidized surface-layer dredged material was collected in the upland area from each of the plots in vegetation zones A, B, and C, as defined by Wilhelm in 1985. These plots correspond with those from which vegetation and invertebrate samples were collected (Figures 7 and 8). Four replicate samples of dredged material were collected from vegetation zones A and C; five replicate samples of dredged material were collected from vegetation zone B. Concentrations of the elements Zn, Cu, Ni, Cd, Cr, and Pb were measured in material from each of these plots. These results are presented in Appendix B, Part I(1), Table 2, and are summarized as mean values in Table 8. Additional information on concentrations of metals in the dredged material at Times Beach, as well as concentrations of organic compounds such as PCBs and PAHs, is available from the reports on the plant and animal

Table 8
Metal Concentrations Measured in Dredged Material and Soil
from Times Beach and Grand Island*

<u>Site/Zone</u>	<u>Element</u>					
	<u>Zn</u>	<u>Cu</u>	<u>Ni</u>	<u>Cd</u>	<u>Cr</u>	<u>Pb</u>
<u>Times Beach Vegetation Zone</u>						
A	289 ^b	51 ^a	28 ^c	3.3 ^b	57 ^a	161 ^a
B	480 ^a	95 ^a	49 ^b	6.4 ^a	137 ^a	212 ^a
C	426 ^{ab}	83 ^a	35 ^b	5.0 ^{ab}	100 ^a	172 ^a
<u>Grand Island</u>						
R	227 ^b	68 ^a	55 ^a	2.5 ^c	37 ^b	44 ^b

Note: Concentrations are mean values per zone expressed as micrograms per gram, dry weight. Mean values in a column followed by the same letter are not significantly different at $p < 0.05$. Nonparametric statistical comparison of the means was employed.

bioassays conducted in 1981 and 1982 (Appendix C). A wide range of metal concentrations were recorded in the dredged material, both across the site and within the substrate profile at any particular plot, indicating a degree of heterogeneity. Of the results given in these earlier reports, some plots were situated in the upland area and some in the wetland area. Variation in contaminant concentrations may also be associated with the degree of saturation of the dredged material--the reduced material containing higher concentrations of metal contaminants (Marquenie, Simmers, and Kay 1987). This may explain some of the variation between the 1986 results (Appendix B, Part I(1), Table 2) determined using ICP and those for dredged material analyzed in 1983 by INAA (Appendix B, Part I(1), Table 1).

70. For comparison, five replicate samples of soil from the Grand Island reference site, collected in 1986, were also analyzed. These results are presented in full in Appendix B, Part IV(I), Table 20; mean values are given in Table 8. These results indicated that concentrations of Zn, Cd, Cr, and Pb were elevated in the Times Beach dredged material in comparison to soil collected at Grand Island.

71. To clarify the relationships suggested in previous studies, concentrations of metals measured at Times Beach and Grand Island (sampled in

November 1986) were statistically compared between vegetation zones at Times Beach and between each of the vegetation zones at Times Beach and the Grand Island site (Table 8). All comparisons were made at the 0.05 level of significance. Within Times Beach, the Cu, Cr, and Pb concentrations were not statistically different between the three vegetation zones. The Cd and Zn concentrations were significantly lower in zone A compared with zone B but not zone C. The Ni concentrations were significantly lower in zone A compared with zones B and C. Comparisons between Times Beach and Grand Island plots indicated significantly greater Cd, Cr, and Pb concentrations in the Times Beach dredged material and significantly greater Ni concentrations in the Grand Island soil (Table 8). The Cu concentrations at Times Beach and Grand Island were not statistically different.

72. Concentrations of PCB congeners in the dredged material collected in 1983 may be found in the report by Marquenie, Simmers, and Kay (1987). The totals of the PCB congeners analyzed in the dredged material at Times Beach were within the range of PCBs reported in freshwater sediments and fell well below the maximum values reported for various drainage basins in the United States (National Academy of Sciences 1979). Highest concentrations of organochlorine compounds were present in the wetland plots, a situation similar to that reported for the heavy metal contaminants (Marquenie, Simmers, and Kay 1987).

Vegetation

73. Collections of live vegetation, as listed in Appendix B, Part I(2), Table 3, and Part II(1), Table 13, were separated according to plant parts (leaves, stems, flowers) prior to metal analysis. Concentrations of Zn, Cu, Ni, Cd, Cr, and Pb were measured in the different species from the upland (A-C) and wetland (D-G) vegetation zones; results are given in Appendix B, Part I(2), Table 4, and Part II(1), Table 14. Interspecific differences were evident, as were differences in metal concentrations between the different plant parts. Some of the species were available for collection from more than one vegetation zone, and comparisons of metal concentrations within a species could then be made across the defined zones (Table 9). For example, *Lythrum salicaria* was collected from zones B, C, D, F, and G; *Typha angustifolia* was collected from zones D, F, and G; and *Solidago altissima* was collected from zones A, B, and C.

Table 9
Metal Concentrations Measured in *L. salicaria* and *T. angustifolia*

<u>Sample</u>	<u>Transect</u>	<u>Zn</u>	<u>Cu</u>	<u>Ni</u>	<u>Cd</u>	<u>Cr</u>	<u>Pb</u>
<u><i>L. salicaria</i></u>							
Leaves	B	205	11	1.1	0.37	1.8	3.5
	C	235	10	1.6	1.1	4.4	5.9
	D	125	9.3	2.3	<0.13	0.95	5.7
	F	161	6.7	1.4	0.28	2.3	10.6
	G	160	8.6	<0.75	<0.13	3.0	6.7
Stems	B	38	10	<0.75	0.34	1.1	<2.6
	C	31	11	<0.75	0.59	1.9	<2.6
	D	37	7.9	<0.75	0.30	0.91	2.8
	F	26	6.8	<0.75	0.32	0.98	2.8
	G	24	7.4	<0.75	<0.13	2.0	<2.6
Flowers	C	84	29	1.9	<0.13	5.3	4.3
	D	73	12	<0.75	<0.13	0.91	2.8
	F	75	16	1.4	0.52	4.7	4.8
	G	61	14	<0.75	<0.13	3.4	2.8
<u><i>T. angustifolia</i></u>							
Leaves	D	19	6.1	<0.75	<0.13	0.69	4.9
	F	15	6.3	<0.75	<0.13	1.10	4.3
	G	26	8.5	1.3	<0.13	0.76	2.8
Flowers	F	21	13	<0.75	<0.13	2.0	<2.6
	G	22	13	<0.75	<0.13	1.5	<2.6

Note: Concentrations are mean values expressed in milligrams per kilogram dry weight.

* For details, see Appendix B, Part I(2), Table 4, and Part II(1), Table 14.

74. Metal concentration measured in the *S. altissima* (leaves, stems, and flowers) fell within the same range across the three vegetation zones, suggesting little difference in metal uptake, with decreasing depth to the water table and increasing proximity to the aquatic area (for data see Appendix B, Part I(2), Table 4). Insufficient replications were available to conduct statistical analysis between sample plots; however, there may be some indication of an increase in concentrations of some of the metal elements, particularly Zn and Cu, in the species *L. salicaria* with increasing distance from the water (Table 9). Additional replication and analysis would be necessary before any further conclusions could be drawn from the data.

75. Metal concentrations were also measured in leaf litter collected from each of the vegetation zones--A, B, and C (Appendix B, Part I(2), Table 4). Concentrations of P, Ca, Zn, Cu, Cd, and Cr appeared to decrease with decreasing distance to the water table, and concentrations of Mg, Fe, and Al increased with decreasing distance to the water table. These figures are based on chemical analysis of one composited sample from each zone; therefore, no statistical analysis was possible, and any suggested trends would need to be confirmed with further sampling and analysis.

76. Metal concentrations measured in the WES plant bioassay species *Cyperus esculentus* are available for comparison (see Appendix C). Measurements of PCB and PAH compounds in the bioassay plant were made, but no replicated PCB data are available from the native vegetation at Times Beach and no PAH analysis of native plants has been carried out. Results of range-finding PCB analysis of wetland plants collected at Times Beach are given in Appendix C, in the 1985 interim report by Marquenie.

Invertebrates

77. Measurements of metal concentrations in invertebrates collected at the CDF are presented in detail in Appendix B, Part I(3), Tables 5d, 6d, 7c, 8c, 9, and 10. In some cases the sample size was so small that the ICP was functioning close to detection limits; this may explain some of the variation in the data and some of the anomalously high figures in a few of the samples.

78. For each taxonomic group, mean metal concentrations were calculated and statistically compared at each of the four sampling times (spring and fall 1985 and spring and fall 1986). The results of these statistical analyses are shown in Tables 10a-d.

79. In 1985, the Grand Island reference site was not sampled by pitfall trapping; however, statistically significant differences in metal concentrations were noted between the vegetation zones at Times Beach. In the spring sample (Table 10a), Zn and Cd concentrations in the Coleoptera were significantly lower in vegetation zone A compared with zones B and C. Cadmium concentrations in the Diplopoda were significantly greater in vegetation zone B compared with zones A and C, and a similar pattern was noted for Cu concentrations in the Araneida. In Fall 1985 (Table 10b), no statistically significant differences were noted between the vegetation zones at Times Beach for any of the four taxa, with the exception of the Isopoda, where Cu concentrations were

Table 10a
Metal Concentrations Measured in Invertebrates Collected
in Pitfall Traps, Times Beach, Spring 1985

Vegetation Zone	Element			
	Zn	Cu	Cd	Pb
<u>Araneida</u>				
A	415 ^a	169 ^b	27 ^a	26 ^{a*}
B	461 ^a	230 ^a	76 ^a	17 ^{a*}
C	307 ^a	182 ^b	111 ^a	6.8 ^{a*}
<u>Coleoptera</u>				
A	90 ^b	14 ^{a*}	1.1 ^b	0.68 ^a
B	108 ^a	15 ^{a*}	2.7 ^a	2.4 ^a
C	113 ^a	15 ^{a*}	2.2 ^a	2.9 ^a
<u>Diplopoda</u>				
A	211 ^a	641 ^a	2.8 ^b	7.5 ^a
B	242 ^a	660 ^a	3.7 ^a	6.1 ^a
C	174 ^a	634 ^a	2.2 ^b	5.8 ^a
<u>Isopoda</u>				
A	180 ^a	182 ^a	33 ^{a*}	14 ^{a*}
B	191 ^a	142 ^a	45 ^{a*}	14 ^{a*}
C	180 ^a	144 ^a	29 ^{a*}	11 ^{a*}

Note: Concentrations are mean values per vegetation zone (two replicates for vegetation zones A and B; three replicates for vegetation zone C) expressed in micrograms per gram, dry weight. Mean values in a column within each taxon followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

Table 10b
Metal Concentrations Measured in Invertebrates Collected
in Pitfall Traps, Times Beach, Fall 1985

Vegetation Zone	Element			
	Zn	Cu	Cd	Pb
<u>Araneida</u>				
A	166 ^a	111 ^a	15 ^a	9.0 ^s
B	140 ^a	77 ^a	8.8 ^a	14 ^a
C	142 ^a	103 ^a	18 ^a	8.5 ^a
<u>Coleoptera</u>				
A	99 ^a	18 ^a	2.1 ^a	7.1 ^a
B	111 ^a	19 ^a	2.6 ^a	5.0 ^a
C	104 ^a	16 ^a	1.6 ^a	4.5 ^a
<u>Diplopoda</u>				
A	195 ^{a*}	728 ^a	2.7 ^a	12 ^a
B	235 ^{a*}	787 ^a	3.1 ^a	12 ^a
C	210 ^{a*}	723 ^a	3.0 ^a	12 ^a
<u>Isopoda</u>				
A	314 ^a	310 ^a	23 ^a	17 ^a
B	326 ^a	223 ^b	22 ^a	16 ^a
C	281 ^a	208 ^b	23 ^a	13 ^a

Note: Concentrations are mean values per vegetation zone (four replicates in vegetation zones A and C; five replicates in vegetation zone B) expressed in micrograms per gram, dry weight. Mean values in a column within each taxon followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

Table 10c
Metal Concentrations Measured in Invertebrates Collected
in Pitfall Traps, Times Beach (A,B,C) and
Grand Island (R), Spring 1986

Vegetation Zone	Element			
	Zn	Cu	Cd	Pb
<u>Araneida</u>				
A	325 ^a	230 ^a	71 ^a	s**
B	311 ^a	177 ^a	36 ^a	s
C	299 ^a	114 ^a	29 ^a	s
R	238 ^a	202 ^a	13 ^a	s
<u>Coleoptera</u>				
A	147 ^a	18 ^a	4.7 ^a	s
B	109 ^b	18 ^a	4.4 ^a	s
C	105 ^b	19 ^a	3.5 ^a	s
R	102 ^b	15 ^a	2.0 ^a	s
<u>Diplopoda</u>				
A	269 ^{a*}	683 ^a	3.9 ^a	22 ^a
B	227 ^{a*}	681 ^a	4.0 ^a	16 ^a
C	254 ^{a*}	755 ^a	4.1 ^a	14 ^a
R	198 ^{a*}	218 ^b	2.7 ^a	s
<u>Isopoda</u>				
A	341 ^a	224 ^a	21 ^a	21 ^a
B	307 ^a	221 ^a	s	s
C	272 ^a	185 ^{ab}	20 ^a	16 ^a
R	260 ^a	153 ^b	3.3 ^b	6.5 ^a

Note: Concentrations are mean values per vegetation zone (four replicates for vegetation zones A and B; five replicates for vegetation zone C and the Grand Island reference site) expressed in micrograms per gram, dry weight. Mean values in a column within each taxon followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

** Insufficient sample size for statistical analysis.

Table 10d
Metal Concentrations Measured in Invertebrates Collected
in Pitfall Traps, Times Beach (A,B,C)
and Grand Island (R), Fall 1986

Vegetation Zone	Element			
	Zn	Cu	Cd	Pb
<u>Araneida</u>				
A	213 ^a	85 ^a	8.6 ^{a*}	6.7 ^a
B	215 ^a	78 ^{ab}	14 ^{a*}	7.2 ^a
C	209 ^a	64 ^b	7.3 ^{a*}	6.6 ^a
R	194 ^a	64 ^b	3.9 ^{b*}	17 ^a
<u>Coleoptera</u>				
A	114 ^{a*}	31 ^{a*}	2.7 ^a	2.5 ^a
B	100 ^{a*}	18 ^{a*}	2.7 ^a	5.0 ^a
C	90 ^{a*}	19 ^{a*}	2.5 ^a	7.1 ^a
R	63 ^{a*}	16 ^{a*}	1.1 ^a	3.8 ^a
<u>Diplopoda</u>				
A	235 ^a	522 ^a	4.5 ^a	14 ^a
B	260 ^a	557 ^a	4.5 ^a	19 ^a
C	222 ^a	469 ^a	4.2 ^a	12 ^a
R	160 ^a	133 ^b	2.4 ^a	6.3 ^b
<u>Isopoda</u>				
A	234 ^a	130 ^{a*}	30 ^a	18 ^a
B	297 ^a	101 ^{a*}	27 ^a	17 ^a
C	332 ^a	186 ^{a*}	23 ^a	17 ^a
R	219 ^a	79 ^{a*}	8.2 ^b	14 ^a

Note: Concentrations are mean values per vegetation zone (four replicates for vegetation zones A and B; five replicates for vegetation zone C and the Grand Island reference site) expressed in micrograms per gram, dry weight. Mean values in a column within each taxon followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

significantly greater in Isopoda from vegetation zone A compared with zones B and C.

80. In 1986, pitfall traps were placed at both the Times Beach CDF and the Grand Island reference site; the results of metal analysis of these samples are statistically compared in Tables 10c and 10d. At Times Beach, there were no statistically significant differences between the vegetation zones, with the exception of Zn concentrations in the Coleoptera in the spring (Table 10c) and Cu concentrations in the Araneida in the fall (Table 10d). In these groups, significantly greater Zn concentrations were measured in the Coleoptera from vegetation zone A compared with vegetation zones B and C (Table 10c), and significantly greater Cu concentrations were measured in the Araneida from vegetation zone A compared with vegetation zone C, but not B (Table 10d).

81. Statistically significant differences between the samples collected at Times Beach and those collected at Grand Island could be assessed in the 1986 samples (Tables 10c and d). The following differences were observed in both the spring and fall samples: Cu concentrations were significantly greater in the Diplopoda collected at Times Beach compared with Grand Island, and Cd concentrations were significantly greater in the Isopoda collected at Times Beach compared with those collected at Grand Island. In spring 1986, Zn concentrations measured in Coleoptera from the Grand Island site were significantly lower than those measured in Coleoptera collected in vegetation zone A but not B and C at Times Beach; also, Cu concentrations in the Isopoda were significantly lower at Grand Island compared to vegetation zones A and B, but not C at Times Beach. Araneida, collected in fall 1986, had significantly lower Cd concentrations at Grand Island compared to Times Beach, and significantly lower Cu concentrations at Grand Island compared to vegetation zone A at Times Beach. Also in fall 1986, Diplopoda collected at Grand Island had significantly lower Pb concentrations compared with those collected at Times Beach.

82. In summary, Tables 10a-d indicated no significant differences in Pb concentrations within each taxon, between the vegetation zones at Times Beach or (with the sole exception of the Diplopoda collected in fall 1986) between Times Beach and Grand Island. Concentrations of Cu in the Diplopoda and Cd in the Isopoda were consistently greater ($p < 0.05$) in the Times Beach samples compared with the Grand Island samples. Patterns of metal concentrations

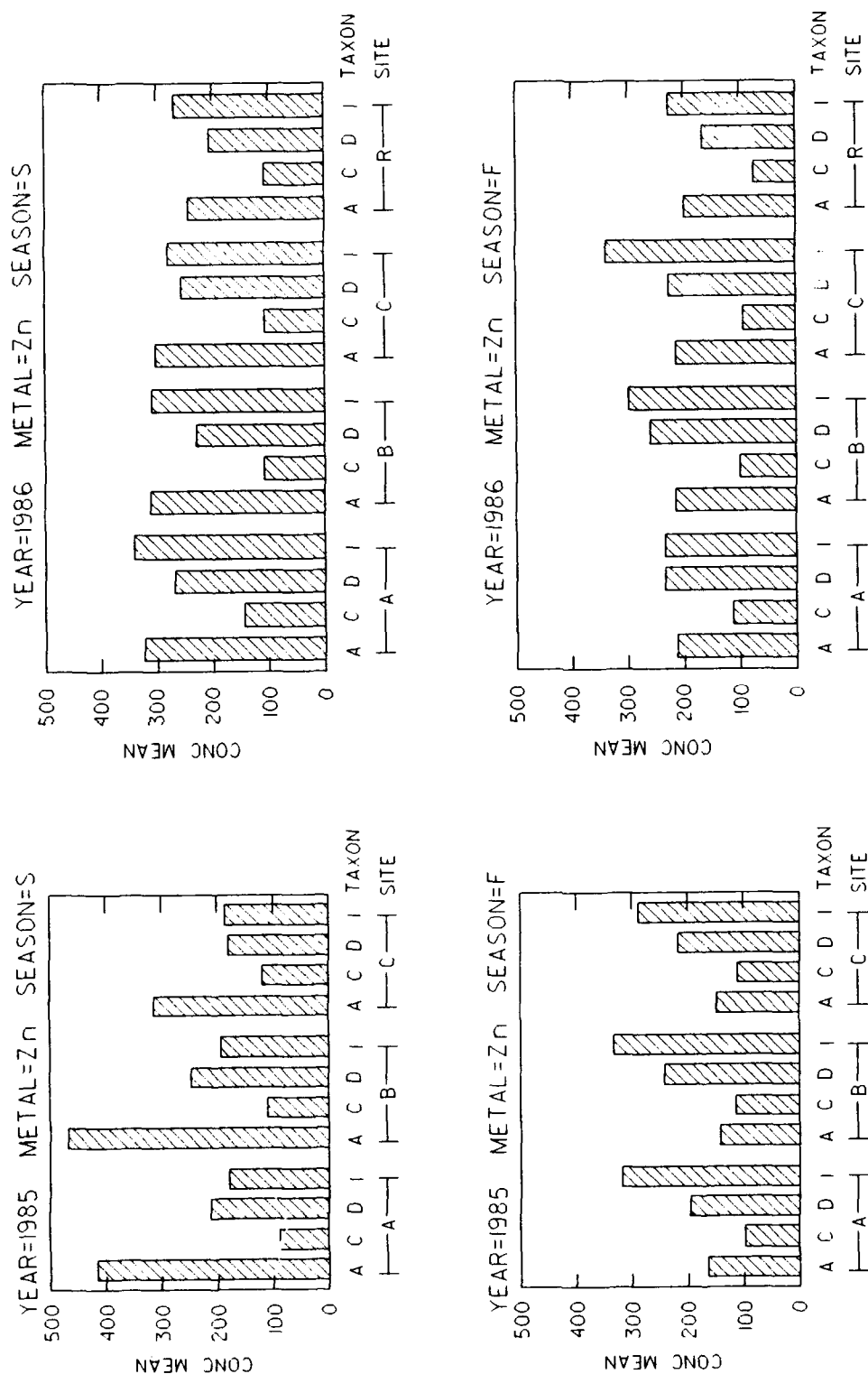
measured in the various taxa at the two sites were clearly repeated at each time of sampling. Figures 10a-d show the metal concentrations measured within each group of invertebrates, by metal element, for each sampling period.

83. In general, concentrations did not appear to differ according to the time of year that the sample was collected. The most notable exception was concentrations of Zn, Cu, and Cd in the Araneida, which were elevated in the spring sample compared with the fall sample in both 1985 and 1986. This pattern is clearly evident in Figures 10a-d. Since expertise was not available to identify the Araneida to genus or species level, it was not possible to ascertain whether this was due to a variation in species composition at different times of year. Over the 2-year sampling period there may have been an increase in the Cd concentrations present in the Coleoptera, Opiolones, and Diplopoda collected; however, this increase would need to be validated through analysis of further samples as time progresses.

84. Differences in metal concentrations between taxonomic groups were clearly evident from the results of chemical analysis and are shown in Figures 10a-d. Within the carnivorous species, the predatory Coleoptera contained the lowest concentrations of metals and Araneida the highest. Other carnivorous groups (Chilopoda and Opiolones) also contained high concentrations of the elements Zn, Cu, and Cd. The detritivorous species (Diplopoda and Isopoda) had high concentrations of the elements Zn, Cu, and Cd, and greater Cd and lower Cu concentrations were observed in the Isopoda compared with the Diplopoda. With the exception of Cd concentrations, the two herbivorous groups analyzed (herbivorous Coleoptera and Orthoptera) had similar tissue metal concentrations. The Cd concentrations appeared to be greater in the Orthoptera. All metal concentrations in herbivorous groups were low compared with the carnivorous and detritivorous groups. Of the taxonomic groups collected in sufficient quantities for metal analysis, the Araneida, Diplopoda, and Isopoda contained the greatest concentrations of heavy metals.

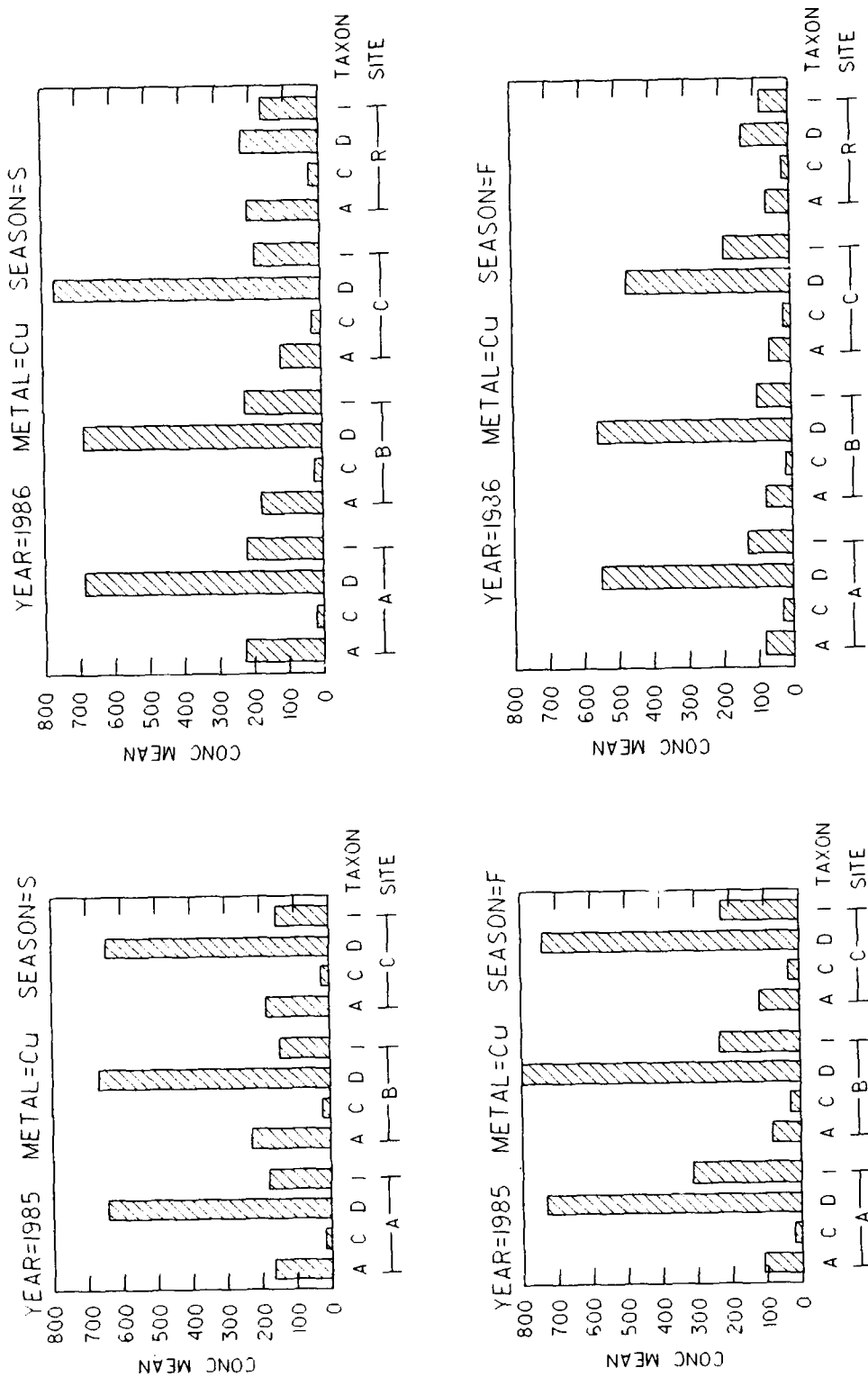
Intraspecific and intergeneric comparisons of metal concentrations

85. To provide background information regarding metal concentrations measured in the groups of species collected and analyzed at Times Beach, two more detailed studies were carried out: the first to assess variation in metal concentrations measured in individuals of the same species (the earthworms *Lumbricus rubellus*), and the second to compare metal concentrations



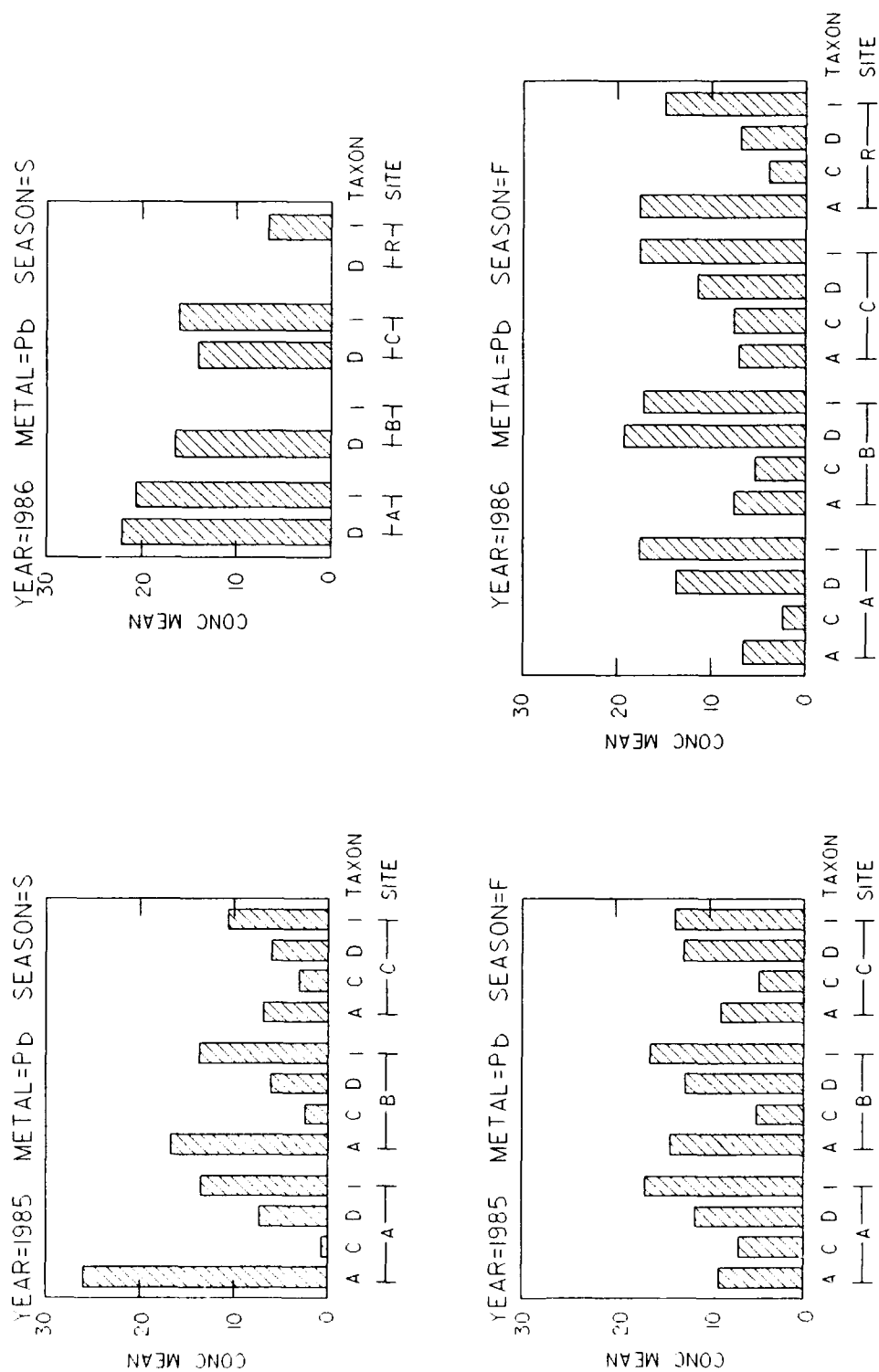
a. Zinc concentrations in invertebrates in 1985 and 1986

Figure 10. Metal concentrations (µg/g, dry weight) in invertebrates captured in pitfall traps at Times Beach (vegetation zones A, B, and C) and Grand Island (R). (Taxon symbols: A = Araneida, C = Coleoptera, D = Diplopoda, and I = Isopoda. Season symbols: (F = fall and S = spring) (Sheet 1 of 4)



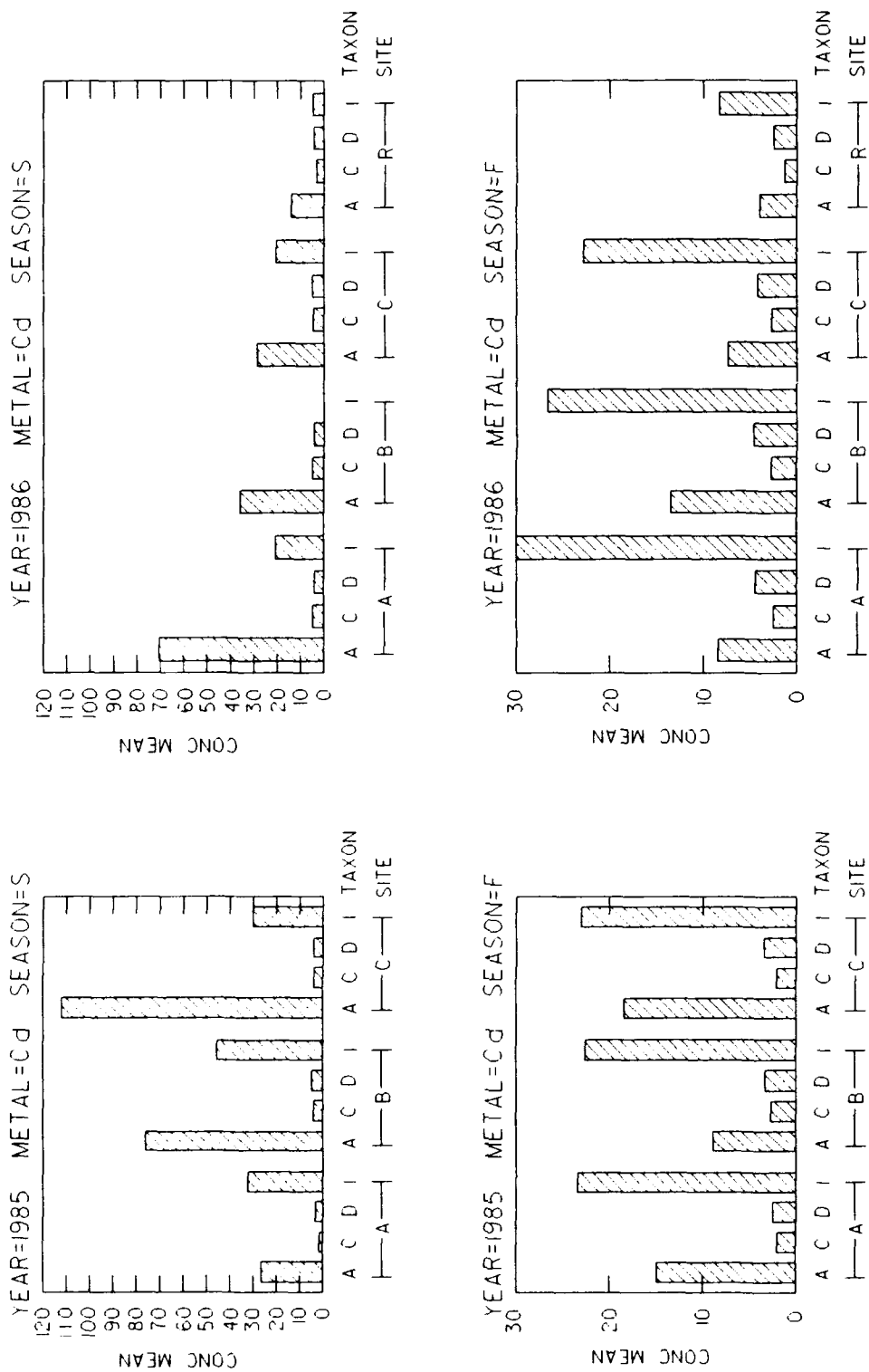
b. Copper concentrations in invertebrates in 1985 and 1986

Figure 10. (Sheet 2 of 4)



c. Cadmium concentrations in invertebrates in 1985 and 1986

Figure 10. (Sheet 3 of 4)



d. Lead concentrations in invertebrates in 1985 and 1986

Figure 10. (Sheet 4 of 4)

between different genera of the same taxonomic group (four genera of woodlice: Order Isopoda).

86. Variations in metal concentrations between individual earthworms of the same species were assessed by comparing *L. rubellus* collected from two vegetation types (A and B) as defined by Wilhelm in 1985. Earthworms were collected using the formaldehyde vermifuge; however, in contrast to previous studies at Times Beach (where acid-insoluble residue was used to correct for soil within the earthworm gut), these earthworms were held at 100-percent humidity for 48 hr to allow for evacuation of soil from the gut before preparation of tissue for analysis. Ten earthworms were collected from plot A1 and six from plot B5 (for plot definition, see Figure 8) and, of these, only three were clitellate. Dried, whole, individual earthworms were weighed and digested using the wet-ashing procedure described previously (see paragraph 41). Oven-dry body weights and heavy metal concentrations of individual earthworms from each sampling plot were recorded (Table 11a). Means and standard deviations of the means for each element are also given.

87. Increase in concentrations of certain elements in earthworms has been associated with increase in the period of exposure to those elements, e.g., Cd (Wade, Bache, and Lisk 1982) and Cu when present at high concentrations (Curry and Cotton 1980). If increasing age were taken as indicative of increase in the period of exposure, adult, clitellate earthworms may be expected to have higher concentrations compared to immature (nonclitellate) specimens, and assuming that body weight increases with age, some correlation between body weight and age may also be expected. Clitellate specimens did not have consistently higher heavy metal concentrations compared to nonclitellate specimens (Table 11a), and in most cases there was a poor correlation between body weight and heavy metal concentration (Table 11b).

88. Concentrations of the elements iron (Fe), aluminum (Al), and/or titanium (Ti) have been used in plant and animal studies of metal uptake to indicate whether soil is present in the samples (McGrath et al. 1982, Cherney and Robinson 1983, Cherney et al. 1983). High concentrations of these elements are known to be present in soils but not in plant and animal tissues. Results in Table 11a indicate that higher concentrations of these elements were observed in earthworms, which also contained higher levels of the elements Cu, Cr, Ni, and Pb, while lower levels of Fe, Al, and Ti were measured in specimens containing lower levels of Cu, Cr, Ni, and Pb. Conversely, Cd,

Table 11a
Variation in Metal Concentration Between Individual *L. rubellus*

Plot*	Sam- ple	Oven- Dry Body Weight mg	Metal Concentration, $\mu\text{g/g}$ dry weight									
			Ca	Ti	Fe	Al	Zn	Cu	Ni	Cd	Cr	Pb
A1	1**	121.2	8159	33	7452	2121	1772	31	5.5	18	17	39
A1	2**	112.5	3887	6.7	1295	239	1559	14	<0.76	61	4.5	9.8
A1	3**	104.1	3855	7.0	1245	326	1372	18	1.6	75	4.5	12
A1	4	102.3	5527	22	6725	1454	1789	24	5.4	69	19	33
A1	5	96.4	7136	20	5184	1199	1675	24	4.3	76	13	26
A1	6	84.4	4548	8.6	1683	304	1667	17	2.0	60	16	13
A1	7	127.9	5768	17	4347	972	1365	22	3.5	35	11	27
A1	8	69.3	5874	13	2337	397	1727	18	1.5	59	6.1	14
A1	9	96.6	6148	28	7587	1689	1379	25	3.4	26	15	38
A1	10	87.9	6041	28	7469	1209	1392	25	7.8	31	17	30
	Mean	100.3	5694	18	4532	991	1570	22	3.6	51	12	24
	SD†	17.3	1354	10	2707	658	177	5.0	2.2	21	5.5	11
B5	1	72.1	5227	11	1446	396	1361	19	<1.0	69	7.4	11
B5	2	133.5	4964	30	5439	1339	1499	37	4.2	43	12	20
B5	3	79.6	4916	19	2760	734	1486	21	2.1	80	8.1	18
B5	4	77.5	7637	17	2390	623	2265	21	1.6	102	8.9	23
B5	5	96.0	4582	11	1923	488	2629	21	1.6	159	5.2	18
B5	6	87.9	4089	16	1776	338	1995	17	1.3	75	4.1	11
	Mean	91.1	5236	17	2622	653	1873	23	2.0	88	7.6	17
	SD	22.4	1240	7.0	1456	366	508	7.2	1.2	40	2.8	4.9

* Entry indicates the plot from which earthworms were collected, as shown in Figure 8.

** Clitellate earthworms.

† Standard deviation of the mean.

Table 11b

Correlation Coefficients for Linear Relationship Between Body Weight of *L. rubellus* and Heavy Metal Concentration and Between Ti, Fe, and Al Concentration* and Heavy Metal Concentrations in Earthworms

Variable	Element					
	Zn	Cu	Ni	Cd	Cr	Pb
Plot A1						
Ti	-0.367	0.865	0.941	-0.618	0.760	0.474
Fe	-0.332	0.965	0.995	-0.507	0.830	0.538
Al	-0.356	0.961	0.981	-0.475	0.886	0.597
Oven-dry body weight	-0.064	0.913	0.904	-0.278	0.522	0.331
Plot B5						
Ti	0.076	0.947	0.832	-0.717	0.744	0.961
Fe	0.031	0.904	0.865	-0.631	0.790	0.971
Al	0.155	0.961	0.742	-0.632	0.739	0.978
Oven-dry body weight	-0.207	0.290	0.106	-0.307	0.020	0.322

* Used as an indication of the presence of soil in the sample.

which is known to accumulate within the earthworm tissue to levels exceeding those of the surrounding soil (see review by Beyer, Chaney, and Mulhern 1982) was measured in lowest concentrations in earthworms which had greatest concentrations of Fe, Al, and Ti, and vice versa (Table 11a). This pattern may be an indication that dredged material was present in the samples as a result of incomplete clearance of the gut by some of the earthworms. Correlation coefficients calculated between earthworm Fe, Al, and Ti concentrations and heavy metal concentrations (Table 11b) indicated a close relationship between these elements and heavy metal concentrations. For all elements except Zn, high correlation coefficients were recorded between worm metal concentrations and concentrations of Ti, Fe, and Al. These results suggest that the variation in metal concentrations between individual earthworms of the same species could be attributed to the presence of soil within the earthworm's gut. Correction to eliminate the effect of soil in the gut, using the method of Stafford and McGrath (1986), is likely to reduce this variation between individuals. It would be necessary to have information on the metal concentrations of the substrate/litter ingested by the earthworms to provide further evidence that the variations in metal concentrations measured in earthworms in this study

were associated with substrate remaining within the earthworm gut.

89. Variation in metal concentrations between genera of the same taxonomic order was assessed using woodlice (Isopoda) collected in the pitfall traps in October 1985. Four genera of Isopoda were identified: Oniscidae *Oniscus*; Porcellionidae *Porcellio*; Trichoniscidae *Trichoniscus*, and Armadillidae *Armadillidium*. For each genus the number of individuals was recorded and their oven-dry weight (in milligrams) measured (Table 12a). The relative numbers and weight of each genus, expressed as a percentage of the total, is also given in parentheses after the numbers and weights in Table 12a.

Table 12a
Numbers and Weights of Isopoda Collected in Pitfall Traps

<u>Plot</u>	<u>Genus</u>	<u>Number</u>	<u>Relative Percent</u>	<u>Weight</u>	<u>Relative Percent</u>
A1	O. <i>Oniscus</i>	44	22.45	0.580	43.19
	P. <i>Porcellio</i>	98	50.00	0.674	50.19
	T. <i>Trichoniscus</i>	48	24.49	0.031	2.31
	A. <i>Armadillidium</i>	6	3.06	0.058	4.32
A2	O. <i>Oniscus</i>	17	14.41	0.249	28.52
	P. <i>Porcellio</i>	72	61.02	0.561	64.26
	T. <i>Trichoniscus</i>	16	13.56	0.026	2.98
	A. <i>Armadillidium</i>	13	11.01	0.037	4.24
A3	O. <i>Oniscus</i>	3	2.94	0.092	13.65
	P. <i>Porcellio</i>	67	65.59	0.453	67.21
	T. <i>Trichoniscus</i>	6	5.88	0.003	0.45
	A. <i>Armadillidium</i>	26	25.49	0.126	18.69
A4	O. <i>Oniscus</i>	10	6.21	0.130	18.44
	P. <i>Porcellio</i>	74	45.96	0.491	69.65
	T. <i>Trichoniscus</i>	65	40.37	0.029	4.11
	A. <i>Armadillidium</i>	12	7.45	0.055	7.80
B1	O. <i>Oniscus</i>	3	1.15	0.077	17.46
	P. <i>Porcellio</i>	46	17.62	0.276	62.58
	T. <i>Trichoniscus</i>	211	80.84	0.076	17.23
	A. <i>Armadillidium</i>	1	0.38	0.012	2.72
B2	O. <i>Oniscus</i>	3	2.48	0.041	11.92
	P. <i>Porcellio</i>	36	29.75	0.267	77.62
	T. <i>Trichoniscus</i>	81	66.94	0.026	7.56
	A. <i>Armadillidium</i>	1	0.83	0.010	2.91

(Continued)

Table 12a (Concluded)

<u>Plot</u>	<u>Genus</u>	<u>Number</u>	<u>Relative Percent</u>	<u>Weight</u>	<u>Relative Percent</u>
B3	O. <i>Oniscus</i>	1	0.47	0.107	24.04
	P. <i>Porcellio</i>	40	18.96	0.261	58.65
	T. <i>Trichoniscus</i>	169	80.09	0.067	15.06
	A. <i>Armadillidium</i>	1	0.47	0.010	2.25
B4	O. <i>Oniscus</i>	11	10.48	0.147	40.50
	P. <i>Porcellio</i>	36	34.29	0.198	54.55
	T. <i>Trichoniscus</i>	57	54.29	0.012	3.31
	A. <i>Armadillidium</i>	1	0.95	0.006	1.65
B5	O. <i>Oniscus</i>	2	3.70	0.034	19.10
	P. <i>Porcellio</i>	23	42.59	0.139	78.09
	T. <i>Trichoniscus</i>	29	53.70	0.005	2.81
	A. <i>Armadillidium</i>	0		0	
C1	O. <i>Oniscus</i>	1	0.55	0.033	6.92
	P. <i>Porcellio</i>	40	22.10	0.348	72.96
	T. <i>Trichoniscus</i>	140	77.35	0.096	20.13
	A. <i>Armadillidium</i>	0		0	
C2	O. <i>Oniscus</i>	15	6.20	0.208	26.94
	P. <i>Porcellio</i>	80	33.06	0.515	66.71
	T. <i>Trichoniscus</i>	147	60.74	0.049	6.35
	A. <i>Armadillidium</i>	0		0	
C3	O. <i>Oniscus</i>	1	0.33	0.027	5.73
	P. <i>Porcellio</i>	25	8.31	0.342	72.61
	T. <i>Trichoniscus</i>	274	91.03	0.090	19.11
	A. <i>Armadillidium</i>	1	0.33	0.012	2.55
C4	O. <i>Oniscus</i>	0		0	
	P. <i>Porcellio</i>	27	19.01	0.264	79.52
	T. <i>Trichoniscus</i>	115	80.99	0.068	20.48
	A. <i>Armadillidium</i>	0		0	

90. Where sufficient biomass was available, each genus, from each plot, was subjected to analysis for heavy metal concentration (using the procedure described in paragraph 41). These results (in micrograms per gram, dry weight) are given in Table 12b.

91. Differences in metal concentrations between genera of Isopoda are clearly evident from Table 12b. Mean metal concentrations for each taxonomic group are compared statistically in Table 12c. Highest concentrations of Cd

Table 12b
Intergeneric Differences in Metal Concentrations* Between Isopoda
Collected in Pitfall Traps

Plot	Genus	Element					
		Zn	Cu	Ni	Cd	Cr	Pb
A1	<i>Oniscus</i>	133	258	2.4	38	4.9	23
	<i>Porcellio</i>	394	405	2.4	12	7.0	14
	<i>Trichoniscus</i>	258	144	3.5	62	21	22
	<i>Armadillidium</i>	278	307	2.0	4.5	9.4	12
A2	<i>Oniscus</i>	134	252	3.6	46	14	21
	<i>Porcellio</i>	367	331	3.7	11	11	19
	<i>Trichoniscus</i>	126	62	6.6	26	65	12
	<i>Armadillidium</i>	322	431	4.7	6.9	24	20
A3	<i>Oniscus</i>	100	174	1.8	41	9.9	31
	<i>Porcellio</i>	441	300	2.4	11	6.8	12
	<i>Armadillidium</i>	330	316	2.9	5.7	10	15
A4	<i>Oniscus</i>	139	227	1.6	52	10	16
	<i>Porcellio</i>	407	342	2.7	15	8.0	14
	<i>Trichoniscus</i>	371	166	10	79	44	52
	<i>Armadillidium</i>	315	427	2.7	7.2	12	15
B1	<i>Oniscus</i>	154	102	2.3	22	13	11
	<i>Porcellio</i>	395	313	2.8	13	7.5	14
	<i>Trichoniscus</i>	676	107	11	63	45	57
B2	<i>Oniscus</i>	97	143	2.0	28	16	12
	<i>Porcellio</i>	315	212	2.7	13	6.8	12
	<i>Trichoniscus</i>	348	145	12	98	50	60
B3	<i>Oniscus</i>	99	165	2.7	30	6.2	28
	<i>Porcellio</i>	343	242	2.8	12	4.8	12
	<i>Trichoniscus</i>	342	102	7.7	79	29	40
B4	<i>Oniscus</i>	117	211	1.6	45	8.8	12
	<i>Porcellio</i>	422	302	2.4	17	13	12
B5	<i>Oniscus</i>	143	122	14	46	9.9	11
	<i>Porcellio</i>	394	246	2.1	13	5.5	12
C1	<i>Oniscus</i>	120	169	<2.8	40	22	<9.6
	<i>Porcellio</i>	303	240	1.9	9.7	4.2	8.5
	<i>Trichoniscus</i>	189	85	3.3	47	11	16
C2	<i>Oniscus</i>	133	169	1.7	33	5.3	11
	<i>Porcellio</i>	397	312	2.5	12	5.9	11
	<i>Trichoniscus</i>	273	120	3.8	62	24	21
C3	<i>Oniscus</i>	158	185	<2.7	37	23	15
	<i>Porcellio</i>	313	249	3.1	9.9	9.2	16
	<i>Trichoniscus</i>	225	92	6.3	59	25	35
C4	<i>Porcellio</i>	285	151	1.4	10	5.3	7.9
	<i>Trichoniscus</i>	229	76	2.4	70	13	13

* Mean concentrations for four traps per plot (in micrograms per gram, dry weight).

Table 12c
Comparisons Between Metal Concentrations of Isopoda of Different Genera

Vegetation Zone	Species	Element					
		Zn	Cu	Ni	Cd	Cr	Pb
Zone A	<i>Armadillidium</i>	311 ^{b*}	370 ^{a*}	3.1 ^b	6.1 ^{c*}	14 ^b	16 ^{a*}
	<i>Oniscus</i>	127 ^{c*}	228 ^{b*}	2.4 ^b	44 ^{a*}	20 ^b	23 ^{a*}
	<i>Porcellio</i>	402 ^{a*}	345 ^{a*}	2.8 ^b	12 ^{b*}	8.2 ^b	15 ^{a*}
	<i>Trichoniscus</i>	252 ^{bc*}	124 ^{b*}	6.7 ^a	56 ^{a*}	43 ^a	29 ^{a*}
Zone B	<i>Armadillidium</i>	s**	s	s	s	s	s
	<i>Oniscus</i>	122 ^b	149 ^b	4.5 ^b	33 ^b	11 ^b	15 ^b
	<i>Porcellio</i>	374 ^a	263 ^a	2.6 ^b	14 ^c	7.5 ^b	12 ^b
	<i>Trichoniscus</i>	455 ^a	118 ^b	10 ^a	76 ^a	41 ^a	52 ^a
Zone C	<i>Armadillidium</i>	s	s	s	s	s	s
	<i>Oniscus</i>	137 ^c	169 ^b	1.5 ^b	37 ^b	17 ^{ab}	12 ^{ab}
	<i>Porcellio</i>	325 ^a	267 ^a	2.2 ^{ab}	10 ^c	6 ^b	11 ^b
	<i>Trichoniscus</i>	229 ^b	93 ^c	4.0 ^a	60 ^a	18 ^a	21 ^a

Note: Concentrations are mean values (micrograms per gram, dry weight). Mean values in a column within each zone followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

** Insufficient sample size for analysis.

were present in the *Trichoniscus* followed by the *Oniscus*, and both of these groups had higher concentrations compared with the *Porcellio* and the *Armadillidium*. Conversely, highest Cu concentrations were measured in *Porcellio* and *Armadillidium* compared with *Oniscus* and *Trichoniscus*. The *Trichoniscus* generally contained higher concentrations of Ni, Cr, and Pb compared with the other three genera, and the *Oniscus* generally contained lower concentrations of Zn compared with the other genera. However, when the contribution of each genus to the total biomass of Isopoda collected in the pitfall trap is also taken into consideration, a different picture emerges (Table 12a). The *Trichoniscus*, usually the most abundant genus in the traps, was also the smallest so that their contribution to the total biomass was also generally small. Conversely the *Oniscus*, while present in small numbers, contributed a greater weight per individual and made up a significant proportion of the total biomass of Isopoda collected in the traps (Table 12a). Thus, both metal concentration and relative biomass are factors that must be taken into consideration when metal concentrations of taxonomic groups are used to assess the nature

and degree of contaminant mobility at a contaminated dredged material disposal facility.

92. Metal concentrations between vegetation zones for the same taxonomic group were then statistically compared (Table 12d). For each group, similar ranges in metal concentrations were recorded in each of the vegetation zones. This suggests either that the invertebrates were moving and feeding between the vegetation zones or that there was little difference between the three zones in terms of metal availability and uptake into the invertebrate tissues. Where statistically significant differences were observed, metal concentrations in the Isopoda tended to be greater in vegetation zone A compared with either zone B or C.

Table 12d
Metal Concentrations in Isopoda Collected from
Vegetation Zones at Times Beach

Species	Vegetation Zone	Element					
		Zn	Cu	Ni	Cd	Cr	Pb
<i>Armadillidium</i>	s*						
<i>Oniscus</i>	A	127 ^a	228 ^a	2.4 ^a	44 ^{a**}	9.7 ^a	23 ^a
	B	122 ^a	149 ^b	4.5 ^a	33 ^{a**}	11 ^a	15 ^{ab}
	C	137 ^a	169 ^{ab}	1.5 ^a	37 ^{a**}	17 ^a	12 ^b
<i>Porcellio</i>	A	402 ^a	345 ^a	2.8 ^a	12 ^{ab}	8.2 ^a	15 ^a
	B	374 ^{ab}	263 ^b	2.6 ^a	14 ^a	7.5 ^a	12 ^a
	C	325 ^b	267 ^a	2.2 ^a	10 ^b	6.2 ^a	11 ^a
<i>Trichoniscus</i>	A	252 ^a	124 ^a	6.7 ^{ab}	56 ^{a**}	43 ^a	29 ^a
	B	455 ^a	118 ^a	10 ^a	76 ^{a**}	41 ^a	52 ^a
	C	229 ^a	93 ^a	4.0 ^b	60 ^{a**}	18 ^a	21 ^a

Note: Concentrations are mean values (micrograms per gram, dry weight). Mean values in a column within each taxon followed by the same letter are not significantly different at $p < 0.05$.

* Insufficient sample size for statistical analysis.

** Nonparametric statistical comparison of the means was employed.

93. Metal concentrations in the tissues of earthworms sampled across the upland area at Times Beach are given in Appendix B, Part I(4), Tables 9 and 10. High concentrations of Zn and Cd were measured in all of the earthworm species collected. Interspecific differences were clearly evident from

the results; for example *A. chlorotica* contained lower concentrations of Zn compared with the remaining species. Within each species, similar concentrations of the elements measured were present in each of the vegetation zones (A, B, and C) (Table 13a).

Table 13a
Comparative Metal Concentrations in Earthworms Collected
from Vegetation Zones at Times Beach

<u>Species</u>	<u>Vegetation Zone</u>	<u>Element</u>			
		<u>Zn</u>	<u>Cu</u>	<u>Cd</u>	<u>Pb</u>
<i>L. rubellus</i>	A	1809 ^a	16 ^{ab}	57 ^a	0.34 ^a
	B	1302 ^a	18 ^a	67 ^a	0.31 ^a
	C	1332 ^a	11 ^b	58 ^a	s*
<i>A. caliginosa</i>	A	1115 ^{a**}	26 ^a	27 ^a	1.2 ^a
	B	1059 ^{a**}	21 ^{ab}	30 ^a	4.3 ^a
	C	995 ^{a**}	16 ^b	37 ^a	s
<i>A. chlorotica</i>	A	412 ^{a**}	23 ^a	32 ^{a**}	5.9 ^a
	B	467 ^{a**}	25 ^a	51 ^{a**}	8.9 ^a
	C	417 ^{a**}	21 ^a	45 ^{a**}	3.6 ^a

Note: Concentrations are mean values (micrograms per gram, dry weight). Mean values in a column within each species followed by the same letter are not significantly different at $p < 0.05$.

* Insufficient sample size for statistical analysis.

** Nonparametric statistical comparison of the means was employed.

94. As a result of the similarity of metal concentrations measured in earthworms from the different vegetation zones at Times Beach, results for each species collected at Times Beach were pooled, and the mean value was compared with the metal concentrations measured in each species collected at the Grand Island site (Table 13b). Generally, greater concentrations of Zn, Cu, and Cd were present in earthworms collected at Times Beach compared with those collected at Grand Island. Copper concentrations in *L. terrestris*, Zn concentrations in *A. chlorotica*, and Cd concentrations in *A. caliginosa* were exceptions; similar concentrations were present in earthworms collected at each site. Differences in metal uptake between the earthworm species may be a reflection of such feeding preferences and of variation in the bioavailability of metals present in the different horizons of the substrate. Of the earthworm species collected, *A. caliginosa* predominantly ingests mineral soil,

Table 13b
Comparative Metal Concentrations in Earthworms from
Grand Island and Times Beach

<u>Species/Site</u>	<u>Element</u>			
	<u>Zn</u>	<u>Cu</u>	<u>Cd</u>	<u>Pb</u>
<i>L. terrestris</i>				
Times Beach	2775 ^a	16 ^{a*}	48 ^a	2.6 ^a
Grand Island**	350 ^b	2.1 ^{a*}	8.9 ^b	4.0 ^a
<i>L. rubellus</i>				
Times Beach	1436 ^a	16 ^a	62 ^a	1.5 ^a
Grand Island	430 ^b	4.6 ^b	13 ^b	0.32 ^b
<i>A. caliginosa</i>				
Times Beach	1064 ^a	22 ^a	34 ^a	2.8 ^a
Grand Island	479 ^b	5.5 ^b	31 ^a	2.5 ^a
<i>A. chlorotica</i>				
Times Beach	434 ^{a*}	23 ^a	43 ^a	7.0 ^a
Grand Island	304 ^{a*}	7.7 ^b	18 ^b	2.3 ^a

Note: Concentrations are mean values (micrograms per gram, dry weight). Mean values in a column within each species followed by the same letter are not significantly different at $p < 0.05$.

* Nonparametric statistical comparison of the means was employed.

** Details of metal concentrations in the native earthworms at Grand Island can be found in Appendix B, Part IV(4), Table 24.

burrowing within the mineral soil horizons; the other three species either predominantly inhabit the litter layer (*L. rubellus* and *A. chlorotica*) or feed mainly on leaf litter (*L. terrestris*). With the exception of Pb concentrations measured in *L. rubellus*, Pb concentrations were similar in earthworms collected at Times Beach and Grand Island, indicating little difference in the bioavailability of this element between the two sites.

95. Compared with the other soil-dwelling invertebrates collected at the Times Beach CDF, the earthworms contained the greatest Zn concentrations. Copper concentrations were greater in the Diplopoda, and Cd concentrations were similar between the earthworms and the Isopoda. Lead concentrations were within a similar range in the earthworms as in the other invertebrate fauna collected in the pitfall traps.

96. In summary, where comparative data were available from collections of earthworms and invertebrates at the reference Grand Island site, a similar

taxonomic composition was recorded at the Grand Island site and the Times Beach CDF. However, metal concentrations measured in the specimens differed between the two sites. Greater Zn and Cd concentrations were evident in the predatory Coleoptera, Araneida, Diplopoda, and Isopoda at Times Beach compared to Grand Island. In particular, concentrations of Cd in the Araneida, Diplopoda, and Isopoda were elevated at Times Beach compared to specimens collected at Grand Island. Similar Cu concentrations were recorded in predatory Coleoptera and Araneida at the two sites, but higher Cu concentrations were observed in Diplopoda and Isopoda collected at Times Beach. For each of the taxonomic groups, similar Pb concentrations were recorded at the two sites. All species of earthworms collected at Times Beach contained significantly higher concentrations of the elements Zn and Cu than the same species sampled from Grand Island. Cadmium concentrations in the *L. terrestris*, *L. rubellus*, and *A. chlorotica* were higher in those earthworms sampled at the Times Beach CDF compared to the Grand Island site; however, earthworms of the species *A. caliginosa* contained similar Cd concentrations at the two sites. Lead concentrations measured in all earthworm species were within a similar range at the two sites.

Vertebrates

97. Selected vertebrates at the CDF were captured and, where applicable, dissected to remove target organs for analysis. A number of PCBs, PAHs, and pesticides (listed in Appendix B, Part I(5), Table 12b) were measured in the specimens and tissues listed in Appendix B, Part I(5), Table 12a. However, the results demonstrated that all compounds were below the detection limits given in Appendix B, Table 12b. At the Times Beach CDF, Red-winged Blackbirds, Mallard Ducks, Muskrats, American Toads, Mice, and Voles were collected. For comparison, Red-winged Blackbirds and Mallard Ducks were also collected at the reference site Amherst. A description of this reference site, selected by Andrle and known to contain relatively low concentrations of contaminants, can be found in the report by Dr. Andrle in Appendix A to this report. Frogs, salamanders, and shrews, which were captured in pitfall traps placed at the Grand Island site designed to capture invertebrates, were also analyzed; these results are given in Appendix B, Part IV(5), Table 25. In some cases a direct comparison of metal levels is not valid due to species differences; but where possible, metal concentrations were compared between the two sites. For example, greater concentrations of Zn and Cd were evident

in the Toads from Times Beach compared with the Frogs from Grand Island; however, this may be a reflection of interspecific differences in metal uptake rather than differences attributable to metal availability in food chains at the two sites.

98. The Muskrats, all five individuals collected from Times Beach, have been divided to give the results for the 12-oz (0.34-kg) individual separately from the mean value of the other four Muskrats (which weighed approximately 3 lb (1.36 kg) each). The results of these analyses are presented in Appendix B, Part I(5), Table 12, and in Part II(2), Table 15. This may indicate an increase in metal load, which could be attributed to increasing age (weight) of the animals. No statistical appraisal can be made due to the small sample size; however, a small increase in concentrations of some elements, for example Zn, Cu, and Cr, is suggested from the tissues that were analyzed.

99. Concentrations of metals in tissues of Mice and Voles collected at the Times Beach CDF have been compared with measurements of metal concentrations in these species collected at a contaminated and uncontaminated site at Binghamton (Appendix B, Part I(5), Table 12(c)). Concentrations of the elements Zn, Cu, Ni, Cd, and Pb in the specimens from Times Beach were greater than those recorded in animals from the control site but lower than those animals captured at the contaminated site.

100. Results of metal analysis of the bird samples have been divided on the basis of the site from which they were sampled and whether they were adult or immature specimens (Appendix B, Part I(5), Table 12(c)). At the reference site, Zn concentrations in immature birds were higher than Zn levels in corresponding tissues of adult birds; however, at Times Beach the adult birds had higher Zn concentrations in the tissues compared with the immature birds. Adult Red-winged Blackbirds from Times Beach had higher Zn concentrations compared with adult birds from the reference site. The Cd concentration in the liver of adult blackbirds from Times Beach was notably higher than the concentration measured in the livers of birds from the reference area. A similar increase was observed for Pb concentrations in the birds. However, Pb concentrations should be interpreted with care. The wide variation in concentrations measured suggests that some Pb contamination resulting from lead shot may have occurred. Blackbird eggs taken from the reference and Times Beach sites showed little difference in metal concentrations of either egg or shell

between the two sites. All immature Mallard Ducks were collected from the reference site, and metal concentrations are included for general comparison of metal loads in vertebrates at a reference area.

Aquatic Area

101. In the aquatic area, water samples contained concentrations of metals which fell below guidance limits as defined by the US Environmental Protection Agency (EPA) (Appendix B, Part 3(1), Table 16). Concentrations of organic compounds measured in the fish tissues varied between species, and this was presumed to be a reflection of differences in feeding habits. Detailed discussion of the results of organic analysis of fish tissues is included in the publication by Kay, Simmers, and Marquenie (1986). Their conclusions were that the results of this preliminary study suggest that the PCB concentrations of gamefishes within the disposal facility may potentially be of concern for public health. Consequently, it was recommended that fishes caught at Times Beach should not be eaten unless further studies are carried out to demonstrate that no harmful effects will result.

102. In Appendix B, Part III(2), Table 18(b), concentrations of metals measured in ducks from Times Beach (adult and immature) and in ducks from sites in The Netherlands known to be contaminated (Harlinvleet Basin) and relatively uncontaminated (Lake Issel) are given. Cadmium concentrations increased in the adult birds compared to the immature birds. Concentrations of Cd, Cu, and Hg were greater in the Times Beach birds compared to birds from the Lake Issel site, and Hg in the Times Beach birds exceeded Hg measurements in the birds from the highly contaminated Harlinvleet Basin.

PART V: DISCUSSION AND CONCLUSIONS

103. The Times Beach CDF provides an ideal opportunity to study ecosystems developing at a dredged material disposal facility, particularly since, within the relatively small area at Times Beach, upland, wetland, and aquatic areas are represented and can be studied simultaneously. The information gathered is not comprehensive; however, the data collated in this report do provide the most comprehensive overview available to date of ecosystem development and contaminant concentrations within the various components of an ecosystem at a dredged material disposal facility. The data will be useful, both in the management of CDFs and for reference in future studies. However, in extrapolating results gathered at Times Beach to other CDFs, due consideration should be given to the fact that these results relate to a single CDF, during a relatively short period of its existence.

104. Dredged material from Times Beach was first collected for chemical analysis in 1981, 5 years after the pumping of dredged material had stopped, to determine the nature and quantity of contaminants present. At that time, preliminary uptake studies were undertaken in the laboratory to ascertain the bioavailability of the contaminants to plants and animals exposed to the dredged material. Although sampling and analysis has continued at the CDF over the past 5 years up to 1986, the aim of these studies was not to monitor changes with time in either the nature or quantities of contaminants present. Therefore, any suggestions of changes in the concentrations or bioavailability of contaminants present are by inference only. A systematic sampling program, carried out as the CDF continues to age, would provide the necessary information to assess changes which are occurring in this respect at the site.

105. In studies carried out in relation to other dredged material disposal operations, sediment "aging" processes have been simulated in the laboratory. These studies have indicated that certain groups of contaminants, particularly the low molecular weight organochlorine compounds, volatilize, degrade, or are metabolically changed, and effectively "disappear" with time. Other groups of contaminants, notably the heavy metals, are persistent in the system, and it is these groups which are likely to remain a potential hazard in the long term (Simmers et al. 1987). Some analysis of organic compounds was conducted in the course of investigations at Times Beach. While concentrations in the dredged material were considered to be elevated (Marquenie,

Simmers, and Kay 1987), there was no indication that these compounds had moved through the food chain to the birds and mammals inhabiting the Times Beach CDF. Previous research has suggested that predators at the top of the food chain are most likely to be target organisms for the bioaccumulation of organic compounds. Failure to detect these compounds in any of the bird or mammal tissue collected for analysis from Times Beach may suggest that these compounds are unlikely to be a hazard at the site. Analysis of water samples collected at Times Beach indicated concentrations below EPA guideline limits; however, based on PCB concentrations measured in gamefishes captured at Times Beach, Kay, Simmers, and Marquenie (1986) suggested that further studies be carried out before recommending that these fish are safe for human consumption.

106. For study of the more persistent contaminants, specifically the heavy metals, the Times Beach CDF was divided into upland, wetland, and aquatic areas. The upland area was subsequently further divided into three vegetation zones (A,B,C), each associated with a different plant community. Various components of the ecosystem in each vegetation zone were then sampled for chemical analysis. Concentrations of the elements Zn, Cu, Ni, Cd, Cr, and Pb in each of these components are summarized in Tables 14-19, respectively, for the Times Beach CDF and in Table 20 for the reference site, Grand Island.

107. Results of chemical analysis of the dredged material from Times Beach suggested considerable heterogeneity in chemical composition of the site, both between the different sampling plots and vertically within the substrate profile at any particular sampling plot. Such heterogeneity may arise as a result of the initial dredging operation; it is unlikely that the dredged material with which the facility was partially filled was of a homogeneous nature. Presumably, the CDF was filled with varying quantities of material dredged from different reaches of the Buffalo Harbor. Additionally, in the period that has elapsed since pumping ceased, the dredged material at the CDF has been subject to different physicochemical conditions, dependent upon proximity to the water table and frequency of inundation due to changes in the water level of Lake Erie. As a result, development of a profile at Times Beach has not occurred uniformly across the site.

108. The results in Appendix B, Part I(2), Table 4, and Part II(1), Table 14, suggest that differences in plant communities established at Times Beach are more likely to reflect differences in physical conditions than

Table 14
Concentrations of Zinc in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	289(22)	480(123)	426(152)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	471	350	131
<i>S. altissima</i> (leaves)	26(0.71)	27(3.6)	31
(stems)	31(8.7)	52(24)	32
(flowers)	27(2.1)	34(5.6)	27
<i>L. salicaria</i> (leaves)	s*	205	235(67)
(stems)	s	38	31(18)
(flowers)	s	s	84
<i>C. stolonifera</i> (leaves)	s	35(29)	s
<i>I. capensis</i> (leaves/stems)	s	87	97(26)
<i>P. australis</i> (leaves)	s	s	39
(stems)	s	s	72
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	1809(341)	1302(311)	1332(351)
<i>A. caliginosa</i>	1115(105)	1059(381)	995(28)
<i>A. chlorotica</i>	412(90)	467(82)	417(370)
<i>L. terrestris</i>	3077(361)	s	1565
Pitfall trap fauna:	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	128(30) 108(36)	107(15) 105(22)	108(12) 97(16)
Araneida	385(69) 202(30)	411(100) 200(39)	305(45) 196(30)
Chilopoda	460(310) 217(91)	219(46) 303(213)	212 138
Herb. Coleoptera	127 222(0)	204 162(13)	190 167
Orthoptera	188 176(34)	188 163(16)	188 172(51)
Diplopoda	250(84) 212(33)	232(36) 244(53)	220(55) 214(56)
Isopoda	287(127) 273(69)	273(65) 312(56)	227(107) 302(81)
VERTEBRATES (ALL PLOTS)			
<i>Bufo americanas</i>	(whole)	117(22)	
(n = 5)	(muscle)	190(78)	
	(bones)	151(25)	
	(liver)	121(22)	
	(kidney)	187(26)	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	117	139
	(muscle)	48	57
	(bone)	119	141
	(liver)	41	72
<i>Microtus pennsylvanicus</i>	(muscle)	99(62)	
(n = 13)	(bone)	170(30)	
	(liver)	150(33)	
	(kidney)	115(17)	
<i>Peromyscus leucopus</i>	(muscle)	92(49)	
(n = 13)	(bone)	187(17)	
	(liver)	194(52)	
	(kidney)	184(66)	

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 15
Concentrations of Copper in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	51(10)	95(33)	84(15)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	14	12	7.8
<i>S. altissima</i> (leaves)	9.7(0.42)	8.1(2.5)	9.6
(stems)	6.6(0.97)	6.2(0.93)	5.7
(flowers)	11(0.01)	13(0.57)	12
<i>L. salicaria</i> (leaves)	s*	11	10(2.5)
(stems)	s	10	11(2.8)
(flowers)	s	s	29
<i>C. stolonifera</i> (leaves)	s	4.4(0.55)	s
<i>I. capensis</i> (leaves/stems)	s	9.8	8.0(1.82)
<i>P. australis</i> (leaves)	s	s	7.5
(stems)	s	s	15
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	16(1.3)	19(3.4)	11(2.7)
<i>A. caliginosa</i>	26(3.3)	21(1.6)	16(4.7)
<i>A. chlorotica</i>	23(2.7)	25(6.4)	21(13)
<i>L. terrestris</i>	15(5.2)	s	18
Pitfall trap fauna			
	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	17(2.3) 25(15)	17(3.3) 18(2.7)	17(3.5) 17(2.9)
Araneida	189(36) 91(14)	212(38) 78(12)	165(35) 71(19)
Chilopoda	61(5.1) 44(5.7)	40(10) 78(61)	50 30
Herb. Coleoptera	33 44(2.8)	34 57(30)	33 26
Orthoptera	56 36(5.6)	56 30(4.7)	56 27(6.0)
Diplopoda	669(97) 652(112)	675(92) 701(163)	703(101) 638(200)
Isopoda	210(31) 220(98)	199(54) 169(68)	165(39) 198(77)
VERTEBRATES (ALL PLOTS)			
<i>Bufo americanas</i>	(whole)	24(6.3)	
(n = 5)	(muscle)	26(15)	
	(bones)	14(5.5)	
	(liver)	88(63)	
	(kidney)	51(11)	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	7.0	11
	(muscle)	8.6	6.9
	(bone)	2.0	1.8
	(liver)	7.8	15
<i>Microtus pennsylvanicus</i>	(muscle)	9.7(2.2)	
(n = 13)	(bone)	7.2(1.3)	
	(liver)	16(1.8)	
	(kidney)	19(4.9)	
<i>Peromyscus leucopus</i>	(muscle)	15(1.8)	
(n = 13)	(bone)	7.7(1.1)	
	(liver)	20(5.9)	
	(kidney)	22(4.7)	

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 16
Concentrations of Nickel in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	29(8.6)	49(20)	35(5.9)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	2.3	2.0	2.5
<i>S. altissima</i> (leaves)	1.1(0.52)	<0.75	<0.75
(stems)	0.8(0.09)	0.90(0.26)	<0.75
(flowers)	1.2(0.31)	2.1(1.0)	1.3
<i>L. salicaria</i> (leaves)	s	1.1	1.6(1.2)
(stems)	s	<0.75	<0.75
(flowers)	s	s	1.9
<i>C. stolonifera</i> (leaves)	s	1.5(0.45)	s
<i>I. capensis</i> (leaves & stems)	s	<0.75	0.61(0.24)
<i>P. australis</i> (leaves)	s	s	1.4
(stems)	s	s	2.4
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	2.4(0.16)	1.9(1.6)	2.9
<i>A. caliginosa</i>	2.9(1.7)	2.9	1.6(2.2)
<i>A. chlorotica</i>	4.6(4.1)	9.1(5.4)	4.3(2.8)
<i>L. terrestris</i>	3.4(3.7)	s	
Pitfall trap fauna	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	1.8(0.74)	1.1 2.2(1.5)	0.74 2.5(1.5)
Araneida	8.8(6.2)	20(4.2) 5.2(3.2)	10 2.3(0.67)
Chilopoda	19(18)	18(21)	12 2.1
Herb. Coleoptera	5.5(3.4)	19(23)	3.6
Orthoptera	5.2(2.9)	4.3(2.3)	3.9(2.1)
Diplopoda	3.3 5.5(4.3)	3.4(1.0) 9.1(11)	3.2(1.9) 4.7(3.2)
Isopoda	4.6(2.1) 3.4(1.0)	3.1(1.1) 4.4(6.6)	7.1(6.3) 5.3(5.0)
VERTEBRATES(ALL PLOTS)			
<i>Bufo americanas</i>	(whole)	2.5(0.65)	
(n = 5)	(muscle)	7.8(1.1)	
	(bones)	6.9(2.9)	
	(liver)	2.5(0.28)	
	(kidney)	9.3	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	0.84	3.0
	(muscle)	<0.91	<0.77
	(bone)	1.7	2.0
	(liver)	<0.96	<0.90
<i>Microtus pennsylvanicus</i>	(muscle)	0.82(0.76)	
	(bone)	3.6(3.4)	
	(liver)	2.4(3.0)	
	(kidney)	2.0(1.4)	
<i>Peromyscus leucopus</i>	(muscle)	2.6(2.4)	
(n = 13)	(bone)	2.9(3.4)	
	(liver)	0.92(0.88)	
	(kidney)	3.7(3.0)	

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 17
Concentrations of Cadmium in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	3.3(0.44)	6.4(2.00)	5.0(1.10)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	5.6	4.9	3.2
<i>S. altissima</i> (leaves)	0.35(0.16)	0.32(0.08)	0.48
(stems)	0.16(0.01)	0.29(0.03)	0.15
(flowers)	0.18(0.06)	0.27(0.11)	0.20
<i>L. salicaria</i> (leaves)	s	0.37	1.1(0.97)
(stems)	s	0.34	0.59(0.12)
(flowers)	s	s	<0.13
<i>C. stolonifera</i> (leaves)	s	0.40(0.20)	s
<i>I. capensis</i> (leaves & stems)	s	1.8	2.3(0.88)
<i>P. australis</i> (leaves)	s	s	<0.13
(stems)	s	s	0.14
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	57(17)	67(2.3)	57(21)
<i>A. caliginosa</i>	27(3.3)	30(5.8)	37(2.8)
<i>A. chlorotica</i>	35(8.7)	51(8.0)	44(31)
<i>L. terrestris</i>	48(9.0)	s	48
Pitfall trap fauna	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	3.5(2.6) 2.4(1.7)	3.9(1.5) 2.7(1.3)	2.9(1.5) 2.1(0.75)
Araneida	42(25) 10(3.2)	63(43) 13(4.5)	90(52) 9.5(4.8)
Chilopoda	9(4.2) 3.8(0.64)	13(11) 6.1(3.6)	5.2 5.0
Herb. Coleoptera	s 1.0(0.08)	s 1.8(1.6)	s 0.72
Orthoptera	3.2 9.2(2.5)	3.2 9.7(4.2)	3.2 8.1(2.9)
Diplopoda	3.5(1.2) 3.4(1.1)	3.9(1.4) 3.7(1.1)	3.3(1.2) 3.4(1.1)
Isopoda	25(8.5) 27(7.7)	28(13) 24(7.8)	26(12) 23(3.0)
VERTEBRATES(ALL PLOTS)			
<i>Bufo american</i>	(whole)	4.5(1.2)	
(n = 5)	(muscle)	3.4(0.21)	
	(bones)	5.8(4.5)	
	(liver)	7.5(2.8)	
	(kidney)	14(4.1)	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	0.17	0.60
	(muscle)	0.14	0.16
	(bone)	0.30	0.32
	(liver)	0.23	2.3
<i>Microtus pennsylvanicus</i>	(muscle)	0.20(0.11)	
(n = 13)	(bone)	0.36(0.22)	
	(liver)	4.9(3.2)	
	(kidney)	10(6.4)	
<i>Peromyscus leucopus</i>	(muscle)	0.39(0.22)	
(n 13)	(bone)	0.45(0.41)	
	(liver)	1.3(0.65)	
	(kidney)	3.9(2.11)	

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 18
Concentrations of Chromium in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	57(16)	137(58)	100(19)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	8.1	2.8	4.8
<i>S. altissima</i> (leaves)	3.9(1.9)	1.4(0.38)	1.4
(stems)	1.5(1.9)	0.92(0.22)	0.64
(flowers)	2.2(0.01)	1.2(0.29)	0.91
<i>L. salicaria</i> (leaves)	s*	1.8	4.4(4.2)
(stems)	s	1.1	1.9(1.6)
(flowers)	s	s	5.3
<i>C. stolonifera</i> (leaves)	s	2.0(0.15)	s
<i>I. capensis</i> (leaves & stems)	s	1.6	0.97(0.21)
<i>P. australis</i> (leaves)	s	s	1.1
(stems)	s	s	1.2
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	s	3.6	
<i>A. caliginosa</i>	7.8(9.5)		
<i>A. chlorotica</i>	14	13(15)	5.8
<i>L. terrestris</i>	1.6	s	
Pitfall trap fauna	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	2.4(1.2) 6.7(2.5)	3.4(1.5) 4.4(2.1)	3.9(1.5) 5.2(2.8)
Araneida	6.0(2.8)	5.5(4.4)	7.8(7.6)
Chilopoda	3.0(0.71)	15(9.3) 12(5.3)	2.9 1.3
Herb. Coleoptera	19(0.71)	44(46)	7.7 22
Orthoptera	7.0 8.5(1.1)	7.0 7.9(4.2)	7.0 5.2(4.5)
Diplopoda	5.6(1.6) 5.9(1.2)	5.6(1.7) 9.0(4.5)	6.7(1.6) 8.3(3.0)
Isopoda	8.5(3.2) 7.4(3.5)	11(4.4) 10(4.0)	10 (3.6) 8.8(2.6)
VERTEBRATES(ALL PLOTS)			
<i>Bufo americanas</i>	(whole)	3.7(1.8)	
(n = 5)	(muscle)	2.8(2.1)	
	(bones)	9.6(5.5)	
	(liver)	7.6(6.9)	
	(kidney)	28(20)	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	0.93	2.4
	(muscle)	1.3	0.59
	(bone)	3.1	8.6
	(liver)	3.4	1.8

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 19
Concentrations of Lead in Times Beach Ecosystem
(micrograms per gram, dry weight)

Sample	Zone A	Zone B	Zone C
TOP-DREDGED MATERIAL	161(39)	212(53)	172(62)
VEGETATION			
<i>P. deltoides</i> (leaf fall)	4.0	4.5	7.8
<i>S. altissima</i> (leaves)	4.3(0.15)	4.9(0.59)	5.1
(stems)	2.0(1.5)	<2.6	<2.6
(flowers)	3.6(0.49)	2.9(0.49)	3.0
<i>L. salicaria</i> (leaves)	s*	3.5	5.9(1.6)
(stems)	s	<2.6	<2.6
(flowers)	s	s	4.3
<i>C. stolonifera</i> (leaves)	s	5.3(1.2)	s
<i>I. capensis</i> (leaves & stems)	s	3.0	<2.6
<i>P. australis</i> (leaves)	s	s	<2.6
(stems)	s	s	5.5
INVERTEBRATES			
Native earthworms			
<i>L. rubellus</i>	0.34	0.31(0.08)	
<i>A. caliginosa</i>	1.2	4.3	
<i>A. chlorotica</i>	5.9(1.3)	8.9(3.0)	3.6
<i>L. terrestris</i>	2.6(0.11)	s	3.6
Pitfall trap fauna	Spring / Fall	Spring / Fall	Spring / Fall
Pred. Coleoptera	5.4(3.8)	4.2 5.2(0.10)	3.9(1.8) 5.7(3.6)
Araneida	30 9.0	8.8(4.2)	7.6(4.5)
Chilopoda	2.8	14 (6.3)	
Herb. Coleoptera	13	13	
Orthoptera	8.3 15(2.6)	8.3 11(3.2)	8.3 8.1(2.4)
Diplopoda	18(9.7) 12(1.9)	15(5.2) 15(4.5)	8.9(4.4) 12(3.3)
Isopoda	17(6.1) 17(3.4)	14(0.71) 17(4.7)	15 (2.3) 15(4.2)
VERTEBRATES (ALL PLOTS)			
<i>Bufo americanas</i>	(whole)	6.5(2.3)	
(n = 5)	(muscle)	4.4(1.1)	
	(bones)	13	
	(liver)	s	
	(kidney)	s	
<i>Agelaius phoeniceus</i>		Immature(n = 3)	Adult(n = 1)
	(feathers)	49	19
	(muscle)	9	<2.7
	(bone)	43	15
	(liver)	<3.4	<3.2
<i>Microtus pennsylvanicus</i>	(muscle)	2.8(0.92)	
(n = 13)	(bone)	23(7.0)	
	(liver)	2.7(0.45)	
	(kidney)	6.0(3.1)	
<i>Peromyscus leucopus</i>	(muscle)	5.1(1.8)	
(n = 13)	(bone)	20(4.0)	
	(liver)	3.8(1.2)	
	(kidney)	4.9(3.8)	

Note: Concentrations are mean values ($\pm$ standard deviation).

* Insufficient sample size for analysis.

Table 20
Concentrations of Metals in Grand Island Ecosystem
(micrograms per gram, dry weight)

Sample	Zn		Cu		Ni	
TOPSOIL	153(104)		68(29)		55(4.0)	
INVERTEBRATES						
Native earthworms						
<i>L. rubellus</i>	430(42)		4.6(2.1)		2.6(2.3)	
<i>A. caliginosa</i>	479(56)		5.5(1.8)		2.3(1.2)	
<i>A. chlorotica</i>	304(0.71)		7.7(3.3)		3.9(2.5)	
<i>L. terrestris</i>	350(56)		2.1(0.15)		1.9(2.5)	
Pitfall trap fauna						
	Spring / Fall		Spring / Fall		Spring / Fall	
Pred. Coleoptera	102(14)	63(8.9)	15(2.5)	16(3.2)	-	2.1(1.4)
Araneida	238	194(14)	202	64(8.2)		11 (6.6)
Chilopoda		148		41		3.2
Herb. Coleoptera	152	86	43	34		2.6
Orthoptera						
Diplopoda	105(86)	160(50)	218(18)	133(106)	17	4.6(2.1)
Isopoda	260(155)	219(71)	153(24)	79 (36)	5.7(1.0)	10(4.6)
VERTEBRATES (ALL PLOTS)						
<i>Rana</i> spp.						
(muscle)	25		9.9		2.5	
(bone)	68		6.5		3.3	
(liver)	71		54		2.3	
Salamanders						
(whole)	85(15)		9.1(4.4)		1.1(0.44)	
(liver)	322		33		<2.8	
Shrews (<i>Sorex</i> sp.)						
(muscle)	90		12		1.7	
(bone)	132		6.7		2.3	
(liver)	86		18		3.2	
(kidney)	82		22		<5.9	

(Continued)

Note: Concentrations are mean values ($\pm$ standard deviation).

Table 20 (Concluded)

Sample	Cd		Cr		Pb	
TOPSOIL	2.5(0.15)		37(1.3)		44(3.3)	
INVERTEBRATES						
Native earthworms						
<i>L. rubellus</i>	13(2.6)		2.5(1.3)		1.5(0.35)	
<i>A. caliginosa</i>	34(2.3)		2.5(1.5)		2.5(2.5)	
<i>A. chlorotica</i>	18(5.7)		2.5(0.14)		2.3	
<i>L. terrestris</i>	8.9(3.8)		0.98(1.1)		4.0	
Pitfall trap fauna						
Spring / Fall			Spring / Fall		Spring / Fall	
Pred.Coleoptera	2.0(0.35)	1.1(0.78)	-	11(13)	-	6.1(4.2)
Araneida	13	3.9(2.6)	3.5	17(10)	-	-
Chilopoda	-	1.5	-	<0.65	-	<8.9
Herb.Coleoptera	-	0.65	8.2(1.6)	2.3	-	<7.4
Orthoptera	-	-	-	-	-	-
Diplopoda	2.7	2.4(1.3)	8.7(4.7)	2.4(1.3)	-	7.7(0.85)
Isopoda	3.3(0.70)	8.2(2.8)	3.7(0.52)	7.5(7.6)	6.5	14(8.2)
VERTEBRATES (ALL PLOTS)						
<i>Rana</i> spp.						
(muscle)	1.2		5.2		<2.1	
(bone)	1.6		5.6		6.0	
(liver)	1.4		4.8		<3.4	
Salamanders						
(whole)	4.2(3.9)		0.23(0.01)		3.4	
(liver)	7.8		37		12	
Shrews (<i>Sorex</i> sp.)						
(muscle)	2.7		23		<5.0	
(bone)	1.7		6.5		6.1	
(liver)	4.0		0.90		<6.5	
(kidney)	3.0		4.8		<21	

differences in contaminant concentrations of the dredged material. However, the differences in physical parameters have been shown to affect the bioavailability of contaminants in the dredged material. For example, bioassay plants grown in flooded sediment, under reduced conditions, contained significantly lower concentrations of heavy metals, especially Zn and Cd, compared with plants grown in sediment under oxidized conditions (Folsom, Lee, and Bates 1981). Therefore, manipulation of the physical conditions to which the dredged material is exposed could be used to influence the bioavailability and movement of metals from the dredged material into the plant communities and associated animal communities.

109. Metal concentrations measured in the various plant species collected for analysis at Times Beach suggested that differences in metal concentrations were associated with interspecific differences in metal uptake, not differences in metal concentrations in the dredged material. For example, *L. salicaria* contained higher Zn concentrations (especially in the leaf parts) compared with other species such as *S. altissima* within the same vegetation zone; *I. capensis* contained higher Cd concentrations in the leaves and stems compared with other species in the same upland vegetation zones. Where the same plant species is present across several vegetation zones, further sampling and analysis would be necessary to establish any trends of increasing or decreasing metal concentrations associated with the different soil physicochemical conditions. Management of the ecosystem to exclude plant species or communities which tend to accumulate contaminants could be used to reduce contaminant mobility and may be a useful procedure on this and similar sites.

110. Measurements of metal concentrations in the Cottonwood leaf litter indicated higher Zn, Ni, and Cd concentrations in these plant parts compared with any other plants sampled in the upland area. These results are based upon a very limited sample size, and any suggested trends should be confirmed through analysis of additional samples. The roots of the Cottonwood trees at Times Beach may effectively draw metals, such as Cd, from the dredged material, depositing them on the soil surface with the annual leaf fall as suggested by Marquenie and Simmers (1984). Data available from research conducted at other sites known to be heavily contaminated with heavy metals have also suggested that concentrations of metals in the litter were higher than in any other component of the woodland ecosystem (Martin, Duncan, and Coughtrey 1982). An excessive accumulation of leaf litter has been associated with the

effects of heavy metal contamination on the activity of decomposer organisms (Hopkin and Martin 1982). The majority of studies of contaminated woodland ecosystems, reported in the literature, have been concerned with contamination as a result of aerial deposition. The possible input of contamination to the Times Beach CDF by this route should not be overlooked, and some estimation of the contribution from aerial pollution to the contaminant load at the Times Beach CDF should be made.

111. Of the soil-dwelling invertebrates captured from Times Beach and analyzed, the carnivorous and detritivorous groups contained the highest concentrations of heavy metals. The herbivorous groups contained comparatively low concentrations of heavy metals. Of the carnivorous groups analyzed, the spiders had the greatest concentrations of the elements Zn, Cu, and Cd. Spiders are recognized as obligate predators, and high concentrations of contaminants at the carnivore trophic level may be indicative of movement of contaminants up the food chain. Centipedes also contained high concentrations of these elements; however, they were not always captured in sufficient quantities for chemical analysis. Predatory beetles contained relatively low concentrations of heavy metals. The detritivorous groups (earthworms, woodlice and millipedes) appeared to be target organisms for the accumulation of Zn, Cu, and Cd. This result once again suggests that the litter layer is the site of accumulation of heavy metal contaminants and is a potential route for movement of metals from the dredged material into the food web.

112. Results of metal analysis of the Cottonwood leaf litter, the detritivorous soil-dwelling invertebrates collected in pitfall traps, and the native earthworms all suggest that high concentrations of metal elements are associated with the decomposing litter layer at Times Beach. This is particularly true for the nonessential element Cd (Table 17). Further evidence for the role of the litter layer in the mobilization of Cd into the ecosystem is furnished by the Cd concentrations measured in the different species of earthworm collected at Times Beach when viewed in the context of their different preferences for inhabiting and feeding in either the mineral soil horizon or the litter layer. Additional sampling and analysis of the leaf litter are essential to provide conclusive evidence of its role in this respect. Management to exclude certain tree species may be a potential route to decrease the movement of Cd into the ecosystem.

113. The potential use of laboratory bioassay tests using earthworms

cannot be established, since analysis of earthworms exposed to the Times Beach dredged material for a 28-day test has not been authorized or completed. At such time, comparisons between the results of metal uptake by earthworms under laboratory conditions and metal concentrations in invertebrates collected in the field can be made. The extent to which the laboratory test represents uptake in the field can then be established. Comparisons will also then be available between the results of the laboratory test with dredged material and soil from Times Beach and Grand Island.

114. Levels of heavy metals measured in carnivores collected at Times Beach may be compared to concentrations recorded in carnivorous invertebrates collected from a contaminated mine site (Roberts and Johnson 1978) and contaminated grasslands (Hunter and Johnson 1982) in the United Kingdom (Table 21).

Table 21

Metal Concentrations* in Trophic Levels of Invertebrates Collected from Metal-Contaminated Sites and Control Sites in the United Kingdom

<u>Site</u>	<u>Zn</u>	<u>Cu</u>	<u>Cd</u>	<u>Pb</u>
Control sites				
Carnivores	60**	22.7†	5.7**/2.0†	59**
Herbivores	50**	16.9†	1.2**/1.2†	8.3**
Detritivores		18.7†	2.2†	
Contaminated sites				
Carnivores	270**	568†	34**/11.3†	127**
Herbivores	230**	310†	11**/10.9†	62**
Detritivores		343†	12.7†	

* Mean values (micrograms per gram, dry weight).

** From Roberts and Johnson (1978).

† From Hunter and Johnson (1982).

Concentrations of heavy metals in carnivorous invertebrates from the control sites in both these studies are also given in Table 21; these generally fall below the mean values recorded in samples from Times Beach. Wade et al. (1980) reported higher concentrations of Pb and Zn in spiders compared with Carabid beetles collected from the same site, results which are similar to those of this study for the elements Zn, Cu, and Cd. Under such

circumstances, pooling results for all groups of any particular trophic level may not be an accurate representation of the movement of contaminants in the food web. More detailed investigations regarding interspecific and intraspecific differences in metal concentrations given in this report also suggest that major differences exist between different genera of the same family. In selection of a representative target organism for metal accumulation, such differences may necessitate the use of an organism identified to species level. Further studies would confirm this. Earthworms and woodlice have frequently been used to assess the extent of metal pollution and bioavailability from metal-polluted soils (Martin, Coughtrey, and Young 1976; Helmke et al. 1979; Wieser 1979; Hopkin and Martin 1982). Concentrations of heavy metals measured in these groups collected from Times Beach were greater than those recorded from control sites in previous studies, but concentrations were not as great as those recorded from extremely polluted sites reported in the literature (Hopkin and Martin 1982, Martin and Coughtrey 1982).

115. The role of target organisms, as indicators or monitors of contaminant mobility in the ecosystem, has received much attention (Martin and Coughtrey 1982). Such organisms should be available in sufficient quantities, numerically and in terms of dry matter biomass, over the entire area under investigation, and tissue contaminant concentrations should reflect maximum bioavailability of contaminants present. At the Times Beach CDF, bioaccumulation of the persistent contaminants, particularly the heavy metals (Cd, Zn, and possibly Cu), seemed to occur in the decomposing litter layer. Detritivorous invertebrate species associated with this layer (such as earthworms, woodlice, and millipedes), as well as the predatory spiders, reflected maximum concentrations of the elements Cd, Zn, and Cu. The detritivorous species fulfilled the requirements of an indicator organism, as listed above, and may have potential for future use in this context. Spiders were less available, in terms of biomass, and metal concentrations were observed to fluctuate with the season of sampling. Comparisons between metal concentrations measured in these groups collected at Times Beach and those collected at Grand Island indicated a greater uptake of the elements Cd, Zn, and Cu at Times Beach.

116. A similar approach in the establishment of target organisms in the wetland and aquatic areas at Times Beach could also be undertaken. In the aquatic area, the Lymnaea and Diptera were present in sufficient quantity for possible use as bioindicators of contaminant availability. The report by

Marquenie et al. (in preparation) provides results on the use of "mussel-watching" as a technique for assessing bioavailability of contaminants in the aquatic area at Times Beach.

117. Studies of the ecosystems that have developed within the upland area, and to a lesser extent the wetland and aquatic areas, furnish a fairly comprehensive inventory of the plant and animal species that have colonized the CDF. In assessing the importance of particular groups of organisms in terms of their effect on the mobility of contaminants through the ecosystem, it is important to consider not only the tissue concentrations of any contaminant but also the biomass of the group, relative to the whole. For example, among the carnivorous species of invertebrates, the spiders had greater body burdens of heavy metals compared with the predatory beetles; however, their contribution to the total biomass collected in the pitfall trap was relatively small compared to that of the beetles. A more complete indication of the role of any part of the ecosystem to the cycling of contaminants would be achieved if tissue concentrations of contaminants were considered in the context of their contribution to the biomass.

118. To achieve this, an estimation of the biomass of the various compartments of the ecosystem needs to be made, which together with measurements of contaminant concentrations could be used to calculate a balance for contaminants of concern (see for example, Martin, Duncan, and Coughtrey 1982). Assessment of the incidence of various species or groups of biota has been made relative to other individuals of the group, for example, the subjective estimate of "perceived relative phytomass" described by Wilhelm and the percent relative biomass in the pitfall traps made by Stafford. Very few estimates of absolute population size at Times Beach have been made, for example, by mark and recapture methods of sampling. However, in order to quantify the movement of contaminants within the ecosystems at Times Beach, and to achieve a "flow/balance" approach to measuring the movement of contaminants within the ecosystem, it would be necessary to obtain absolute measurements of the population and biomass of the major components of the ecosystems. This information, used in conjunction with data on contaminant concentrations, will allow the calculation of absolute quantities of contaminants moving through the ecosystem and provide an overall budget of contaminant mobility at the CDF, at the same time identifying major routes of contaminant movement. Future management of the CDF could harness such information to manipulate the

ecosystem in such a way as to exclude or at least minimize pathways where contaminant mobility exists.

119. Concentrations of heavy metals in the birds and mammals captured at Times Beach have been compared with concentrations measured in the same species from control and heavily contaminated sites. Limited additional trapping is necessary to secure sufficient higher vertebrates for a more rigorous statistical comparison. Generally, concentrations of heavy metals in specimens collected from Times Beach were below those recorded at heavily contaminated sites but above the values given from the designated control or reference areas. In many cases, comparisons with research reported in the literature are difficult due to differences in species captured for analysis, and differences in the tissues selected for analysis. However, Barr et al. (1985), studying a site affected by smelter emissions in Pennsylvania, collected toads and frogs from the same site (Bake Oven Knob), which contained metal concentrations in the soil similar to those at Times Beach. Toads and frogs contained similar metal concentrations despite species differences. These may be compared to results of analysis of toads from Times Beach and frogs from Grand Island. Similar Zn and Pb concentrations were recorded in the toads at Times Beach and the toads and frogs from Bake Oven Knob; however, concentrations of Cu and Cd were greater in specimens from Times Beach. Concentrations of all elements were greater in toads at Times Beach compared with frogs collected at Grand Island.

120. Tables 14-19 summarize the data for metal concentrations measured in the Times Beach upland ecosystem and generally suggest that there is little movement of the elements Pb, Ni, and Cr from the dredged material through the food webs at the CDF. Comparisons between measurements of these elements in components of the ecosystem at Times Beach and Grand Island also provided little indication that mobility of these elements was greater at the Times Beach CDF. Some movement of the elements Zn, Cu, and Cd was indicated by the results of measurements made at Times Beach, and significantly greater concentrations of these elements were recorded in samples collected at Times Beach compared with Grand Island. Of these three elements, Zn and Cu are essential elements that are necessary for the functioning of biological systems; Cd is nonessential. Cadmium has also been shown to be highly persistent in the environment, although the studies presented in this report have not documented

detrimental effects that can be associated with the concentrations present at Times Beach.

121. Although the information gathered is not comprehensive, the data collated in this report provide the most comprehensive overview available to date of ecosystem development and contaminant concentrations within the various components of an ecosystem at a dredged material disposal facility. Information available from this report should provide valuable assistance in the future management of dredged material disposal facilities, by indicating target organisms or compartments within the ecosystem which may be particularly susceptible to contaminant buildup or bioconcentration. Management to exclude such components of the ecosystem could reduce the potential for movement of contaminants from the dredged material to indigenous organisms or out of the confines of the site.

PART VI: RECOMMENDATIONS

122. The recommendations drawn from this report fall into two main categories: recommendations regarding the future management of Times Beach, which are based on technically defensible conclusions drawn from existing data, and recommendations for further research, which is anticipated to provide valuable data for formulating management strategies for other CDFs, based on the Times Beach studies.

123. Chemical analysis of the dredged material sampled across the upland portion of the Times Beach CDF served to establish the heterogeneity of the material. Analysis of the colonizing species of flora and fauna demonstrated the unifying role of the biota in presenting an assessment of contaminant mobility at a CDF. However, the effect of physical conditions on the bioavailability of contaminants in the dredged material, for example the degree of inundation by water, needs to be assessed. This could be achieved by sampling and analyzing plant species that occur at the site under a range of physical conditions. Based on the results of this work, manipulation of physical conditions at the site may be possible to reduce contaminant mobility. Manipulation of the physical conditions at CDFs may also be used to control which species colonize the CDF and to eliminate species that have been shown to accumulate contaminants.

124. Comparisons of results from chemical analysis of biota sampled at Times Beach served to demonstrate the extent of variation in metal concentrations that occurs between different genera and species of individuals of the same taxonomic group. These results illustrate the drawbacks of pooling groups of organisms, for example according to trophic level, in assessing the degree of contaminant mobility within the ecosystem, and also the importance of accurately identifying target organisms. However, in the upland area at Times Beach, the decomposing litter layer, with associated fauna, was established as a major zone of accumulation of the nonessential persistent element Cd. Target organisms for the accumulation of heavy metal contaminants were evident from the data available, and the earthworms exploiting this layer contained the highest concentrations of heavy metals in the ecosystem. It is recommended that these target organisms and this zone be used in the future for sampling and analysis to ascertain the degree of contamination of the environment by the persistent contaminants, such as Cd.

125. At present, data on metal concentrations in the leaf litter of the Cottonwood trees are limited to a single grab sample from each of the vegetation zones. It is recommended that additional replicated samples of leaf litter be collected for analysis, from each of the three vegetation zones at Times Beach. Since the Cottonwood leaf fall is probably the major input to the litter zone, it is recommended that an estimate be made of the total annual biomass of leaf litter. To conclusively demonstrate that contaminants in the leaf litter are derived from the dredged material, it is recommended that the extent of contamination derived from aerial deposition be measured.

126. The major pathways of contaminant mobility at Times Beach could be more clearly established by more extensive measurements of total biomass of other groups of organisms at Times Beach. This information, used in conjunction with the results of chemical analysis, could be used to calculate the flow/balance of contaminants within the ecosystems at Times Beach (for example, the information derived from the research recommended in paragraph 125). Manipulation of the ecosystem to eliminate major routes of transfer of contaminants could then be part of the management strategy at Times Beach and extended to other CDFs.

127. The compartmentalization of metals in the upland ecosystem is the best documented of the areas of research at Times Beach. There remains a need for the collection and analysis of additional vertebrates to permit statistical treatment of the food chain relationships that have been suggested. The observed enhanced metal availability to soil-dwelling invertebrates observed in the Cottonwood leaf litter should be investigated more fully with a view to the modification of Cd movement by the selection of species in the plant cover at Times Beach and other metal-contaminated upland sites or filled CDFs. The chemical analysis of the tissues from the extensive growth chamber earthworm bioassay is also recommended in that these data will permit the normalization of the mobility of metals throughout the site in terms of a single index species.

128. The fate of organic contaminants in the upland ecosystem has not been fully quantified. The apparent disappearance of PCB and PAH contaminants in the oxidized, upland dredged material was first observed at Times Beach, and may be critical to long-term management of CDFs. Chemical analysis of adequately replicated samples of selected vegetation, invertebrate, and vertebrate target organism tissue samples with appropriately low detection limits

will quantify the movement of PCBs and PAHs through the food web. There is also an excellent opportunity to address the processes resulting in the apparent degradation of organic contaminants under controlled laboratory conditions.

129. The processes occurring in the wetland and aquatic areas are least understood. It is recommended that characterization of the plant and animal species present in the wetland and aquatic areas be carried out as has been achieved in the upland area and that a laboratory study be conducted using an index species to normalize the data throughout the communities. Frequently occurring species can be analyzed for both metals and organic contaminants. Based on PCB concentrations measured in fish collected at Times Beach, further studies are required before recommending that these fish are safe for human consumption. The extensive duck and muskrat populations have previously been sampled. Contaminant concentrations in the duck samples indicated some uptake of contaminants. Additional trapping of higher vertebrates, including muskrats, from an uncontaminated ecosystem is recommended to allow valid statistical comparisons to be made. There is also a need to critically examine the plant and animal materials that compose the main food sources. This approach can be used to address the source of the elevated Cd and Hg observed in the ducks and additionally to address the potential uptake of organic contaminants. These studies will provide insight into the most appropriate management techniques for permanent or transient wetland and aquatic areas at CDFs.

REFERENCES

- Barr, W. N., Pattee, O. H., Sileo, L., Hoffman, D. J., and Mulhern, B. M. 1985. "Metal Contamination in Wildlife Living Near Two Zinc Smelters," Environmental Pollution (Series A) 38:63-86.
- Beyer, W. N., Chaney, R. L., and Mulhern, B. M. 1982. "Heavy Metal Concentrations in Earthworms from Soil Amended with Sewage Sludge," Journal Environmental Quality 11(3):381-385.
- Cherney, J. H., and Robinson, D. L. 1983. "A Comparison of Plant Digestion Methods for Identifying Soil Contamination of Plant Tissue by Ti Analysis," Agronomy Journal 75:145-147.
- Cherney, J. H., Robinson, D. L., Kappel, L. C., Hembry, F. G., and Ingraham, R. H. 1983. "Soil Contamination and Elemental Concentrations of Forages in Relation to Grass Tetany," Agronomy Journal 75:447-451.
- Curry, J. P., and Cotton, D. C. F. 1980. "Effects of Heavy Pig Slurry Contamination on Earthworms in Grassland," Proceedings of the VII International Soil Zoology Colloquim, D. Dindal, ed., Syracuse, NY, July 29-August 3, 1979, pp 336-343.
- Fernald, M. L. 1950. Gray's Manual of Botany, 8th ed., American Book Company, New York.
- Folsom, B. L., Lee, C. R., and Bates, D. J. 1981. "Influence of Disposal Environment on Availability and Plant Uptake of Heavy Metals in Dredged Material," Technical Report EL-81-12, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Goldberg, E. D. 1976. The Health of the Oceans, Unesco Press, Paris.
- Helmke, P. D., Robarge, W. P., Korotev, R. L., and Schomberg, P. J. 1979. "Effects of Soil Applied Sewage Sludge on Concentrations of Elements in Earthworms," Journal of Environmental Quality 8(3):322-327.
- Hopkin, S. P., and Martin, M. H. 1982. "The Distribution of Zinc, Cadmium, Lead and Copper Within the Woodlouse *Oniscus asellus* (Crustacea, Isopoda)," Oecologia (Berl.) 54:227-232.
- Hunter, B. A., and Johnson, M. S. 1982. "Food Chain Relationships of Copper and Cadmium in Contaminated Grassland Ecosystems," Oikos 38:108-117.
- Kay, S. H., Simmers, J. W., and Marquenie, J. M. 1986. "Polychlorinated Biphenyls in Fishes from the Times Beach Confined Disposal Site, Buffalo, New York," Proceedings of the 2nd International Conference on Environmental Contamination, Amsterdam, September 1986, CEP Consultants, Ltd., pp 269-271.
- Marquenie, J. M., and Simmers, J. W. 1984. "Bioavailability of Heavy Metals, PCB and PCA Components to the Earthworm, *Eisenia foetida*," Proceedings of the 1st International Conference on Environmental Contamination, London, July 1984, CEP Consultants, Ltd., pp 318-326.
- Marquenie, J. M., Simmers, J. W., and Kay, S. H. 1987. "Bioaccumulation of Metals and Organic Contaminants at the Times Beach Confined Disposal Site, Buffalo, New York," Miscellaneous Paper EL-87-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

- Marquenie, J. M., Simmers, J. W., Rhett, R. G., and Brandon, D. "Distribution of PCB and Pesticide Contaminants in the Vicinity of the Times Beach Confined Disposal Facility, Buffalo, New York," Miscellaneous Paper (in preparation), US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Martin, M. H., and Coughtrey, P. J. 1982. "The Use of Terrestrial Animals As Monitors and Indicators of Environmental Contamination by Heavy Metals," Biological Monitoring of Heavy Metal Pollution, Applied Science Publishers, London, pp 221-460.
- Martin, M. H., Coughtrey, P. J., and Young, E. W. 1976. "Observation on the Availability of Lead, Zinc, Cadmium and Copper in Woodland Litter and the Uptake of Lead, Zinc and Cadmium by the Woodlouse *Oniscus asellus*," Chemosphere 5:313-318.
- Martin, M. H., Duncan, E. M., and Coughtrey, P. J. 1982. "The Distribution of Metals in a Contaminated Woodland Ecosystem," Environmental Pollution (Series B) 3:147-157.
- McGrath, D., Poole, D. B. R., Fleming, G. A., and Sinnott, J. 1982. "Soil Ingestion by Grazing Sheep," Irish Journal of Agricultural Research 21:135-145.
- National Academy of Sciences. 1979. Polychlorinated Biphenyls, Washington, DC.
- Raw, F. 1959. "Estimating Earthworm Populations by Using Formalin," Nature (London) 184:1661.
- Roberts, R. D., and Johnson, M. S. 1978. "Dispersal of Heavy Metals from Abandoned Mine Workings and Their Transference Through Terrestrial Food Chains," Environmental Pollution 16:293-310.
- Simmers, J. W., Rhett, R. G., Kay, S. H., and Marquenie, J. M. 1986. "Bioassay and Biomonitoring Assessments of Contaminant Mobility from Dredged Material," The Science of the Total Environment 56:173-182.
- Simmers, J. W., Rhett, R. G., Brown, C. P., and Stafford, E. A. 1987. "Long Term Prediction of Contaminant Mobility from Dredged Material," Proceedings of 21st Annual Conference on Trace Substances in Environmental Health, May 25-28, 1987, St. Louis, MO.
- Sokal, R. R., and Rohlf, F. D. 1981. Biometry, 2d ed., Freeman, San Francisco, CA.
- Stafford, E. A., and McGrath, S. P. 1986. "The Use of Acid Insoluble Residue to Correct for the Presence of Soil-Derived Metals in the Gut of Earthworms Used as Bio-indicator Organisms," Environmental Pollution (Series A) 42:233-246.
- Swink, F., and Wilhelm, G. 1979. Plants of the Chicago Region, The Morton Arboretum, Lisle, IL.
- Wade, K. J., Flanagan, J. T., Currie, A., and Curtis, D. J. 1980. "Roadside Gradients of Lead and Zinc Concentrations in Surface-Dwelling Invertebrates," Environmental Pollution (Series B) 1:87-93.
- Wade, S. E., Bache, C. A., and Lisk, D. J. 1982. "Cadmium Accumulation by Earthworms Inhabiting Municipal Sludge Amended Soil," Bulletin of Environmental Contamination and Toxicology 28:557-560.

Weimeyer, S. N., Moore, J. F., and Mulhern, B. M. 1984. "Formalin Preservation of Avian Blood for Metal and DDE Analysis," Bulletin of Environmental Contamination and Toxicology 33:525-532.

Wieser, W. 1979. "The Flow of Copper Through a Terrestrial Food Web," Copper in the Environment: Part 1, J. O. Nriagu, ed., John Wiley and Sons, New York, pp 325-355.

Winer, B. J. 1971. Statistical Principles in Experimental Design, 2d ed., McGraw-Hill, New York.

APPENDIX A: DETAILED STUDIES AND REPORTS - INVENTORIES
OF FLORA AND FAUNA, TIMES BEACH

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VEGETATION OF THE TIMES BEACH DISPOSAL AREA Buffalo, New York

During the summer of 1983, a field survey of the vegetation of the Times Beach disposal area was undertaken. The area was divided into two topographic areas, each of which was formed from dredge material fill deposited from 1972 through 1976. A vegetational survey was done on two transects which were layed out in the very low areas, and on one transect which traversed the dryer wooded area in the northeast portion of the fill. Vegetation of the stone block dike area which encloses the marsh and open water on the north, west, and south was also recorded.

METHODS

All of the areas were surveyed and evaluated qualitatively using the technique described by Swink & Wilhelm, 1979. While this technique is generally not employed in the evaluation of vegetation far outside the 22 county Chicago region, the remarkably close resemblance the Times Beach site shares with similar sites in the Chicago region makes the technique quite useful, in this case, for making comparisons among floristic areas within the disposal site.

Two linear transects, A & B, were established in the marsh and extend to include lower portions of the wooded area. Each transect consists of 8 sample plots ca 25 feet in diameter, with their centers about 65 feet apart. Both measurements were paced, so are, therefore, rough. Transects A & B share plot #1 [AB1]. For each plot, estimates were made regarding the % phytomass for each vascular plant taxon noted within the plot. The % phytomass is likely to change somewhat from season to season with respect to species composition but mid-summer (7 July) is a good point of reference. Also within each plot, all living trees were counted and their DBH, if 1 inch or greater, recorded. In this case, all of the trees sampled were *Populus deltoides*.

A 400 foot transect was layed out through the upland wooded area, beginning at the 'No Trespassing' sign which reads: "Danger, fill being placed, will not support human beings." [This admonition is quite obsolete.] This sign is at the east edge of the fill, and is the third such sign from the north along Fuhrmann Boulevard. The transect begins at the sign, and consists of 9 sample plots, each ca 50 feet apart; it extends perpendicular to the road in a westerly direction. The vegetation was recorded in a manner described for transects A and B, as was the circumscription of the plots.

A riparian marsh, of about 1 acre, was located by Buffalo District personnel, and is situated on the northeastern shore of Grand Island. The species present were recorded for comparison in a general way with those present on the Times Beach fill.

All botanical nomenclature follows Fernald (1950), while common names are those employed by Swink & Wilhelm (1979).

RESULTS

The low ground marsh area between the open water and the dry wooded area is a relatively rich wetland area; 65 species, of which 75% are native to New York, were recorded during this survey. The overall mean quality coef-

ficient, as described by Swink & Wilhelm, is 3.1 and yields an Index of 25. This means that there is a relatively rich mix of species which are of native origin and which together demonstrate a fair degree of synecological stability.

The significance of these numbers is dramatized somewhat when the marsh is compared with the adjacent dryer wooded area which is substantially lower in floristic integrity. The latter registers a mean quality coefficient of 1.3 and an index of 11.

By way of further comparisons, most old fields and meadows have mean quality coefficients on the order of 0.5 to 1.0, with indices from 3 to 7 or so. An acre of relatively undisturbed native marsh, forest, or prairie, for examples, will have mean quality coefficients from 5.0 to 7.5 or more, with Indices from 40 to 65 or 70. It is unlikely that the marsh at Times Beach will ever attain such quality, but it already can be regarded as in a relatively advanced stage of succession, and should be considered as a valuable wetland amenity from a vegetational standpoint.

The reference marsh on Grand Island is fairly disturbed, but it is growing on natural substrates. When only the native species are considered, this marsh has a mean quality coefficient of 4.5 and an Index of 39. The marsh on the fill at Times Beach has a native mean quality coefficient of 4.2 and an Index of 30. The Times Beach marsh compares well with the reference marsh.

If one applies the Sørensen correlation of similarity formula to the two sites, the correlation index is 0.37. This points up the fact that, while the two marshes have certain basic similarities as wetlands, there is a fairly wide disparity in their floristic character.

The submergent vegetation of the open water area consists largely of *Potamogeton pectinatus*, with frequent occurrence of *Elodea nuttallii*, *Myriophyllum exalbescens*, and *Chara* sp.* Much of the adjacent area is dominated by *Typha latifolia*, with occasional plants of *Sagittaria latifolia*, *Scirpus validus creber*, and scattered fronds of *Lemna minor*. The edge of the dike, at the water's edge, is typified by *Lythrum salicaria*, *Lycopus americanus*, *Populus deltoides*, and *Cornus stolonifera*.

Between the *Typha* marsh and the low wooded area is an area dominated in most places by *Lythrum salicaria* and *Leersia oryzoides*, but there is also a rather rich assemblage of other wetland plants, mostly grasses, sedges, and rushes. Most of these are frequent to common locally here and there throughout. For a listing of the plants recorded in the marsh area, see Appendix A. The plants recorded from the reference marsh on Grand Island are listed in Appendix C.

The plants and number of individual trees recorded from each of the sample plots are recorded below. Figure I is a tabulation of the transect survey results by plot. Figure II is a graph which shows the number of trees in each size class when data from all the sample plots are combined. Six of the 16 sample plots were dominated by *Populus deltoides*. There is an average of about 8.5 trees per plot, or 1 tree per 60 ft². In all six of the wooded plots the canopy is closed.

*It is reasonable to speculate that the *Myriophyllum exalbescens*, which is native, might actually be *Myriophyllum spicatum* from Europe, but the plants were not in flower and the taxonomy is confusing at best.

Figure I. Tabulation of the two transects, A & B, showing the % phytomass estimated in mid-summer for each species.

Plant Species	Sample Plots															
	AA	AB	A2	A3	A4	A5	A6	A7	A8	B2	B3	B4	B5	B6	B7	B8
<i>Achillea millefolium</i>	-	-	-	-	-	-	-	-	5	5	-	-	15	-	-	-
<i>Carex cristatella</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex hystericina</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex scoparia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex stipata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex tenera</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex vulpinoidea</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cirsium vulgare</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cornus stolonifera</i>	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
<i>Eleocharis calva</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Erigeron philadelphicus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eupatorium perfoliatum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Geum laciniatum trichocarpum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Impatiens capensis</i>	-	-	-	-	-	-	-	-	-	10	-	-	15	10	-	-
<i>Juncus effusus</i>	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
<i>Leersia oryzoides</i>	-	5	45	80	5	-	-	-	-	-	40	-	5	-	-	-
<i>Lythrum salicaria</i>	-	-	20	10	50	5	-	-	10	5	45	10	50	80	-	-
<i>Phalaris arundinacea</i>	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
<i>Phragmites communis berlandieri</i>	-	-	-	-	-	75	-	-	-	-	-	20	-	-	100	100
<i>Poa compressa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Poa palustris</i>	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
<i>Poa pratensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Populus deltoides</i>	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-
<i>Rumex crispus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sagittaria latifolia</i>	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-
<i>Salix interior</i>	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
<i>Scirpus atrovirens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Solidago altissima</i>	-	-	-	-	-	-	-	-	35	-	-	-	-	-	-	-
<i>Solidago gigantea</i>	-	-	-	-	-	5	85	75	30	-	-	-	5	-	-	-
<i>Sphenopholis intermedia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Typha angustifolia</i>	-	-	-	-	-	-	-	-	-	90	-	20	-	-	-	-
<i>Typha latifolia</i>	100	95	5	-	-	-	-	-	-	-	-	-	-	-	5	-
<i>Urtica procera</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Verbena hastata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

LOWLAND SAMPLE PLOT DATA

Plot AA: solid *Typha* marsh; water about 1 inch deep

- 100% *Typha latifolia*
- *Leersia oryzoides*

Plot AB1: edge of *Typha* marsh, about $\frac{1}{4}$ inch of water

- 95% *Typha latifolia*
- 5% *Leersia oryzoides*
- *Impatiens capensis*
- *Lythrum salicaria*
- *Phragmites communis berlandieri*

Plot A2: marsh, wet soil

- 45% *Leersia oryzoides*
- 20% *Lythrum salicaria*
- 5% *Typha latifolia*
- *Carex cristatella*
- *Carex stipata*
- *Carex vulpinoidea*
- *Impatiens capensis*
- *Juncus effusus*
- *Phalaris arundinacea*
- *Poa palustris*

Plot A3: marsh, wet soil

- 80% *Leersia oryzoides*
- 10% *Lythrum salicaria*
- *Carex cristatella*
- *Carex stipata*
- *Eleocharis calva*
- *Impatiens capensis*
- *Salix interior*

Plot A4: moist ground, about 15 feet from wooded area; ground covered with dead and decaying *Typha* stems

- 50% *Lythrum salicaria*
- 10% *Phalaris arundinacea*
- 5% *Impatiens capensis*
- 5% *Leersia oryzoides*
- 5% *Salix interior*
- *Achillea millefolium*
- *Carex scoparia*
- *Eleocharis calva*
- *Eupatorium perfoliatum*
- *Poa palustris*
- *Populus deltoides*
- *Solidago gigantea*
- *Verbena hastata*

Plot A5: low wooded area

Populus deltoides
6 individuals; DBH: 1, 1, 1.5, 2, 3, 4
75% *Phragmites communis berlandieri*
5% *Lythrum salicaria*
5% *Salix interior*
5% *Solidago gigantea*
- *Carex cristatella*
- *Cirsium vulgare*
- *Cornus stolonifera*
- *Poa palustris*
- *Rumex crispus*
- *Sphenophlis intermedia*

Plot A6: low wooded area

Populus deltoides
8 individuals; DBH: 1, 1, 1.5, 1.5, 2, 2, 2.5, 3
85% *Solidago gigantea*
5% *Poa palustris*
- *Carex cristatella*
- *Cornus stolonifera*
- *Impatiens capensis*
- *Lythrum salicaria*

Plot A7: low wooded area

Populus deltoides
9 individuals; DBH: 1, 1, 1, 1, 1, 1.5, 1.5, 2, 3
75% *Solidago gigantea*
15% *Populus deltoides*
5% *Carex cristatella*
- *Impatiens capensis*
- *Lythrum salicaria*
- *Poa compressa*

Plot A8: low wooded area

Populus deltoides
8 individuals: DBH: 1, 1, 1.5, 1.5, 2, 2, 2.5, 2.5
35% *Solidago altissima*
30% *Solidago gigantea*
10% *Impatiens capensis*
10% *Lythrum salicaria*
5% *Carex cristatella*
- *Carex stipata*
- *Erigeron philadelphicus*
- *Poa compressa*
- *Poa palustris*
- *Poa pratensis*
- *Scirpus atrovirens*

Plot B2: saturated soil, *Typha* marsh

90% *Typha latifolia*
5% *Lythrum salicaria*

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Plot B2 continued . . .

- *Impatiens capensis*
- *Leersia oryzoides*
- *Sagittaria latifolia*

Plot B3: marsh, wet soil

- 45% *Lythrum salicaria*
- 40% *Leersia oryzoides*
- 5% *Eleocharis calva*
- *Carex cristatella*
- *Carex hystericina*
- *Carex stipata*
- *Impatiens capensis*
- *Typha latifolia*

Plot B4: marsh about 20 feet from low wooded area

- 40% *Salix interior*
- 20% *Phragmites communis berlandieri*
- 20% *Typha angustifolia*
- 10% *Lythrum salicaria*
- *Carex cristatella*
- *Carex scoparia*
- *Impatiens capensis*
- *Leersia oryzoides*

Plot B5: low wooded area

- Populus deltoides*
14 individuals; DBH: 1, 1, 1, 1, 1.5, 1.5, 1.5, 2, 2, 2.5,
2.5, 3, 3.5, 3.5
- 50% *Lythrum salicaria*
- 15% *Carex cristatella*
- 15% *Impatiens capensis*
- 5% *Geum laciniatum trichocarpum*
- 5% *Leersia oryzoides*
- 5% *Solidago gigantea*
- *Carex tenera*
- *Phragmites communis berlandieri*
- *Urtica procera*

Plot B6: low wooded area

- Populus deltoides*
6 individuals; DBH: 1.5, 2, 2.5, 3, 4, 4.5
- 80% *Lythrum salicaria*
- 10% *Impatiens capensis*
- 5% *Typha latifolia*
- *Eleocharis calva*
- *Leersia oryzoides*
- *Phragmites communis berlandieri*

Plot B7: marsh 25 feet from low wooded area; duff 6-12 inches deep

- 100% *Phragmites communis berlandieri*
- *Impatiens capensis*
- *Lythrum salicaria*

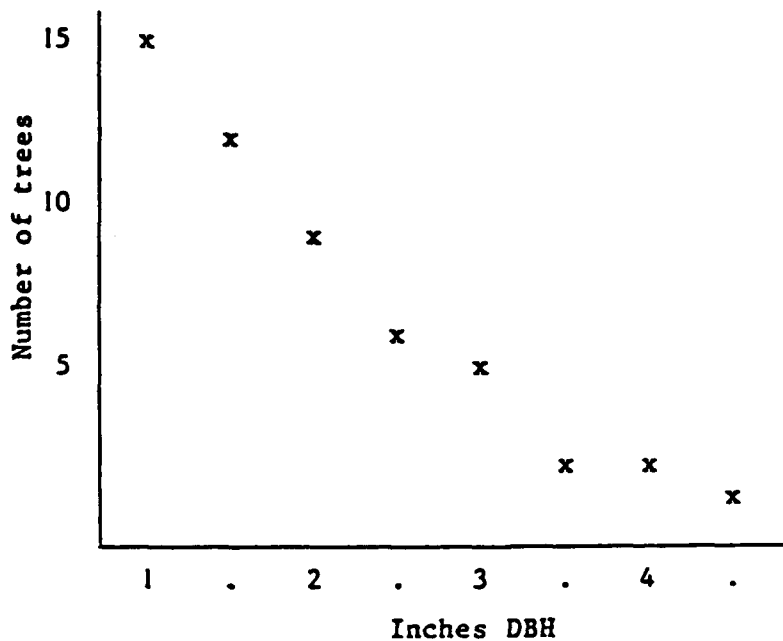
Plot B8: marsh; duff 6-12 inches deep

Phragmites communis berlandieri

Impatiens capensis

Figure II.

Number of trees in each size class; six wooded sample plots from transects A & B



While 75 species of plants were recorded from the dryer wooded area between Fuhrmann Boulevard and the marsh, it is completely dominated in most places by *Populus deltoides* and *Solidago altissima*, and is generally very low in quality. About 50% of the species are non-native to New York. The woods in the driest portions have quality coefficients down around 0.6; these coefficients increase to around 2.0 where the woods intergrade with the lower ground. For a listing of the plants seen in the wooded area, see Appendix C.

The plants and number of individual trees recorded from each of the sample plots in the transect are recorded below. The trees in the very dry plots I - VI number on the average about 1 per plot, and they are of mixed size classes, ranging from 2.5 to 22.0 inches DBH. Off the terrace, in plots VII - IX, there is an average of about 9 trees per plot, a situation similar to that of the wooded plots in transects A & B. In these plots the average DBH is much smaller. Figure III is a tabulation of the transect survey by plot.

UPLAND SAMPLE PLOT DATA

Plot I: on east side of 'No Trespassing' sign

- 90% *Solidago altissima*
- *Agropyron repens*
- *Agrostis alba*
- *Aster pilosus*
- *Cynanchum nigrum*
- *Daucus carota*
- *Nepeta cataria*
- *Oenothera biennis*
- *Poa compressa*
- *Poa pratensis*

Plot II. just west of large colony of *Cornus stolonifera*

- 90% *Solidago altissima*
- 5% *Cornus stolonifera*
- *Agrostis alba*
- *Poa pratensis*

Plot III.

- Populus deltoides*
2 individuals; DBH: 2, 22
- 95% *Solidago altissima*
- *Cornus stolonifera*
- *Epipactis helleborine*
- *Poa pratensis*

Plot IV.

- Populus deltoides*
1 individual; DBH: 2.5
- 80% *Solidago altissima*
- 5% *Poa pratensis*
- 5% *Vitis riparia*
- *Agrostis alba*
- *Cornus stolonifera*
- *Poa compressa*

Plot V.

- 85% *Solidago altissima*
- 5% *Poa pratensis*
- *Agrostis alba*
- *Cornus stolonifera*
- *Vicia cracca*

Plot VI. The summit of a sharp drop-off of about 5' elevation in the fill

- Populus deltoides*
3 individuals; DBH: 3, 4, 7
 - 90% *Solidago altissima*
 - 5% *Cornus stolonifera*
 - *Convolvulus sepium*
- continued next page . . .

Plot VI continued . . .

- *Equisetum arvense*
- *Poa pratensis*
- *Rhamnus cathartica*
- *Verbena hastata*

Plot VII.

- Populus deltoides*
9 individuals; DBH: 3, 3, 3, 3.5, 3.5, 4, 4, 4, 6
- 100% *Solidago altissima*
- *Carex* sp.
- *Cynanchum nigrum*

Plot VIII.

- Populus deltoides*
8 individuals; DBH: 1, 1, 1, 1.5, 2, 2, 2.5, 2.5
- 95% *Solidago altissima*
- *Daucus carota*
- *Poa compressa*
- *Poa pratensis*

Plot IX.

- Populus deltoides*
11 individuals; DBH: 1, 1, 1, 1, 1, 1.5, 1.5, 2, 2, 2.5, 2.5
- 95% *Solidago altissima*
- *Cornus stolonifera*
- *Lythrum salicaria*
- *Petasites hybridus*
- *Phragmites communis berlandieri*
- *Poa compressa*
- *Poa pratensis*
- *Salix rigida*

The flora of the stone block dike area itself was also surveyed. While 59 species were recorded, it is not surprising that they represent an utterly ruderal assemblage. The dike flora has a mean quality coefficient of 0.2, with an index of 1.5. Were it not for a few of the wetland elements encroaching near the base, the dike would have registered an absolute "0" on the open land rating scale. This is because such areas develop rapidly and in just about all waste ground areas of the northeastern United States. No special substrates or developmental efforts are required. Over 75% of the flora consists of Eurasian weeds. Very common along the dike is *Cornus stolonifera*, *Polygonum cuspidatum*, and *Lythrum salicaria*, but most of the other plants listed in Appendix D are also frequent to occasional at various places along the dike.

Appendix E is a list of all the plants recorded from the Times Beach disposal site as a whole, with a listing of their common names.

Figure III. Tabulation of the plots I-IX in the dry wooded area, showing the % phytomass estimated in mid-summer for each species.

Plant Species	Sample Plots								
	I	II	III	IV	V	VI	VII	VIII	IX
<i>Agropyron repens</i>	-								
<i>Agrostis alba</i>	-	-		-	-				
<i>Aster pilosus</i>	-								
<i>Carex</i> sp.							-		
<i>Convolvulus sepium</i>						-			
<i>Cornus stolonifera</i>		5	-	-	-	5			-
<i>Cynanchum nigrum</i>	-						-		
<i>Daucus carota</i>	-							-	
<i>Epipactis helleborine</i>			-						
<i>Equisetum arvense</i>						-			
<i>Lythrum salicaria</i>									-
<i>Nepeta cataria</i>	-								
<i>Oenothera biennis</i>	-								
<i>Petasites hybridus</i>									-
<i>Phragmites communis</i>									
<i>berlandieri</i>									-
<i>Poa compressa</i>	-			-				-	-
<i>Poa pratensis</i>	-	-	-	5	5	-		-	-
<i>Rhamnus cathartica</i>						-			
<i>Salix rigida</i>									-
<i>Solidago altissima</i>	90	90	95	80	85	90	100	95	95
<i>Verbena hastata</i>						-			
<i>Vicia cracca</i>					-				
<i>Vitis riparia</i>				5					

LITERATURE CITED

- Fernald. 1950. Gray's manual of botany. 8th ed. New York: American Book Company.
- Swink & Wilhelm. 1979. Plants of the Chicago region. The Morton Arboretum. Lisle, Illinois.

APPENDIX A

The following is a list of plants recorded from the marsh at the Times Beach disposal site 7 July, 1983. Each plant is preceded by its quality coefficient. Species non-native to the northeastern United States are shown in *Italic type face*.

1 <i>Agrostis alba</i>	-1 <i>Rumex crispus</i>
2 <i>Apocynum sibiricum</i>	4 <i>Sagittaria latifolia</i>
-3 <i>Arctium minus</i>	0 <i>Salix fragilis</i>
3 <i>Aster simplex</i>	1 <i>Salix interior</i>
3 <i>Calamagrostis canadensis</i>	4 <i>Salix nigra</i>
10 <i>Carex crinita</i>	5 <i>Salix interior</i>
4 <i>Carex cristatella</i>	1 <i>Sambucus canadensis</i>
4 <i>Carex hystericina</i>	7 <i>Scirpus americanus</i>
8 <i>Carex lurida</i>	4 <i>Scirpus atrovirens</i>
7 <i>Carex scoparia</i>	5 <i>Scirpus validus creber</i>
2 <i>Carex stipata</i>	-3 <i>Solanum dulcamara</i>
8 <i>Carex tenera</i>	1 <i>Solidago altissima</i>
2 <i>Carex vulpinoidea</i>	3 <i>Solidago gigantea</i>
-3 <i>Cirsium arvense</i>	4 <i>Sphenopholis intermedia</i>
-3 <i>Cirsium vulgare</i>	2 <i>Typha angustifolia</i>
6 <i>Cornus stolonifera</i>	1 <i>Typha latifolia</i>
5 <i>Cuscuta</i> sp.	2 <i>Urtica procera</i>
1 <i>Cyperus strigosus</i>	4 <i>Verbena hastata</i>
1 <i>Dactylis glomerata</i>	
5 <i>Eleocharis calva</i>	
7 <i>Eleocharis nuttallii</i>	
1 <i>Epilobium hirsutum</i>	
5 <i>Eupatorium maculatum</i>	
6 <i>Eupatorium perfoliatum</i>	
5 <i>Festuca obtusa</i>	
7 <i>Geum aleppicum strictum</i>	
1 <i>Geum laciniatum trichocarpum</i>	
-1 <i>Hordeum jubatum</i>	
3 <i>Impatiens capensis</i>	
5 <i>Juncus articularis</i>	
4 <i>Juncus dudleyi</i>	
7 <i>Juncus effusus</i>	
6 <i>Juncus nodosus</i>	
0 <i>Juncus tenuis</i>	
5 <i>Leersia oryzoides</i>	
5 <i>Lemna minor</i>	
0 <i>Lolium perenne</i>	
5 <i>Lycopus americanus</i>	
1 <i>Lythrum salicaria</i>	
7 <i>Myriophyllum exalbescens</i>	
0 <i>Phalaris arundinacea</i>	
4 <i>Phragmites communis berlandieri</i>	
0 <i>Poa compressa</i>	
9 <i>Poa palustris</i>	
0 <i>Poa pratensis</i>	
2 <i>Populus deltoides</i>	
6 <i>Potamogeton pectinatus</i>	

Total quality: 207
Mean quality: 3.1
Number of taxa: 65
Index: 25

APPENDIX B

The following is a list of plants recorded from the reference marsh on Grand Island on 2 August, 1983. Each plant is preceded by its quality coefficient. Species non-native to the northeastern United States are shown in *italic type face*.

1 <i>Agrostis alba</i>	7 <i>Juncus effusus</i>
4 <i>Alisma subcordatum</i>	0 <i>Juncus tenuis</i>
-3 <i>Alliaria officinalis</i>	5 <i>Leersia oryzoides</i>
1 <i>Allium canadense</i>	5 <i>Lemna minor</i>
8 <i>Alnus rugosa americana</i>	7 <i>Lindera benzoin</i>
6 <i>Apios americana</i>	6 <i>Lobelia siphilitica</i>
5 <i>Arisaema atrorubens</i>	5 <i>Lycopus americanus</i>
4 <i>Aster novae-angliae</i>	6 <i>Lycopus uniflorus</i>
10 <i>Aster praealtus</i>	-1 <i>Lysimachia nummularia</i>
3 <i>Aster simplex</i>	1 <i>Lythrum salicaria</i>
1 <i>Bidens frondosa</i>	5 <i>Mentha arvensis villosa</i>
2 <i>Böhmeria cylindrica</i>	4 <i>Monarda fistulosa</i>
3 <i>Calamagrostis canadensis</i>	20 <i>Myosotis laxa</i>
10 <i>Carex lacustris</i>	7 <i>Myriophyllum exalbescens</i>
3 <i>Carex sparganioides</i>	8 <i>Onoclea sensibilis</i>
2 <i>Carex stipata</i>	0 <i>Oxalis europaea</i>
5 <i>Carex stricta</i>	2 <i>Parthenocissus quinquefolia</i>
2 <i>Carex vulpinoidea</i>	5 <i>Penthorum sedoides</i>
0 <i>Circaea quadrisulcata canadensis</i>	0 <i>Phalaris arundinacea</i>
-3 <i>Cirsium arvense</i>	1 <i>Phleum pratense</i>
-3 <i>Cirsium vulgare</i>	5 <i>Pilea pumila</i>
1 <i>Convolvulus sepium</i>	0 <i>Plantago major</i>
5 <i>Cornus obliqua</i>	0 <i>Poa compressa</i>
6 <i>Cuscuta sp.</i>	0 <i>Poa pratensis</i>
1 <i>Daucus carota</i>	15 <i>Polygonum arifolium pubescens</i>
-3 <i>Dipsacus sylvestris</i>	0 <i>Polygonum persicaria</i>
6 <i>Dryopteris thelypteris pubescens</i>	10 <i>Polygonum sagittatum</i>
5 <i>Eleocharis calva</i>	0 <i>Prunella vulgaris lanceolata</i>
3 <i>Epilobium glandulosum adenocaulon</i>	4 <i>Quercus macrocarpa</i>
1 <i>Epilobium hirsutum</i>	8 <i>Quercus palustris</i>
0 <i>Equisetum arvense</i>	1 <i>Rhus radicans</i>
4 <i>Erigeron philadelphicus</i>	6 <i>Ribes sp.</i>
5 <i>Eupatorium maculatum</i>	-1 <i>Rumex crispus</i>
6 <i>Eupatorium perfoliatum</i>	4 <i>Sagittaria latifolia</i>
4 <i>Eupatorium rugosum</i>	0 <i>Salix fragilis</i>
7 <i>Fraxinus pennsylvanica</i>	1 <i>Sambucus canadensis</i>
<i>pennsylvanica</i>	9 <i>Sanicula canadensis</i>
2 <i>Fraxinus pennsylvanica</i>	4 <i>Scirpus atrovirens</i>
<i>subintegerrima</i>	1 <i>Solidago altissima</i>
8 <i>Galium tinctorium</i>	3 <i>Solidago graminifolia nuttallii</i>
0 <i>Geum canadense</i>	-2 <i>Sonchus uliginosus</i>
1 <i>Geum laciniatum trichocarpum</i>	5 <i>Stachys tenuifolia hispida</i>
4 <i>Glyceria striata</i>	0 <i>Taraxacum officinale</i>
-1 <i>Hordeum jubatum</i>	5 <i>Thalictrum dasycarpum</i>
3 <i>Impatiens capensis</i>	2 <i>Tovara virginiana</i>
5 <i>Iris virginica shrevei</i>	2 <i>Typha angustifolia</i>

Appendix B continued . . .

1 *Typha latifolia*
4 *Verbena hastata*
5 *Verbena urticifolia*
5 *Viburnum dentatum*
5 *Viburnum lentago*
4 *Vitis riparia*

Total quality: 333
Mean quality: 3.5
Number of taxa: 96
Index: 34

Native quality: 345
Native mean quality: 4.5
Number of native taxa: 77
Natural area index: 39

APPENDIX C

The following is a list of plants recorded from the wooded area at the Times Beach disposal site 7 July, 1983. Each plant is preceded by its quality coefficient. Species non-native to the northeastern United States are shown in *italic type face*.

1 <i>Achillea millefolium</i>	1 <i>Phelum pratense</i>
-2 <i>Agropyron repens</i>	1 <i>Plantago lanceolata</i>
1 <i>Agrostis alba</i>	0 <i>Poa compressa</i>
0 <i>Ambrosia artemisiifolia elatior</i>	0 <i>Poa pratensis</i>
0 <i>Ambrosia trifida</i>	-1 <i>Polygonum cuspidatum</i>
-3 <i>Arctium minus</i>	2 <i>Populus deltoides</i>
1 <i>Artemisia vulgaris</i>	6 <i>Potentilla anserina</i>
0 <i>Asclepias syriaca</i>	0 <i>Prunella vulgaris lanceolata</i>
4 <i>Aster novae-angliae</i>	-3 <i>Rhamnus cathartica</i>
1 <i>Aster pilosus</i>	-3 <i>Rhamnus frangula</i>
3 <i>Aster simplex</i>	3 <i>Rhus typhina</i>
1 <i>Barbarea vulgaris</i>	-1 <i>Rumex crispus</i>
0 <i>Bromus japonicus</i>	0 <i>Salix fragilis</i>
* <i>Camelina micropcarpa</i>	1 <i>Salix interior</i>
4 <i>Carex cristatella</i>	5 <i>Salix rigida</i>
8 <i>Carex tenera</i>	-1 <i>Saponaria officinalis</i>
1 <i>Chrysanthemum leucanthemum</i>	4 <i>Scirpus atrovirens</i>
-3 <i>Cirsium arvense</i>	-3 <i>Solanum dulcamara</i>
-3 <i>Cirsium vulgare</i>	1 <i>Solidago altissima</i>
1 <i>Convolvulus sepium</i>	3 <i>Solidago gigantea</i>
6 <i>Cornus stolonifera</i>	4 <i>Sphenopholis intermedia</i>
1 <i>Cynanchum nigrum</i>	0 <i>Taraxacum officinale</i>
1 <i>Dactylis glomerata</i>	1 <i>Typha latifolia</i>
1 <i>Daucus carota</i>	4 <i>Ulmus rubra</i>
1 <i>Epilobium hirsutum</i>	2 <i>Urtica procera</i>
2 <i>Epipactis helleborine</i>	1 <i>Verbascum thapsus</i>
0 <i>Equisetum arvense</i>	4 <i>Verbena hastata</i>
4 <i>Erigeron philadelphicus</i>	5 <i>Verbena urticifolia</i>
5 <i>Festuca obtusa</i>	0 <i>Vicia cracca</i>
1 <i>Geum laciniatum trichocarpum</i>	4 <i>Vitis riparia</i>
0 <i>Hypericum perforatum</i>	
3 <i>Impatiens capensis</i>	
0 <i>Iris pseudacorus</i>	
5 <i>Leersia oryzoides</i>	
-1 <i>Linaria vulgaris</i>	
0 <i>Lolium perenne</i>	
-2 <i>Lychnis alba</i>	
4 <i>Lysimachia ciliata</i>	
1 <i>Lythrum salicaria</i>	
0 <i>Mirabilis nyctaginea</i>	
-1 <i>Nepeta cataria</i>	
1 <i>Oenothera biennis</i>	
7 <i>Panicum clandestinum</i>	
-3 <i>Pastinaca sativa</i>	
* <i>Petasites hybridus</i>	
0 <i>Phalaris arundinacea</i>	
4 <i>Phragmites communis berlandieri</i>	

Total quality: 97
Mean quality: 1.3
Number of taxa: 75
Index: 11

APPENDIX D

The following is a list of plants recorded from the dike area at the Times Beach disposal site 7 July, 1983. Each plant is preceded by its quality coefficient. Species non-native to the northeastern United States are shown in *Italic type face*.

1 <i>Achillea millefolium</i>	2 <i>Populus deltoides</i>
1 <i>Agrostis alba</i>	1 <i>Potentilla recta</i>
-3 <i>Arctium minus</i>	3 <i>Rhus typhina</i>
0 <i>Asclepias syriaca</i>	-1 <i>Rumex crispus</i>
1 <i>Barbarea vulgaris</i>	0 <i>Salix fragilis</i>
-1 <i>Brassica nigra</i>	-1 <i>Saponaria officinalis</i>
0 <i>Bromus japonicus</i>	-1 <i>Setaria viridis</i>
-2 <i>Carduus nutans</i>	-3 <i>Solanum dulcamara</i>
* <i>Chaenorrhinum minus</i>	1 <i>Solidago altissima</i>
1 <i>Chrysanthemum leucanthemum</i>	3 <i>Solidago gigantea</i>
1 <i>Cichorium intybus</i>	-1 <i>Sonchus asper</i>
-3 <i>Cirsium arvense</i>	0 <i>Taraxacum officinale</i>
-3 <i>Cirsium vulgare</i>	1 <i>Verbascum thapsus</i>
-3 <i>Convolvulus arvensis</i>	4 <i>Vitis riparia</i>
1 <i>Convolvulus sepium</i>	
6 <i>Cornus stolonifera</i>	
1 <i>Dactylis glomerata</i>	Total quality: 12
1 <i>Daucus carota</i>	Mean quality: 0.2
-3 <i>Dipsacus sylvestris</i>	Number of taxa: 59
1 <i>Echium vulgare</i>	Index: 1.5
1 <i>Erigeron annuus</i>	
2 <i>Fraxinus pennsylvanica</i>	
<i>subintegerrima</i>	
1 <i>Helianthus annuus</i>	
0 <i>Hypericum perforatum</i>	
3 <i>Impatiens capensis</i>	
-1 <i>Lactuca scariola</i>	
0 <i>Lepidium virginicum</i>	
-1 <i>Linaria vulgaris</i>	
0 <i>Lolium perenne</i>	
-3 <i>Lonicera X muendeniensis</i>	
-3 <i>Lonicera tatarica</i>	
-2 <i>Lychnis alba</i>	
5 <i>Lycopus americanus</i>	
1 <i>Lythrum salicaria</i>	
-2 <i>Melilotus officinalis</i>	
0 <i>Mirabilis nyctaginea</i>	
-1 <i>Nepeta cataria</i>	
1 <i>Oenothera biennis</i>	
1 <i>Parthenocissus inserta</i>	
-3 <i>Pastinaca sativa</i>	
8 <i>Physocarpus opulifolius</i>	
1 <i>Plantago lanceolata</i>	
0 <i>Poa compressa</i>	
0 <i>Poa pratensis</i>	
-1 <i>Polygonum cuspidatum</i>	

APPENDIX E

The following is a list of all the vascular plant species, with common names, recorded from the Times Beach disposal area during the mid-summer survey.

Achillea millefolium YARROW, MILFOIL
Agrostis alba REDTOP
Ambrosia artemisiifolia elatior COMMON RAGWEED
Ambrosia trifida GIANT RAGWEED
Apocynum sibiricum INDIAN HEMP
Arctium minus COMMON BURDOCK
Artemisia vulgaris MUGWORT
Asclepias syriaca COMMON MILKWEED
Aster novae-angliae NEW ENGLAND ASTER
Aster simplex PANICLED ASTER
Barbarea vulgaris YELLOW ROCKET
Brassica nigra BLACK MUSTARD
Bromus japonicus JAPANESE CHESS
Calamagrostis canadensis BLUE JOINT GRASS
Camefina microcarpa SMALL-FRUITED FALSE FLAX
Carduus nutans NODDING THISTLE
Carex crinita FRINGED SEDGE
Carex cristatella CRESTED SEDGE
Carex hystericina BOTTLEBRUSH SEDGE
Carex lurida
Carex scoparia
Carex stipata
Carex tenera
Carex vulpinoidea FOX SEDGE
Chaenorrhinum minus SMALL SNAPDRAGON
Chrysanthemum leucanthemum OX-EYE DAISY
Cichorium intybus CHICKORY
Cirsium arvense FIELD THISTLE
Cirsium vulgare BULL THISTLE
Convolvulus arvensis FIELD BINDWEED
Convolvulus sepium HEDGE BINDWEED
Cornus stolonifera RED OSIER DOGWOOD
Cuscuta sp. DODDER
Cynanchum nigrum BLACK SWALLOW-WORT
Dactylis glomerata ORCHARD GRASS
Daucus carota WILD CAROT, QUEEN ANNE'S LACE
Dipsacus sylvestris COMMON TEASEL
Echium vulgare VIPER'S BUGLOSS
Eleocharis calva RED-ROOTED SPIKE RUSH
Elodea nuttallii SLENDER WATERWEED
Epilobium hirsutum HAIRY WILLOW HERB
Epipactis helleborine HELLEBORINE
Equisetum arvense HORSETAIL
Erigeron annuus ANNUAL FLEABANE
Erigeron philadelphicus MARSH FLEABANE
Eupatorium maculatum SPOTTED JOE PYE WEED
Eupatorium perfoliatum COMMON BONESET

Festuca obtusa NODDING FESCUE
Fraxinus pennsylvanica subintegerrima GREEN ASH
Geum aleppicum strictum YELLOW AVENS
Geum laciniatum trichocarpum ROUGH AVENS
Helianthus annuus GARDEN SUNFLOWER
Hordeum jubatum SQUIRREL-TAIL GRASS
Hypericum perforatum COMMON ST. JOHN'S WORT
Impatiens capensis ORANGE JEWELWEED
Iris pseudacorus YELLOW IRIS
Juncus articulatus JOINTED RUSH
Juncus dudleyi DUDLEY'S RUSH
Juncus effusus COMMON RUSH
Juncus nodosus JOINT RUSH
Juncus tenuis PATH RUSH
Lactuca scariola PRICKLY LETTUCE
Leersia oryzoides RICE CUT GRASS
Lemna minor SMALL DUCKWEED
Lepidium virginicum COMMON PEPPERCRESS
Linaria vulgaris BUTTER-AND-EGGS
Lolium perenne PERENNIAL RYE GRASS
Lonicera X muendeniensis BUSH HONEYSUCKLE
Lonicera tatarica BUSH HONEYSUCKLE
Lychnis alba WHITE CAMPION
Lycopus americanus COMMON WATER HOREHOUND
Lysimachia ciliata FRINGED LOOSESTRIFE
Lythrum salicaria PURPLE LOOSESTRIFE
Melilotus officinalis YELLOW SWEET CLOVER
Mirabilis nyctaginea FOUR O'CLOCK
Myriophyllum exalbescens SPIKED WATER MILFOIL
Nepeta cataria CATNIP
Oenothera biennis COMMON EVENING PRIMROSE
Panicum clandestinum DEER-TONGUE GRASS
Parthenocissus inserta THICKET CREEPER
Pastinaca sativa WILD PARSNIP
Petasites hybridus COLT'S FOOT
Phalaris arundinacea REED CANARY GRASS
Phleum pratense TIMOTHY
Phragmites communis berlandieri COMMON REED
Physocarpus opulifolius NINEBARK
Plantago lanceolata ENGLISH PLANTAIN
Poa compressa CANADA BLUE GRASS
Poa palustris MARSH BLUE GRASS
Poa pratensis KENTUCKY BLUE GRASS
Polygonum cuspidatum JAPANESE KNOTWEED
Populus deltoides EASTERN COTTONWOOD
Potamogeton pectinatus SAGO PONDWEED
Potentilla anserina SILVERWEED
Potentilla recta SULFUR CINQUEFOIL
Prunella vulgaris lanceolata SELF HEAL
Rhamnus cathartica COMMON BUCKTHORN
Rhamnus frangula GLOSSY BUCKTHORN
Rhus typhina STAGHORN SUMAC
Rumex crispus CURLY DOCK
Sagittaria latifolia COMMON ARROWHEAD

Salix fragilis CRACK WILLOW
Salix interior SANDBAR WILLOW
Salix nigra BLACK WILLOW
Salix rigida HEART-LEAVED WILLOW
Sambucus canadensis ELDERBERRY
Saponaria officinalis SOAPWORT
Scirpus americanus CHAIRMAKER'S RUSH
Scirpus atrovirens DARK GREEN RUSH
Scirpus validus creber GREAT BULRUSH
Setaria viridis GREEN FOXTAIL
Solanum dulcamara BITTERSWEET NIGHTSHADE
Solidago altissima TALL GOLDENROD
Solidago gigantea LATE GOLDENROD
Sonchus asper SPINY SOW THISTLE
Sphenopholis intermedia SLENDER WEDGE GRASS
Taraxacum officinale DANDELION
Typha angustifolia NARROW-LEAVED CATTAIL
Typha latifolia BROAD-LEAVED CATTAIL
Ulmus rubra SLIPPERY ELM
Urtica procera TALL NETTLE
Verbascum thapsus COMMON MULLEIN
Verbena hastata BLUE VERVAIN
Verbena urticifolia WHITE VERVAIN
Vicia cracca COW VETCH
Vitis riparia RIVERBANK GRAPE

Gerould Wilhelm
Department of Botany
Southern Illinois Univ.
Carbondale, Illinois
62901

5 September, 1983

PLANT SAMPLING AND SURVEY AT TIMES BEACH, N. Y.

1 October 1985

by
Gerould Wilhelm
The Morton Arboretum
Lisle, Illinois 60532

Introduction

One of our goals is to learn to what extent changing physicochemical conditions in the developing rhizosphere of a dredge material can alter the mobility and availability of elements regarded as contaminants. Clearly, highly reduced, saturated dredge material, newly disposed, is an altogether different growth medium than the same material which ten years later has been oxidized, better drained, and elaborated by a decade of root zone development.

The Times Beach, New York site is ideal for studying dredge material development. It began its evolution over ten years ago as a partially filled diked disposal area. The site is still underlain by material which resembles the original. There is a gradual elevation gradient from what is now oxidized, well-drained upland to reduced wetland. This gradient is identified by no fewer than seven definable zones of vegetation. Each zone is marked by a distinct association of vascular plants, and each zone has its own physiognomic characteristics.

Differences in species associations, together with differences in edaphics, result in differences in rhizosphere chemistry--and presumably in contaminate availability and mobility. Productivity and phytomass decomposition are different as well, so the movement of contaminants into the vegetation and the characteristics of contaminant biocycling are different as well. Species diversity also contributes to complex root-soil chemistries.

Superimposed over all of these factors is the fact that plant succession is occurring in each zone. Succession, while seemingly slow, has produced what we see today at Times Beach in a relatively short time. This results in continued change in rhizosphere development. Vegetational succession is a phenomenon which is present on nearly all dredge materials wherever they are placed in the upland. Results of initial tests for bioavailability become quickly obsolete.

The Times Beach site offers us an opportunity to study several different successional paradigms, to learn what effects such processes have on a given substrate, and the extent to which the physicochemical dynamics of this substrate, once perceived as highly active from a contaminant standpoint, can become diffused to the point where it is at least as acceptable as the ambient urban substrates.

Because this site has an elevation gradient, we can learn to what depth above the ground water confined disposal areas can be filled to produce the most desirable results. Ultimately, management techniques such as fire, mowing, or even purposeful restoration can be employed to achieve a sustainable, steady state ecosystem which will operate in an agreeable biocycling mode.

Transects

During the summer, seven sampling transects were laid out across elevation gradients at the Times Beach Disposal. The existence of such a gradient among Transects D, E, and F, however, is only presumed. With the exception of Transect E, each transect consists of three permanent quadrats 5 meters square (264 ft²); Transect E has only one. The quadrats are designated A1, A2, A3, B1, etc. See the map and the accompanying Table 1. Transects A-C are in the "upland" wooded area; for each of the quadrats in these three transects, the total number of living trees 1" DBH and over were counted and recorded. Though each transect was selected on the basis of a commonality in its dominant vegetation, coefficients of similarity with respect to species composition among quadrats, even within a transect, varied broadly (see Figure 1).

All of the trees, but particularly those in Transects B and C, are infested by canker. They are heavily over-stocked (about 1300 per acre) and are therefore under severe competition stress among themselves. Rapid growth among most of them seems to have ceased. Their incapacity to outgrow the canker, their density, and vulnerability to water level fluctuations, will render most of them dead within a few years. Many are dead already. For the last couple of years, no seedlings of Cottonwood (*Populus deltoides*) have been observed on the site, though seed production in the area has been quite evident.

Essentially all of the trees are without lichen growth. The only lichens known from the site are represented by disparate thalli from a few of the larger Cottonwoods on the "old beach". They are species which are typical of trees from urban areas around the Great Lakes. All are stratified foliose and corticolous: *Parmelia sulcata*, *Phaeophyscia pusilloides*, *Physcia adscendens*, *P. millegrana*, and *P. stellaris*.

Transect A is the highest and driest of the transects. It is wooded--almost entirely Cottonwood. These trees average 4.2" $\pm$ 2.2" DBH, and have a density of about 1100 trees per acre. It is dominated beneath by the perennial Tall Goldenrod (*Solidago altissima*). The incipient "A" horizon here is the deepest and most oxidized of all the transects; inundation even for short periods is rare. There is probably a loss of nutrients each year due to leaching, though decomposition of the non-ligneous annual productivity does not appear to be complete.

Transect B is, on the whole, 2 to 3 feet lower in elevation than Transect A; it is also dominated in the canopy by Cottonwood, but there is a lower story characterized by the Red-Osier Dogwood (*Cornus stolonifera*) along with a few willows (*Salix* spp.). The ground cover is relatively diverse and is variously populated by the Common Jewel Weed (*Impatiens capensis*), Purple Loosestrife (*Lythrum salicaria*), Goldenrods (*Solidago* spp.), and others. Here the Cottonwoods average 3.2" $\pm$ 1.9" and have a density of about 1500 trees per acre. While the upper foot or so of soil is fairly well oxidized, this transect is evidently inundated for short periods every year. Decomposition of the non-ligneous annual productivity appears to be more complete than in Transect A, but the annual yield is not as high.

Transect C is the lowest of the transects. It is characterized by a canopy of Cottonwoods which average 3.5" $\pm$ 1.3" DBH; there are about 1400 trees per acre. There is no significant middle shrub story. The

TIMES BEACH DISPOSAL AREA **BUFFALO, NEW YORK**

Locations of Vegetation Sample Quadrats

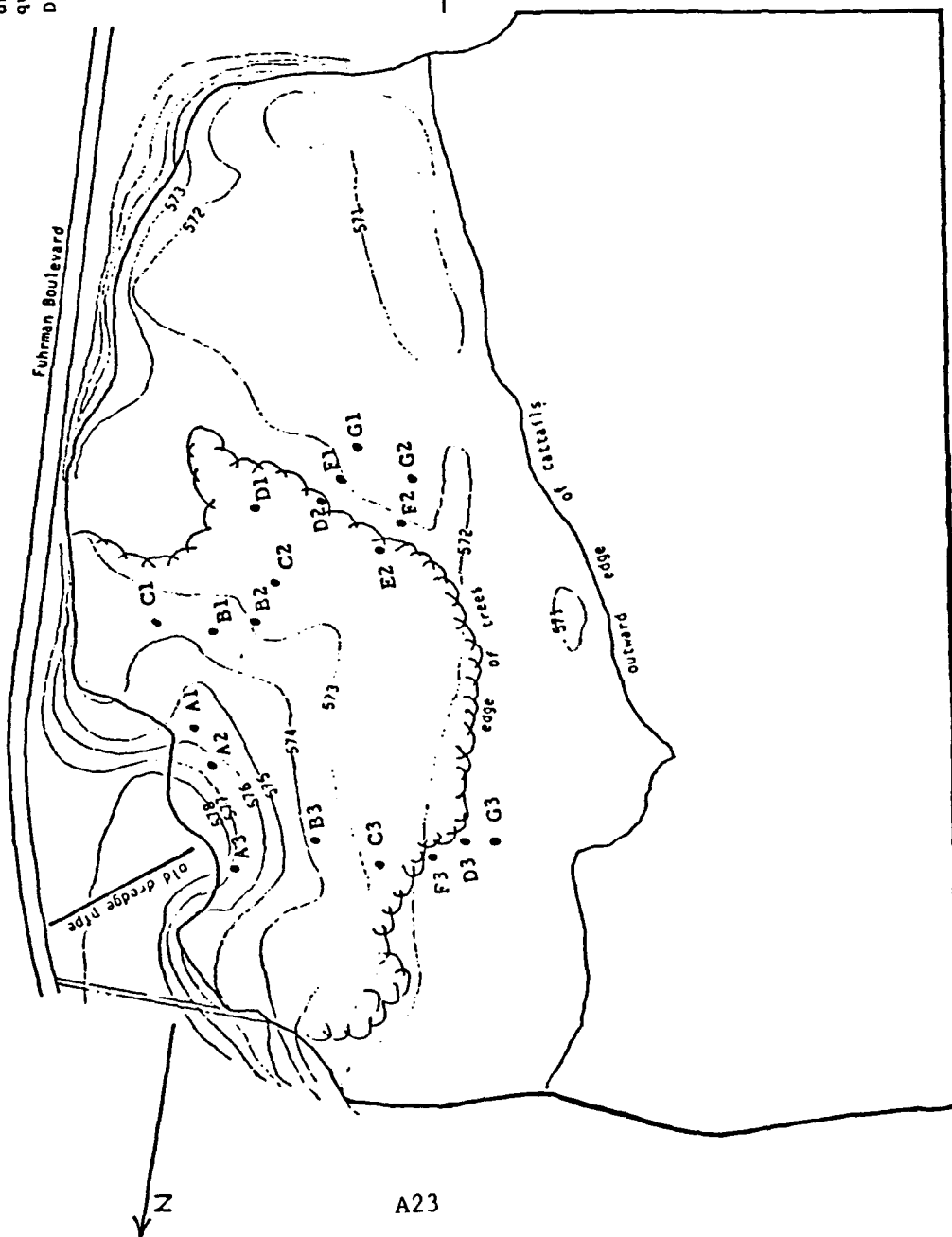
Table 1

Locations of 5 m² vegetation sample quadrats, with respect to degrees (clockwise from 0° north) and the distance, expressed in meters, between neighboring quadrats.

Degrees	Quadrat	Meters
165	Pipe - A1	53
175	Pipe - A2	35
305	Pipe - A3	18
150	A1 - C1	55
275	C1 - B1	30
250	B1 - B2	19
195	B2 - C2	24
155	C2 - D1	38
200	D2 - D2	47
240	C2 - E2	52
215	D2 - F1	12
200	F1 - G1	16
210	E2 - F2	16
180	F2 - G2	23
240	A3 - B3	39
280	B3 - C3	32
250	C3 - F3	21
255	F3 - D3	15
260	D3 - G3	14

Transect Descriptions

- A Upper Cottonwood
- B Dogwood/Cottonwood
- C Lower Cottonwood
- D Giant Reed Grass
- E Reed Canary Grass
- F Purple Loosestrife Marsh
- G Cattail



ground cover is nearly everywhere dominated by *Impatiens capensis*. The decomposition of seasonally produced phytomass is nearly or quite complete, though non-ligneous productivity is much reduced when compared with the other six transects. Only the top few inches are fully oxidized, and it is evident that the transect area is subjected to frequent inundations, vulnerable to the vagaries of water level fluctuations in Lake Erie.

Transect D is dominated by Giant Reed (*Phragmites australis*). Only desultory stems of Cattail (*Typha* spp.) and *Lythrum salicaria* are apparent. During the July sampling period the leaves of the Giant Reed were heavily infested by aphids. This transect is under the influence of regular inundation. Decomposition of the annual phytomass production is poor, though much of it appears to be broken mechanically and spread as flotsam to accumulate in shallow ridges along high water lines.

Transect E is dominated by Reed Canary Grass (*Phalaris arundinacea*). Though it is not a significant plant at this particular disposal site, this small stand was selected for analysis only because elsewhere in the Great Lakes region it is a very abundant and aggressive component in disturbed wetlands. Analysis of this species in the context of the Times Beach Site would seem to be useful. It represents a clone-like stand within an area which is transitional between Transects C and F.

Transect F comprises most of the paludal zones below the "upland" wooded area and above the Cattail marsh. It is fairly diverse, though until mid-summer there is very little productivity because of lingering levels of high water. Later, however, it becomes dominated by *Lythrum salicaria*, and later yet by Rice-Cut Grass (*Leersia oryzoides*). Productivity late in the year is fairly high, and decomposition appears to be high as well; either that or the dead plant parts are washed out into the deeper marshes. The caudices of the *Lythrum* in many instances are thick and quite esconced, evidently unperturbed by fluctuating water levels. Young seedlings of this perennial are also everywhere apparent.

Transect G is the lowest in elevation, inundated nearly or quite all of the time. It is dominated by two Cattail species: *Typha latifolia* and *T. angustifolia*. Productivity here appears high, though accumulations of duff seem not to be as great as in some other Cattail marshes. Fluctuating water levels, ice, and wave action appear to break up the leaves and distribute them as flotsam, not only throughout the littoral zones, but probably also in the deeper portions of the marsh and diked area as well.

Sampling

In 1985, following the recommendations of the working group, the Times Beach site was sampled twice for phytomass analysis, once in early July and again in late September. During the mid-summer sampling period, each of the quadrats was sampled for plant part analysis. Leaves (Lvs), stems (Sts), roots (Rts), rhizomes (Rhs), and fruits (Frs) were sampled from the dominant phytomass producer in each plot; this was repeated in September. Roots and rhizomes were bagged together and separated and cleaned in the laboratory. Stems, leaves, and flowers were all bagged separately to avoid any post-collection translocation of contaminants from tissue to tissue. Plant parts rendered in all capital letters were collected in fall only; those collected in spring are given in boldface type.

Factors involving phenological development and other practical limitations precluded a full matrix collection of all plant parts of each species. Some plants, for example, had not even bloomed by July 2; others had already produced infructescences. *Leersia oryzoides*, all but absent in July, was in full production by September 24 when the fall sampling occurred.

For each species a perceived relative phytomass coefficient was assigned in July. This coefficient ranged from 0 to 100 and was given subjectively in increments of 5. Species preceded by a "-" symbol were present in only trace amounts during July. For the most part, perceived relative phytomass did not change significantly from July to September. In Transect F, however, *Leersia* was scarcely evident in July, whereas in September, it could be considered as much as half the phytomass in some areas. Likewise, in Transects B and C, the relative amounts of *Impatiens* increased sharply from July to September. Interestingly, however, a frost on the night of September 24th literally demolished the sensitive *Impatiens*, a fact which changed completely its perceived relative phytomass overnight.

When collecting *Impatiens* for analysis, the succulent stems and leaves were bagged together. The roots were cut away to avoid contamination of the sample with soil particles. Since it is assumed that, being an ephemeral annual, any contaminants in its tissues are returned quickly to the soil through rapid decomposition of all of the plant parts, there is no need to treat the leaves and stems separately.

Lythrum was just forming inflorescences during the July sampling period; by late September, most of the plants had developed seeds and the calyces were dried and brown.

All of the trees in the quadrats were recorded in July, so there was no need to repeat this in September. Net productivity, as measured by the standing crop of four dominant non-ligneous species, was sampled September 25th. (see Table 2). Each tree in the listing below is succeeded by a series of numbers which represent the trunk diameters in inches at 4½ feet above the ground (DBH). The number succeeding *Cornus stolonifera* in Transect B represents the numbers of stems greater than or equal to 2 meters high. The plants shown in parentheses in some of the quadrats were noted only during the fall sampling period.

Below is a detailed accounting of each sampling period. It is of some interest to note that leguminous and nodule-bearing species are wholly absent from the quadrats.

<u>Lvs</u>	<u>Sts</u>	<u>Rts</u>	<u>Rhs</u>	<u>Fls</u>	<u>Quadrats</u>
					A1 <i>Populus deltoides</i> 4, 6, 9, 10
Lvs	Sts	Rts	Rhs	FRS	95 <i>Solidago altissima</i> (<i>Aster lateriflorus</i>) - <i>Carex cristatella</i> - <i>Geum laciniatum trichocarpum</i> - <i>Impatiens capensis</i> - <i>Phalaris arundinacea</i> - <i>Rumex obtusifolius</i> - <i>Solanum dulcamara</i> (<i>Vitis riparia</i>)

					A2	Populus deltoides	1, 1, 1, 2, 3, 3, 3, 5	
Lvs	Sts	Rts	Rhs	FRS		95	Solidago altissima	
							- Asclepias incarnata	
							- Carex cristatella	
							- Convolvulus sepium	
							- Cornus stolonifera	
							- Geum laciniatum trichocarpum	
							- Poa pratensis	
							- Salix fragilis	
							- Taraxacum officinale	
					A3	Populus deltoides	2, 3, 3, 4, 5, 5, 9	
Lvs	Sts	Rts	Rhs	FRS		95	Solidago altissima	
							- Poa compressa	
							- Poa pratensis	
							- Rhus typhina	
							- Solanum dulcamara	
					B1	Populus deltoides	1, 1, 1, 2, 2, 2, 3, 6	
Lvs						80	Cornus stolonifera	[22]
Lvs	Sts					5	Impatiens capensis	
Lvs	Sts	Rts	Rhs				- Solidago altissima/gigantea	
							- Achillea millefolium	
							- Carex cristatella	
							- Geum laciniatum trichocarpum	
							- Glyceria striata	
							- Lythrum salicaria	
							- Poa pratensis	
					B2	Populus deltoides	2, 2, 2, 2, 3, 3, 3, 3, 3, 4	
Lvs						40	Cornus stolonifera	[15]
Lvs	Sts	Rts				30	Lythrum salicaria	
Lvs	Sts	Rts	Rhs	FRS		5	Solidago altissima/gigantea	
						5	Carex cristatella	
						5	Poa pratensis	
							- Aster novae-angliae	
							- Epilobium hirsutum	
							- Eupatorium perfoliatum	
							- Geum laciniatum trichocarpum	
							- Impatiens capensis	
							- Juncus dudleyi	
							- Solidago graminifolia nuttallii	
					B3	Populus deltoides	2, 2, 3, 4, 4, 4, 5, 5, 6, 10	
							Salix bebbiana	1
							Salix rigida	1, 2

Lvs				Frs
Lvs	Sts	Rts	Rhs	FRS

50 Cornus stolonifera [26]
 5 Solidago altissima
 5 Lysimachia ciliata
 - Calamagrostis canadensis
 - Carex cristatella
 - Eupatorium maculatum
 - Geum laciniatum trichocarpum
 - Impatiens capensis
 - Lythrum salicaria

C1 Populus deltoides 2, 2, 2, 2, 3,
 4, 5
 Salix rigida 5

Lvs	Sts

95 Impatiens capensis
 - Geum laciniatum trichocarpum
 - Solidago altissima

C2 Populus deltoides 2, 2, 3, 3, 4,
 4, 5, 5, 6

Lvs	Sts	
Lvs	Sts	Rts

80 Impatiens capensis
 5 Lythrum salicaria
 - Carex brevior
 - Carex cristatella
 - Carex stipata
 - Cornus stolonifera
 - Geum laciniatum trichocarpum
 - Phalaris arundinacea
 - Rumex crispus
 - Solidago altissima
 (Viburnum opulus)

C3 Populus deltoides 3, 3, 3, 3, 3,
 4, 5, 5, 6

Lvs	Sts	Rts	Rhs
Lvs	Sts		
Lvs	Sts	Rts	
Lvs	Sts		

80 Solidago altissima/gigantea
 10 Impatiens capensis
 5 Lythrum salicaria
 - Phragmites australis
 - Carex cristatella
 - Carex stipata
 - Geum laciniatum trichocarpum
 - Glyceria striata
 - Poa palustris
 - Salix rigida
 - Solidago graminifolia nuttallii

D1

Lvs	Sts	Rts	Rhs	FRS
Lvs		Rts	Rhs	FRS

95 Phragmites australis
 - Typha angustifolia
 - Typha latifolia (rare)

Lvs	Sts	Rts	Rhs	FRS	D2	100 Phragmites australis - Lythrum salicaria
Lvs	Sts	Rts	Rhs	FRS	D3	80 Phragmites australis
Lvs		Rts	Rhs	FRS		15 Typha latifolia
Lvs	Sts	Rts		FRS		5 Lythrum salicaria
Lvs	Sts	Rts			E2	95 Phalaris arundinacea - Salix interior
Lvs	Sts	Rts		FRS	F1	95 Lythrum salicaria - Eleocharis calva - Leersia oryzoides
Lvs	Sts	Rts		FRS	F2	95 Lythrum salicaria - Carex lurida - Carex cristatella - Carex stipata - Eleocharis calva - Leersia oryzoides
Lvs	Sts	Rts		FRS	F3	40 Lythrum salicaria
Lvs		Rts	Rhs	FRS		20 Typha angustifolia
LVS						20 Salix interior
						5 Carex cristatella
						5 Eleocharis calva
						- Carex lurida
						- Carex stipata
						- Eupatorium perfoliatum
						- Juncus effusus
						(Leersia oryzoides)
						- Phragmites australis
						- Scirpus atrovirens
						- Scirpus validus creber
Lvs		Rts	Rhs	FRS	G1	100 Typha latifolia
Lvs		Rts	Rhs	FRS	G2	100 Typha latifolia
Lvs		Rts	Rhs	FRS	G3	95 Typha latifolia
Lvs	Sts	Rts		FRS		5 Lythrum salicaria

Treatment of Plant Parts

Plant parts were handled and treated following the written instructions of Professor W. H. O. Ernst of Free University, Amsterdam, Holland. They were put immediately into polyethylene, "zip-lock" bags and placed in ice to avoid biomass diminution by respiration. The above-ground parts, with the exception of the flowers and fruits, were washed three times for one minute in distilled water, then blotted between filter paper and dried at 80°C for 48 hours. Below-ground parts were cleaned roughly then washed three times for five minutes in 0.1 mol KCL solution. This was followed by three washings for 5, 3, and 1 minute in distilled water. Exterior layers of bulbs (dead material) and rhizomes (periderm) were removed. Inasmuch as the roots remained contaminated by soil material, the soil material (silica fraction) was collected after wet ashing. It was dried, weighed, and the contamination calculated. The dried plant material (up to 250 mg) was mineralized by wet ashing in a 10 ml acid solution of 7 parts 65% HNO₃ and 1 part 70% HClO₄ in 100 ml Kjeldal ashing bottles. The remnant acid was diluted to 10 ml with double distilled water for analysis by the AAS.

Table 2

Net productivity of four dominant non-ligneous plants on the Times Beach disposal area. Amounts are given in grams per square meter. Daily rate is calculated on an effective growing season of 125 days.

Ovendry Weight	Mean Daily Rate	% of wet Weight	Species
2773	22.1	40.3	<i>Solidago altissima</i>
2174	17.4	37.6	<i>Typha latifolia</i>
3106	24.8	46.7	<i>Phragmites australis</i>
2995	24.0	38.5	<i>Lythrum salicaria</i>

Figure 1. Sorensen coefficients of species similarity (X100) among quadrats in Transects A-G, as sampled during July, 1985 on the Times Beach, New York dredge disposal site.

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E2	F1	F2	F3	G1	G2	G3
A1	100																		
A2	42	100																	
A3	43	38	100																
B1	56	60	38	100															
B2	48	43	31	70	100														
B3	50	45	22	63	56	100													
C1	61	40	36	53	44	59	100												
C2	63	48	23	67	58	61	50	100											
C3	50	36	22	64	56	58	59	61	100										
D1	0	0	0	0	0	0	0	0	13	100									
D2	0	0	0	17	13	14	0	15	29	40	100								
D3	0	0	0	15	13	13	0	14	27	67	80	100							
E2	0	0	0	0	0	0	0	0	0	0	0	0	100						
F1	0	0	0	15	13	13	0	14	13	0	40	33	0	100					
F2	14	13	0	25	21	22	0	35	33	0	25	22	0	67	100				
F3	10	9	0	18	24	17	0	26	33	27	29	27	14	27	33	100			
G1	0	0	0	0	0	0	0	0	0	50	0	40	0	0	0	0	100		
G2	0	0	0	0	0	0	0	0	0	50	0	40	0	0	0	0	100	100	
G3	0	0	0	17	13	14	0	15	14	40	50	40	0	40	25	29	0	0	100

Report on TIMES BEACH - Dike Disposal Area No. 2, Buffalo, New York

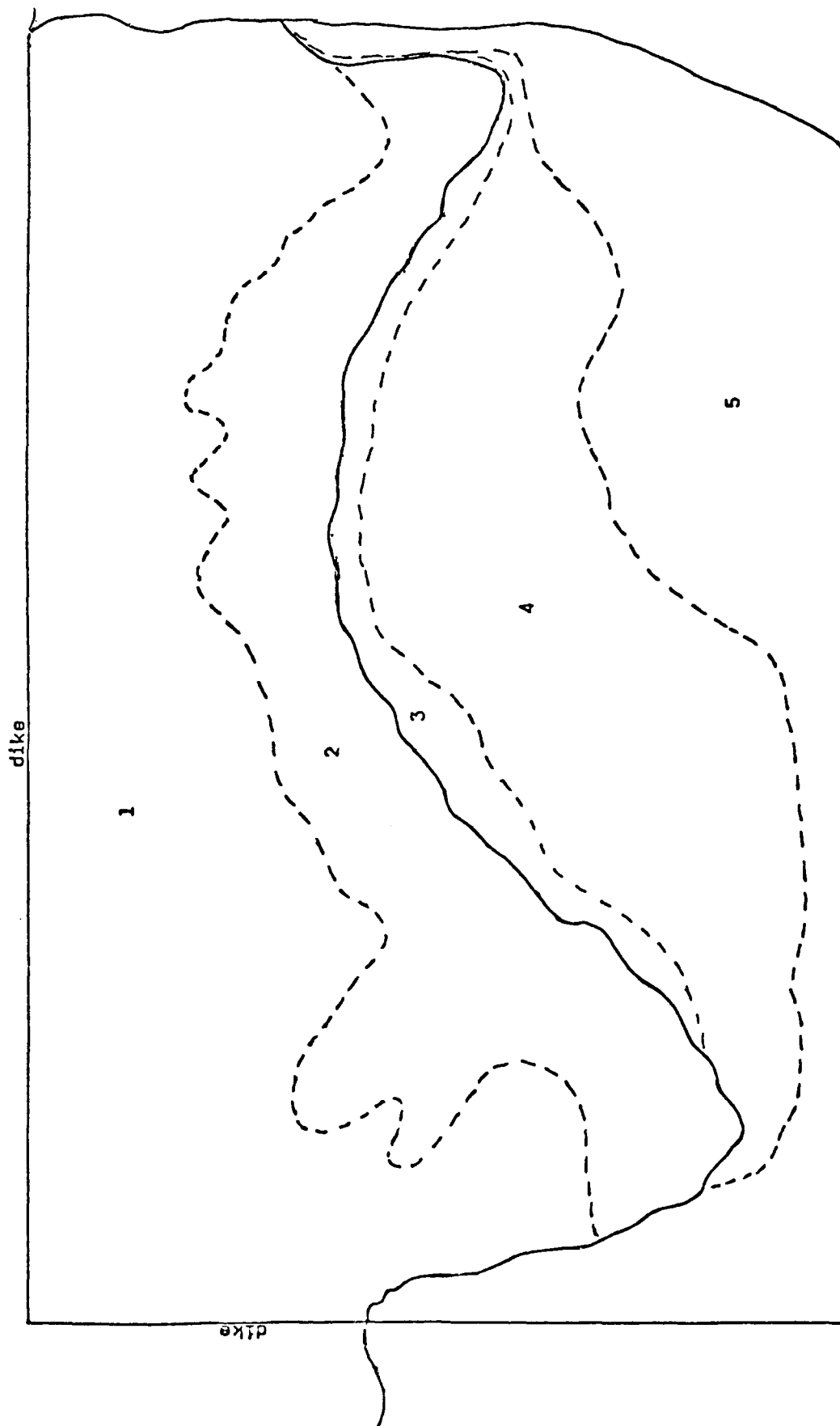
The following account presents a brief outline of existing physical features and vegetation of the site and changes in the plants occurring there. The potential of this City of Buffalo owned area for a wildlife preserve and its value as a public nature education facility are evaluated, some recommendations made and necessary management procedures outlined. Included are a map of the site and appendices containing lists of birds and plants recorded there.

I. At least five overlapping physical zones can be defined in this approximately 18 hectare (46 acre) roughly rectangular area (dimensions ca. 600 x 375 m). A deep water zone up to about 2 m in depth occupies the western sector with submergent aquatic plants. A gradually sloping shallow water zone with both submergent and emergent aquatic plants is transitional between the deep water zone and the roughly semicircular terrestrial sector which encompasses about one-third of the site in the northeast portion. A curving littoral zone subject to periodic wind initiated inundation lies along the perimeter of the land area and contains terrestrial and aquatic plants. A low-lying mud or silt flat zone occupies a variable width where low to tall herbaceous plants grow with some intrusions of woody species. The upland zone in the extreme east and northeast parts of the site is transitional with the silt flat and contains tall herbs, grasses and stands of variously sized trees and shrubs. Some dense beds of aquatic vegetation have developed in the shallow water area in the southeast corner and there is a narrow tree and shrub covered upland along part of the southern border.

The Times Beach site is characterized essentially by vegetation succession on the terrestrial section and variable plant development in the aquatic portion. There is pioneer tree and shrub growth in the upland zone with gradual elimination of open grass and herb areas taking place. Woody plants are encroaching into the silt flat and herbaceous plants are developing and expanding in it. Terrestrial and aquatic plants are developing to a lesser extent and degree in the littoral zone and submergent aquatic plants in the shallow and deep water zones. Wind-driven oscillation of water over the littoral and periphery of the silt flat tends to inhibit

TIMES BEACH Dike Disposal Area No. 2

↗ N



Fuhrmann Boulevard

- Zones:
- 1 - deep water
 - 2 - shallow water
 - 3 - littoral
 - 4 - silt flat
 - 5 - upland

Scale: 1.5" = 100 m

establishment and development of some plants in the littoral and shallow water zones.

II. Potential for a Wildlife Preserve

Many vertebrate and invertebrate animals are currently attracted to or resident in the Times Beach diked disposal area. Up to the present time, however, only birds and to a lesser extent plants have been studied there. Bird occurrences in the various zones at Times Beach have been very unusual in kind, number and variety, as attested to in Appendix A, which has been compiled from data in the files and publications of the Buffalo Ornithological Society. The site's sheltered waters provide ideal resting and feeding places for migrating waterfowl, particularly surface-feeding but also diving ducks. The site lies on an important flyway for migrating water and land birds, a key factor substantially enhancing its potential for wildlife. Its location at the eastern end of Lake Erie also makes it a logical focal point for water-oriented birds moving eastward along both north and south shores of the lake.

The total of 170 species of birds recorded to date at Times Beach is exceptional, especially the number of waterfowl (26 species of ducks, geese and swans with a maximum of about 400 birds on one day), shorebirds (29 species with maxima of 14 species and about 600 individuals on single days), gulls (10 species and a maximum of at least 3,500 on one day), and warblers (23 species). These include some remarkable rarities, with several European forms, and the grand total of bird species identified there is almost as large as that for the Tifft Farm Nature Preserve, which is over five times greater in area. From an ornithological standpoint, it is a unique place without parallel in this region.

Although plant life in the upland section is fairly simple at present, it is nevertheless attractive to terrestrial wildlife, particularly migrating birds. The plants established in the silt flat and littoral zones are sufficiently varied to create a desirable environment for both terrestrial and aquatic animals. Appendix B, derived largely from the Botany Division of the Buffalo Museum of Science, lists some of the more important plants on the site.

Times Beach, at its present stage of filling, has developed into an excellent wildlife area because it possesses the five broad and overlapping zones listed above. These consist of various habitats that differ in their current attractiveness and potential for animals. The key habitats which give the area its exceptional potential for water-oriented wildlife and that make it unique in this region are in the littoral and shallow water zones. The deposition of dredged disposal material in the form of slurry from centrally located pipes created a roughly semicircular area that slopes very gradually into deeper water at its periphery. The flat thus formed, partially submerged and with a fluctuating water level over it, provides excellent feeding and resting areas for many water and shore birds. They utilize the drier areas for resting and the exposed wet and shallowly inundated sectors for both resting and probing in the substratum for minute invertebrates, and for feeding on submergent aquatic plants and on small fish.

The southern end of the flat supports dense growths of cattails and rushes, providing nesting habitat for ducks, gallinules and other water-related birds. Broods of Mallard, American Wigeon and Common Gallinule have been seen there. Many broods of Ring-necked Pheasants have also been observed. Among the mammals, to our knowledge only Eastern Cottontail and Muskrat have so far been noted, but other medium and small sized mammals probably occur and will increasingly do so as terrestrial vegetation develops or is managed for maximum attractiveness and diversity. Some fish survive from when the area was diked, and gulls, terns and kingfishers have been observed capturing the smaller individuals, while diving ducks, coots and grebes frequent the deeper water and feed on fish and submergent plants. A good variety of invertebrate animals is also attracted to the site, but no studies have been made of them. Although several studies are in progress by the U. S. Army Corps of Engineers on the effects of dredged disposal sediment constituents on water quality, aquatic organisms and plants, we know of none at present concerning their effects on vertebrates. A study of mercury accumulation in Buffalo Harbor dike disposal areas (Perrott, Great Lakes Laboratory 1973) showed no apparent problem with plants that are eaten by vertebrates absorbing mercury. Also, the soil in these areas appeared non-toxic to most plant species that were growing there, and nothing in the

limnetic habitats seemed to limit growth of submergent forms except turbidity during deposition (Sweeney, Great Lakes Laboratory 1973).

Following of the management procedures outlined subsequently should essentially maintain and in some sections enhance the site's attractiveness for wildlife. The key habitats at Times Beach mentioned above are not present at nearby Tifft Farm Nature Preserve, and because they are not duplicated there many animal species occurring at Times Beach do not frequent the Preserve. Thus these two areas nicely complement each other in their attraction for wildlife. It should be noted that the New York State Department of Environmental Conservation, in a recent report based on a field inspection of Times Beach, stated that it is a unique wetland wildlife habitat with flourishing resident wildlife communities, and also recommended that it be preserved on the basis of value to the long term wildlife resources in Western New York.

III. : Value as a Nature Education Area

The recent creation of the Tifft Farm Nature Preserve was a significant first step in introducing to Buffalo a unique wetland-oriented natural area which is destined to become a valuable educational and recreational asset to its citizens. As other progressive cities have done, it seems most appropriate to provide as large a variety of opportunities as possible on the Buffalo waterfront for citizens to participate in such activities. In addition to the extensive industrial and commercial areas that dominate Buffalo's waterfront, public parks, marinas and now a new nature observation and learning area have been created - Tifft Farm Nature Preserve. Opportunities to diversify and expand these people-oriented places should be taken when available.

The creation of two diked dredge disposal areas in Buffalo Harbor, one at the Small Boat Harbor and the other at Times Beach, and the construction of a large one off the South Pierhead Light provide such opportunities. The first location, since it is almost filled, could eventually provide a park-oriented, partially tree-shaded, grassy recreation area focused on passive leisure and sport activities such as strolling, picnicking and fishing.

This would be compatible with and add variety to the nearby activities of boating, nature study at the Tifft Farm Nature Preserve and active sports at the Tifft Playfields. The Times Beach area, if preserved and maintained at its present stage, would provide a unique natural wildlife and plant study site that could be ideally utilized in conjunction with the Tifft Preserve education program both for the general public and for school groups and other special guided visits. It is already being used by many persons for nature study and simply enjoying the peace and beauty of a developing natural area.

Both maintenance and control of this site for nature education could be accomplished with relatively small effort and expense. One or possibly two trails could be maintained to allow examination of several habitats at close hand and one or two low observation towers, strategically placed, would permit excellent views to be obtained of the entire area without disturbing wildlife. The potential of the Times Beach site for such purposes is high. This is an opportunity that should not be lost. It is a situation where man has created an exceptional and increasingly beautiful natural area which could be an outstanding asset to the City and its citizens.

IV. Management Recommendations and Related Considerations

As emphasized earlier, the key habitats which give the Times Beach site its great potential for a variety of water-oriented wildlife and that make it unique in this region are in the littoral and shallow water zones. An extensive more or less open mud or silt flat littoral, as now exists at Times Beach, is an essential element of such a condition, and this can only be maintained by either periodic flooding (raising water level of the site to eliminate vegetation, then lowering), or plant removal in these zones. Since the first method does not appear to be possible or at least practical because of water filtration through the dike, the second seems to be the only alternative. Principal actions recommended to accomplish this are 1) periodically eliminate herbaceous plants from the littoral zone, particularly at the silt flat periphery and in shallow water adjacent to the shoreline; 2) eliminate all woody plant intruders and some tall-growing herbaceous plants from the outer silt flat; 3) control terrestrial upland woody plants to maintain

diversity of open and tree-shrub areas; 4) plant shrubs and trees attractive for wildlife in upland zone and other appropriate places. Management objectives might be accomplished by the efforts of youth in municipal summer programs or by voluntary work by members of various youth organizations and local conservation and natural science groups. Study of plant succession on the site could be incorporated in the education program for visitors, as well as explanations of why the site is being managed in this way.

In view of the above, any expansion of shallow water within the site by additional filling of deeper water or by excavation of the upland to increase wetland area would only provide more opportunity for emergent aquatic plant growth, decrease the vital open littoral section and necessitate more work to remove vegetation in this zone. It would also cater too much to surface-feeding ducks, largely exclude shorebirds, gulls and terns, and effectively eliminate the site's present attractiveness for deep water diving ducks, grebes and coots. In other words, it would reduce the site's present wildlife diversity and serve to attract some forms of marsh birds already present at the Tifft Farm Nature Preserve.

One possible solution to the problem of where to dump the 1976 season spoil, if no location other than Times Beach can be found, is to utilize part of the upland zone at Times Beach by creating there a low dike of already deposited spoil to contain the solid dredged disposal material. Any runoff of water that might occur through this dike to the present open water would not affect its depth. Some upland vegetation would be destroyed, but it would regenerate and there would be a higher section created that could facilitate observation of the rest of the site.

If the Times Beach site is preserved and maintained essentially as it now exists for the purposes of a wildlife preserve and nature education in conjunction with Tifft Farm Nature Preserve, any use of it for hunting would not only be completely incompatible with these purposes but would be illegal. If hunting were permitted, there would be an immediate diminution of wildlife on the site and an interference and conflict during much of the Fall because this would not only remove much of the wildlife from viewing by others but

would create disturbances inimical to satisfactory and effective wildlife observation and nature education. City of Buffalo ordinances prohibit the discharge of firearms within City limits and the carrying of loaded shotguns and rifles in public places. Since City boundaries extend to the International Boundary in Lake Erie, this makes hunting with them illegal at Times Beach as well as at Tiffet Farm Nature Preserve and the rest of the Buffalo waterfront. Even now fishermen on the north and south dikes at Times Beach and bird observers walking out on the site cause some disturbance to wildlife. Therefore, it would be essential to have use of and access to this area properly controlled to make it most useful for nature study and education. Such control and security would be comparatively easy to maintain because of the site's relatively small size, its rectangular shape and proximity to a regularly patrolled road.

Robert F. Andrie Ph.D.
Buffalo Ornithological Society
Buffalo Museum of Science
September 22, 1975

Appendix A

Birds Recorded at Times Beach Dike Disposal Area No. 2, Buffalo, N.Y.

The list totals 174 species identified from 1972 to date. Some annotations are included on noteworthy occurrences and numbers and for status of certain species.

Pied-billed Grebe Podilymbus podiceps. A regular fall migrant at the site. It may conceivably attempt to breed in the marsh portion.

Double-crested Cormorant Phalacrocorax auritus. An uncommon migrant recorded flying over the site on two separate occasions.

Great Blue Heron Ardea herodias.

Green Heron Butorides virescens.

Great Egret Casmerodius albus. An uncommon visitor observed on 7 August 1974.

Black-crowned Night Heron Nycticorax nycticorax.

Whistling Swan Olor columbianus. There are two spring records.

Canada Goose Branta canadensis. Three birds were seen on 18 May 1975.

Brant Branta bernicla. An uncommon migrant; one was seen on 16 and 17 November 1974.

Egyptian Goose Alopochen aegyptiacus. The six individuals observed on 24 August 1973, were undoubtedly escaped birds.

Mallard Anas platyrhynchos. One of the most common ducks with over 200 individuals reported on several occasions. This species also nests there with young being seen from May to August.

Black Duck Anas rubripes. Much less common than the Mallard, a maximum of 15 birds has been recorded.

Gadwall Anas strepera. Considered a very rare summer visitor, this species has been observed on several occasions during July and August. Dates of occurrence range from 26 May to 12 September with a maximum of 10 individuals. Five other duck species also rare during the summer have occurred, thus showing the site's value as a summer feeding and resting area for waterfowl.

Pintail Anas acuta.

American Green-winged Teal Anas crecca. A maximum of five has been recorded.

Blue-winged Teal Anas discors. Another common duck which has been seen between 3 April and 12 October with a maximum of 50 individuals.

Cinnamon Teal Anas cyanoptera. This small duck was found here with a group of Blue-winged Teal on 15 August 1973. It is the first record of this species for the Niagara Frontier Region. It is also one of the few records for eastern North America.

American Wigeon Anas americana. A transient and also an irregular rare summer resident which has bred on the site. An adult and six young were noted on 13, 16 and 19 August 1973. This species' dates of occurrence range from 25 April to 14 September with a maximum of 24 individuals.

Shoveler Anas clypeata. Has been recorded in August and September with a maximum of five birds.

Wood Duck Aix sponsa. A new species at the site during 1975.

Redhead Aythya americana. All records of this species are in the summer when it is considered very rare. A maximum of 13 individuals was noted on 11 September 1972. This may be the result of a stocking program around western Lake Erie.

Ring-necked Duck Aythya collaris. This species has occurred on two occasions.

Canvasback Aythya valisineria.

Greater Scaup Aythya marila.

Lesser Scaup Aythya affinis. Has occurred between 24 March and 18 September with a maximum of 12 individuals.

Common Goldeneye Bucephala clangula. A rare summer visitor which has partially summered at the site.

Bufflehead Bucephala albeola.

Oldsquaw Clangula hyemalis. The single record on 1 August 1973, is noteworthy since this species is considered a rare summer visitor.

Surf Scoter Melanitta perspicillata. An open water duck which was seen on 6 October 1974.

Ruddy Duck Oxyura jamaicensis.

Hooded Merganser Lophodytes cucullatus. Nearly all the records are in the summer months when this bird is considered rare.

Red-breasted Merganser Mergus serrator.

Sharp-shinned Hawk Accipiter striatus. Reported in migration over the site.

Red-tailed Hawk Buteo borealis

Marsh Hawk Circus cyaneus. Another migrant over the site.

American Kestrel Falco sparverius. Regularly seen in spring, summer and fall and occasionally in winter. It is believed to nest in an abandoned elevator nearby.

Ring-necked Pheasant Phasianus colchicus. A year-round common inhabitant which breeds on the site.

Sora Porzana carolina.

Common Gallinule Gallinula chloropus. Occurrence dates range from 10 July to 10 September with breeding known from the presence of 7 downy young with 2 adults on 3 August 1973.

American Coot Fulica americana.

Semipalmated Plover Charadrius semipalmatus. This small plover's dates of occurrence are from 15 May to 21 September with a spring maximum of 11 on 15 May 1975, and a fall maximum of 21 on 17 August 1975.

Killdeer Charadrius vociferus. Our commonest shorebird which is also known to breed at the site. A maximum of 90 individuals was recorded on 18 September 1974.

American Golden Plover Pluvialis dominica. A fall migrant recorded for the past two years.

Black-bellied Plover Pluvialis squatarola. The earliest arrival date for this region was set on 1 May 1975 when 3 were seen at the site. A noteworthy spring late departure date of 26 June was also recorded in 1975. A maximum of 20 was noted on 15 September 1973.

Ruddy Turnstone Arenaria interpres. Although it has been recorded in both spring and fall with a maximum of 4 on 4 June 1975, this is not a shorebird of the mudflats.

Common Snipe Capella gallinago. Has been recorded once.

Whimbrel Numenius phaeopus. One record on 23 August 1973.

Spotted Sandpiper Actitis macularia. A common spring, summer and fall shorebird which breeds at the site. A spring maximum of 25 birds was noted on 28 May 1975.

Solitary Sandpiper Tringa solitaria.

Willet Catoptrophorus semipalmatus. The date range for this large rare shorebird runs from 8 August to 22 September with all dates after 15 September being unusually late. The maximum of five counted on 2 September 1974, is the second highest number for this region.

Greater Yellowlegs Tringa melanoleucus. The maximum of four was seen on 18 September 1974.

Lesser Yellowlegs Tringa flavipes. Has occurred fairly regularly from 27 June through 8 September with a noteworthy maximum of 131 birds on 4 August 1974.

Red Knot Calidris canutus. Recorded between 4 August and 12 October with a rather high maximum of 23 noted on 25 August 1973.

Pectoral Sandpiper Calidris melanotos. A count of 55 on 22 September 1974, is the maximum for this species. It has occurred between 27 July and 30 September.

White-rumped Sandpiper Calidris fuscicollis. Has been recorded in both June and August with a maximum of four. This species is rare in spring and uncommon in the fall.

Baird's Sandpiper Calidris bairdii. Recorded only in the fall from 7 August to 27 September with a maximum of three. Another uncommon species.

Least Sandpiper Calidris minutilla. This is a mudflat species whose dates of occurrence for spring range from 9 May to 28 May and for fall migration from 26 June to 2 September. Recently a flock of 48 was seen.

Dunlin Calidris alpina. Migrant dates range from 3 May to 15 June and from 14 September to 8 November. A maximum of 40 individuals was noted on 12 October 1974. Of special interest was a summering bird first seen on 27 June 1975, and still present in early September.

Semipalmated Sandpiper Calidris pusillus. A common small shorebird in the spring between 8 and 28 May and in the fall from 27 June through 9 September. The 27 June date is a new fall migration arrival date for this species in the region. A maximum of 500 birds was counted on 10 August 1974.

Western Sandpiper Calidris mauri. A rare shorebird which has been seen on five occasions with a maximum of three birds on 5 September 1973.

Sanderling Calidris alba. A sand beach type of shorebird which does not usually inhabit mudflats but which has been found on the site on three occasions.

Short-billed Dowitcher Limnodromus griseus. The only spring record is of two birds on 10 May 1975, a week earlier than usual. Fall dates range from 11 July to 27 September. The maximum of 86 individuals on 13 July 1975, is the second highest count on record for this species.

Long-billed Dowitcher. Limnodromus scolopaceus. There is one definite record of this occasional very rare transient visitor on 16 September 1974.

Stilt Sandpiper Micropalama himantopus. A new fall migration arrival date was set when five of these birds were seen on 11 July 1975. Dates extend from 11 July to 14 September with a maximum of eight on 7 August 1974.

Marbled Godwit Limosa fedoa. One of these occasional very rare transient visitors occurred here on 11 July 1975, the earliest arrival date and the seventh record for this region.

Hudsonian Godwit Limosa haemastica. Another occasional very rare transient visitor, 37 of which were found on 17 August 1974. This is an unprecedented number of this species for this area and possibly for inland United States.

Ruff Philomachus pugnax. With only two previous records for Western New York of this European wanderer, the one at Times Beach on 27 and 28 July 1975, is especially noteworthy. It is also the farthest west this species has been seen in the state.

American Avocet Recurvirostra americana. This impressively marked large shorebird is a casual very rare visitor in this region. There have been only three verified records of its occurrence and, remarkably, two are at Times Beach. Five Avocets were sighted on 22 August 1972, and two on 26 August 1975.

Wilson's Phalarope Steganopus tricolor. Recorded twice at the site with one of the birds staying from 4 to 30 August 1974, allowing many viewers to enjoy studying this rare species.

Parasitic Jaeger Stercorarius parasiticus. A single individual of this rare pelagic species was noted flying low over the site on 25 August 1972.

Glaucous Gull Larus hyperboreus. This large wintering species of gull was recorded for the first time on 18-25 April 1975.

Iceland Gull Larus glaucoides. Another wintering gull species which was observed at the site on 20 April 1975.

Great Black-backed Gull Larus marinus.

Herring Gull Larus argentatus.

Ring-billed Gull Larus delawarensis. One of our commonest local gulls which nests on nearby Donnelley's Pier in Buffalo Harbor. Numbers of this species use the site as a resting and feeding place.

Black-headed Gull Larus ridibundus. An Old World species which is a very rare fall and winter visitor in this region and has been recorded once at the site.

Laughing Gull Larus atricilla. A common gull of the Atlantic Coast; inland records are rare and usually in the fall. It is especially noteworthy that the records at Times Beach are in the spring. An adult and an immature were observed on several dates in early May 1975.

Franklin's Gull Larus pipixcan. An uncommon species which has become of regular occurrence at Times Beach. It has been recorded as early as 31 July 1972 and as late as 20 October 1974, with a maximum of five on the last date.

Bonaparte's Gull Larus philadelphia. This abundant migrant has been recorded in spring between 18 April and 4 June with fall migration dates from mid-July to 10 September. Maximum numbers have totaled 150 for the spring on 25 April 1975, and 3,500 for the fall on 17 August 1975. The site is a favorite afternoon resting place for this species.

Little Gull Larus minutus. This uncommon and sometimes rare visitor has become quite regular at Times Beach. In 1975 they have been fairly numerous at times. Their dates of occurrence range from 28 July to 24 November with a maximum of at least 12 on 17 August 1975. As with the Bonaparte's Gulls, this species uses the site as an afternoon resting location.

Forster's Tern Sterna forsteri. Times Beach is one of the very few locations which has records of this species in recent times. A very early individual arrived on 31 July 1975, while the latest date has been 3 September 1973.

Common Tern Sterna hirundo. Dates range from 18 April through September for this abundant migrant which also breeds in Buffalo Harbor. A peak of 500 was recorded on 18 August 1974.

Caspian Tern Hydroprogne caspia. There are two spring records for this large uncommon species, one on 25 April 1975 with a maximum of 14 birds. Fall dates are from 17 July to 24 September with a maximum of nine on 29 August 1974.

Black Tern Chlidonia nicae. An abundant fall migrant whose dates of occurrence range from 1 to 27 August with a maximum of 350 birds on 17 August 1975.

Rock Dove Columba livia.

Mourning Dove. Zenaida macroura.

Snowy Owl Nyctea scandiaca. Occasionally recorded in winter.

Common Nighthawk Chordeiles minor.

Chimney Swift Chaetura pelagica.

Belted Kingfisher Mecocoryle alcyon.

Common Flicker Colaptes auratus.

Red-headed Woodpecker Melanerpes erythrocephalus.

Yellow-bellied Sapsucker Sphyrapicus varius.

Downy Woodpecker Dendrocopos pubescens.

Eastern Kingbird Tyrannus tyrannus.

Willow Flycatcher Empidonax traillii.

Least Flycatcher Empidonax minimus.

Horned Lark Eremophila alpestris.

Tree Swallow Iridoprocne bicolor.

Bank Swallow Riparia riparia.

Rough-winged Swallow Stelgidopteryx ruficollis.
Barn Swallow Hirundo rustica.
Purple Martin Progne subis.
Blue Jay Cyanocitta cristata.
Common Crow Corvus brachyrhynchos.
Black-capped Chickadee Parus atricapillus.
White-breasted Nuthatch Sitta carolinensis.
Red-breasted Nuthatch Sitta canadensis.
House Wren Troglodytes aedon.
Carolina Wren Thryothorus ludovicianus. Rare species recorded once.
Long-billed Marsh Wren Telmatodytes palustris.
Gray Catbird Dumetella carolinensis.
Brown Thrasher Toxostoma rufum.
American Robin Turdus migratorius.
Hermit Thrush Catharus guttatus.
Swainson's Thrush Catharus ustulatus.
Veery Catharus fuscens.
Blue-gray Gnatcatcher Polioptila caerulea.
Golden-crowned Kinglet Regulus satrapa.
Ruby-crowned Kinglet Regulus calendula.
Water Pipit Anthus spinoletta.
Cedar Waxwing Bombycilla cedrorum.
Loggerhead Shrike Lanius ludovicianus. Very uncommon species noted once.
Starling Sturnus vulgaris.
Red-eyed Vireo Vireo olivaceus.
Philadelphia Vireo Vireo philadelphicus.

Warbling Vireo Vireo gilvus.
Black-and-white Warbler Mniotilta varia.
Blue-winged Warbler Vermivora pinus.
Tennessee Warbler Vermivora peregrina.
Orange-crowned Warbler Vermivora celata.
Nashville Warbler Vermivora ruficapilla.
Parula Warbler Parula americana.
Yellow Warbler Dendroica petechia.
Magnolia Warbler Dendroica magnolia.
Cape May Warbler Dendroica tigrina.
Black-throated Blue Warbler Dendroica caerulescens.
Yellow-rumped Warbler Dendroica coronata.
Black-throated Green Warbler Dendroica virens.
Blackburnian Warbler Dendroica fusca.
Chestnut-sided Warbler Dendroica pensylvanica.
Bay-breasted Warbler Dendroica castanea.
Blackpoll Warbler Dendroica striata.
Prairie Warbler Dendroica discolor. Rare transient found once on site.
Palm Warbler Dendroica palmarum.
Ovenbird Seiurus aurocapillus.
Northern Waterthrush Seiurus noveboracensis.
Common Yellowthroat Geothlypis trichas.
Wilson's Warbler Wilsonia pusilla.
Canada Warbler Wilsonia canadensis.
American Redstart Setophaga ruticilla.
House Sparrow Passer domesticus.
Bobolink Dolichonyx oryzivorus.
Eastern Meadowlark Sturnella magna.

Red-winged Blackbird Agelaius phoeniceus.
Rusty Blackbird Euphagus carolinus.
Common Grackle Quiscalus quiscula.
Brown-headed Cowbird Molothrus ater.
Scarlet Tanager Piranga olivacea.
Cardinal Cardinalis cardinalis.
Rose-breasted Grosbeak Pheucticus ludovicianus.
Indigo Bunting Passerina cyanea
Purple Finch Carpodacus purpureus.
American Goldfinch Spinus tristis.
Rufous-sided Towhee Pipilo erythrophthalmus.
Savannah Sparrow Passerculus sandwichensis.
Dark-eyed Junco Junco hyemalis.
Chipping Sparrow Spizella passerina.
Field Sparrow Spizella pusilla.
White-crowned Sparrow Zonotrichia leucophrys.
White-throated Sparrow Zonotrichia albicollis.
Lincoln's Sparrow Melospiza lincolni.
Swamp Sparrow Melospiza georgiana.
Song Sparrow Melospiza melodia.

Compiled by A. Schaffner
A. R. Clark
R. F. Andrie

Buffalo Ornithological Society

Appendix B

Some Characteristic Plants of Times Beach Diked Disposal Area No. 2, Buffalo, N.Y.

1. Deep water zone	<u>Sparganium</u> sp.	Bur-reed
2. Shallow water zone	<u>Vallisneria americana</u>	"Eelgrass"
	<u>Ceratophyllum demersum</u>	Hornwort

3. Littoral zone	<u>Typha latifolia</u>	Common Cattail
4. Silt flat zone	<u>Typha angustifolia</u>	Narrow-leaved Cattail
	* <u>Sagittaria latifolia</u>	Arrowhead
	<u>Phragmites communis</u>	Common Reed Grass
	<u>Echinochloa muricata</u>	Barnyard Grass
	* <u>Scirpus</u> sp.	Bulrush
	<u>Eleocharis</u> sp.	Spike Rush
	<u>Carex</u> sp.	Sedge
	* <u>Populus deltoides</u>	Eastern Cottonwood
	* <u>Polygonum lapathifolium</u>	Pale Smartweed
	<u>Polygonum hydropiper</u>	Common Smartweed
	<u>Polygonum persicaria</u>	Ladies' Thumb
	<u>Sagittaria officinalis</u>	Bouncing Bet
	<u>Melilotus alba</u>	White Sweet Clover
	* <u>Lythrum salicaria</u>	Swamp Loosestrife
	<u>Solidago</u> spp.	Goldenrods
	<u>Ambrosia artemisiifolia</u>	Common Ragweed
	<u>Xanthium strumarium</u>	Cocklebur

5. Upland zone	* <u>Populus deltoides</u>	Eastern Cottonwood
	* <u>Salix nigra</u>	Black Willow
	<u>Salix</u> sp.	Willow
	<u>Polygonum cuspidatum</u>	Japanese Knotweed
	<u>Rhus typhina</u>	Staghorn Sumac
	<u>Oenothera parviflora</u>	Evening Primrose

* <u>Daucus carota</u>	Queen Anne's Lace
<u>Asclepias syriaca</u>	Common Milkweed
<u>Nepeta cataria</u>	Catnip
* <u>Solidago spp.</u>	Goldenrods
<u>Ambrosia artemisiifolia</u>	Common Ragweed
<u>Ambrosia trifida</u>	Great Ragweed

* major component

Compiled by: Richard H. Zander Ph.D.
Curator of Botany
Buffalo Museum of Science

(additions by R. F. Andrie
and from Robert A. Sweeney,
Great Lakes Laboratory 1973)

Vertebrate Research at Times Beach Confined Disposal Site

Buffalo, New York

Interim Draft Report

Robert F. Andrie

Buffalo Museum of Science

30 August 1985

The transition which has occurred in Times Beach ecosystems during the past several decades during which it has changed from its original tree and shrub-bordered sand beach condition fronting Buffalo Harbor to a completely diked enclosure in which dredged river and harbor sediments and other solid materials have been deposited has been marked. Not only have these changes affected its flora and fauna, but they have combined with long and short-term fluctuations in Lake Erie levels acting through the porous parts of the dikes to create even more alterations in these ecosystems.

Methods

This interim report is based on 14 visits of varying durations to the site from mid-May through August 1985 (three daily visits in May and July and four each in June and August). These investigations were conducted on foot during diurnal, crepuscular and nocturnal time periods and were focused primarily on identifying vertebrate animals and observing their behavior. They were based on a north - south oriented 100 yard scale grid superimposed on a U. S. Army Corps of Engineers constructed topographic and general terrestrial - aquatic outline map (1985). They covered terrestrial and aquatic vegetated areas and the open water submerged and bottom vegetated sections where depth and subsurface sediments permitted entry. During each visit

observations were conducted systematically in all existing habitats and were concentrated on mammals, birds, reptiles and amphibians. (Note: small mammal live trapping during the same period by mark - recapture methods was arranged for previously and was carried out by a research team from Cornell University, and some fish have been captured and studied previously by U. S. Army Waterways Experiment Station researchers).

The three most profound general changes that have taken place on the site are the long-term growth and expansion lakeward of cottonwoods (Populus) and willow (Salix); the long-term succession from various types of more or less drier habitat terrestrial herbaceous plants on the dredged material to wetland plant species (Typha, Juncus, Scirpus, etc.); and the short-term very rapid and considerable rise in Lake Erie's level that occurred and which considerably extended the water-inundated area of the site. Prior to this sudden rise, Lake Erie had undergone several lesser fluctuations since the site was utilized for disposal, and it has been mostly at a fairly high level during this time. These variations have affected plant succession and generally resulted in expansion of emergent and submergent aquatic vegetation. As is generally known, winds of sufficient strength from an easterly component lower Lake Erie's level and consequently through the porous dike sections Times Beach's water levels in the short-term (from a few hours to a day or more), and this affects the use of the site by wildlife, particularly marsh and wading birds.

Results

Very few species and individuals of mammals, reptiles and amphibians

were recorded on the site despite careful observations and intensive efforts to investigate likely habitats for them. In general, except for possibly small mammals, habitats within the site are too small to contain large populations and numbers of species of resident vertebrates. This was also concluded by Marquenie et al (1985). There is also a condition that has in recent years been studied by zoologists, particularly ornithologists, of low vertebrate animal numbers and variety in reference to wooded area extent and disruption by surrounding non-woodland habitats. An analogy could be drawn on this point in the theories on island biogeography (MacArthur and Wilson, 1967) where (in this case, of course) water and distance from the mainland act on limiting the fauna of islands.

Both Times Beach and the larger (ca. 5X+) Tifft Farm Nature Preserve, which lies about two miles to the south and possesses some similar habitats, are partly isolated from similar wildlife habitats by commercial developments. The resulting paucity of variety and/or numbers of some resident vertebrates is apparent at the latter locality, which perhaps partially explains the situation at Times Beach. Thus, conditions nearby and in part directly adjacent to the site are not conducive for colonization by vertebrates and the carrying capacity of its habitats is limited.

Also present in the conditions at Times Beach is the difficulty of observing mammals, as many are nocturnal, vegetation is dense in many places and relatively few medium to large size species likely inhabit it. Reasons for the apparent paucity of reptiles and amphibians could be partially the same as stated above, and in their case the lateness in the Spring that investigations commenced, April and early May being their

more active vocalization and breeding season. Other reasons for the same thing with the herpetofauna could be the frequent waterlevel fluctuations in the site, the comparatively few natural or other type exposed objects in the water for them, especially frogs and turtles, to use as resting and sunning places isolated from shore disturbances, and finally the existence of an oily substance within the dredged material substrate and both in and on the water, particularly in the marsh and deeper open water areas. Further investigations earlier in Spring 1986 will likely record a few more species of these classes on site.

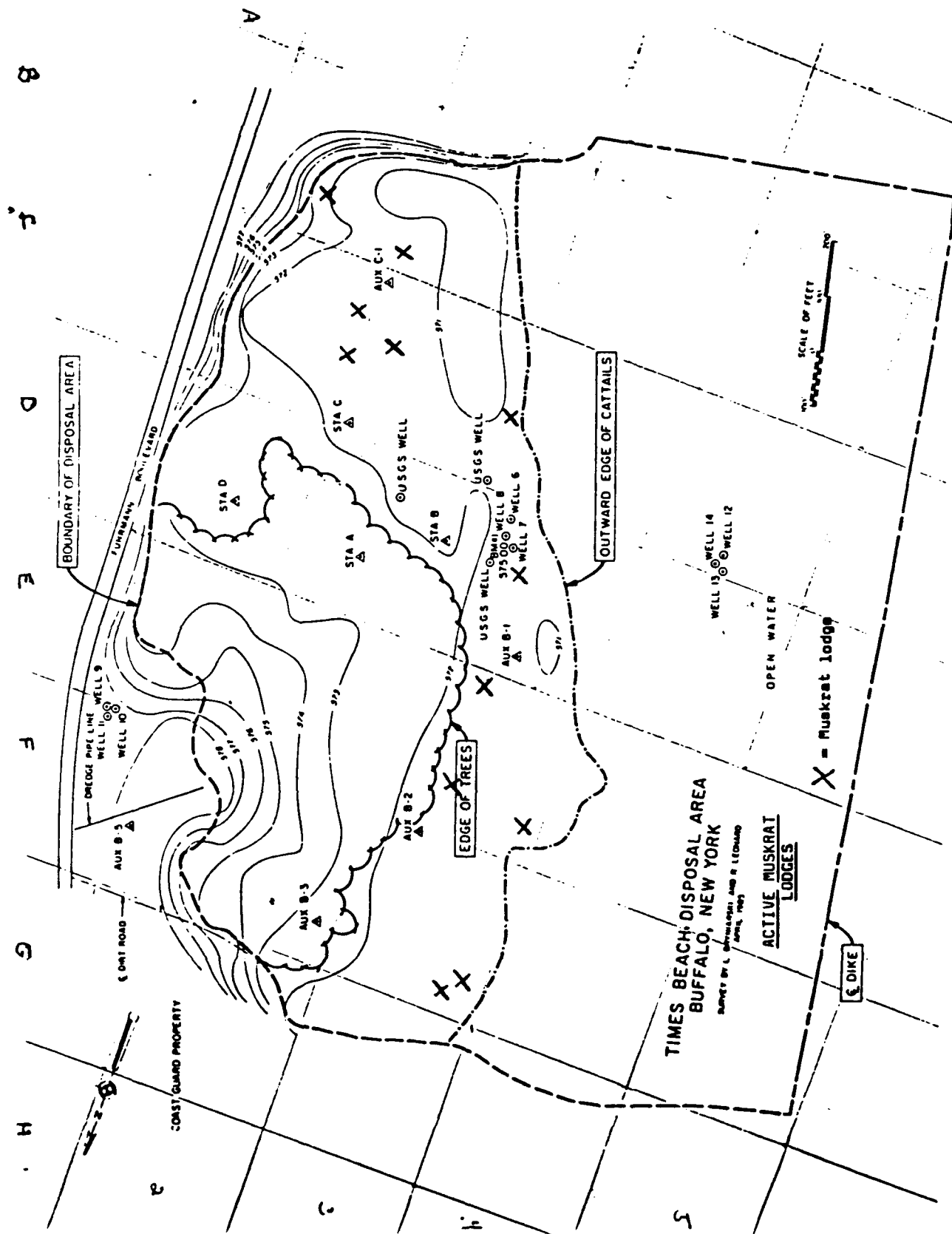
Mammals (letters and numbers refer to map coordinates in grid system)

Five species of mammals were noted on the site:

<u>Ondatra zibethicus</u>	Muskrat
<u>Sylvilagus floridanus</u>	Eastern Cottontail
<u>Procyon lotor</u>	Raccoon
<u>Microtus pennsylvanicus</u>	Meadow Vole
<u>Vulpes fulva</u>	Red Fox (dead)

The Red Fox was found much decomposed on a trail in the woodland (E-2) and it is not known whether it inhabited the site or was deposited there by someone. Tracks were seen in the mud of the marsh (D-2) which were possibly fox but may have been Canis as at least one person runs his hounds on site. Of course, if present, the fox would be high in the food chain and have adequate prey available in small rodents.

Musk rats were observed frequently, mostly swimming and feeding in cattail area openings and in open water. High water levels facilitate their



their movement, feeding and breeding. One was seen to swim and enter an opening in the rocks of the south dike (A-3), so there is likely a small dike population. The majority live in the lodges in the cattail marsh section. They are one of the most numerous and important mammals in the food web, subsisting mainly on aquatic plant stems and roots but also turning carnivorous in emergencies and eating e.g., muskrats, shellfish, frogs, turtles and fish. Their total site population fluctuates and is difficult to estimate, but it does not appear to be excessively high. Based on sightings, active muskrat lodges (marked on the enclosed map), plus dike individuals, plants eaten, trails, scats, average number of young per litter and number of litters per season, an estimated range of numbers after this breeding season might be 75 to 125 individuals.

Although Eastern Cottontails range over most of the terrestrial area, they seem to be most numerous in the north and south sections where there is more debris (including rocks and broken concrete piles) for them to find cover. Based on observations and lack of sightings of young, their total population would appear to be rather low. U. S. Coast Guard men say that they are frequently seen feeding in the short grass adjacent to the north border of the site.

The single medium-size Raccoon was noted in the cattail marsh as it crossed (17 August) the variable width cattail wrack corridor (E-3) that winds its way generally lengthwise through it, and which incidentally serves as a feeding and resting place for mammals and birds, particularly young of the latter. The shallows in the corridor made out to test wells 6, 7 and 8 also served this function until higher vegetation became established later in the season. Cornell University trappers secured a few other species of

small to medium size rodents. Microtus pennsylvanicus, Meadow Vole, its scats and runways were seen in various portions of the uplands. An unknown mammal, possibly Peromyscus sp., was seen at dawn to come out and return to a hole between rocks on the south dike (A-3) before I could identify it with headlamp. There may be a small population at various points on the dikes, especially where plants are more easily accessible at the inner water edge. Also, a food item of such small rodents on the dikes could be the abundant spider Dolomedes. No bats were seen on the site despite the large number of insects present in the site and flying about the lights of the marina across the road. There are probably few or no day harboring places for them on site, though nearby buildings, some older trees and the grain elevator near it could provide some.

The only reptile that I found on site was Thamnophis sirtalis, Garter Snake, which was not noted very often in terrestrial areas. All were about 18 - 22" in length. Occasionally one was seen sunning in an open area. The Cornell mammal trapping team reported two "black" snakes in (F-1), an open area in the woodland. These were probably the melanistic phase of the Garter Snake which is more frequently seen near the Great Lakes. They also reported trapping two snakes in small live mammal traps, one possibly not being a Garter Snake, but their description was insufficient for identification. It was somewhat surprising in extensive marsh and water searching to find no Natrix, Northern Water Snake, but perhaps the oily conditions and contaminants in places are adverse for this species.

Despite examining many places and overturning objects (there are few which are not human-deposited), no salamanders were located. The season of the investigation may be the reason for the lack of amphibians, e.g., Diemictylus viridescens, Red-spotted Newt, as well as water and substrate

conditions mentioned previously. The only amphibian located was Rana catesbeiana, Bullfrog, one each of which was encountered in the shallow edges of the marsh near open water along the north and south dikes (B-2; G-2) among Juncus, Typha and Sagittaria. Very likely there are a few other reptile and amphibian species present, which may yet be located this late Summer, Fall or in early Spring.

Birds

As is to be expected, birds are the most conspicuous animals on site both in numbers and variety. A total of 222 species have been recorded since initiation of the disposal, most, of course being migrants and visitants. An indication of the importance of this site for birds is the fact that this is more species than have been recorded at Tifft Farm Nature Preserve, which is over five times larger and contains more types of habitats. During the report period including a few species observed in April and May by members of the Buffalo Ornithological Society, a total of 76 species was recorded. These comprised the species noted on the appended check-list and the total list attached and consisted of 26 proven resident or possible breeding species, 32 visitants and 18 migrants. This total of resident breeding species is over half of the total recorded breeding in 1984 at Tifft Farm Nature Preserve. As the period reported on herein mostly does not encompass the migration seasons, the number of migrants is expectedly low.

Since resident birds are one of the most important elements of the food web at the site and some are at the top of the food chain, they should provide a good indication of contaminant mobility and pollution if it exists at this level. At the request of the Waterways Experiment Station, during the study

period seven immature resident specimens at different ages of two species of ducks, Anas platyrhynchos, Mallard and Anas americana, American Wigeon comprising four different broods were secured in various parts of the site for subsequent analysis.

Since a large initial portion of the avian breeding season was not able to be studied during this period, even though there is some variation from year to year, more detailed comments on behavior and indices of abundance including a keyed breeding distribution map of resident breeding birds would better be presented in the final report to illustrate the breeding season picture at the site.

The passerine and nonpasserine species resident on site utilize both vegetable and animal foods in their diets. Consequently, they vary in significance in relation to their numbers and importance in the food web and possible movement of contaminants. Increasing mobility of fledged resident breeders and visitants as the season progresses tends to complicate the avian picture. Added to this, e.g., the most common resident species, Agelaius phoeniceus, Red-winged Blackbird, is usually polygamous and thus its numbers are more difficult to assess. Yet, its young could be an important test object in the ecosystems that they inhabit as the adults acquire food for them mostly on site.

Another aspect of Times Beach is its use by visitants, mostly Sturnus vulgaris, European Starling and Quiscalus quiscula, Common Grackle, which visit the site beginning in May to secure invertebrate food for their young being raised elsewhere. Later the young also feed on site when fledged. It appears that one of the major invertebrates which provide food for resident and non-resident birds are members of the Chironomidae, non-biting midges,

large hatches of which occur on site from aquatic larvae in the marsh and open water and then occur abundantly in the flying adult stage in the woodland and shrubs at all levels. Another perhaps lesser food source for birds is the Hydropsychidae, caddis flies, which, although originating in running water, occur in good numbers in the woodland and other portions of Times Beach, in adult flying stages. Ground-inhabiting invertebrates also are utilized as food by birds of the lower story in the woodland as they are also numerous, especially under and about natural and human debris.

A major change that has occurred in the avian fauna of Times Beach, chiefly migratory species, since its initiation and the subsequent termination of material deposition and owing to expansion of marsh habitat and general rise in water level, is the increase in marsh-related resident birds and the diminution in numbers and variety of migrant shorebirds and other water birds (gulls and terns), because of the lack of shallow water resting and feeding places. (The Buffalo Ornithological Society's proposal to the City of Buffalo for Times Beach as a wildlife area recommended some specific vegetation control to remedy this). However, coupled with the growth of woodland and shrub habitats in the terrestrial portions of the site, and the probability that the marsh and water level conditions are also likely to persist indefinitely, evidently more on-site resident breeding species now are present than before, although no study of this has heretofore been made. This should provide better sources for contaminant mobility studies in the future.

One final remarkable occurrence at Times Beach during this study period, and which may persist if habitat conditions remain essentially the same, seems worth mentioning. This is the marked increase in breeding of Anas americana, American Wigeon, a duck which has been known to breed twice before at

the site and a few times elsewhere in the Niagara Frontier Region but is classified as an irregular rare breeding bird in western New York. No less than six broods totaling at least 30 young were observed during this investigation, an unprecedented occurrence in the region.

References and Literature Cited

- Andrie, R. F. 1975. Report on Times Beach - dike disposal area no. 2, Buffalo, New York. Unpublished manuscript, 7 p.
- Andrie, R. F., A. Schaffner, and A. R. Clark. 1975. Birds recorded at Times Beach dike disposal area no. 2, Buffalo, New York. Buffalo Ornithological Society, Unpublished manuscript. Appendix A - 9 p.; Supplement 1976, 2 p. Second Supplement and additions 1978, 1980, 1 p. Zander, R. H., and R. F. Andrie, Appendix B. 1975. Some characteristic plants of Times Beach diked disposal area no. 2, Buffalo, N. Y. 2 p.
- Burt, W. H. 1957. Mammals of the Great Lakes region. Univ. of Michigan Press, Ann Arbor. 246 p.
- Conant, R. 1958. A field guide to reptiles and amphibians. Houghton Mifflin Co., Boston. 366 p.
- Harrison, C. 1978. A field guide to the nests, eggs and nestlings of North American birds. Collins, New York. 416 p.

Headstrom, R. 1971. Identifying animal tracks. Dover Publ., Inc., New York
141 p.

Kay, S. H. 1985. Long-Term biological monitoring and contaminant cycling
at the Times Beach confined disposal site. Unpublished manuscript, 13 p.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography.
Princeton. 203 p.

Marquenie, J. M., J. W. Simmers, and S. H. Kay. 1985. Bioaccumulation of
heavy metals and organic contaminants at the Times Beach confined disposal
site, Buffalo (N.Y.). Misc. Paper EL-85. Draft Report, Department of the
Army Environmental Laboratory, Waterways Experiment Station, Corps of Engin-
eers, Vicksburg. 84 p.

Murie, O. J. 1975. A field guide to animal tracks. Houghton Mifflin Co.,
Boston. 375 p.

Oliver, J. A. 1955. The natural history of North American amphibians and
reptiles. Van Nostrand, Princeton. 359 p.

Peterson, R. L. 1966. The mammals of eastern Canada. Oxford Univ. Press,
Toronto. 465 p.

Ralph, C. J., and M. Scott, eds. 1981. Estimating numbers of terrestrial birds.
Cooper Ornith. Soc. Studies in Avian Biology No. 6. 630 p.

Weller, M. W. 1981. Freshwater marshes; ecology and wildlife management.

Univ. of Minnesota, Minneapolis. 146 p.

Wilhelm, G. n.d. Vegetation of the Times Beach disposal area, Buffalo, New

York. Unpublished manuscript, 14 p.

Appendix A

Bird Species Recorded at Times Beach Confined Disposal Site*

Buffalo, New York

May - August 1985 (** April)

<u>Podilymbus podiceps</u>	Pied-billed Grebe
<u>Ixobrychus exilis</u>	Least Bittern
<u>Ardea herodias</u>	Great Blue Heron
<u>Casmerodius albus</u>	Great Egret
<u>Butorides striatus</u>	Green-backed Heron
<u>Nycticorax nycticorax</u>	Black-crowned Night Heron
<u>Cygnus olor</u>	Mute Swan
<u>Branta canadensis</u>	Canada Goose
<u>Aix sponsa</u>	Wood Duck
<u>Anas rubripes</u>	American Black Duck
<u>Anas platyrhynchos</u>	Mallard
<u>Anas discors</u>	Blue-winged Teal
<u>Anas americana</u>	American Wigeon
<u>Aythya affinis</u>	Lesser Scaup
<u>Mergus serrator</u>	Red-breasted Merganser
<u>Pandion haliaetus**</u>	Osprey
<u>Accipiter striatus**</u>	Sharp-shinned Hawk
<u>Falco sparverius</u>	American Kestrel
<u>Phasianus colchicus</u>	Ring-necked Pheasant
<u>Rallus limicola</u>	Virginia Rail
<u>Porzana carolina</u>	Sora
<u>Gallinula chloropus</u>	Common Moorhen
<u>Pluvialis squatarola</u>	Black-bellied Plover
<u>Charadrius semipalmatus</u>	Semipalmated Plover
<u>Charadrius vociferus</u>	Killdeer
<u>Tringa flavipes</u>	Lesser Yellowlegs
<u>Actitis macularia</u>	Spotted Sandpiper
<u>Calidris pusilla</u>	Semipalmated Sandpiper

<u>Calidris minutilla</u>	Least Sandpiper
<u>Scolopax minor</u>	American Woodcock
<u>Larus delawarensis</u>	Ring-billed Gull
<u>Larus argentatus</u>	Herring Gull
<u>Sterna caspia</u>	Caspian Tern
<u>Sterna hirundo</u>	Common Tern
<u>Columba livia</u>	Rock Dove
<u>Zenaida macroura</u>	Mourning Dove
<u>Asio flammeus</u>	Short-eared Owl
<u>Chaetura pelagica</u>	Chimney Swift
<u>Ceryle alcyon</u>	Belted Kingfisher
<u>Colaptes auratus</u>	Northern Flicker
<u>Contopus borealis</u>	Olive-sided Flycatcher
<u>Contopus virens</u>	Eastern Wood-Pewee
<u>Empidonax alnorum</u>	Alder Flycatcher
<u>Empidonax traillii</u>	Willow Flycatcher
<u>Empidonax minimus</u>	Least Flycatcher
<u>Tyrannus tyrannus</u>	Eastern Kingbird
<u>Progne subis</u>	Purple Martin
<u>Tachycineta bicolor</u>	Tree Swallow
<u>Stelgidopteryx serripennis</u>	Northern Rough-winged Swallow
<u>Riparia riparia</u>	Bank Swallow
<u>Hirundo rustica</u>	Barn Swallow
<u>Corvus brachyrhynchos</u>	American Crow
<u>Thryethorus ludovicianus</u>	Carolina Wren
<u>Troglodytes troglodytes</u>	Winter Wren
<u>Cistothorus palustris</u>	Marsh Wren
<u>Turdus migratorius</u>	American Robin
<u>Dumetella carolinensis</u>	Gray Catbird
<u>Bombycilla cedrorum</u>	Cedar Waxwing
<u>Sturnus vulgaris</u>	European Starling
<u>Vireo gilvus</u>	Warbling Vireo
<u>Dendroica petechia</u>	Yellow Warbler

Dendroica pensylvanica
Dendroica coronata
Dendroica striata
Geothlypis trichas
Wilsonia pusilla
Phaucticus ludovicianus
Melospiza melodia
Melospiza lincolni
Zonotrichia leucophrys
Agelaius phoeniceus
Sturnella magna
Quiscalus quiscula
Molothrus ater
Carpodacus mexicanus
Carduelis tristis

Chestnut-sided Warbler
Yellow-rumped Warbler
Blackpoll Warbler
Common Yellowthroat
Wilson's Warbler
Rose-breasted Grosbeak
Song Sparrow
Lincoln's Sparrow
White-crowned Sparrow
Red-winged Blackbird
Eastern Meadowlark
Common Grackle
Brown-headed Cowbird
House Finch
American Goldfinch

* after Check-List of North American Birds. American Ornithologists' Union
Sixth Edition 1983

Vertebrate Investigations at Times Beach Confined Dredged

Material Disposal Site, Buffalo, New York, 1985 - 1986

Final Report

Robert F. Andrie Ph.D

Buffalo Museum of Science

22 July 1986

General descriptions of Times Beach and its natural habitats, and also preliminary information and abundance of its invertebrate and vertebrate animals, together with technical data on heavy metal and organic elements in resident species, have been recently reported on by Marquenie et al. (1985), Leonard (1985) and Andrie (1985).

Thirty-seven visits to the site were made by the author from 12 May 1985 through 31 May 1986 in order to record and identify resident, migrant and visitant vertebrates, to determine as far as possible their occurrence, distribution and abundance, and position in the food web there. These visits involved day, nocturnal and crepuscular periods (see Andrie ibid. Methods). Selected resident species were collected for technical analysis. In addition, comparative specimens from elsewhere were secured.

Andrie (ibid.) previously mentioned the apparent limited numbers of some vertebrates, such as amphibians and reptiles, on the site owing to its comparatively small size, isolation from other similar natural habitats, and possibly the nature of part of its substrate. Also a limiting factor in regard to habitat affecting some vertebrate abundance and variety is that the secondary woodland is composed mainly of cottonwoods and willows with internal and peripheral shrubby areas also of rather small extent resulting in a rather simple association of plant communities as far as these animals are concerned.

Results

Avifauna

The breeding, migrant and visitant birds are the most conspicuous and probably most abundant of the vertebrate animals on site through the year except in winter season when there is little food there to support them and their numbers and variety are few. From an historical standpoint, it seems reasonable to state, though no specific and systematic studies have been done, and keeping in mind the dynamic changing nature of most bird communities, that the breeding avifauna of the site has increased since its creation, particularly in the aquatic sections but also in the uplands to a lesser extent. More extensive marsh, maturation of the woodland and increase in edge and understory density and height of shrubs and thickets have undoubtedly contributed to this. However, there has been an overall decrease in certain migrant and visitant bird species because of the growth and expansion of the cattail marsh and considerably higher water levels eliminating the open substrate feeding areas which had initially existed and attracted about 30 species that no longer or seldom occur now.

Each year there is some change in the distribution, abundance and kind of species of resident birds at Times Beach for various reasons, e.g., accident, change in carrying capacity of habitat, water depth, plant succession, etc. The breeding species recorded in 1985 at the site are listed in Table 1 by number of pairs in order of abundance. Their core home territories are shown on Figure 1, which is an outline map of the site constructed by the U. S. Army Corps of Engineers, upon which is superimposed a north-south coordinate grid of 300 x 300 feet squares which was used for orientation and to plot each species. Territories of not a few species are considerably larger than shown as some range quite far from their home or core areas (e.g., Common Moorhen, Red-winged Blackbird). Waterfowl species are shown where broods of young were sighted because no nests were actually located before young had fledged.

Table 1 shows that at least 117 pairs of birds bred or probably did so on site in 1985. The total is based on singing males and pairs

and nests located plus fledged precocial young. It probably is somewhat more than this because Red-winged Blackbirds are often polygamous, males pairing with up to 2-3 females, and the parasitic Brown-headed Cowbird frequently visits the site. It is of interest to note that the three most numerous species, Red-winged Blackbird, Song Sparrow and Yellow Warbler, at the site are also the most numerous at nearby Tifft Farm Nature Preserve based on a breeding bird census taken there in 1972 (Andrie 1972). It is not possible to make accurate comparisons between the censuses at Times and Tifft for various reasons, but it is evident that the former compares very favorably with Tifft in number and variety of breeding birds and probably exceeds it in pairs per 100 acres overall. However, the relatively small size of the site, its isolation from similar habitats and the simple (pioneer) structure and composition of its woodland limit the number of pairs of forest breeding birds that inhabit it compared to other types of native upland woods.

Table 1

Breeding Avifauna at Times Beach Dredged Material

Disposal Site, Buffalo, New York, in 1985

(see following key for explanation of letters and numbers)

Number	Species	Key	Pairs
1	<u>Agelaius phoeniceus</u>	Red-winged Blackbird; B, <u>3, 4</u> ; C, <u>7, 8</u> ; <u>a, b</u> <u>c, 9, 10</u>	30+
2	<u>Melospiza melodia</u>	Song Sparrow C, <u>6, 7, 8</u> ; E, <u>9, 10</u> ; F	23
3	<u>Dendroica petechia</u>	Yellow Warbler C, <u>7</u> ; E, <u>3</u>	9
4	<u>Anas platyrhynchos</u>	Mallard A, <u>1, 2</u> ; B, <u>3, 4, 5</u>	8
5	<u>Anas americana</u>	American Wigeon A, <u>1, 2</u> ; B, <u>1, 3, 5</u> ; E, <u>9</u>	7
6	<u>Turdus migratorius</u>	American Robin C, <u>6, 7</u> ; B, <u>a, b</u>	6
7	<u>Actitis macularia</u>	Spotted Sandpiper B; C, <u>6</u> ; F; E, <u>9</u>	5
8	<u>Dumetella carolinensis</u>	Gray Catbird C, <u>6, 7</u> ; E, <u>9, 10</u>	5
9	<u>Empidonax traillii</u>	Willow Flycatcher D; E, <u>9, 10</u>	5
10	<u>Charadrius vociferus</u>	Killdeer B, <u>4</u> ; F	2
11	<u>Carduelis tristis</u>	American Goldfinch C, <u>8, b, c</u> ; E, <u>9</u> ; F	2
12	<u>Gallinula chloropus</u>	Common Moorhen B, <u>3, 4, 5</u>	2
13	<u>Tyrannus tyrannus</u>	Eastern Kingbird E, <u>10, 11</u>	2
14	<u>Ixobrychus exilis</u>	Least Bittern B, <u>3, 4</u>	1

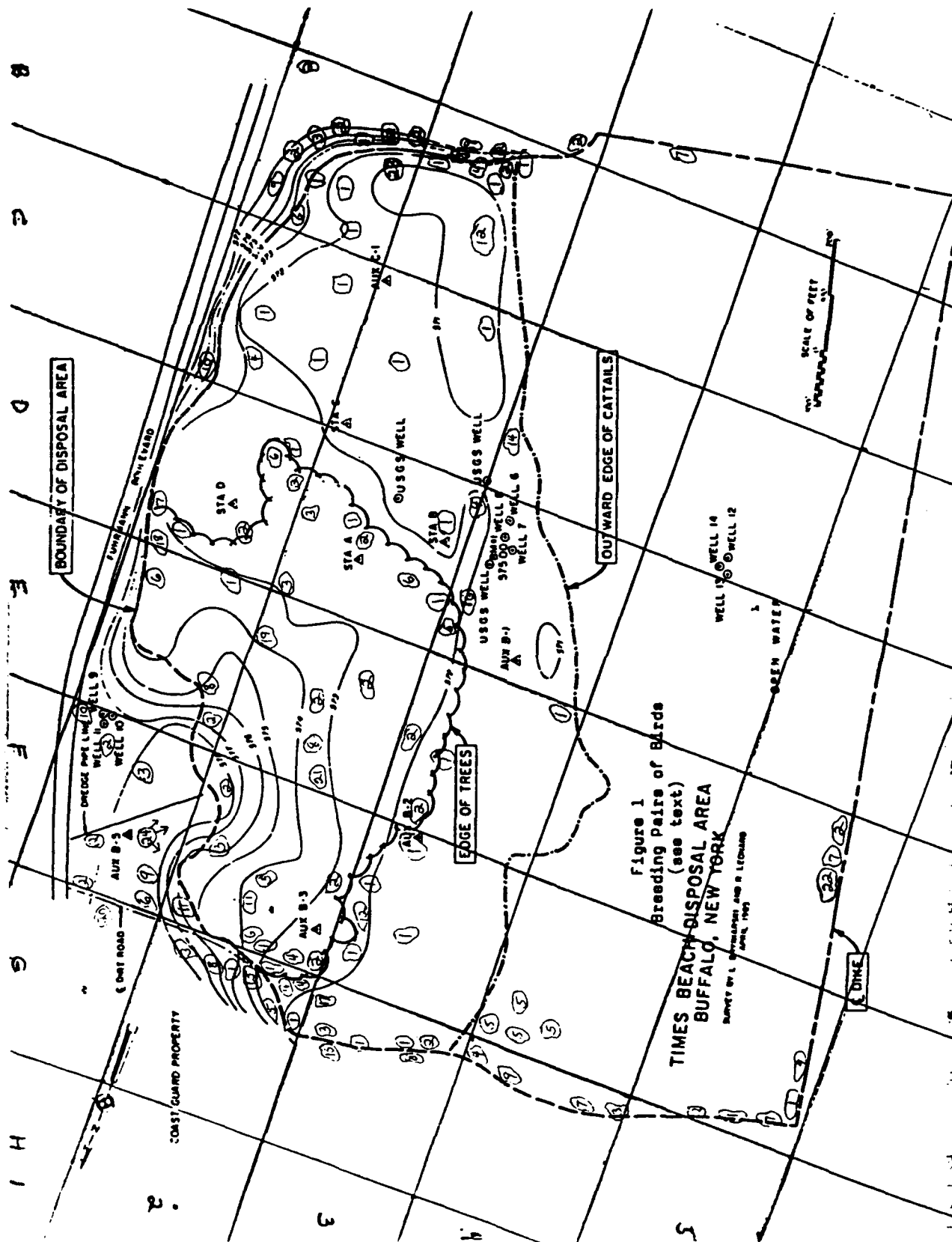
Table 1 (cont.)

15	<u>Phasianus colchicus</u>	Ring-necked Pheasant	C, <u>6</u> ; E, 9; F	1
16	<u>Rallus limicola</u>	Virginia Rail	B, 3, <u>4</u>	1
17	<u>Porzana carolina</u>	Sora	B, 3, <u>4</u>	1
18	<u>Scolopax minor</u>	American Woodcock	C, <u>6</u> ; E, 9	1
19	<u>Corvus brachyrhynchos</u>	American Crow	C, 8, a, <u>b</u> , <u>c</u>	1
20	<u>Vireo gilvus</u>	Warbling Vireo	C, 8, b, <u>c</u>	1
21	<u>Geothlypis trichas</u>	Common Yellowthroat	B; C, 6, <u>7</u> ; D	1
22	<u>Branta canadensis</u>	Canada Goose	A, 1, <u>2</u> ; B, 3, <u>4</u> , <u>5</u> , 1	
23	<u>Butorides striatus</u>	Green-backed Heron	B, 3, 4, <u>5</u> ; C, 8, a, b, 1 c; E, <u>9</u> , 10, 11	1
24	<u>Molothrus ater</u>	Brown-headed Cowbird	<u>C</u> ; D; E	1+

Almost all the resident birds usually spend their entire time on the site in various habitats and therefore are directly involved in the food chain there. They consume a great variety of insectivorous and other invertebrate and vertebrate life. Although sometimes visual sightings of food eaten are possible, examination of stomach contents is the only practical way to determine major food sources. Most of them feed at one time or another either on or in waters or terrestrial plants above or growing in the dredged material, especially the waterfowl, marsh birds and terrestrial feeders such as American Woodcock, Ring-necked Pheasant and Spotted Sandpiper. Those species that feed directly in or on the dredged material are probably most valuable for determining routes of possible contaminant uptake in the food web, while those that feed on plant or animal matter above the substrate may be less important.

Following are annotations on the habits, habitats and food of each resident species:

- 1 Red-winged Blackbird - Nests in cattails, in shrubs along dikes and woods edge and sometimes in other herbaceous plants at marsh or woods edge. Stomach content analysis data (of 1083) show food to be about 75% vegetable matter and 25% animal matter, mainly insects. During the breeding season the latter percent is increased as young are fed insects. Invertebrate larvae also utilized. Feeds in marsh and woods from ground or water level to medium levels in trees.



- 2 Song Sparrow - Nests on ground or low in shrub or herbaceous vegetation in woods, along dikes and in grassy and weedy areas. Feeds from ground to low levels. Food varies considerably but is about 75% weed seeds and 25% insects, the latter percent increasing to feed young during breeding season. Also feeds young larvae of various invertebrates.
- 3 Yellow Warbler - Nests in shrub or sapling at low level in woodland and on dike or edge of site. Food is entirely animal matter, mainly small insects.
- 4 Mallard - Nests on the ground in grass or weeds or at base of tree or near log or debris. Omnivorous, including frogs, tadpoles, toads, newts, small fish, leeches, earthworms, grass, seeds, aquatic plants and invertebrates.
- 5 American Wigeon - Nests on the ground among bushes or weeds sometimes away from water. Food is 90% vegetable matter - pondweeds (Potamogeton 42%), algae, smartweed, duckweed, small mollusks, insects.
- 6 American Robin - Nests at low to medium levels in tree in woods or groves of trees. Food is 42% animal matter, principally insects, plus small fruits and berries (350 stomachs).
- 7 Spotted Sandpiper - Nests on ground in depression among grasses near water. Food is animal matter, mostly insects with some crustaceans.
- 8 Gray Catbird - Nests in shrubbery in woods, on dikes and at borders of site. Food (645 stomachs) is 44% animal matter, chiefly insects, and 56% vegetable, mostly wild fruit.
- 9 Willow Flycatcher - Nests in shrubs usually near water, up to about 6 ft above ground, on dike, at woods edge and along southern edge of marsh. Food is entirely insects.
- 10 Killdeer - Nests in depression on ground in open. Food is mainly insects and aquatic invertebrates.

- 11 American Goldfinch - Nests within about 5 ft of ground in sapling or shrub at edge of woods or open area. Food is weed seeds and a variety of insects.
- 12 Common Moorhen - Nests in marsh on platform of dry cattails above or floating on water. Food is a combination of vegetable and animal matter - aquatic plant seeds, pondweeds, caddis fly larvae and insects.
- 13 Eastern Kingbird - Nests in tree along dike or marsh edge. Food 85% insects. Ranges over marsh and other areas when feeding.
- 14 Least Bittern - Nests in marsh on cupped platform of dead cattails above water. Food is 40% fish (93 stomachs), crustaceans, aquatic insects, dragonflies.
- 15 Ring-necked Pheasant - Nests on ground in depression at woods edge or in grassy area. Food is weed seeds and insects.
- 16 Virginia Rail - Nests in marsh on hollowed platform of dead cattails above water. Food is seeds, berries, insects, snails, small crustaceans.
- 17 Sora - Nests in marsh on hollowed platform of dried cattails above water. Food is seeds, snails, insects, small mollusks.
- 18 American Woodcock - Nests in depression on ground in woods often near water. Food is earthworms, crane flies, other insects, grasshoppers.
- 19 American Crow - Nests in tree at usually medium heights in woods in stick nest. Food is 72% vegetable, 28% animal matter; crickets, grasshoppers, beetles, caterpillars, snakes, lizards, mice, rats, young birds, eggs, grain and seeds.
- 20 Warbling Vireo - Nests high in tree in woods edge or tree grove - cup shaped, suspended in fork. Food is insects.
- 21 Common Yellowthroat - Nests near ground in damp situation in woods or shrubbery. Food is insects.

- 22 Canada Goose - Nests usually in marshes on a mound, but at Times Beach one had a nest among rocks on the outer dike. Food is largely vegetable matter, roots of rushes, reeds, grasses.
- 23 Green-backed Heron - Nests on stick platform in tree in woods or in tall shrub. Food is 40% fish (200+ stomachs), 24% crustaceans, 27% insects.
- 24 Brown-headed Cowbird - Parasitizes nests of many small bird species, especially warblers. Seen frequently in woods at site. Food is 78% vegetable, 22% animal - weed seeds, grains, variety of insects.

Toward the end of the breeding season in July and August and subsequently a great many immature and adult birds, both residents and visitants, augmented by migrants, feed on site, particularly in the woodland, and roost in the marsh so that the total avian population there is increased considerably. During late Fall, Winter and early Spring food and cover at the site are at a minimum and consequently bird populations are very low and sometimes nonexistent.

Nonbreeding bird species were recorded on or over the site by the investigator during his studies and additionally by members of the Buffalo Ornithological Society. Numbers of these species varied considerably depending on the season, daily weather conditions and times of day during which the site was under study. They ranged from flying over the site (some while feeding) to foraging in all habitats and at all levels in the vegetation down to the ground, as well as underwater (surface-feeding waterfowl in the shallows and diving waterfowl in deeper portions of the water area). These species are particularly numerous during migration "waves" in May and September. Time on site for both migrants and visitants can range from only a few minutes to days and weeks at a time, in the case of the latter, a large part of the year (e.g., Mute Swan). Also, many of the species nesting at Times Beach occur as migrants and visitants as well. Table 2 contains, with annotations, the 101 species of these birds recorded on site during the investigation.

Table 2

Migrant and Visitant Bird Species Recorded at Times Beach
Dredged Material Disposal Site, Buffalo, New York; 12 May 1985
to 31 May 1986.

Migrant - generally a species which is pausing on site during its
passage to its usually distant breeding or wintering areas.

Visitant - generally a species which visits the site from usually
nearby Fall and Wintering areas or during wandering post-
breeding dispersal.

(see following Key for explanation of letters and numbers)

- 1 Podilymbus podiceps Pied-billed Grebe V May; Aug - Oct; 1(5);A1,2
- 2 Phalacrocorax auritus Double-crested Cormorant V flying over 9 Dec; 1(5)
- 3 Ardea herodias Great Blue Heron V May; Jun - Sept; 1(5);B3,4,5
- 4 Casmerodius albus Great Egret V May; Aug; 2(6);B3,4,5
- 5 Nycticorax nycticorax Black-crowned Night-Heron V Apr - Oct; 1(4);B4,5; C8bc; E10,11
- 6 Cygnus olor Mute Swan V Apr - Nov; 4(7);A1,2; B4,5,6 (one bird)
- 7 Aix sponsa Wood Duck V May - Aug; 1(5);B4,5
- 8 Anas rubripes American Black Duck V May, Jun, Aug; 2(6);A; B,4,5
- 9 Anas discors Blue-winged Teal V May, Jun, Aug; 1(5);A; B,4,5
- 10 Anas strepera Gadwall V May, Sept; 2(5);A,1; B,4,5
- 11 Aythya marila Greater Scaup V Nov; 1(5);A1,2
- 12 Aythya affinis Lesser Scaup V May, Jul, Sept; 2(5);A,1,2
- 13 Melanitta nigra Black Scoter V Nov; 3(6);A,1,2
- 14 Lophodytes cucullatus Hooded Merganser V Apr; 2(5);A,1,2
- 15 Mergus serrator Red-breasted Merganser V May, Nov; 1(4);A,1,2
- 16 Pandion haliaetus Osprey M flying over Apr; 3(7)
- 17 Accipiter striatus Sharp-shinned Hawk M flying over Apr, Sept; 2(5)
- 18 Buteo platypterus Broad-winged Hawk M flying over Apr; 3(5)
- 19 Buteo jamaicensis Red-tailed Hawk V flying over Nov; 2(6)
- 20 Falco sparverius American Kestrel V Jul, Sept, Nov; 1(5); E,11
- 21 Falco peregrinus Peregrine Falcon V flying over Oct; 5(7)
- 22 Fulica americana American Coot V Oct; 2(5);A,1,2; B,1,2,3,4,5
- 23 Tringa flavipes Lesser Yellowlegs M Apr, Jul, Sept; 1(5)B,4,5
- 24 Calidris pusilla Semipalmated Sandpiper M Jul; 2(5); B,4,5

Table 2 (cont.)

- 25 Calidris minutilla Least Sandpiper M Aug;2(5);B,4,5
- 26 Capella gallinago Common Snipe V May;2(6);B,4
- 27 Larus delawarensis Ring-billed Gull V Apr - Oct;1(4);A,1 flying over
- 28 Larus argentatus Herring Gull V Apr - Nov;1(5);A,1 flying over
- 29 Sterna hirundo Common Tern V May - Sept;1(4);A,1 flying over
- 30 Sterna caspia Caspian Tern V May,Jul,Sept;1(5);A,1
- 31 Columba livia Rock Dove V Aug;2(5) flying over
- 32 Zenaida macroura Mourning Dove V May - Sept;1(5);E,9,10;C,8;F
- 33 Asio flammeus Short-eared Owl V Jul;4(7) flying over marsh
- 34 Nyctea scandiaca Snowy Owl V Feb;3(6) dike
- 35 Chaetura pelagica Chimney Swift V Apr - Jun;2(5) flying over
- 36 Ceryle alcyon Belted Kingfisher V May - Sept;1(5);A,1 flying over
- 37 Sphyrapicus varius Yellow-bellied Sapsucker M Apr - May,Sept-Oct;1(5);C,8,b
- 38 Picoides pubescens Downy Woodpecker V Sept - May;1(5);C,7,8;E,9,10
- 39 Colaptes auratus Northern Flicker V Apr - Sept;1(5);C,8,a,b,c;E,10,11
- 40 Nuttallornis borealis Olive-sided Flycatcher M May;4(7);C,8,c;E,11
- 41 Contopus virens Eastern Wood-Pewee M May - Aug;1(5);C,8,b,c
- 42 Empidonax flaviventris Yellow-bellied Flycatcher M Sept;3(6);C,9,10
- 43 Empidonax alnorum Alder Flycatcher M May;3(6);E,9,10
- 44 Empidonax minimus Least Flycatcher M May,Sept;1(5);C,8,a,b;E,9,10
- 45 Progne subis Purple Martin V Aug;1(5-2);8; roosts; flying over
- 46 Tachycineta bicolor Tree Swallow V Apr,May,Aug;1(5,4,2);8; roosts; flying over
- 47 Stelgidopteryx ruficollis Nor. Rough-winged Swallow V Apr - Jul;1(5); flying over
- 48 Riparia riparia Bank Swallow V May - Aug;1(5-2);8; roosts; flying over
- 49 Hirundo rustica Barn Swallow V May - Aug;1(5-2);8; roosts; flying over
- 50 Cyanocitta cristata Blue Jay V May;1(5);C,7,8,b,c
- 51 Parus atricapillus Black-capped Chickadee V any month;1(5);C,7,8abc;E9,10
- 52 Sitta canadensis Red-breasted Nuthatch M Apr,Sept;2(5);C,8b,c
- 53 Certhia familiaris Brown Creeper M Oct ; poss. other mos. 2(6);C,8,a,b
- 54 Thryothorus ludovicianus Carolina Wren V Aug,Oct,Jan;4(7);C,7,8
- 55 Troglodytes aedon House Wren V May,Sept;1(5);C,6,7,8
- 56 Troglodytes troglodytes Winter Wren M Apr, Sept;1(5);C,6,7
- 57 Cistothorus palustris Marsh Wren V Aug;3(6);8,3
- 58 Regulus satrapa Golden-crowned Kinglet M Sept,Oct;1(5);C,7,8,a,b,c

Table 2 (cont.)

59	<u>Regulus calendula</u>	Ruby-crowned Kinglet	M Sept, Oct; 1(5); C, 7, 8, a, b, c
60	<u>Catharus ustulatus</u>	Swainson's Thrush	M May, Sept; 1(5); C, 6, 7, 8, a, b, c
61	<u>Catharus guttatus</u>	Hermit Thrush	M May, Sept-Oct; 1(5); C, 6, 7, 8, a, b, c
62	<u>Hylocichla mustelina</u>	Wood Thrush	M May; 1(5); C, 6, 7, 8, a, b, c
63	<u>Toxostoma rufum</u>	Brown Thrasher	M May, Sept; 1(6); C, 6, 7, 8, a, E, 9
64	<u>Bombycilla cedrorum</u>	Cedar Waxwing	M May, Jul-Oct; 1(4); C, 8, b, c; E, 10
65	<u>Sturnus vulgaris</u>	European Starling	V any month; 1(4-3); C, 6, 7, 8; E, 9, 10, 11; F
66	<u>Vireo griseus</u>	White-eyed Vireo	M May; 3(7); C, 7; E, 9
67	<u>Vireo solitarius</u>	Solitary Vireo	M Sept; 2(6); C, 8, b, c
68	<u>Vireo philadelphicus</u>	Philadelphia Vireo	M May; 2(5); C, 8, b, c
69	<u>Vireo olivaceus</u>	Red-eyed Vireo	M May-June; 1(5); C, 8, b, c
70	<u>Vermivora peregrina</u>	Tennessee Warbler	M May; 1(5); C, 8, a, b, c
71	<u>Vermivora ruficapilla</u>	Nashville Warbler	M May, Sept-Oct; 1(5); C, 7, 8, a, b; E, 9, 10
72	<u>Dendroica pensylvanica</u>	Chestnut-sided Warbler	M May; C, 7, 8, a, b; 1(5)
73	<u>Dendroica magnolia</u>	Magnolia Warbler	M May, Sept; 1(5); C, 7, 8, a, b
74	<u>Dendroica tigrina</u>	Cape May Warbler	M May; 1(5); C, 8, b, c
75	<u>Dendroica caerulescens</u>	Black-throated Blue Warbler	M May, Sept; 1(5); C, 7, 8, a, b
76	<u>Dendroica coronata</u>	Yellow-rumped Warbler	M May, Sept-Oct; 1(5-4); C, 7, 8, a, b, c; E, 9, 10, 11
77	<u>Dendroica virens</u>	Black-throated Green Warbler	M Sept; 1(5); C, 8, b, c; E, 10, 11
78	<u>Dendroica palmarum</u>	Palm Warbler	M May, Sept; 1(5); C, 7, 8, a, b; E, 9
79	<u>Dendroica castanea</u>	Bay-breasted Warbler	M May, Sept; 1(5); C, 8, a, b, c; E, 10, 11
80	<u>Dendroica striata</u>	Blackpoll Warbler	M May, Sept; 1(5); C, 8, a, b, c; E, 10, 11
81	<u>Mniotilta varia</u>	Black-and-white Warbler	M Sept; 1(5); C, 7, 8, a, b; E, 9, 10
82	<u>Setophaga ruticilla</u>	American Redstart	M May, Sept; 1(5); C, 8, a, b, c; E, 9, 10
83	<u>Seiurus noveboracensis</u>	Northern Waterthrush	M May; 2(6); C, 6, 7; D; E, 9
84	<u>Wilsonia pusilla</u>	Wilson's Warbler	M May, Sept; 1(5); C, 7, 8, a, b; E, 9, 10
85	<u>Wilsonia canadensis</u>	Canada Warbler	M Aug; 1(6); C, 6, 7, 8, a; E, 9
86	<u>Cardinalis cardinalis</u>	Northern Cardinal	V Oct; 2(6); C, 6, 7, 8, a, b; E, 9, 10
87	<u>Phaeucticus ludovicianus</u>	Rose-breasted Grosbeak	M May, Aug; 1(5); C, 8, b, c; E, 10, 11
88	<u>Pipilo erythrophthalmus</u>	Rufous-sided Towhee	M May, Oct; 1(5); C, 8, 7, 8, a, b; E, 9
89	<u>Spizella arborea</u>	American Tree Sparrow	V Nov, Jan; 1(5); E, 9
90	<u>Spizella passerina</u>	Chipping Sparrow	V May; 2(6); E, 9, 10
91	<u>Spizella pusilla</u>	Field Sparrow	V Sept; 2(6); E, 9
92	<u>Melospiza lincolni</u>	Lincoln's Sparrow	M May, Sept; 1(6); C, 6, 7, 8, a; E, 9

Table 2 (cont.)

93	<u>Melospiza georgiana</u>	Swamp Sparrow V	Oct;1(5);B, <u>3</u> ;C, <u>6</u> , <u>7</u> ,8,a;E, <u>9</u>
94	<u>Zonotrichia albicollis</u>	White-throated Sparrow M	May,Sept;C, <u>6</u> , <u>7</u> ,8,a,b;E, <u>9</u> ,10;1(5)
95	<u>Zonotrichia leucophrys</u>	White-crowned Sparrow M	Apr;1(5);C, <u>7</u> ,8,a;E, <u>9</u>
96	<u>Junco hyemalis</u>	Dark-eyed Junco M	Sept,Nov,Jan;1(6-5);C,6,7,8, <u>a</u> ;E,9
97	<u>Sturnella magna</u>	Eastern Meadowlark V	May;4(7);F
98	<u>Euphagus carolinus</u>	Rusty Blackbird M	Sept;3(5);B, <u>3</u> ;C, <u>7</u> ,8,a,b
99	<u>Quiscalus quiscula</u>	Common Grackle V	Apr-Aug-;1(5-4);C,6, <u>7</u> ,8, <u>a</u> ,b,c
100	<u>Icterus galbula</u>	Northern Oriole V	May-June;1(5);C,8,b, <u>c</u> ;E,10, <u>11</u>
101	<u>Carpodacus mexicanus</u>	House Finch V	May,Sept,Nov;1(5);C,8,a, <u>b</u> ,c;E, <u>9</u> ,10,11

After each breeding species in Table 1 are given its macro and micro habitat foraging key letters and numbers. Double underlined letters and numbers indicate most utilization. After each nonbreeding species in Table 2 the same foraging key letters and numbers are given plus numbers indicating its occurrence and relative abundance at Times Beach based on known status, sightings and projections (Beardslee and Mitchell 1965). Obviously, periodic visits to the site during the study could not record all migrants and visitants (which total over 200), nor could they ascertain their frequency of occurrence and relative abundance with complete accuracy, so previous data are drawn upon.

Keys to Foraging, Frequency of Occurrence and Relative
Abundance of Birds at Times Beach

Habitat Foraging

Macro	Micro
A Open water	1 Open water surface 2 Underwater and bottom substrate
B Marsh	3 Cattails and other emergent aquatics 4 Dead marsh vegetation and muskrat lodges 5 Marsh water surface and underwater to bottom substrate
C Woodland	6 Woodland floor 7 Understory woody and herbaceous plants 8 Trees a Low level b Medium level c Upper level

Key (cont.)

D Woodland -shrub - marsh ecotones

E Dikes and upland shrubs, thickets and tree clumps 9 Low level to ground (shrubs)
10 Medium level (shrubs & trees)
11 Upper level (shrubs & trees)

Frequency of Occurrence

- 1 Regular - recorded every year
- 2 Irregular - recorded less than every year, but more than one year in every four, on an average
- 3 Occasional - recorded between one year in every four and one year in every nine, on an average
- 4 Sporadic - recorded between one year in every ten and one year in every twenty, on an average
- 5 Casual - recorded less than once in 20 years, on an average, but expected to occur again
- 6 Accidental - recorded, and because of its range not expected to occur again

Relative Abundance

- (1) Abundant, 500*
- (2) Very common, 100 - 500*
- (3) Common, 25 - 100*
- (4) Fairly Common, 5 - 25*
- (5) Uncommon, 1 - 5*, 25**
- (6) Rare, 5**
- (7) Very rare 1**

* occurring in such numbers that a competent observer at the proper time and place might see the number shown in a single day.

** occurring in such numbers that a competent observer at the proper times and places would not be likely to see more than the number shown in a season.

Mammals

The number of species of mammals recorded on Times Beach remains low, probably for the reasons given in the Interim Report (Andrie 1985). Populations of the medium and small size mammals fluctuate rapidly, usually affected by a number of in-population and external natural factors. Table 3 lists the species recorded and Figure 2 shows the places on site where certain individuals were sighted. It also shows the areas outlined where the Eastern Cottontail appears to have the highest concentrations, especially during the colder months when food and cover are at a minimum.

Table 3

Mammal Species Recorded at Times Beach Dredged Material
Disposal Site, Buffalo, New York; 12 May 1985 to 31 May 1986.

- 1 Ondatra zibethicus Muskrat
- 2 Sylvilagus floridanus Eastern Cottontail
- 3 Procyon lotor Raccoon
- 4 Peromyscus leucopus White-footed Mouse
- 5 Microtus pennsylvanicus Meadow Vole
- 6 Vulpes fulva Red Fox
- 7 Mustela sp. weasel (tracks)

Cornell University researchers trapped small mammals on Times Beach in summer 1985. They remarked on the apparent absence of shrews on site based on their trapping results. This does seem unusual, and indeed, so far none have been trapped or sighted. They are usually in most every suitable habitat and may yet be found.

Muskrats seem to be increasing in the marsh as more trails, cuttings, scats and lodges were noted during the period. Their lodges increased from 12 in 1985 to at least 18 in 1986 (see map of lodge locations in Interim Draft Report). One dead muskrat was found floating in shallow water off the marsh edge on 14 Sept 1985, and a skeleton in the cattail marsh wrack the same date. No other mammal mortality other than the Red Fox was found on site. The fairly high population of muskrats, their frequenting of marsh and much of the open water areas with contact of the substrate, their stem and root plant diet plus the fact that occasionally they are carnivorous, should make them an important

link in the food web at the site.

The Eastern Cottontail population on the site during the investigation did not seem to be very high. After the winter snow had melted, debarked shrubs were noted, particularly in the areas outlined in Figure 2. Individuals were sighted infrequently, even on nocturnal and crepuscular visits. Some of these animals move from the site at its northern end to feed on the open grassy area of the adjacent U. S. Coast Guard Station. After the severe storm in early December several cottontails were picked up dead by U.S. Coast Guard personnel (CWO Grimble, pers. comm.). Soon after this storm snow and later ice cover formed in the woodland on site, so mortality of Sylvilagus could have been somewhat higher from this event. Since Eastern Cottontail populations vary with the seasons as well as go through a cycle of changing abundance, it is difficult to estimate the current numbers. They may raise three or four litters of four to seven young each in one year. Based on average numbers elsewhere and upon Times Beach sightings, there could be 10 to 20 adults on site. Since these animals are herbivorous, including bark and twigs of woody plants in winter, and they range over uplands on site which have received dredged disposal material, they could show evidence of contamination depending on the uptake of such into the vegetation there.

No other signs of Raccoon other than the one seen in the marsh (Figure 2) were found. It is likely that they are occasional visitors. From tracks sighted, it is likely that a few weasels are resident, as the mouse and vole population is sufficient to support them. Fox tracks were noted several times in the snow, and it is likely that one or both species visit the area to hunt but are probably not resident as a den and young are usually fairly easy to locate.

Although the researchers from Cornell had their trap lines disrupted during the summer on a few occasions, and so were not able to obtain a reliable estimate of Microtus and Peromyscus density in the upland part of Times Beach, it is evident from their results and from observations of tracks, tunnels, runways, and scats that a fairly substantial population composed of both species exists. Since both these species are quite prolific and their populations cyclic, more study is needed to determine their abundance on site. Since their food consists essentially of seeds and insects (Peromyscus) and

grasses and sedges (Microtus) plus roots and bulbs, they should be important indicators of contaminant movement to this level of the food web. The Cornell researchers reported on their uptake of metals.

Reptiles and Amphibians

The apparent low variety of these animals on Times Beach is probably a consequence of its isolation from similar habitats, the lack of woodland pools, possibly the nature of much of the substrate where dredged disposal has occurred (oily), and possibly the continual and sometimes high fluctuations in water level. There is also a minimum of isolated and exposed resting and sunning places in the marsh and water areas, which frogs and turtles utilize. Table 4 lists the species recorded and Figure 3 shows the locations of the Bullfrogs, the American Toad heard calling, and the area where Garter Snakes seemed to be most numerous.

Table 4
Reptile and Amphibian Species Recorded at Times Beach
Dredged Material Disposal Site, Buffalo, New York;
12 May 1985 to 31 May 1986

- 1 Thamnophis sirtalis Eastern Garter Snake
- 2 Bufo americanus American Toad
- 3 Rana catesbeiana Bullfrog

Both young and adult Garter Snakes were noted in fair numbers in most portions of the uplands, either sunning themselves or under some debris. The black phase is also present and was seen several times. Food of these snakes is mostly insects and other invertebrates, although the larger specimens will take voles, mice, and frogs if available. The American Toad's food is at least 75% insects, with earthworms, spiders, and other invertebrates also consumed. Metals in trapped toads were reported on by researchers and summarized by Leonard (1985). Depending on its size, the Bullfrog will consume insects, young ducklings, fish, and sometimes small snakes. The two heard in 1985 were not detected subsequently.

Although fish were not directly studied for this report, it seems appropriate to mention that no more than three small dead individuals were found on site during the period. It is also of interest that on 24 May 1986 a visit to the site revealed a mating event by Carp, Cyprinus carpio involving scores of large individuals (5 - 6 lbs) in the shallow (4 - 10 in) water among grasses, purple loosestrife, and cattails at the edge of and into the cottonwoods- willow woodland, extending out to the USACE test wells (#s 6,7,8) in at least grid blocks D -2,3 and E -3. No such event was noted during the same period or at all in 1985.

Finally, the investigator secured specimens from Times Beach during the period for future analysis. These consisted of Muskrats, ducklings (2 species), Garter Snakes, birds (immatures and eggs of four species), and a large specimen of Carp. Also collected were eggs, adult and young of Red-winged Blackbird at a control site, and arrangements were made with biologists at the Iroquois National Wildlife Refuge to secure examples of some of the animals there which are the same species as those at Times Beach for another control area. The impacts of the severe storm at Times Beach in early December 1985 on the site and its fauna and flora are being analyzed, and will be reported on in a subsequent paper.

Literature Cited and References

Andrie, R. F. 1972. Birds of the Tiffit natural area in Buffalo, New York. The Prothonotary 38: 91 - 95.

_____. 1985. Vertebrate research at Times Beach confined disposal site, Buffalo, New York. Interim Draft Report to U.S.A. Corps of Engineers.

Beardslee, C, S. and H. D. Mitchell. 1965. Birds of the Niagara Frontier Region. Bull. of the Buffalo Soc. Nat. Sci. Vol. 22

Bull, J. 1974. Birds of New York State. Doubleday/Natural History Press, Garden City, N.Y.

- Burt, W. H. 1957. Mammals of the Great Lakes Region. Univ. of Michigan Press, Ann Arbor.
- Harrison, C. 1978. A field guide to the nests, eggs and nestlings of North American birds. Collins, New York.
- Leonard, R. P. 1985. Food chain studies at Times Beach confined dredged material disposal site. U.S. Army Corps of Engineers, Buffalo, New York.
- Marquenie, J. M., J. W. Simmers, and S. H. Kay. 1985. Bioaccumulation of heavy metals and organic contaminants at Times Beach confined disposal site, Buffalo (N.Y.). Misc. Paper EL-85. Draft Report, Department of the Army Environmental Laboratory, Waterways Experiment Station, Corps of Engineers, Vicksburg.
- Murie, O. J. 1975. A field guide to animal tracks. Houghton Mifflin Co., Boston.
- Oliver, J. A. 1955. The natural history of North American amphibians and reptiles. Van Nostrand, Princeton.
- Pearson, T. G.(ed.) 1936. Birds of America. Doubleday, New York.
- Ralph, C. J., and M. Scott, (eds.) 1981. Estimating numbers of terrestrial birds. Cooper Ornith. Soc. Studies in Avian Biology No. 6.
- Wright, A. H. and A. A. Wright. 1949. Handbook of frogs and toads. Comstock Publishing Co., Ithaca, N.Y.

Vertebrate Investigations at Times Beach Confined Dredged
Material Disposal Site, Buffalo, New York, 1986 - 1987

Progress Report (Contract No. DACW49-86-C-0021)

Robert F. Andrie Ph.D
Buffalo Museum of Science

11 December 1986

During the first six months of this phase of the study 17 visits of varying durations were made to the site from early June to late November 1986. Study methods followed those outlined in Andrie (1985). The three most striking general changes involving vegetation types and water levels that have occurred on site and are still taking place were described in that paper.

General Considerations

This period was characterized by quite high water levels during some heavy rains in June and July, a general lowering into August and September, and higher water again in October and November, especially during strong west and southwest winds. For the second year conditions were good for breeding of vertebrates, and evidence of this was repeatedly noted, particularly in the numbers of young observed. Collecting of specific animal species for future analysis was continued in June, and again in late August and October. By the end of the period much of the marsh was thinly iced over, most bird migrants had passed through the site, some waterfowl continued to visit or remained in the open water, and permanent resident animals were storing food for the winter.

It was noted during the period that cat-tails in parts of the marsh were severely cut back by Muskrats, and also diminished by high water, especially in the southern part of the marsh. The high water and flooding have apparently weakened the dredged material substrate through the woodland border so that some cottonwoods and willows are tilting toward the east and northeast from the wind, and still others have fallen. Common

reed and purple loosestrife are spreading in the southern sections of the woodland and in the shallow water around the woods edge, especially on the southwest.

Following are specific comments about the site and its flora and fauna in each of the six months of the period.

June

A new breeding bird species, the Northern Flicker Colaptes auratus, was located nesting in the woodland (E-1). The Mute Swan Cygnus olor remained on site through the period. Eastern Garter Snakes were active, young were noted as were specimens in the black phase which were first found here in 1985. Again, no amphibians were discovered. Although no complete census of breeding bird species was taken this year, their variety and abundance was at least equal to 1985 season, and most species were successful in fledging young. It is possible that House Finch Carpodacus mexicanus also nested for the first time on site. In 1985 it had been seen just outside the area. Specimens of birds and reptiles collected on the site in June are as follows:

		Grid Sq.
Mallard	<u>Anas platyrhynchos</u>	4 (immature) D-2
Red-winged Blackbird	<u>Agelaius phoeniceus</u>	3 eggs D-3
"	"	3 (immature) B-2, F-3, D-1
Eastern Garter Snake	<u>Thamnophis sirtalis</u>	2 (immature) F-1, E-1

July

This month another new breeding bird species was discovered - Black-crowned Night-Heron Nycticorax nycticorax. Two nests low in cottonwoods were found in the southwest edge of the woodland (D-3). Both contained eggs later in the month, but apparently they were not successful as broken eggs were located subsequently in the water below, indicating possible predation. This species was formerly a more common breeder in parts of western New York, but recently it has only been noted nesting at Niagara Falls. This heron visits Times Beach regularly to roost and hunt its food of fish, insects, voles, etc. With a friend assisting, the two nest trees

were flashed at their bases with sheet metal to prevent them from being cut down by Beaver Castor canadensis, whose tree and branch cuttings (up to 6 cm DBH), small lodge, and trails were also found in this location - another species new to the site. A third tree was also flashed to prevent it possibly falling against one of the others.

More Mallard and American Wigeon Anas americana young appeared this month, the former with broods of 6 and later full grown young, the latter with broods of 12, 5, 13, and 4 ducklings. Apparently nesting success for each of these species was at least as good as in 1985. Other species found with young in nest or recently fledged were Red-winged Blackbird Agelaius phoeniceus, American Robin Turdus migratorius, Northern Flicker Colaptes auratus, Common Grackle Quiscalus quiscula, and European Starling Sturnus vulgaris (the last two visitors to site). A young Eastern Cottontail Sylvilagus floridanus was sighted as well as several more immature Eastern Garter Snakes. A Veery Catharus fuscescens, probably a post-breeding wanderer, was a new species for the site's 1985 - 1986 list. This summer the usual abundant hatch of non-biting midges and caddis flies provided food for many of the insectivorous animals. Water striders (Gerridae) were seen this month in numbers for the first time in the marsh.

August

An almost full-grown young Common Moorhen Gallinula chloropus was seen off the south marsh edge, and three were noted there later in the month. More visitant birds were observed in their post-breeding movements. A Ring-necked Pheasant with about 5 half-grown young was seen near the north edge of the site. A new visitor to Times Beach was a Great Horned Owl Bubo virginianus, observed several times, once pursued by American Crows and an American Kestrel. A highlight of this month was the discovery of a second Beaver lodge, fresh cuttings, and water trails at the north edge of the marsh (G-3). Sumac, dogwood, and cottonwood branches as well as small logs and boards were utilized by this animal to build up its lodge, which measured about 4 x 2 x 1.5 meters. It is not known at present how many of these animals are present in the marsh. More inroads on cat-tails by muskrats and

beavers were sighted in the northern portion of the marsh. The first southward bound migrant, a Cape May Warbler Dendroica tigrina, appeared this month. The following bird specimens were collected for future analysis:

Red-winged Blackbird	<u>Agelaius phoeniceus</u>	1 (adult)	Grid Sq. G-3
Song Sparrow	<u>Melospiza melodius</u>	3	F-2,D-2,G-2

September

This month of lower water levels and exposed mud at the site is characterized by many migrant land and water birds as well as local visitants and some of the summer breeding species and their offspring (see Check-list appended). Algae and other water plants now cover a large part of the open water, and both muskrat and beaver lodges are being built up with mud, cattails, and sticks. In some places oil is evident on the marsh water surface. Maximums of 60 Canada Geese and 24 American Wigeon were sighted feeding in the open water.

October

A passage Cooper's Hawk Accipiter cooperii is a first record for 1985 - 1986. Much muskrat activity is evident. The Great Horned Owl remains, and is observed being pursued in flight by an American Kestrel. This owl feeds on mammals up to medium size and anything else that it is able to secure. American Wigeon numbers rise to a maximum of 37 on one day, but many summer breeding birds have left. No amphibians have been noted this year on the site. Now and then an Eastern Garter Snake is seen taking advantage of the sun to warm itself. High water again occurs from wind, and five willow trees are downed in grid square G-2 at the edge of the woodland, and several more cottonwoods are downed in the vicinity of the smaller beaver lodge, also by wind. Few bird migrants occur this month except for waterfowl. Specimens of mammals secured for testing are:

Muskrat	<u>Ondatra zibethicus</u>	3 (incl. 1 young)	Grid Sq. D-2,E-3,C-3

November

Water on site is high from an early month gale which gusted to over 40 mph, flooding the marsh and lower portions of the woodland. Waterfowl of several species feed in the open water and marsh. Feathers of a Rock Dove Columba livia are found in grid square E-1 with fox tracks in the snow. Many Eastern Cottontail tracks are evident in the snow, together with tracks of fox, mice and voles, and Ring-necked Pheasant. Large Beaver tracks are conspicuous in the mud and snow near the smaller lodge, considerable cutting and gnawing of trees and logs are visible, and several cottonwoods up to 4 cm DBH have been cut down by this mammal. A new mammal for the site was discovered - Norway Rat Rattus norvegicus, when tracks were seen (B-1) and a medium size dead individual was found (E-2) in the woodland. There is nothing but natural food on site for this unwelcome species.

The only mortality of wildlife found during the period was the small dead fish (sp.?) floating in the marsh, the Rock Dove remains mentioned earlier, and the dead Norway Rat in the woodland, which may have been dropped there by a predator.

Many of the migratory birds that visit Times Beach are insectivorous, while later in the year and in winter and early spring plant seeds and fruit are eaten. There appears to be an abundant supply of insects and other invertebrates for the migrants as well as for those breeding species which also eat insects and feed them to their young. As noted by Wilhelm (n.d.), the low ground marsh area is relatively rich (64 sp.; 75% native) in plant species, thus affording vegetable and animal matter for the resident animals which utilize that sector regularly. The submergent vegetation of the open water area also supports plant species that supply both breeding and migratory waterfowl with food in addition to the fish that are consumed by some waterfowl. Though the pioneer woodland contains less quality plants (70 sp.; 50% non-native), which is reflected in the number and variety of resident animals, such a condition is to be expected. Fruit-bearing plants are also not numerous, thus providing little food for birds in seasons when insect

food is absent. The dike flora is also of lower quality and is in many places sparse or non-existent. So it also supports a lower number and variety of vertebrate animals. Overall, however, considering its small size, Times Beach provides habitats and food for a good number and variety of vertebrate animals with the exception of reptiles and amphibians.

The Storm of 2 December 1985

On 1 December a low pressure center formed over southern Illinois and moved rapidly northeast across the Great Lakes into Quebec by the following morning, intensifying as it went. As a result, temperature at Buffalo dropped from a high of 56°F to a low of 19°F. Thunderstorm, ice pellets, and blowing snow occurred as .41 in. of precipitation fell and winds averaging 32 mph gusted to 55 mph from the southwest. The barometer fell to a very low 28.76 in. during this day. The storm surge of water at Times Beach reached 6 to 8 feet driven by even higher sustained wind and gusts, inundating most of the site for a part of the day. Considerable debris, grasses, cat-tails, and logs were blown or carried by water into the marsh and woodland. Mostly below freezing temperatures the following few days and generally lowering temperatures the rest of December tended to freeze water and substrate on site.

Very little mortality of animals was evident as a result, although some ground-dwelling and subterranean species could have succumbed. Several Eastern Cottontails were found dead. Subsequent light snow, however, revealed abundant animal tracks on site - fox, mice, voles, E. Cottontails, and Ring-necked Pheasants, as well as a possible weasel. The storm-induced inundation was apparently of too short a duration to have seriously affected the terrestrial vertebrates. Muskrats were able to survive in their lodges. Few passerine birds inhabit Times Beach in winter months, so no mortality of such species would likely result from such a storm. In addition to the fairly large amount of debris and natural materials deposited in Times Beach during the storm, several fair size cottonwoods were blown down, particularly in the northern and southeastern parts of the woodland. The overall effect of this was to enhance wildlife habitats by providing more cover, breeding places, and possibly food for animals.

References Cited

Andrie, R. F. 1985. Vertebrate research at Times Beach confined disposal site, Buffalo, New York. Interim Draft Report to U.S. Army Corps of Engineers.

Wilhelm, G. n.d. Vegetation of the Times Beach disposal area, Buffalo, New York. Report submitted to U.S. Army Corps of Engineers.

bird species recorded at

Buffalo, N.Y.

2

Buffalo Museum of Science

FIELD CHECK-LIST # new per site

2000

2

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APPENDIX B: RESULTS OF SAMPLE COLLECTION AND
ANALYSIS FOR CONTAMINANT CONCENTRATIONS

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UPLAND AREA: TIMES BEACH

PART I(1) TABLE 1

TABLE 1 Preliminary characterization of the dredged material collected, in 1983, from the upland area of the Times Beach confined dredged material disposal facility (CDF).

Metal concentrations (single grab sample, ug/g, dry weight)

Element	unconsolidated deep layer material.* ¹	oxidized surface layer material.* ²
Na	4,960	5,990
Mg	10,200	15,600
Al	53,000	85,000
Cl	740	150
K	15,100	20,400
Ca	<30,000	<30,000
Sc	10	10
Ti	3,500	5,600
V	80	126
Cr	1,780	381
Mn	820	1,325
Fe	93,900	70,500
Co	20	17
Ni	<800	<900
Cu	660 (611)*	530 (269)*
Zn	1,010	1,190
As	193 (159)	62 (53)*
Se	5.0	<7.0
Br	70	22
Mo	22	<20
Cd	<30 (6.9)	<30 (7.7)
Sb	107	39
I	<8.0	<20
Cs	4.1	5.1
Ba	360	400
La	32	34
Ce	50	<60
Tb	0.85	0.95
Hf	6.6	7.2
Ta	2.2	1.2
W	3.9	<7.0
Au	<0.02	<0.02
Hg	23 (15)	<5.0 (7.5)
Th	7.6	8.6
U	2.8	3.8
Pb	- (611)	- (632)

* values in parentheses assessed by AAS, those not in parentheses by INNA.

*¹. One time observation: dredged material below the water table > 1 m depth.

*². One time observation: dredged material in surface 20 cm depth.

PART I(1) TABLE 2

TABLE 2 Metal concentrations measured in the oxidized layer of dredged material at the Times Beach CDF (Four pooled samples per plot, ug/g, dry weight). NOVEMBER 1986.

Samples collected using a 15 cm depth soil corer, from each of the vegetation zones defined by Wilhelm (1985).

PLOT	Zinc	Copper	Nickel	Cadmium	Chromium	Lead
A1	292	62	38	3.8	75	159
A2	266	50	27	3.1	49	124
A3	310	42	21	3.0	46	201
A4	Sample lost.					
B1	547	102	42	6.8	163	192
B2	551	128	73	8.7	184	252
B3	304	46	30	4.2	58	132
B4	599	118	67	7.7	186	265
B5	400	81	32	4.4	94	221
C1	528	89	37	6.0	105	209
C2	453	91	41	5.6	115	175
C3	520	94	35	5.0	107	219
C4	204	61	27	3.5	71	83

Metal concentrations of composited samples (four 5 cm by 15 cm cores) taken from each plot.

PART I(2) TABLE 3

TABLE 3 An inventory of the vegetation present at the Times Beach CDF was made and based on the defined vegetation zones the following samples of vegetation were collected for analysis of heavy metal content. JULY 1985.

Plot	Plant species	Plant parts
A1	<u>Solidago altissima</u>	Stems
A2	"	Leaves, stems and flowers
A3	"	Leaves, stems and flowers
B1	<u>Cornus stolonifera</u> <u>Impatiens capensis</u> <u>Solidago altissima</u>	Leaves Leaves and stems Leaves, stems and flowers
B2	<u>Cornus stolonifera</u> <u>Lythrum salicaria</u> <u>Solidago altissima</u>	Leaves Leaves and stems Leaves, stems and flowers
B3	<u>Cornus stolonifera</u> <u>Solidago altissima</u>	Leaves Leaves, stems and flowers
C1	<u>Impatiens capensis</u>	Leaves and stems
C2	<u>Impatiens capensis</u> <u>Lythrum salicaria</u>	Leaves and stems Leaves and stems
C3	<u>Solidago altissima</u> <u>Impatiens capensis</u> <u>Lythrum salicaria</u> <u>Phragmites australis</u>	Leaves, stems and flowers Leaves and stems Leaves, stems and flowers Leaves and stems
A, B & C	<u>Populus deltoides</u>	Leaf litter

PART I(2) TABLE 4

TABLE 4 Metal concentrations measured in the vegetation samples collected at the Times Beach CDF (ug/g, dry weight). JULY 1985.

Vegetation type A

Species/Tissue/Plot		Zn	Cu	Ni	Cd	Cr	Pb
<u>Solidago altissima</u>							
Leaves	A2	26	10	0.76	0.46	5.2	4.4
	A3	25	9.4	1.5	0.24	2.5	4.1
	x	26	9.7	1.1	0.35	3.9	4.3
Stems	A1	27	6.8	-	-	-	3.0
	A2	25	7.4	0.88	0.15	2.8	<2.6*
	A3	41	5.5	<0.75	0.17	0.17	<0.26
	x	31	6.6	0.82	0.16	1.5	2.0
Flowers	A2	25	11	1.4	<0.13	2.2	3.9
	A3	28	11	0.96	0.22	2.2	3.2
	x	27	11	1.2	0.18	2.2	3.5

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART I(2) TABLE 4 contd...

Vegetation type B

Species/Tissue/Plot		Zn	Cu	Ni	Cd	Cr	Pb
<u>Cornus stolonifera</u>							
Leaves	B1	20	4.4	1.1	0.31	2.1	4.2
	B2	17	3.8	1.5	0.27	1.8	6.5
	B3	69	4.9	2.0	0.63	2.0	5.3
	x	35	4.4	1.5	0.40	2.0	5.3
<u>Solidago altissima</u>							
Leaves	B1	24	6.5	<0.75*	0.39	1.4	4.5
	B2	26	6.8	<0.75	0.34	1.7	5.6
	B3	31	11	<0.75	0.24	0.95	4.7
	x	27	8.1	<0.75	0.32	1.4	4.9
Stems	B1	33	5.2	<0.75	0.26	1.1	<2.6
	B2	45	7.0	1.2	0.32	0.97	<2.6
	B3	79	6.5	<0.75	0.29	0.68	<2.6
	x	52	6.2	0.90	0.29	0.92	<2.6
Flowers	B1	29	12	2.4	0.24	1.5	3.5
	B2	33	13	3.0	0.39	1.0	2.7
	B3	40	13	1.0	0.17	1.0	<2.6
	x	34	13	2.1	0.27	1.2	2.9
<u>Lythrum salicaria</u>							
Leaves		205	11	1.1	0.37	1.8	3.5
Stems		38	10	<0.75	0.34	1.1	<2.6
<u>Impatiens capensis</u>							
Leaves & stems		87	9.8	<0.75	1.8	1.6	3.0

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART I(2) TABLE 4 contd...

Vegetation type C

Species/Tissue/Plot		Zn	Cu	Ni	Cd	Cr	Pb
<u>Solidago altissima</u>							
Leaves	C3	31	9.6	<0.75*	0.48	1.4	5.1
Stems	C3	32	5.7	<0.75	0.15	0.64	<2.6
Flowers	C3	27	12	1.3	0.20	0.91	3.0
<u>Lythrum salicaria</u>							
Leaves	C2	187	8.4	<0.75	0.43	1.4	4.8
	C3	282	12	2.4	1.8	7.4	7.0
	x	235	10	1.6	1.1	4.4	5.9
Stems	C2	18	9.0	<0.75	0.50	0.70	<2.6
	C3	43	13	<0.75	0.68	3.0	<2.6
	x	31	11	<0.75	0.59	1.9	<2.6
Flowers	C3	84	29	1.9	<0.13	5.3	4.3
<u>Impatiens capensis</u>							
Leaves & stems	C1	77	6.0	<0.75	1.3	0.91	<2.6
	C2	88	8.3	<0.75	2.7	0.80	<2.6
	C3	127	9.6	0.34	2.9	1.2	<2.6
	x	97	8.0	0.61	2.3	0.97	<2.6
<u>Phragmites australis</u>							
Leaves	C3	39	7.5	1.4	<0.13	1.1	<2.6
Stems	C3	72	15	2.4	0.14	1.2	5.5

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART I(2) TABLE 4 contd...

Vegetation types A, B & C

TABLE 4 Metal concentrations measured in leaf litter (Populus deltoides) collected from each of the vegetation zones (single grab sample expressed in ug/g, dry weight). NOVEMBER 1986.

Zone	P	K	Ca	Mg	Na	Fe	Al
Veg. A	1331	5408	27485	1534	81	307	115
Veg. B	1112	6035	25765	2450	168	700	192
Veg. C	961	5996	20818	3176	615	1726	406

Zone	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	471	14	2.3	5.6	8.1	4.0
Veg. B	350	12	2.0	4.9	2.8	4.5
Veg. C	131	7.8	2.5	3.2	4.8	7.8

PART I(3) TABLE 5

Soil-Dwelling Invertebrates.

Surface active soil dwelling invertebrates were collected at the Times Beach CDF in the Spring and Fall seasons for two consecutive years. Identification of the families collected was made, and a record of the relative abundance calculated. Where sufficient material was available metal analysis was carried out. Insufficient material was available for analysis of any organic compounds.

TABLE 5(a) Record of numbers of soil dwelling invertebrates collected in pitfall traps. MAY 1985.

PLOT	COL.	ARAN.	CHIL.	DIPL.	ISOP.	OTHERS
A1	9	4	3	23	148	2 Lumbricidae/2 Orthoptera/1 Diptera 2 Hymenoptera/1 Coleoptera L.
A4	9	3	3	29	120	10 Lumbricidae/5 Coleoptera L.
B4	26	11	1	19	244	4 Lumbricidae/3 Coleoptera L. 3 Hymenoptera/3 Thysanoptera/1Diptera
B5	10	2	2	19	183	17 Lumbricidae/5 Coleoptera L.
C1	23	8	-	11	44	2 Amphibia/2 Diptera/1 Acarina 1 Thysanoptera/2 Hymenoptera
C2	8	2	-	8	124	6 Lumbricidae/2 Acarina/3 Amphibia 2 Hemiptera
C4	51	6	-	6	19	1 Lumbricidae/2 Hymenoptera/ 2 Hemiptera/1 Lepidoptera L.

PART 1(3) TABLE 5 contd...

TABLE 5(b) Identification of major groups of soil dwelling invertebrate fauna collected in pitfall traps. MAY 1985

1. COLEOPTERA

PLOT	SUB-ORDER	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Geodephaga	Carabidae	<u>Carabus</u> sp	2
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Sternoxia	Elatiderae	<u>Agriotes</u> sp	1
	Rhynchophora	Curculionidae		
		Otiorrhynchinae		2
	Rhynchophora	Curculionidae		1
	Brachelytra	Staphylinidae		1
	Geodephaga	Carabidae	<u>Bradycellus</u> sp	1
A4	Geodephaga	Carabidae	<u>Carabus</u> sp	8
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Brachelytra	Staphylinidae		
		Tachyporidae	<u>Tachyporus</u> sp	1
	Rhynchophora	Curculionidae		
		Otiorrhynchinae	<u>Barypithes</u> sp?	1
B4	Geodephaga	Carabidae	<u>Carabus</u> sp	2
	Geodephaga	Carabidae	<u>Chlaenius</u> sp	2
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	17
	Lamellicornia	Scarabidae		1
	Brachelytra	Staphylinidae	<u>Staphylinius</u> sp	1
	Brachelytra	Staphylinidae		
		Tachyporinae	<u>Tachyporus</u> sp	2
B5	Geodephaga	Carabidae	<u>Carabus</u> sp	4
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	5
	Lamellicornia	Trogidae	<u>Trox</u> sp	2

PART I(3) TABLE 5(b) contd...

PLOT	SUB-ORDER	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
C1	Geodephaga	Carabidae	<u>Chlaenius</u> sp	10
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	10
	Sternoxia	Elatiderae	<u>Agriotes</u>	1
	Brachelytra	Staphylinidae		
		Oxytelinidae		1
C2	Geodephaga	Carabidae	<u>Carabus</u>	1
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Brachelytra	Staphylinidae		
		Tachyporidae		1
	Geodephaga	Carabidae	<u>Chlaenius</u> sp	2
	Brachelytra	Staphylinidae		
		Oxytelinidae		1
	Clavicornia	Nitidulidae		
		Nitidulinae		2
C4	Geodephaga	Carabidae	<u>Chlaenius</u> sp	19
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	9
	Geodephaga	Carabidae	<u>Bembidion</u> sp	2
	Geodephaga	Carabidae	<u>Agonum</u> sp	2
	Clavicornia	Nitidulidae		
		Nitidulinae		1
	Brachelytra	Staphylinidae		17

2. All Araneida identified as belonging to the Family Agriopoidea.

3. All Chilopoda identified as belonging to the Family Scutigerae.

PART I(3) TABLE 5(b) contd...

4. DIPLOPODA

PLOT	FAMILY	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Blaniulidae	20
	Polydesmidae	3
A4	Blaniulidae	29
	Polydesmidae	4
B4	Blaniulidae	14
	Polydesmidae	6
B5	Blaniulidae	17
	Polydesmidae	4
C1	Blaniulidae	12
C2	Blaniulidae	8
C4	Blaniulidae	6

PART I(3) TABLE 5(b) contd...

5. ISOPODA

PLOT	FAMILY	ABUNDANCE	* least common **** most common
A1	Porcellionidae	***	
	Trichoniscidae	****	
	Oniscidae	**	
A4	Porcellionidae	***	
	Oniscidae	**	
	Trichoniscidae	****	
	Armadillidiidae	*	
B4	Porcellionidae	***	
	Trichoniscidae	****	
	Oniscidae	**	
B5	Porcellionidae	***	
	Trichoniscidae	****	
C1	Porcellionidae	***	
	Trichoniscidae	****	
	Oniscidae	**	
C2	Porcellionidae	***	
	Trichoniscidae	****	
	Oniscidae	**	
C4	Porcellionidae	***	
	Trichoniscidae	****	

PART I(3) TABLE 5 contd...

TABLE 5(c) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a three day period at Times Beach. Total dry matter (g) contribution and percentage dry matter contribution (%) per plot. MAY 1985.

PLOT	PRED. COL.	ARAN.	CHIL.	DIPL.	ISOP.	OTHERS
A1 (g)	0.3479	0.0060	0.0700	0.1063	0.2774	0.12
(%)	37.26	0.64	7.51	11.41	29.77	13.40
A4 (g)	1.5008	0.0091	0.0615	0.1995	0.2500	0.14
(%)	69.50	0.42	2.85	9.24	11.58	6.41
B4 (g)	0.9868	0.0391	0.0187	0.1345	0.1988	1.74
(%)	31.65	1.25	0.60	4.31	6.38	55.81
B5 (g)	0.9064	0.0045	0.0531	0.2237	0.1331	0.26
(%)	57.36	0.28	3.36	14.16	8.42	16.42
C1 (g)	0.5727	0.0170	-	0.1053	0.0626	0.01
(%)	48.74	1.45	-	9.01	5.33	0.85
C2 (g)	0.2547	0.0125	-	0.029	0.1049	0.05
(%)	24.25	1.19	-	9.01	5.33	0.85
C4 (g)	1.0407	0.1063	-	0.054	0.0395	-
(%)	83.22	8.50	-	4.32	3.16	-

PART I(3) TABLE 5 contd...

TABLE 5(d) Metal concentrations in major groups of invertebrate fauna, four pooled samples per plot (ug/g, dry weight). MAY 1985

CARNIVOROUS SPECIES

(1) Predatory COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	92	14	<0.43	0.85	2.6	<1.5
A4	87	14	<0.35	1.3	1.7	<1.2
B4	115	16	1.1	2.6	5.5	4.2
B5	100	13	<0.34	2.8	1.7	<1.2
C1	114	17	0.74	2.1	4.7	5.1
C2	108	11	<0.59	1.9	3.0	<2.1
C4	118	18	<0.72	2.6	3.5	2.6

(2) ARANEIDA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	369	165	<13	28	117	<44
A4	461	172	<8.3	26	52	30
B4	411	253	<1.9	112	14	<6.8
B5	511	207	17	40	85	<59
C1	336	182	<4.5	114	30	<16
C2	342	190	<6.1	148	37	<21
C4	244	174	<0.71	70	6.1	<2.5

(3) CHILOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	279	60	<1.1	6.0	6.8	<3.8
A4	283	57	<1.2	12	7.3	<4.3
B4	193	45	<4.0	25	22	<14
B5	272	28	<1.4	4.2	8.9	<5.0

PART I(3) TABLE 5(d) contd...

DETRITIVOROUS SPECIES

(4) DIPLOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	228	630	<2.5	2.9	5.8	10.4
A4	194	652	<1.5	2.6	4.3	<9.7
B4	280	693	1.9	3.5	8.7	7.9
B5	204	626	<1.7	3.8	4.2	<8.4
C1	158	581	1.0	1.8	5.8	6.2
C2	178	731	<2.6	2.4	9.2	<9.2
C4	187	591	<1.4	2.3	7.1	6.6

(5) ISOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	195	192	3.5	31	13	13
A4	164	171	2.9	35	7.6	14
B4	209	157	2.3	41	14	13
B5	173	127	3.9	49	11	14
C1	113	110	2.4	21	9.3	12
C2	179	149	2.9	45	12	16
C4	249	173	<1.9	21	15	<6.7

There was insufficient biomass of herbivorous invertebrates collected for chemical analysis.

PART I(3) TABLE 6

TABLE 6(a) Record of numbers of soil dwelling invertebrates collected in pitfall traps. OCTOBER 1985

PLOT	COL.	ARAN.	CHIL.	DIPL.	ISOP.	ORTH.	OTHERS
A1	20	18	3	26	196	5	5 Diptera/1 Dermaptera/1 Mollusc 4 Hemiptera/15 Hymenoptera 7 Neuroptera/2 Lepidoptera/1 Lumb.
A2	14	11	2	20	118	7	1 Acarina/1 Diptera/2 Hemiptera/ 22 Hymenoptera/1 Mollusca 1 Lumbricidae
A3	5	5	2	31	102	7	2 Acarina/4 Diptera/37 Hymenoptera 1 Neuroptera/2 Lumbricidae
A4	19	35	8	49	161	28	7 Acarina/4 Diptera/1 Hemiptera 27 Hymenoptera/1 Mollusca/ 6 Lumbricidae
B1	23	29	1	12	261	10	7 Acarina/1 Diptera/2 Hemiptera 8 Hymenoptera/2 Mollusca 2 Lumbricidae
B2	29	51	2	5	121	34	6 Acarina/2 Dermaptera/2 Diptera 6 Hemiptera/8 Hymenoptera
B3	23	32	5	60	211	8	4 Acarina/10 Hymenoptera 1 Lumbricidae
B4	15	36	2	33	105	9	5 Acarina/5 Hemiptera/ 13 Hymenoptera/2 Lepidoptera 3 Lumbricidae
B5	26	25	2	17	54	14	4 Acarina/1 Dermaptera/5 Hemiptera 16 Hymenoptera/1 Thysanoptera 8 Lumbricidae
C1	69	33	1	7	301	62	6 Acarina/3 Diptera/1 Hemiptera 14 Hymenoptera/1 Mollusca 5 Lumbricidae
C2	107	28	5	16	243	58	15 Acarina/1 Dermaptera/4 Diptera 20 Hymenoptera/2 Neuroptera/ 5 Lumbricidae
C3	31	33	5	27	181	28	5 Acarina/4 Diptera/15 Hymenoptera 1 Lepidoptera/2 Mollusca 1 Lumbricidae
C4	16	38	6	6	142	17	10 Acarina/2 Diptera/1 Hemiptera 18 Hymenoptera/1 Mollusca 5 Lumbricidae

PART I(3) TABLE 6 contd...

TABLE 6(b) Identification of major groups of soil dwelling invertebrate fauna. OCTOBER 1985

1. COLEOPTERA

PLOT	SUB-ORDER	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Geodephaga	Carabidae	<u>Amara</u> sp	12
	Lamellicornia	Trogidae	<u>Trox</u> sp	2
	Rhynchophora	Curculionidae		1
	Rhynchophora	Otiorynchinae		1
	Clavicornia	Nitidulidae		2
	Lamellicornia	Scarabidae	<u>Aphodius?</u>	1
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	1
A2	Geodephaga	Carabidae	<u>Pterostichus</u>	2
	Geodephaga	Carabidae	<u>Amara</u>	5
	Clavicornia	Nitidulinidae	?	3
	Rhynchophora	Curculionidae	?	4
A3	Geodephaga	Carabidae	<u>Calathus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	1
	Clavicornia	Nitidulinidae	?	1
	Rhynchophora	Curculionidae	?	2
A4	Geodephaga	Carabidae	<u>Carabus</u> sp	1
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	10
	Geodephaga	Carabidae	<u>Harpalus</u> sp	1
	Geodephaga	Carabidae	<u>Bembidion</u> sp	1
	Geodephaga	Carabidae		1
	Lamellicornia	Trogidae	<u>Trox</u> sp	1
	Rhynchophora	Curculionidae		3

PART 1(3) TABLE 6(b) contd...

PLOT	SUB-ORDER	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
B1	Geodephaga	Carabidae	<u>Pterostichus</u> sp	5
	Geodephaga	Carabidae	<u>Harpalus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	12
	Geodephaga	Carabidae	<u>Clivina?</u> sp	1
	Geodephaga	Carabidae		1
	Rhynchophora	Curculionidae		2
	Brachelytra	Staphylinidae	<u>Aleocharinae</u>	1
B2	Geodephaga	Carabidae	<u>Carabus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	15
	Geodephaga	Carabidae	<u>Pterostichus</u>	1
	Geodephaga	Carabidae		3
	Clavicornia	Nitidulinidae		1
	Rhynchophora	Curculionidae		1
	?	Chrysomelidae	<u>Altica?</u>	3
	Brachelytra	Staphylinidae	<u>Aleocharinae</u>	2
	Brachelytra	Staphylinidae	<u>Omalinae</u>	1
	Brachelytra	Staphylinidae	<u>Staphylininae</u>	1
B3	Geodephaga	Carabidae	<u>Carabus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	15
	Geodephaga	Carabidae	<u>Pterostichus</u>	1
	Geodephaga	Carabidae	?	3
	Clavicornia	Nitidulinidae	?	1
	Rhynchophora	Curculionidae	?	1
	?	Chrysomelidae	<u>Altica?</u>	3
	Brachelytra	Staphylinidae	<u>Aleocharine</u>	2
	Brachelytra	Staphylinidae	<u>Omalinae</u>	1
	Brachelytra	Staphylinidae	<u>Staphylininae</u>	1
B4	Geodephaga	Carabidae	<u>Amara</u> sp	11
	Lamellicornia	Trogidae	<u>Trox</u> sp	1
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	1
	Clavicornia	Nitidulinidae	?	2
B5	Geodephaga	Carabidae	<u>Amara</u> sp	19
	Lamellicornia	Trogidae	<u>Trox</u> sp	1
	Clavicornia	Nitidulidae		1
	Brachelytra	Staphylinidae	<u>Aleocharinae</u>	1
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	1
	Brachelytra	Staphylinidae	<u>Omaliniiae</u>	2
	Brachelytra	Staphylinidae		1

PART I(3) TABLE 6(b) contd...

PLOT	SUB-ORDER	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
C1	Geodephaga	Carabidae	<u>Carabus</u> sp	1
	Geodephaga	Carabidae	<u>Amara</u> sp	57
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	3
	Geodephaga	Carabidae	<u>Agonum</u>	1
	Geodephaga	Carabidae	<u>Clivina</u> sp	1
	Geodephaga	Carabidae	?	2
	Clavicornia	Nitidulidae	?	1
	?	Chrysomelidae	?	1
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	2
C2	Geodephaga	Carabidae	<u>Carabus</u>	1
	Geodephaga	Carabidae	<u>Amara</u>	76
	Geodephaga	Carabidae	<u>Pterostichus</u>	14
	Geodephaga	Carabidae	?	1
	Clavicornia	Nitidulidae	?	1
	Lamellicornia	Trogidae	<u>Trox</u> sp	2
	Rhynchophora	Curculionidae	?	2
	Geodephaga	Carabidae	<u>Bembidion</u> sp	1
	Brachelytra	Staphylinidae	<u>Omaliniinae</u>	1
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	2
	Brachelytra	Staphylinidae	<u>Aleocharinae</u>	4
	?	Chrysomelidae	<u>Halticinae</u>	2
C3	Geodephaga	Carabidae	<u>Amara</u> sp	7
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Geodephaga	Carabidae	?	6
		Otiorynchinae	?	1
	Clavicornia	Nitidulidae	?	4
	Geodephaga	Carabidae	<u>Bembidion</u> sp	2
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	6
	Brachelytra	Staphylinidae	<u>Aleocharine</u>	2
	?	Chrysomelidae	?	1
	?			1
C4	Geodephaga	Carabidae	<u>Amara</u> sp	3
	Geodephaga	Carabidae	<u>Pterostichus</u> sp	1
	Geodephaga	Carabidae	<u>Agonus</u> sp	2
	Geodephaga	Carabidae	<u>Harpalus</u> sp	2
	Geodephaga	Carabidae	?	3
	Clavicornia	Nitidulidae	?	1
	Brachelytra	Staphylinidae	<u>Omaliniinae</u>	3
	Brachelytra	Staphylinidae	<u>Tachyporus</u> sp	1
	Brachelytra	Staphylinidae	<u>Philonthius</u> sp	1
	Brachelytra	Staphylinidae	<u>Aleocharinae</u>	1

PART I(3) TABLE 6(b) contd...

4. DIPLOPODA

PLOT	FAMILY	GENUS	SPECIES	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	6
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	19
	Polydesmidae	<u>Brachydesmus</u>	sp	1
A2	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	7
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	13
A3	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	7
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	23
	Polydesmidae	<u>Brachydesmus</u>	sp	1
A4	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	13
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	24
	Polydesmidae	<u>Brachydesmus</u>	sp	12
B1	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	3
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	9
B2	Blaniulidae	<u>Choneiulus</u>	<u>littoralis</u>	4
	Polydesmidae	<u>Brachydesmus</u>	sp	1
B3	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	17
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	40
	Polydesmidae	<u>Brachydesmus</u>	sp	3
B4	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	20
	Polydesmidae	<u>Brachydesmus</u>	sp	13
B5	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	17
C1	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	1
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	6
C2	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	3
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	9
	Polydesmidae	<u>Brachydesmus</u>	sp	12
C3	Blaniulidae	<u>Isobates</u>	<u>littoralis</u>	1
	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	6
C4	Blaniulidae	<u>Choneiulus</u>	<u>palmatus</u>	6

PART I(3) TABLE 6(b) contd...

5. ISOPODA

PLOT	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Oniscidae	<u>Oniscus</u>	44
	Porcellionidae	<u>Porcellio</u>	98
	Trichoniscidae	<u>Trichoniscus</u>	48
	Armadillidiidae	<u>Armadillidium</u>	6
A2	Oniscidae	<u>Oniscus</u>	17
	Porcellionidae	<u>Porcellio</u>	72
	Trichoniscidae	<u>Trichoniscus</u>	16
	Armadillidiidae	<u>Armadillidium</u>	13
A3	Oniscidae	<u>Oniscus</u>	3
	Porcellionidae	<u>Porcellio</u>	67
	Trichoniscidae	<u>Trichoniscus</u>	6
	Armadillidiidae	<u>Armadillidium</u>	26
A4	Oniscidae	<u>Oniscus</u>	10
	Porcellionidae	<u>Porcellio</u>	74
	Trichoniscidae	<u>Trichoniscus</u>	65
	Armadillidiidae	<u>Armadillidium</u>	12
B1	Oniscidae	<u>Oniscus</u>	3
	Porcellionidae	<u>Porcellio</u>	46
	Trichoniscidae	<u>Trichoniscus</u>	211
	Armadillidiidae	<u>Armadillidium</u>	1
B2	Oniscidae	<u>Oniscus</u>	3
	Porcellionidae	<u>Porcellio</u>	36
	Trichoniscidae	<u>Trichoniscus</u>	81
	Armadillidiidae	<u>Armadillidium</u>	1
B3	Oniscidae	<u>Oniscus</u>	1
	Porcellionidae	<u>Porcellio</u>	40
	Trichoniscidae	<u>Trichoniscus</u>	169
	Armadillidiidae	<u>Armadillidium</u>	1
B4	Oniscidae	<u>Oniscus</u>	11
	Porcellionidae	<u>Porcellio</u>	36
	Trichoniscidae	<u>Trichoniscus</u>	57
	Armadillidiidae	<u>Armadillidium</u>	1
B5	Oniscidae	<u>Oniscus</u>	2
	Porcellionidae	<u>Porcellio</u>	23
	Trichoniscidae	<u>Trichoniscus</u>	29
	Armadillidiidae	<u>Armadillidium</u>	0

PART I(3) TABLE 6(b) contd...

PLOT	FAMILY	GENUS	NUMBER IN POOLED SAMPLE AT EACH PLOT
C1	Oniscidae	<u>Oniscus</u>	1
	Porcellionidae	<u>Porcellio</u>	25
	Trichoniscidae	<u>Trichoniscus</u>	274
	Armadillidiidae	<u>Armadillidium</u>	1
C2	Oniscidae	<u>Oniscus</u>	15
	Porcellionidae	<u>Porcellio</u>	80
	Trichoniscidae	<u>Trichoniscus</u>	147
	Armadillidiidae	<u>Armadillidium</u>	0
C3	Oniscidae	<u>Oniscus</u>	1
	Porcellionidae	<u>Porcellio</u>	40
	Trichoniscidae	<u>Trichoniscus</u>	140
	Armadillidiidae	<u>Armadillidium</u>	0
C4	Oniscidae	<u>Oniscus</u>	0
	Porcellionidae	<u>Porcellio</u>	27
	Trichoniscidae	<u>Trichoniscus</u>	115
	Armadillidiidae	<u>Armadillidium</u>	0

6. ORTHOPTERA

PLOT	FAMILY	NUMBER IN POOLED SAMPLE AT EACH PLOT
A1	Tettigoniidae	5
A2	Tettigoniidae	7
A3	Tettigoniidae	7
A4	Tettigoniidae	28
B1	Tettigoniidae	10
B2	Tettigoniidae	34
B3	Tettigoniidae	8
B4	Tettigoniidae	9
B5	Tettigoniidae	14
C1	Tettigoniidae	61
	Acridiidae	1
C2	Tettigoniidae	58
C3	Tettigoniidae	28
C4	Tettigoniidae	17

PART I(3) TABLE 6 contd...

TABLE 6(c) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a ten day period at Times Beach. Total dry matter (g) contribution and percentage dry matter contribution (%) per plot.
OCTOBER 1985

PLOT	PRED. COL.	ARAN.	OPIO.	CHIL.	HERB. COL.	ORTH.	DIPL.	ISOP.	OTHERS
A1 (g)	0.068	0.016	0.055	0.035	0.028	0.069	0.126	1.343	0.054
(%)	3.8	0.89	3.1	2.0	1.6	3.8	7.0	74.9	3.0
A2 (g)	0.102	0.094	0.073	0.019	0.008	0.089	0.108	0.873	0.034
(%)	7.3	6.7	5.2	1.4	0.57	6.4	7.7	62.4	2.4
A3 (g)	0.008	0.113	0.030	0.001	0.003	0.092	0.135	0.673	0.038
(%)	0.73	10.3	2.7	0.09	0.27	8.4	12.4	61.6	3.5
A4 (g)	0.373	0.013	0.177	0.029	0.020	0.273	0.705	0.221	0.197
(%)	18.6	0.6	8.8	1.4	1.0	13.6	35.1	11.0	9.8
B1 (g)	0.401	0.006	0.095	0.002	0.005	0.128	0.102	0.441	0.029
(%)	33.2	0.50	7.9	0.17	0.41	10.6	8.4	36.5	2.4
B2 (g)	0.543	0.011	0.113	0.027	0.005	0.342	0.040	0.334	0.078
(%)	36.4	0.74	7.6	1.8	0.33	22.9	2.7	22.4	5.2
B3 (g)	0.314	0.005	0.107	0.084	0.003	0.077	0.285	0.444	0.093
(%)	2.2	0.35	7.5	5.9	0.21	0.50	20.2	31.4	6.6
B4 (g)	0.108	0.040	0.120	0.005	0.003	0.062	0.165	0.363	0.070
(%)	11.5	4.3	12.8	0.5	0.3	6.6	0.2	38.8	7.5
B5 (g)	0.343	0.030	0.092	0.017	0.009	0.163	0.142	0.178	0.104
(%)	31.8	2.8	8.5	1.6	0.8	15.1	13.2	16.5	9.6
C1 (g)	1.270	0.071	0.086	0.002	0.001	0.867	0.117	0.478	0.278
(%)	40.1	2.2	2.7	0.63	0.03	27.4	3.7	15.1	8.8
C2 (g)	2.222	0.038	0.134	0.111	0.034	0.690	0.107	0.772	0.154
(%)	52.1	0.9	3.1	2.6	0.8	16.2	2.5	18.1	3.6
C3 (g)	0.153	0.071	0.086	0.037	0.034	0.308	0.207	0.337	0.061
(%)	11.86	5.5	6.6	2.9	2.6	23.8	16.0	26.0	4.7
C4 (g)	0.185	0.089	0.062	0.026	<0.001	0.164	0.052	0.333	0.082
(%)	18.6	9.0	6.2	2.6	-	16.5	5.2	33.5	8.3

PART I(3) TABLE 6 contd...

TABLE 6(d) Metal concentrations in major groups of invertebrate fauna, four pooled samples per plot (ug/g, dry weight). OCTOBER 1985

CARNIVOROUS SPECIES

(1) Predatory COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	77	15	<1.1	0.56	6.1	<3.9
A2	104	22	1.4	4.0	10	9.5
A3	-	-	-	-	-	-
A4	117	16	1.1	1.6	6.6	9.7
B1	103	17	1.3	2.6	4.1	5.3
B2	103	16	<0.69	1.0	4.1	5.2
B3	143	21	0.87	4.0	3.1	4.0
B4	122	21	1.8	4.5	8.6	7.0
B5	82	18	0.48	0.82	2.3	3.2
C1	108	15	0.97	1.6	2.4	2.6
C2	123	18	1.4	2.3	2.4	2.9
C3	108	16	1.9	1.7	7.7	8.2
C4	76	14	2.7	0.89	8.4	4.2

(2) ARANEIDA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	166	111	18	15	-	9.0
Veg. B	140	77	4.8	8.8	11	14
Veg. C	142	103	2.4	18	21	8.5

(3) OPIOLONES

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	165	37	1.9	14	3.9	8.5
Veg. B	121	38	2.1	12	2.6	8.6
Veg. C	132	39	1.5	16	4.2	8.1

PART I(3) TABLE 6(d) contd..

(4) CHILOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	152	48	32	4.2	3.5	<2.9
Veg. B	152	37	3.8	3.5	8.5	9.1
Veg. C	138	30	2.1	5.0	1.3	<7.9

HERBIVOROUS SPECIES

(5) Herbivorous COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	222	42	3.1	0.99	19	13
Veg. B	153	35	2.2	0.69	11	13
Veg. C	167	26	3.6	0.72	22	<7.9

(6) ORTHOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	175	31	2.3	12	7.4	11
A2	217	36	4.4	9.8	9.9	16
A3	182	45	6.7	11	8.6	15
A4	186	34	3.3	6.8	7.9	17
B1	164	28	3.7	17	7.3	10
B2	192	31	2.5	14	5.0	8.9
B3	168	35	3.3	9.1	8.1	14
B4	155	30	2.5	5.5	12	11
B5	150	23	1.7	10	3.3	5.6
C1	229	28	2.0	12	1.9	5.2
C2	250	32	5.2	11	2.8	6.3
C3	183	33	3.9	6.8	14	9.4
C4	120	19	2.2	8.6	3.0	6.6

PART I(3) TABLE 6(d) contd...

DETRITIVOROUS SPECIES

(7) DIPLOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	186	784	2.7	2.8	6.6	12
A2	176	706	2.7	2.3	6.6	12
A3	188	662	1.8	2.3	6.9	11
A4	229	760	1.7	3.2	3.5	11
B1	222	632	2.1	2.8	8.5	13
B2	243	839	<1.8	2.8	12	10
B3	248	901	2.9	3.5	6.1	16
B4	244	765	2.9	3.2	6.3	11
B5	216	798	2.2	3.4	5.2	12
C1	124	494	1.3	1.9	4.0	8.0
C2	248	718	2.5	2.8	7.1	12
C3	252	962	3.6	4.0	7.8	17
C4	217	716	<1.4	3.3	7.9	9.1

(8) ISOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	243	328	2.1	33	7.8	16
A2	291	305	3.8	22	14	20
A3	373	285	2.4	14	7.9	15
A4	349	320	2.8	24	10	16
B1	402	239	4.3	23	15	21
B2	291	198	3.3	21	11	16
B3	283	201	3.5	27	9	20
B4	318	261	2.4	21	6.9	12
B5	335	216	4.4	19	6.2	11
C1	274	136	1.6	22	6.8	9.0
C2	292	263	2.1	29	11	12
C3	286	226	3.5	20	13	19
C4	270	206	2.2	19	6.7	10

PART I(3) TABLE 7.

TABLE 7 Record of numbers of soil dwelling invertebrates collected in pitfall traps. MAY 1986

PLOT	COL.	ARAN.	CHIL.	DIP.	ISOP.	OTHERS
A1	9	2	5	98	17	1 Homoptera/5 Hymenoptera/1 Diptera 1 Mollusca
A2	48	3	2	53	17	3 Hymenoptera/1 Acarina
A3	20	5	1	11	11	6 Hymenoptera/2 Diptera/5 Acarina 1 Lepidoptera
A4	14	6	-	59	10	3 Hymenoptera/3 Acarina/1 Neuroptera 1 Orthoptera
B1	39	6	-	20	5	1 Orthoptera/1 Lumbricidae
B2	13	7	-	34	14	3 Hymenoptera/1 Diptera
B3	3	2	1	39	13	1 Hymenoptera/2 Hemiptera
B4	42	15	3	14	28	8 Hymenoptera/4 Acarina/1 Orthoptera
B5	32	12	1	48	12	3 Hymenoptera/4 Acarina 1 Lumbricidae
C1	59	7	5	14	2	1 Acarina/1 Orthoptera/2 Lumbricidae
C2	11	7	3	65	124	1 Hymenoptera/2 Lumbricidae
C3	42	18	-	12	1	1 Hymenoptera/7 Diptera/2 Acarina 1 Hemiptera/2 Orthoptera/1 Lumbric.
C4	43	8	2	30	37	6 Hymenoptera/5 Diptera/3 Acarina

PART I(3) TABLE 7 contd...

TABLE 7(b) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a ten day period at Times Beach. Total dry matter (g) contribution and percentage dry matter contribution (%) per plot. MAY 1986

PLOT	PRED. COL.	ARANEIDA	CHILOPODA	HERB. COL.	DIPLOPODA	ISOPODA	OTHERS
A1 (g)	1.056	-	0.010	0.002	0.371	0.128	0.024
(%)	66.4	-	0.06	0.10	23.3	8.0	1.5
A2 (g)	4.369	0.018	-	-	0.234	0.069	0.004
(%)	93.5	0.4	-	-	4.7	1.4	0.1
A3 (g)	0.222	0.001	-	0.014	0.031	0.046	0.239
(%)	40.1	0.2	-	2.5	5.6	8.3	43.2
A4 (g)	0.706	0.002	-	0.003	0.247	0.036	0.018
(%)	69.8	0.2	-	0.3	24.4	3.6	1.8
B1 (g)	0.578	0.049	-	-	0.122	0.022	0.153
(%)	62.6	5.3	-	-	13.2	2.4	16.6
B2 (g)	0.188	0.097	-	-	0.168	0.052	0.002
(%)	37.1	19.1	-	-	33.1	10.3	0.4
B3 (g)	0.018	0.005	-	-	0.161	0.015	0.001
(%)	9.0	2.5	-	-	80.5	7.5	0.5
B4 (g)	0.439	0.008	0.002	0.025	0.080	0.060	0.028
(%)	66.3	1.2	3.3	3.8	12.1	9.1	4.2
B5 (g)	0.620	0.125	0.001	0.003	0.212	0.046	0.071
(%)	57.5	11.6	0.1	0.3	19.6	4.3	6.6
C1 (g)	1.056	-	0.010	0.002	0.371	0.128	0.024
(%)	66.4	-	0.6	0.1	23.3	8.0	1.5
C2 (g)	0.131	0.029	0.076	0.041	0.274	0.235	0.011
(%)	16.4	3.6	9.5	5.1	34.4	29.5	1.4
C3 (g)	0.159	0.030	0.141	-	0.069	0.019	0.060
(%)	61.9	3.6	16.8	-	8.2	2.3	7.2
C4 (g)	0.314	0.020	0.048	0.008	0.445	0.116	0.047
(%)	48.7	3.1	7.4	1.2	21.9	16.0	1.7

PART I(3) TABLE 7 contd...

TABLE 7(c) Metal concentrations in major groups of invertebrate fauna, four pooled samples per plot (ug/g, dry weight). MAY 1986

CARNIVOROUS SPECIES

(1) Predatory COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	148	19	-	2.0	4.3	-
A2	140	19	-	7.1	1.4	-
A3	149	18	-	3.5	2.0	-
A4	151	16	-	6.1	-	-
B1	123	16	-	3.8	4.0	-
B2	83	14	-	3.2	2.2	-
B3						
B4	112	22	-	4.1	3.4	-
B5	119	19	-	6.6	-	-
C1	120	21	-	3.4	4.3	-
C2	84	15	-	1.0	2.0	-
C3	109	21	-	5.0	6.5	-
C4	106	18	-	4.6	2.9	-

(2) ARANEIDA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	325	230	-	71	5.9	-
Veg. B	311	177	23	36	4.6	-
Veg. C	299	114	10	29	5.3	-

(3) CHILOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	818	67	-	-	-	-
Veg. B	193	47	-	9.0	-	-
Veg. C	212	50	12	5.2	2.9	-

PART I(3) TABLE 7(c) contd...

HERBIVOROUS SPECIES

(4) Herbivorous COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	127	33	-	-	-	-
Veg. B	204	34	-	-	-	-
Veg. C	190	33	-	-	7.7	-

(5) ORTHOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
All plots.	188	56	-	3.2	7.0	8.3

PART I(3) TABLE 7(c) contd...

DETRITIVOROUS SPECIES

(6) DIPLOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	213	839	3.3	3.9	6.2	15
A2	393	551	-	2.2	8.3	29
A3	304	639	-	5.4	5.2	-
A4	167	702	-	4.1	3.8	-
B1	266	689	-	6.9	6.9	23
B2	218	851	3.3	3.1	5.6	18
B3	176	556	4.4	2.8	5.3	15
B4	242	683	4.3	3.3	5.1	14
B5	235	628	3.0	3.9	3.7	12
C1	323	876	-	5.0	8.4	-
C2	238	705	4.2	3.7	5.0	-
C3	241	756	-	4.5	6.3	-
C4	214	683	4.3	3.3	5.1	14

(7) ISOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	226	242	4.3	20	5.5	15
A2	501	223	7.6	27	12	26
A3	374	243	-	11	7.2	-
A4	263	186	-	27	5.8	-
B1	251	189	-	17	7.8	-
B2	343	194	-	14	11	-
B3	326	295	-	22	19	-
B4	290	237	-	29	7.6	-
B5	323	192	-	24	6.6	-
C1 & 3	421	221	-	11	12	-
C2	167	142	16	28	6.1	-
C4	232	192	7.1	20	6.1	16

PART I(3) TABLE 8.

TABLE 8(a) Record of numbers of soil dwelling invertebrates collected in pitfall traps. NOVEMBER 1986

PLOT	COL.	ARAN.	OPIO.	CHIL.	DIPL.	ISOP.	ORTH.	OTHERS
A1	9	8	5	1	11	43	-	12 Diptera/ 3 Hemiptera 1 Mollusca/ 2 Hymenoptera
A2	14	21	3	-	19	84	-	13 Diptera/21 Hymenoptera 4 Dermaptera/3 Hemiptera
A3	6	12	18	6	62	421	2	4 Acarina/I Mollusc/1 Lum 12 Diptera/1 Hemiptera 9 Hymenoptera/3 Mollusca 9 Lumbricidae
A4	9	4	3	3	34	62	-	4 Diptera/1 Hemiptera 1 Mollusca/1 Hymenoptera 6 Lumbricidae
B1	12	11	1	1	4	5	1	6 Diptera/4 Hymenoptera 8 Mollusca
B2	12	19	4	1	4	6	1	9 Diptera/2 Hymenoptera 15 Mollusca/4 Hemiptera
B3	9	14	11	1	13	94	4	9 Diptera/1 Hemiptera 2 Neuroptera/1 Mollusca
B4	10	14	3	2	5	11	3	4 Diptera/8 Hymenoptera 37 Mollusca/1 Acarina 1 Lumbricidae
B5	12	5	8	1	2	260	1	6 Diptera/9 Hymenoptera 7 Mollusca/1 Lumbricidae
C1	7	18	2	-	2	20	-	2 Diptera/4 Mollusca 1 Lumbricidae
C2	16	16	4	-	7	82	5	12 Diptera/1 Hymenoptera 4 Dermaptera/4 Mollusca
C3	13	26	2	-	2	3	7	19 Diptera/1 Hymenoptera 2 Mollusca/1 Lepidoptera
C4	15	25	2	1	2	2	2	9 Diptera/1 Hymenoptera 1 Hemiptera/1 Acarina 1 Mollusca/1 Lepidoptera

PART I(3) TABLE 8 contd...

TABLE 8(b) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a ten day period at Times Beach. Total dry matter (g) contribution and percentage dry matter contribution (%) per plot.
NOVEMBER 1986.

PLOT	PRED. COL.	ARAN.	OPIO.	CHIL.	HERB. COL.	DIPL.	ISOP.	ORTH.	OTHERS
A1 (g)	0.289	0.011	0.036	0.001	-	0.013	0.119	-	0.090
(%)	51.69	1.97	6.44	0.18	-	2.33	21.29	-	16.10
A2 (g)	0.253	0.025	0.013	0.112	0.006	0.061	0.232	-	0.190
(%)	28.36	2.80	1.46	12.56	0.67	6.84	26.01	-	21.30
A3 (g)	0.066	0.021	0.110	0.029	0.001	0.169	0.303	0.021	0.110
(%)	7.95	2.53	13.25	3.49	0.12	20.36	36.51	2.53	13.25
A4 (g)	0.109	0.006	0.025	0.109	0.016	0.004	0.561	-	0.210
(%)	10.48	0.58	2.40	10.48	1.54	0.38	53.94	-	20.19
B1 (g)	0.074	0.037	0.009	0.024	0.001	0.009	0.004	0.016	0.020
(%)	38.14	19.07	4.64	12.37	0.52	4.64	2.06	8.25	10.31
B2 (g)	0.044	0.076	0.026	0.003	0.004	0.007	0.016	0.016	0.020
(%)	20.75	35.85	12.26	1.42	1.89	3.30	7.55	7.55	9.43
B3 (g)	0.112	0.038	0.088	0.001	-	0.031	0.100	0.038	0.030
(%)	25.57	8.68	20.09	0.23	-	7.08	22.83	8.68	6.85
B4 (g)	0.121	0.009	0.016	0.004	0.001	0.020	0.017	0.044	0.140
(%)	32.53	2.42	4.30	1.08	0.27	5.38	4.57	11.83	37.63
B5 (g)	0.108	0.009	0.044	0.005	-	0.053	0.230	0.011	0.080
(%)	20.00	1.67	8.15	0.93	-	9.81	42.59	2.04	14.81
C1 (g)	0.038	0.084	0.017	-	-	0.016	0.037	-	0.270
(%)	8.23	18.18	3.68	-	-	3.46	8.01	-	58.44
C2 (g)	0.202	0.031	0.017	-	-	0.044	0.058	0.075	0.160
(%)	34.41	5.28	2.89	-	-	7.49	9.88	12.78	27.26
C3 (g)	0.072	0.099	0.017	-	-	0.005	0.003	0.087	0.130
(%)	17.43	23.97	4.12	-	-	1.21	0.73	21.07	31.47
C4 (g)	0.147	0.124	0.021	-	-	0.029	0.016	0.027	0.150
(%)	28.59	24.12	4.09	-	-	5.64	3.11	5.25	29.18

PART I(3) TABLE 8 contd...

TABLE 8(c) Metal concentrations in major groups of invertebrate fauna, four pooled samples per plot (ug/g, dry weight). NOVEMBER 1986

CARNIVOROUS SPECIES

(1) Predatory COLEOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	179	54	3.0	4.9	2.4	2.4
A2	120	36	1.3	-	7.5	2.4
A3	78	17	1.4	1.1	8.9	<4.0
A4	80	17	2.3	2.1	5.6	3.1
B1	96	22	4.1	1.5	7.6	10
B2	139	20	4.6	4.3	4.3	<6.0
B3	86	16	2.3	2.4	2.3	5.8
B4	85	14	1.4	2.4	2.7	2.2
B5	95	16	3.3	3.0	4.4	4.1
C1	98	23	5.2	1.9	6.5	14
C2	86	17	2.5	3.0	1.0	4.2
C3	82	16	2.9	2.0	6.4	5.0
C4	94	20	5.5	3.2	6.4	5.0

(2) ARANEIDA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1 & A4	221	82	7.2	8.8	8.1	<16
A2	231	93	4.9	8.0	2.8	<11
A3	188	79	5.4	9.0	7.0	<13
B1	207	89	5.1	18	6.5	9.5
B2	193	60	1.5	14	<0.26	3.8
B3	213	74	9.2	7.1	0.56	8.0
B4 & B5	248	90	<4.4	15	4.1	<15
C1	215	57	3.0	7.2	7.2	14
C2	208	71	<2.4	7.1	5.3	<8.6
C3	205	67	1.4	8.2	1.9	4.6
C4	208	59	2.5	6.8	3.7	3.6

PART I(3) TABLE 8(c) contd...

(3) OPIOLONES

ZONE	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	526	53	5.4	31	15	7.1
Veg. B	483	44	3.9	28	4.2	11
Veg. C	414	33	18	17	11	18

(4) CHILOPODA

ZONE	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	281	40	6.9	3.3	2.5	2.8
Veg. B	454	121	33	8.6	16	18

Veg. C Insufficient sample

HERBIVOROUS SPECIES

(5) Herbivorous COLEOPTERA

ZONE	Zn	Cu	Ni	Cd	Cr	Pb
Veg. A	222	46	7.9	1.1	18	<11
Veg. B	171	78	35	2.9	76	<57

Veg. C Insufficient sample

(6) ORTHOPTERA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1, A2 & A4			Insufficient sample			
A3	122	32	9.5	6.5	-	<13
B1 & B2	174	35	8.1	9.5	16	16
B3	143	32	5.6	4.1	6.0	11
B4 & B5	154	23	7.1	8.4	5.4	9.7
C1			Insufficient sample			
C2	133	22	3.2	9.2	4.1	9.7
C3	141	23	2.8	4.7	2.1	7.6
C4	146	34	8.1	4.4	8.8	12

PART I(3) TABLE 8(d) contd...

DETRITIVOROUS SPECIES

(7) DIPLOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1 & A4	236	461	12	4.8	6.8	16
A2	267	611	10.4	4.9	5.2	11
A3	201	586	7.0	3.8	5.9	14
B1 & B2	335	711	29	5.8	18	22
B3	291	555	19	4.7	11	21
B4 & B5	154	405	6.0	3.1	5.0	13
C1, C3 & C4	270	518	8.0	5.0	10.1	13
C2	174	419	8.1	3.3	5.0	10

(8) ISOPODA

PLOT	Zn	Cu	Ni	Cd	Cr	Pb
A1	229	110	5.2	24	6.4	17
A2	305	150	4.1	24	5.3	16
A3	235	118	3.7	37	4.6	24
A4	166	142	3.3	35	3.0	13
B1 & B2	320	106	18	16	12	25
B3	290	124	5.9	18	6.2	16
B4	369	84	20	31	17	<15
B5	207	89	5.6	41	6.8	18
C1	235	148	5.4	25	6.9	16
C2	280	96	6.4	28	7.0	17
C3 & C4	481	314	16	15	10.3	19

PART I(4) TABLE 9

Native earthworms.

Metal concentrations measured in the native earthworms collected using formalin vermifuge from the defined vegetation zones at Times Beach. All concentrations expressed as ug/g, dry weight.

TABLE 9 Native earthworms collected at Times Beach. MAY 1985

All species, from each plot pooled for analysis and no correction made for the presence of substrate within the earthworm gut.

Plot	Zn	Cu	Ni	Cd	Cr	Pb
A1	1089	65	9.0	43	27	44
A4	1139	159	13	91	42	77
B5	530	79	9.1	101	18	31
C2	517	78	16	18	70	77

PART I(4) TABLE 10

TABLE 10 Native earthworms collected in NOVEMBER 1986.

Species from each plot pooled for analysis and concentrations corrected to eliminate the effect of substrate within the earthworm gut (Stafford & McGrath, 1986). All concentrations expressed as ug/g, dry weight.

Vegetation type A

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
<u>Lumbricus terrestris</u>						
A1	2921	23	8.8	39	-	-
A2	2790	13	0.80	60	-	2.5
A3	3604	12	1.4	45	1.6	2.7
A4	2994	12	2.5	46	-	-
<u>Lumbricus rubellus</u>						
A3	2050	15	2.5	69	-	0.34
A4	1567	17	2.3	44	-	-
<u>Allolobophora caliginosa</u>						
A1	1115	23	-	28	-	-
A2	1220	25	1.7	24	1.0	-
A4	1010	30	4.1	30	15	1.2
<u>Allolobophora chlorotica</u>						
A1	461	22	0.57	35	-	-
A2	467	21	4.6	36	14	6.8
A4	309	26	8.7	26	-	5.0
Means for vegetation type A by earthworm species:						
<u>L. terrestris</u>	3077	15	3.4	48	1.6	18
<u>L. rubellus</u>	1809	16	2.4	57	-	0.34
<u>A. caliginosa</u>	1115	26	2.9	27	7.8	1.2
<u>A. chlorotica</u>	412	23	4.6	35	14	27

PART I(4) TABLE 10 contd...

Vegetation type B

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
<u>Lumbricus rubellus</u>						
B1	945	15	2.5	69	-	0.36
B2	1149	22	3.1	64	3.6	0.25
B3	1490	16	0.05	67	-	-
B4	1625	20	-	68	-	-
<u>Allolobophora caliginosa</u>						
B1	789	19	2.85	34	-	4.3
B3	1328	22	-	26	-	-
<u>Allolobophora chlorotica</u>						
B1	477	23	11	53	1.1	8.7
B2	544	32	13	58	30	6.0
B3	381	20	3.0	43	6.5	12
Means for vegetation type B by earthworm species:						
<u>L.rubellus</u>	1302	19	1.9	67	3.6	0.31
<u>A.caliginosa</u>	1059	21	2.9	30	-	4.3
<u>A.chlorotica</u>	467	25	9.1	51	13	8.9

PART I(4) TABLE 10 contd...

Vegetation type C

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb

Lumbricus rubellus

C2	1580	13	2.9	73	-	-
C3	1084	9	-	42	-	-

Allolobophora caliginosa

C1	975	19	0.10	39	-	-
C3	1014	13	3.2	35	-	-

Allolobophora chlorotica

C2	678	30	6.3	67	5.8	3.6
C3	155	12	2.4	22	-	-

Means for vegetation type C by earthworm species:

<u>L.terrestris</u>	1565	18	-	48	-	-
<u>L.rubellus</u>	1332	11	2.9	57	-	-
<u>A.caliginosa</u>	995	16	1.6	37	-	-
<u>A.chlorotica</u>	417	28	4.3	44	5.8	3.6

PART I(5) TABLES 11, 12 & 13 Vertebrate species collected in Times Beach upland area and used for analysis.

TABLE 11 Toads (Bufo americanas) collected in pitfall traps and pooled for analysis (ug/g, dry weight).

MAY 1985

Tissue	Zn	Cu	Ni	Cd	Cr	Pb
Whole specimens	131	-	2.3	5.9	5.7	9.5
	130	30	1.9	4.5	5.4	5.8
	138	29	2.0	5.4	2.7	4.1
Liver	115	100	<2.4	9.2	12	<8.5
	145	173	<4.2	6.9	15	<15
Kidney	172	61	<11	12	35	<37
	217	36	<11	13	44	<40
Bone	180	7.6	<1.4	3.1	15	<5.0

NOVEMBER 1986

Tissue	Zn	Cu	Ni	Cd	Cr	Pb
Whole specimens	94	21	3.0	3.4	1.4	<4.0
	92	17	3.4	3.3	3.4	6.7
Muscle	135	15	8.6	3.2	4.2	5.2
	245	36	7.0	3.5	1.3	3.6
Liver	94	39	2.7	10	2.3	<3.4
	129	40	2.3	3.8	1.1	<5.1
Kidney	-	54	-	20	-	-
	171	54	9.3	11	5.4	<20
Bones	134	16	8.9	11	7.8	13
	138	18	4.8	3.3	4.1	<7.8

PART I(5) TABLE 12(a)

Birds and mammals collected at Times Beach and designated reference areas.

Species	Site	Date	Tissues collected for analysis
RED-WING BLACKBIRDS (RWBB) - <u>Agelaius phoeniceus</u>			
RWBB Adult	Times Beach	25 Aug 86	Feathers, Liver, Kidney, Muscle, Bone.
RWBB Immature	Times Beach	19 Jun 86	Feathers, Liver, Kidney, Muscle, Bone.
RWBB Immature	Times Beach	20 Jun 86	Feathers, Liver, Kidney, Muscle, Bone.
RWBB Immature	Times Beach	20 Jun 86	Feathers, Liver, Kidney, Muscle, Bone.
RWBB Adult	Amherst*	7 Jun 86	Feathers, Liver, Kidney, Muscle, Bone.
RWBB Immature	Amherst*	7 Jun 86	Feathers, Liver, Kidney, Muscle, Bone.
7 RWBB Egg	Times Beach	13 Jun 86	Shell, Yolk & Albumin.
4 RWBB Egg	Amherst*	7 Jun 86	Shell, Yolk & Albumin.

MALLARD DUCKS - Anas platyrhynchos

Duck Immature	Reference	Feathers, Liver, Kidney, Muscle, Bone.
Duck Immature	Reference	Feathers, Liver, Kidney, Muscle, Bone.
Duck Immature	Reference	Feathers, Liver, Kidney, Muscle, Bone.
Duck Immature	Reference	Feathers, Liver, Kidney, Muscle, Bone.

MUSKRAT - Ondatra zibethica

Muskrat 21b 10oz	Times Beach	19 Oct 86	Fur, Liver, Kidney, Muscle, Bone, Spleen.
Muskrat 31b 2oz	Times Beach	18 Oct 86	Fur, Liver, Kidney, Muscle, Bone, Spleen.
Muskrat 31b 1oz	Times Beach	12 May 86	Fur, Liver, Kidney, Muscle, Bone, Spleen.
Muskrat 31b 4oz	Times Beach	24 May 86	Fur, Liver, Kidney, Muscle, Bone, Spleen.
Muskrat 12oz	Times Beach	18 Oct 86	Fur, Liver, Kidney, Muscle, Bone, Spleen.

RED-WING BLACKBIRDS Egg Measurements.

Sample	Site	Length(mm)	Width(mm)	Total wt(g)	Shell thickness
RWBB-1	Times Beach	25.9	17.0	1.267	0.30
RWBB-2	Times Beach	26.1	17.3	1.463	0.30
RWBB-3	Times Beach	25.2	16.8	2.047	0.30
RWBB-4	Times Beach		No measurement		
RWBB-10	Times Beach		No measurement		
RWBB-11	Times Beach	23.7	17.6	1.178	0.30
RWBB-12	Times Beach	23.5	17.3	1.217	0.25
RWBB-5	Amherst*	25.6	17.8	3.704	0.30
RWBB-6	Amherst*	26.1	17.5	0.878	0.25
RWBB-7	Amherst*	26.1	17.8	crushed	0.30
RWBB-8	Amherst*	24.9	17.1	1.253	0.35

* Amherst = designated reference area

PART I(5) TABLE 12(b).

TABLE 12(b) All samples listed in the Table 12(a) were subject to specified PCB, PAH and pesticide analysis and determination of Hg and As content. The results of these analyses are given below.

Compound/Element	Detection limit
PCB Components:	
2,4,4'-Trichlorobiphenyl	0.10
2,2',5,5'-Tetrachlorobiphenyl	0.10
2,2',4,5'-Tetrachlorobiphenyl	0.10
2,3',4',5-Tetrachlorobiphenyl	0.10
2,2',4,5,5'-Pentachlorobiphenyl	0.10
2,2',3,4,5'-Pentachlorobiphenyl	0.10
2,2',4,4',5,5'-Hexachlorobiphenyl	0.10
2,2',3,4,4',5'-Hexachlorobiphenyl	0.10
2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.10
PAH Components:	
Phenanthrene	0.30
Anthracene	0.30
Fluoranthene	0.30
Pyrene	0.30
3,6-Dimethylphenanthrene	0.50
Triphenylene	0.50
Benzo(b)Fluorene	0.50
Benzo(a)Anthracene	0.50
Chrysene	0.50
Benzo(e)pyrene	0.50
Benzo(j)fluoranthene	0.50
Perylene	0.50
Benzo(b)Fluoranthene	0.50
Benzo(a)pyrene	0.50
Dibenzo(a,j)anthracene	1.0
Dibenzo(a,i)pyrene	1.0
Benzo(ghi)perylene	1.0
Indeno(1,2,3-c,d)pyrene	1.0
3-Methylcholanthrene	1.0
Anthanthrene	1.0
Misc. Pesticides	
o,p-DDE	0.10
p,p'-dde	0.10
Hexachlorobenzene	0.10
Metals	
Mercury	0.60
Arsenic	0.07

Concentrations of organic compounds expressed as mg/kg wet weight
 Concentrations of metals expressed as mg/Kg dry weight.
 All samples analyzed were below the detection limits given above.

PART I(5) TABLE 12(c).

TABLE 12(c) Metal concentrations measured in the birds and mammals collected at Times Beach and the designated reference area. Mean concentration and maximum and minimum values in parentheses (ug/g, dry weight).

Sample	Zn	Cu	Ni	Cd	Cr	Pb
RED-WING BLACKBIRDS. - <u>Agelaius phoeniceus</u>						
Times Beach - Immature (n=3)						
Feathers	117	7.0	0.84	0.17	0.93	49
	(112-124)	(5.5-8.3)	(0.72-0.98)	(0.13-0.21)	(0.79-1.2)	(2.6-138)
Liver	41	7.8	<0.96	0.23	3.4	<3.4
	(36-45)	(5.9-9.7)		(0.20-0.26)	(1.8-4.9)	
Muscle	48	8.6	<0.91	0.14	1.3	9
	(25-62)	(6.9-10)		(<0.16&0.11)	(0.69-1.8)	(<3.2&18)
Bone	119	2.0	1.7	0.30	3.1	43
	(108-128)	(1.7-2.4)	(1.5-2.0)	(<2.5-0.33)	(2.3-4.7)	(<5.1-115)
Times Beach - Adult (n=1)						
Feathers	139	11	3.0	0.60	2.4	19
Liver	72	15	<0.90	2.3	1.8	<3.2
Muscle	57	6.9	<0.77	0.16	0.59	<2.7
Bone	141	1.8	2.0	0.32	8.6	15
Reference - Immature (n=1)						
Feathers	133	6.2	1.7	<0.13	1.4	<2.6
Liver	63	14	1.4	0.50	12	<3.4
Muscle	56	7.4	0.67	0.17	2.1	<1.6
Bone	180	2.0	3.0	0.38	3.8	6.7
Reference - Adult (n=1)						
Feathers	133	9.5	2.9	<0.13	1.7	9.0
Liver	61	18	<0.96	0.39	8.2	4.7
Muscle	29	14	<0.48	<0.09	1.2	<1.7
Bone	106	1.5	2.8	0.33	4.2	6.7
Times Beach - Eggs (n=3)						
Yolk & Alb.	70	2.4	1.17	<0.20	0.55	<4.1
	(69-71)	(2.2-2.8)			(0.25-0.91)	
Shell	8.9	5.0	3.1	0.52	2.3	6.3
	(5.3-14)	(2.5-9.3)	(2.4-3.5)	(0.44-0.61)	(2.0-2.6)	(5.5-7.4)
Reference - Eggs (n=2, pooled)						
Yolk & Alb.	49	2.8	<0.81	<0.14	<0.21	<2.9
Yolk & Alb.	69	2.9	<0.81	<0.14	<0.21	<0.29
Shell	21	2.0	3.5	0.61	2.2	7.1
Shell	94	2.2	2.5	0.82	2.3	8.1

PART I(5) TABLE 12(c) contd...

TABLE 12(c) Mice and vole tissue metal concentrations at the Times Beach and designated reference areas. Mean metal concentration $\pm$ standard deviation (ug/g, dry weight).

Sample	Zn	Cu	Ni	Cd	Pb
MEADOW VOLE - <u>Microtus pennsylvanicus</u>					
Times Beach (n=13)					
Liver	150 $\pm$ 33	16 $\pm$ 1.8	2.4 $\pm$ 3.0	4.9 $\pm$ 3.2	2.7 $\pm$ 0.45
Kidney	115 $\pm$ 17	19 $\pm$ 4.9	2.0 $\pm$ 1.4	10 $\pm$ 6.4	6.0 $\pm$ 3.1
Muscle	99 $\pm$ 62	9.7 $\pm$ 2.2	0.82 $\pm$ 0.76	0.20 $\pm$ 0.11	2.8 $\pm$ 0.92
Bone	179 $\pm$ 30	7.2 $\pm$ 1.3	3.6 $\pm$ 3.4	0.36 $\pm$ 0.22	23 $\pm$ 7.0
Binghamton Control (n=10)*					
Liver	101 $\pm$ 14	17 $\pm$ 1.7	1.2 $\pm$ 0.94	0.27 $\pm$ 0.08	1.4 $\pm$ 0.73
Kidney	93 $\pm$ 9.1	19 $\pm$ 2.4	7.1 $\pm$ 7.1	1.4 $\pm$ 0.33	3.7 $\pm$ 2.1
Muscle	63 $\pm$ 43	7.8 $\pm$ 1.9	0.80 $\pm$ 0.34	0.15 $\pm$ 0.05	0.57 $\pm$ 0.28
Bone	168 $\pm$ 48	6.6 $\pm$ 0.58	3.0 $\pm$ 1.7	0.37 $\pm$ 0.17	7.2 $\pm$ 2.1
Binghamton Contaminated (n=13)*					
Liver	173 $\pm$ 41	20 $\pm$ 1.6	1.4 $\pm$ 0.79	9.0 $\pm$ 3.1	1.8 $\pm$ 0.97
Kidney	128 $\pm$ 17	21 $\pm$ 2.7	5.2 $\pm$ 4.2	24 $\pm$ 10	6.6 $\pm$ 2.7
Muscle	64 $\pm$ 20	9.0 $\pm$ 0.75	0.90 $\pm$ 0.34	0.28 $\pm$ 0.13	2.8 $\pm$ 0.79
Bone	214 $\pm$ 91	8.4 $\pm$ 1.8	2.4 $\pm$ 1.5	0.35 $\pm$ 0.25	14 $\pm$ 3.2
WHITE FOOTED MICE - <u>Peromyscus leucopus</u>					
Times Beach (n=13)					
Liver	194 $\pm$ 52	20 $\pm$ 5.9	0.92 $\pm$ 0.88	1.3 $\pm$ 0.65	3.8 $\pm$ 1.2
Kidney	184 $\pm$ 66	22 $\pm$ 4.7	3.7 $\pm$ 3.0	3.9 $\pm$ 2.1	4.9 $\pm$ 3.8
Muscle	92 $\pm$ 49	15 $\pm$ 1.8	2.6 $\pm$ 2.4	0.39 $\pm$ 0.22	5.1 $\pm$ 1.8
Bone	187 $\pm$ 17	7.7 $\pm$ 1.1	2.9 $\pm$ 3.4	0.45 $\pm$ 0.41	20 $\pm$ 4.0
Binghamton Control (n=10)*					
Liver	141 $\pm$ 52	19 $\pm$ 2.9	3.5 $\pm$ 1.7	0.36 $\pm$ 0.13	1.6 $\pm$ 0.94
Kidney	123 $\pm$ 21	21 $\pm$ 2.1	3.5 $\pm$ 1.7	1.6 $\pm$ 0.64	2.9 $\pm$ 1.9
Muscle	64 $\pm$ 33	9.8 $\pm$ 1.9	0.50 $\pm$ 0.23	0.18 $\pm$ 0.06	0.46 $\pm$ 0.14
Bone	167 $\pm$ 29	7.2 $\pm$ 1.7	2.4 $\pm$ 0.96	0.32 $\pm$ 0.18	5.9 $\pm$ 3.0
Binghamton Contaminated (n=13)*					
Liver	226 $\pm$ 46	26 $\pm$ 3.8	2.1 $\pm$ 1.6	3.1 $\pm$ 1.6	2.2 $\pm$ 1.1
Kidney	159 $\pm$ 22	22 $\pm$ 1.6	6.1 $\pm$ 4.8	6.0 $\pm$ 2.0	6.6 $\pm$ 5.1
Muscle	90 $\pm$ 19	12 $\pm$ 1.7	1.3 $\pm$ 0.52	0.23 $\pm$ 0.11	3.1 $\pm$ 1.0
Bone	183 $\pm$ 68	11 $\pm$ 1.9	3.8 $\pm$ 1.7	0.54 $\pm$ 0.31	14 $\pm$ 3.0

* Designated reference areas were the Binghamton control and contaminated sites.

WETLAND AREA: TIMES BEACH

PART II(1) TABLE 13

TABLE 13 An inventory of the vegetation present at the Times Beach CDF was made and three vegetation zones defined. In each zone the following samples of vegetation were collected for analysis of heavy metal content. JULY 1985.

Plot	Plant species	Plant parts
D1	<u>Phragmites australis</u> <u>Typha angustifolia</u>	Leaves, stems, flowers. Leaves
D2	<u>Phragmites australis</u>	Leaves, stems, flowers.
D3	<u>Phragmites australis</u> <u>Typha latifolia</u> <u>Lythrum salicaria</u>	Leaves, stems, flowers. Leaves & flowers. Leaves, stems, flowers.
E2	<u>Phalaris arundinacea</u>	Leaves, stems, flowers.
F1	<u>Lythrum salicaria</u> <u>Leersia oryzoides</u>	Leaves, stems, flowers. Leaves & stems.
F2	<u>Lythrum salicaria</u> <u>Leersia oryzoides</u>	Leaves, stems, flowers. Leaves & stems.
F3	<u>Lythrum salicaria</u> <u>Typha angustifolia</u> <u>Salix interior</u>	Leaves, stems, flowers. Leaves, flowers. Leaves.
G1	<u>Typha latifolia</u>	Leaves, flowers.
G2	<u>Typha latifolia</u>	Leaves, flowers.
G3	<u>Typha angustifolia</u> <u>Lythrum salicaria</u>	Leaves, flowers. Leaves, stems, flowers.

PART II(1) TABLE 14

TABLE 14 Metal concentrations measured in the vegetation samples collected at the Times Beach CDF, composite sample from each plot (ug/g, dry weight). JULY 1985.

Vegetation type D

Species/Tissue/Plot		Zn	Cu	Ni	Cd	Cr	Pb
<u>Lythrum salicaria</u>							
Leaves	D3	125	9.3	2.3	<0.13	0.95	5.7
Stems	D3	37	7.9	<0.75	0.30	0.91	2.8
Flowers	D3	81	15	1.4	<0.13	1.1	2.7
<u>Phragmites australis</u>							
Leaves	D1	27	9.5	<0.75*	<0.13	0.92	3.8
	D2	33	5.9	<0.75	<0.13	0.68	4.5
	D3	22	5.7	<0.75	<0.13	0.59	3.3
	x	27	7.0	<0.75	<0.13	0.73	3.9
Stems	D1	54	9.0	<0.75	0.22	0.88	4.0
	D2	30	6.3	<0.75	<0.13	0.79	<2.6
	D3	45	6.7	<0.75	<0.13	0.91	<2.6
	x	43	7.3	<0.75	0.16	0.86	3.1
Flowers	D1	74	11	0.77	<0.13	1.1	2.8
	D2	79	14	<0.75	<0.13	0.92	2.9
	D3	65	10	<0.75	<0.13	0.70	<2.6
	x	73	12	<0.75	<0.13	0.91	2.8
<u>Typha angustifolia</u>							
Leaves	D1	19	6.1	<0.75	<0.13	0.69	4.9
<u>Typha latifolia</u>							
Leaves	D3	20	5.1	1.1	<0.13	0.66	2.7
Flowers	D3	24	9.1	1.0	<0.13	0.37	<2.6

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART II(1) TABLE 14 contd...

Vegetation zone E

Species/Tissue/Plot			Zn	Cu	Ni	Cd	Cr	Pb
<u>Phalaris arundinacea</u>								
Leaves	E2	57		7.6	0.83	<0.13	1.7	3.4
Stems	E2	37		7.0	0.81	<0.13	0.87	<2.6
Flowers	E2	32		4.0	1.6	<0.13	5.2	35

PART II(1) TABLE 14 contd...

Vegetation zone F

Species/Tissue/Plot			Zn	Cu	Ni	Cd	Cr	Pb
<u>Lythrum salicaria</u>								
Leaves	F1	172		5.7	1.8	0.55	2.2	16
	F2	120		7.0	1.0	0.14	2.1	9.8
	F3	191		7.3	1.3	0.15	2.5	5.9
	x	161		6.7	1.4	0.28	2.3	10.6
Stems	F1	20		6.6	<0.75	0.33	0.49	<2.6*
	F2	28		7.4	<0.75	0.60	0.68	3.0
	F3	30		6.5	<0.75	<0.13	1.76	2.9
	x	26		6.8	<0.75	0.32	0.98	2.8
Flowers	F1	74		14	1.1	<0.13	1.4	5.3
	F2	78		18	1.8	1.3	11	5.5
	F3	74		15	1.4	<0.13	1.7	3.6
	x	75		16	1.4	0.52	4.7	4.8
<u>Typha angustifolia</u>								
Leaves	F3	15		6.3	<0.75	<0.13	1.1	4.3
Flowers	F3	21		13	<0.75	<0.13	2.0	<2.6
<u>Leersia oryzoides</u>								
Leaves & Stems	F1	67		4.5	<0.75	<0.13	0.80	2.9
	F2	97		6.0	1.6	0.25	3.0	4.7
	x	82		5.3	1.2	0.19	1.9	3.8
<u>Salix interior</u>								
Leaves	F3	454		6.2	1.2	2.2	2.0	3.7

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART II(1) TABLE 14 contd...

Vegetation type G

Species/Tissue/Plot			Zn	Cu	Ni	Cd	Cr	Pb
<u>Lythrum salicaria</u>								
Leaves	G3	160		8.6	<0.75	<0.13	3.0	6.7
Stems	G3	24		7.4	<0.75	<0.13	2.0	<2.6
Flowers	G3	61		14	<0.75	<0.13	3.4	2.8
<u>Typha latifolia</u>								
Leaves	G1	16		4.4	0.82	<0.13*	2.5	5.7
	G2	15		3.6	<0.75	<0.13	1.4	6.0
	x	16		4.0	0.79	<0.13	0.57	5.9
Flowers	G1	20		7.3	0.81	<0.13	0.53	<2.6
	G2	26		9.0	<0.75	<0.13	0.61	<2.6
	x	23		8.2	0.78	<0.13	0.57	<2.6
<u>Typha angustifolia</u>								
Leaves	G3	26		8.5	1.3	<0.13	0.76	2.8
Flowers	G3	22		13	<0.75	<0.13	1.5	<2.6

* For the purposes of statistical analysis values below the detection limit of the machine were assumed to be equal to the value of the detection limit.

PART II(2) TABLE 15

TABLE 15 Metal concentrations measured in the mammals collected in the wetland area at Times Beach and the designated reference area. Mean metal concentrations and maximum and minimum values in parentheses (ug/g, dry weight). NOVEMBER 1986.

Sample	Zn	Cu	Ni	Cd	Cr	Pb
MUSKRATS - <u>Ondatra zibethica</u>						
Times Beach - Juvenile (12oz) (n=1)						
Fur	48	1.9	1.9	<0.07	1.3	192
Liver	85	6.3	<0.75	<0.13	0.96	<2.6
Muscle	39	1.7	<3.8	<0.07	0.87	1.7
Bone	87	1.0	2.0	<0.33	2.9	9.9
Spleen	44	2.2	1.9	<0.23	8.3	<4.5
Times Beach - Adults (31b) (n=4)						
Fur	191	5.7	1.5	0.18	9.4	98
Fur c*	191	14.8	2.8	0.58	16	54
Liver	90	9.4	<0.75	<0.13	2.1	<2.6
	(82-94)	(5.6-12)			(1.1-4.7)	
Muscle	74	2.7	0.39	<0.07	1.4	1.7
	(57-82)	(1.6-3.3)	(0.37-0.42)		(0.88-2.5)	(+3@<1.3)
Bone	83	1.5	3.5	0.67	7.2	9.0
	(73-89)	(0.82-2.4)	(3.3-3.8)	(0.39-1.2)	(3.9-14)	(6.6-11)
Spleen	69	4.3	1.7	0.22	25	14
	(59-79)	(2.7-7.5)	(1.0-2.8)	(0.15-0.31)	(4.4-76)	(+3@<3.9)

Fur c* Titanium concentrations suggested that two of the muskrat fur samples could have been contaminated by dredged material. The mean value of these two samples is therefore given separately from the mean value of the other two samples.

AQUATIC AREA: TIMES BEACH

PART III(1) TABLE 16. Results of water quality analysis of samples collected at Times Beach.

TABLE 16(a) Concentrations of metals in Times Beach water samples and EPA drinking water maximum levels. (ug/g)

Parameter	Times Beach	EPA Drinking Water*1
Arsenic	<0.005	0.05
Cadmium	<0.001 - 0.005	0.01
Chromium	<0.001 - 0.002	0.05
Copper	0.003 - 0.020	-
Lead	<0.001 - 0.007	0.05
Nickel	0.002 - 0.008	-
Zinc	<0.05	-
Mercury	<0.0008	0.002

*1. Federal Register Vol. 45, No. 98, May 19, 1980.

TABLE 16(b) Concentration of organic compounds in Times Beach water samples and levels of organic compounds known to be toxic to fish (ug/g).

Parameter	Times Beach	Level Toxic to Fish*2
PCB (Arachlor 1242)	<0.05	3 - 433
PCB (Arachlor 1254)	<0.05	3 - 433
Bis (2-ethylhexyl) phthalate	<0.01	0.2 - 4.0
Aniline	<0.01	-
1-amino-napthalene	<0.01	-
N-benzyl-N-ethyl-aniline	<0.01	-
4-(dimethyl-amino) benzophenone	<0.01	-
4,4-methylene bis (N,N-dimethyl-aniline)	<0.01	-
N,N,N',N'-tetramethyl benzodine	<0.01	-
P,P'-benzylidene bis (N,N-dimethyl-aniline)	<0.01	-
Benzo-(a)-pyrene	<0.01	-
1,2-dichlorobenzene	<0.01	-
1,3-dichlorobenzene	<0.01	-
1,4-dichlorobenzene	<0.01	-
Napthalene	<0.01	-
Phenanthrene	<0.01	-
Anthracene	<0.01	-
Fluoranthene	<0.01	-
Pyrene	<0.01	-
Benzo-(a) anthracene	<0.01	-
Chrysene	<0.01	-

*2. US Dept of the Interior Fish and Wildlife Service Resource Publication 137

PART III(1) TABLE 17 Water quality analysis of groundwater samples collected from wells at Times Beach.

TABLE 17(a) Maximum metal contaminant levels in the Times Beach monitoring wells (ug/l).

Parameter	Upland		Wetland		Aquatic	
	F.*	UF#	F	UF	F	UF
Arsenic	12	32	<4	<4	<4	<4
Barium	110	290	160	130	140	120
Cadmium	<1.0	26	3	2	<1.0	1.3
Chromium	20	20	<20	<20	90	50
Copper	60	130	30	60	100	370
Lead	<5.0	16	5	9	<5	<5
Mercury	<0.3	0.7	<0.3	<0.3	5	11
Nickel	20	40	120	150	30	40
Thallium	<5	8	<5	6	<5	<5
Zinc	30	60	40	30	40	30

*F = Filtered #UF = Unfiltered

TABLE 17(b) Organic compounds monitored in Times Beach groundwater. All organic compounds were below the detection limits given below, except for Chlorobenzene which was present at 1 - 4 ug/l.

Organic compound	Detection limit (ug/l)
Benzene	1.0
Ethylbenzene	1.0
Dichlorobenzene (3)	1.0
Nitrosamines (3)	1.0 - 2.0
Aniline	1.0
4 - Chloroaniline	1.0
Napthalene	1.0
PAH's (12)	1.0 - 2.0

PART III(2) TABLE 18

TABLE 18(a) Metal concentrations measured in the ducks collected at the Amherst reference area (ug/g, dry weight). Mean concentration and maximum and minimum values in parentheses.

Sample	Zn	Cu	Ni	Cd	Cr	Pb
MALLARD DUCKS - <u>Anas platyrhynchos</u>						
Reference - Immature (n=4)						
Feathers	83	11	1.7	0.51	3.8	188
	(77-91)	(9.9-14)	(0.88-2.9)	(0.35-0.66)	(1.7-8.1)	(10-589)
Liver	122	38	<1.2	0.55	2.0	4.3
	(72-228)	(35-47)		(0.37-0.97)	(0.73-5.6)	(0.3-4.2)
Muscle	73	9.0	2.0	0.33	1.0	41
	(56-109)	(8.6-10)	(0.3-0.79)	(0.3-0.17)	(0.35-1.9)	(3.5-143)
Bone	140	2.2	2.5	0.47	3.5	41
	(136-149)	(1.9-3.6)	(1.9-3.6)	(0.41-0.51)	(2.9-3.9)	(5.6-977)

TABLE 18(b) Metal concentrations in liver tissue of ducks captured at the Times Beach CDF and comparative metal concentrations in liver tissue of ducks captured in The Netherlands (Hg and Cd expressed in ug/Kg, dry weight, Cu and Zn in ug/g, dry weight).

Metal	Times Beach Adult	Times Beach Immature	Lake Issel(NL)	Harlingvleet Basin(NL)
Cd	3098 2912	1364 1010 895	771 538 886	2251 1530 2047
Cu	107 110	127 153 158	61 74 106	228 172 219
Hg	787 770	849 632 637	224 338 310	526 476 383
Zn	162 159	198 171 173	201 140 166	239 218 238

PART III(2) TABLE 19

TABLE 19 Polychlorinated biphenyls in fishes from the Times Beach CDF, Buffalo, NY.

PCB	IUPAC		Tissue	Yellow Perch/Pumpkinseed/Rock Bass	Carp
	No.	Sed.			
2,4,4'-tri	28	0.05	muscle	0.10(0.02)	0.15(0.03)
			liver	1.8 (1.0)	0.42(0.08)
2,2',4,5'					
-tetra	49	0.11	muscle	0.13(0.26)	0.21(0.04)
			liver	2.5 (1.4)	0.59(0.11)
2,2',5,5'					
-tetra	52	0.18	muscle	0.18(0.04)	0.29(0.05)
			liver	3.4 (1.9)	0.75(0.14)
2,3',4',5					
-tetra	70	0.15	muscle	0.16(0.03)	0.29(0.05)
			liver	2.9 (1.6)	0.78(0.15)
2,2',3,4,5'					
-penta	87	0.05	muscle	0.06(0.01)	0.11(0.02)
			liver	0.84(0.48)	0.36(0.07)
2,2'4,5,5'					
-penta	101	0.07	muscle	0.13(0.03)	0.21(0.04)
			liver	2.3 (1.3)	0.60(0.11)
2,2',3,4,4',5'					
-hexa	138	0.05	muscle	0.06(0.01)	0.10(0.02)
			liver	0.58(0.33)	0.33(0.06)
2,2',4,4',5,5'					
-hexa	153	0.02	muscle	0.07(0.01)	0.12(0.02)
			liver	0.75(0.43)	0.37(0.07)
2,2',3,4,4',5,5'					
-hepta	180	0.01	muscle	0.02(0.00)	0.05(0.01)
			liver	0.33(0.19)	0.19(0.04)
TOTAL**	-	0.70	muscle	0.91(0.18)	1.5 (0.28)
			liver	15 (8.6)	4.4 (0.83)

Concentrations expressed on the basis of ug/g dry weight in sediments, ug/g ash free dry weight in tissues and (in parenthesis) ug/g fresh weight in tissues.

** sum of the 9 PCB congeners analyzed.

Source: Kay et al.(1986)

IUPAC = International Union of Pure and Applied Chemists.

REFERENCE SITE: GRAND ISLAND

PART IV(1) TABLE 20

TABLE 20 Metal concentrations measured in soil collected at the Grand Island reference site, composite sample of four soil cores (15 cm depth). All values expressed in ug/g, dry weight. NOVEMBER 1986

Plot	Zn	Cu	Ni	Cd	Cr	Pb
Ref. 1	242	110	51	2.3	38	47
Ref. 2	208	42	52	2.5	38	40
Ref. 3	210	66	59	2.7	38	43
Ref. 4	241	42	59	2.6	37	43
Ref. 5	236	80	52	2.6	35	48

PART IV(2) TABLE 21

TABLE 21 Results of 28 day earthworm bioassay conducted using E. foetida.

Earthworms added to the plexiglass cylinders:				
Time = 0			Time = 28 days	
Replicate	Weight (g)	Number	Weight (g)	Number
R1	30.8	85	20.2	74
R2	30.4	91	19.6	86
R3	30.7	91	16.1	70
R4	30.7	92	17.3	67

TABLE 21 (contd.) Metal concentrations measured in earthworms at T = 0 and T = 28 days. All values expressed as ug/g, dry weight.

Sample	Zn	Cu	Ni	Cd	Cr	Pb
T = 0						
I1	101	9.7	2.2	3.0	1.1	<4.2
I2	99	8.8	2.4	2.6	2.4	<2.7
I3	93	8.5	2.8	2.6	2.9	<2.7
T = 28 days						
R1	103	11	14	4.5	2.0	<2.7
R2	97	10	2.3	4.1	1.8	<2.7
R3	97	9.7	2.9	4.5	1.8	<2.7
R4	106	10	4.4	4.4	2.8	<2.7

PART IV(3) TABLE 22

TABLE 22 Soil dwelling invertebrates - Grand Island reference site.

TABLE 22(a) Record of numbers of soil dwelling fauna sampled in pitfall traps. MAY 1986

PLOT	COL.	ARAN.	CHIL.	DIPL.	ISOP.	OTHERS
Ref 1	61	6	-	1	21	1 Acarina
Ref 2	26	1	-	6	27	1 Acarina/1 Diptera 1 Opiolones/1 Hymenoptera 1 Homoptera/1 Homoptera
Ref 3	14	-	-	5	37	1 Acarina/1 Diptera
Ref 4	11	-	-	4	58	2 Acarina/2 Opiolones 2 Hemiptera/1 Homoptera
Ref 5	12	1	-	4	37	1 Acarina/1 Diptera 2 Hemiptera

TABLE 22(b) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a ten day period at Grand Island. Total dry matter contribution (g) and percentage dry matter contribution (%) per plot. MAY 1986.

PLOT	PRED. COL.	ARAN.	CHIL.	HERB. COL.	DIPL.	ISOP.	OTHERS
Ref 1 (g)	0.853	0.051	-	0.011	0.024	0.084	0.001
(%)	83.3	5.0	-	1.1	2.3	8.2	0.1
Ref 2 (g)	1.370	0.016	-	0.027	0.031	0.212	0.019
(%)	81.8	1.0	-	1.6	1.9	12.7	1.1
Ref 3 (g)	0.655	-	-	0.013	0.011	0.247	0.001
(%)	70.7	-	-	1.4	1.2	26.6	0.1
Ref 4 (g)	0.871	-	-	0.011	0.040	0.291	0.019
(%)	70.7	-	-	1.0	3.2	23.6	1.5
Ref 5 (g)	0.293	0.003	-	0.005	0.011	0.208	0.013
(%)	55.0	0.6	-	0.9	2.1	39.0	2.4

PART IV(3) TABLE 22 contd...

TABLE 22(c) Metal concentrations in major groups of invertebrate fauna collected in pitfall traps at Grand Island. Four pooled samples from each plot. MAY 1986.

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
CARNIVOROUS SPECIES						
Predatory COLEOPTERA						
Ref 1	109	17	-	-	-	-
Ref 2	107	17	-	2.2	-	-
Ref 3	109	15	-	1.7	-	-
Ref 4	108	16	-	-	-	-
Ref 5	77	11	-	-	-	-
ARANEIDA						
Ref 1 - 5	238	202	-	13	3.5	-
OPIOLONES						
Ref 1 - 5	311	58	-	7.1	-	-
HERBIVOROUS SPECIES						
Herbivorous COLEOPTERA						
Ref 1	113	38	-	-	9.3	-
Ref 2	96	31	-	-	7.1	-
Ref 3	246	60	-	-	-	-
DETRITIVOROUS SPECIES						
DIPLOPODA						
Ref 1	189	231	-	-	5.3	-
Ref 2 - 5	206	205	17	2.7	12	-
ISOPODA						
Ref 1	240	175	-	4.3	4.5	-
Ref 2	144	123	6.3	3.0	3.7	-
Ref 3	512	179	4.7	3.3	3.5	-
Ref 4	281	152	4.9	3.5	3.1	-
Ref 5	123	138	6.8	2.4	3.5	6.5

PART IV(3) TABLE 23

TABLE 23(a) Record of numbers of soil dwelling invertebrates sampled in pitfall traps, Grand Island. NOVEMBER 1986.

PLOT	COL.	ARAN.	OPIO.	CHIL.	DIPL.	ISOP.	ORTH.	Others
Ref 1	5	3	21	-	1	7	1	1 Diptera
Ref 2	11	2	15	-	4	15	-	1 Diptera/1Hymenoptera 1 Lepidoptera L.
Ref 3	8	2	19	1	5	13	-	1 Acarina/2 Mollusca 2 Hymenoptera
Ref 4	10	2	24	-	1	58	-	1 Acarina/1 Mollusca 6 Hymenoptera
Ref 5	2	2	5	-	-	26	1	4 Diptera/2Hymenoptera 7 Mollusca/2 Lumb.

TABLE 23(b) Composition of soil dwelling invertebrate fauna sampled by pitfall trapping over a seven day period at Grand Island. Total dry matter contribution (g) and percentage dry matter contribution (%) per plot. NOVEMBER 1986

PLOT	PRED. COL.	ARAN.	OPIO.	HERB. COL.	CHIL.	DIPL.	ISOP.	OTHERS
Ref 1(g)	0.0926	0.0143	0.1148	-	-	0.0494	0.0242	0.0161
(%)	29.74	4.59	36.87	-	-	15.86	7.77	5.17
Ref 2(g)	0.1402	0.0082	0.0713	-	-	0.0991	0.0872	0.0510
(%)	30.68	1.79	15.60	-	-	21.68	19.08	11.16
Ref 3(g)	0.0686	0.0191	0.1018	0.0356	0.0298	0.0887	0.0265	0.0848
(%)	15.08	4.20	22.38	7.82	6.51	19.50	5.83	18.52
Ref 4(g)	0.1120	0.0053	0.0846	0.0022	-	0.0666	0.2372	0.0423
(%)	20.36	0.96	15.38	0.40	-	12.10	43.11	7.69
Ref 5(g)	0.0312	0.0027	0.0300	-	-	-	0.0883	0.2092
(%)	8.63	0.75	8.30	-	-	-	24.43	57.89

PART IV(3) TABLE 23 contd...

TABLE 23(c) Metal concentrations in major groups of invertebrate fauna collected in pitfall traps at Grand Island. Four pooled samples per plot (ug/g, dry weight). NOVEMBER 1986

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
CARNIVOROUS SPECIES						
Predatory COLEOPTERA						
Ref 1	59	18	1.4	1.2	29	3.1
Ref 2	52	13	0.84	0.46	6.2	<1.9
Ref 3	71	13	1.9	0.66	5.9	<3.8
Ref 4	69	19	4.1	2.2	1.0	9.0
ARANEIDA						
Ref 1	196	68	<5.3	2.7	10	<18
Ref 2	206	58	18	7.7	18	37
Ref 3	173	57	5.1	2.9	9.8	<14
Ref 4 & 5	199	74	9.2	2.1	31	<32
OPIOLONES						
Ref 1	194	34	4.9	6.9	6.1	5.7
Ref 2	197	30	3.9	5.4	4.2	5.3
Ref 3	170	36	4.0	6.3	2.9	<2.6
Ref 4	246	38	4.4	7.1	4.9	5.7
Ref 5	315	58	4.9	9.4	2.5	14
CHILOPODA						
Ref 3	148	41	3.2	1.5	<0.65	<8.9
HERBIVOROUS SPECIES						
Herbivorous COLEOPTERA						
Ref 1 - 5	86	34	2.6	0.65	2.3	<7.4
DETRITIVOROUS SPECIES						
DIPLOPODA						
Ref 1	142	288	6.7	4.2	8.1	8.5
Ref 2	225	112	4.7	1.9	4.8	7.8
Ref 3	167	75	5.2	2.3	2.6	6.8
Ref 4	106	56	1.8	1.1	0.59	<4.0
ISOPODA						
Ref 1	303	85	17	13	21	27
Ref 2	214	57	6.4	7.8	3.8	7.8
Ref 3	229	41	12	7.0	4.2	16
Ref 4	242	136	11	7.5	5.9	13
Ref 5	107	74	5.5	5.7	2.6	6.6

PART IV(4) TABLE 24

TABLE 24 Native earthworms collected at the Grand Island reference site, Composite samples of each species per plot expresses as ug/g, dry weight. All results corrected to eliminate the effect of soil within the earthworm gut. NOVEMBER 1986

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
<u>Lumbricus terrestris</u>						
Ref 1 & 2	392	2.1	-	5.4	2.2	-
Ref 3	371	2.3	3.7	13	0.29	4.0
Ref 4 & 5	287	2.0	0.15	8.4	0.45	-
<u>Lumbricus rubellus</u>						
Ref 1 & 2	384	6.6	5.0	10	1.5	1.2
Ref 3	467	4.9	2.3	14	4.0	1.7
Ref 4 & 5	438	2.4	0.35	15	2.1	-
<u>Allolobophora caliginosa</u>						
Ref 1 & 2	514	7.5	2.5	33	2.1	2.1
Ref 3	509	4.3	1.1	37	4.2	0.29
Ref 4 & 5	415	4.6	3.4	33	1.3	5.2
<u>Allolobophora chlorotica</u>						
Ref 1 & 2	304	10	5.6	22	2.4	-
Ref 4 & 5	303	5.3	2.1	14	2.6	2.3
Mean metal concentrations for reference site by earthworm species:						
<u>L. terrestris</u>	350	2.1	1.3	8.8	0.99	4.0
<u>L. rubellus</u>	430	4.6	2.5	13	2.5	1.5
<u>A. caliginosa</u>	479	5.5	2.3	34	2.5	2.5
<u>A. chlorotica</u>	304	7.8	3.9	18	2.5	2.3

PART IV(5) TABLE 25

TABLE 25 Metal concentrations measured in vertebrate species collected by pitfall trapping, Grand Island. Concentrations expressed as ug/g, dry weight. NOVEMBER 1986.

Species/Plot	Zn	Cu	Ni	Cd	Cr	Pb
Frogs. <u>Rana</u> sp. Ref 2 & 3.						
Liver	71	54	2.3	1.4	4.8	<3.4
Muscle	25	9.9	2.5	1.2	5.2	<2.1
Bone	68	6.5	3.3	1.6	5.6	6.0
Salamanders. <u>Plethodon</u> . Ref 1 & 2.						
Whole specimen	93	15	0.91	2.4	0.22	<2.7
Whole specimen	71	6.1	<0.73	0.65	<0.19	<2.6
Whole specimen	74	9.8	1.6	1.1	0.24	3.4
Whole specimen	101	5.4	0.78	9.0	<0.20	<2.7
Liver	322	33	<2.8	7.8	37	12
Shrews. <u>Sorex</u> sp. Ref 2 & 4.						
Liver	86	18	3.2	4.0	0.90	<6.5
Kidney	82	22	<5.9	3.0	4.8	<21
Muscle	90	12	1.7	2.7	23	<5.0
Bone	132	6.7	2.3	1.7	6.5	6.1

APPENDIX C: UNPUBLISHED REPORTS OF CONTAMINANT
MOBILITY STUDIES AT TIMES BEACH

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MEMORANDUM FOR RECORD

SUBJECT: Interpretive Summary - Evaluation of Availability and Animal Uptake of Contaminants from Dredged Material from the Times Beach Disposal Site, Buffalo, NY

1. A terrestrial animal contact bioassay under growth chamber conditions and associated chemical analyses were performed on dredged material from the Times Beach Disposal Site, Buffalo, NY. The objectives of the test were to determine the availability and uptake of contaminants by a soil-dwelling invertebrate species and relate these data to plant uptake studies previously conducted. The experiments were conducted in growth chamber facilities located at the Waterways Experiment Station (WES).
2. During the summer of 1981 a field and greenhouse plant bioassay was conducted with dredged material from the Times Beach Disposal Site. The results of these studies are related in a Memorandum for Record by Dr. Bobby L. Folsom, Jr., dated 29 Jan 82 (Incl 1). The chemical analysis of the dredged material indicated the presence of certain contaminants, and the plants grown on the contaminated dredged material showed a slight inhibition of growth; however, the plants were not considered to show significant uptake or assimilation of heavy metals or organic contaminants from the dredged material. Even though there does not appear to be significant contaminant uptake and bioaccumulation in plants on the Times Beach Disposal Site, it was possible that dredged material dwelling invertebrates may be potential bioaccumulators of contaminants from the dredged material and could present an avenue for contaminant mobility into the terrestrial food web. This possibility was addressed using a terrestrial animal contact bioassay.
3. The Times Beach dredged material used in these experiments was that collected for the plant greenhouse studies of the previously cited study. The 16 inner buckets of the WES Plant Bioassay apparatus containing the dredged material were dumped and the material mixed and re-potted in similar buckets. Each bucket contained 7.75 lb (3.5 kg) dry weight of dredged material moistened to field capacity with deionized water. Thirty grams of Eisenia foetida,

WESES

31 January 1983

SUBJECT: Interpretive Summary - Evaluation of Availability and Animal Uptake of Contaminants from Dredged Material from the Times Beach Disposal Site, Buffalo, NY

common "red wiggler" earthworms, were placed in each bucket and kept in the growth chamber for 28 days. The technique employed was patterned after that of the European Economic Commission developed by Dr. C. A. Edwards. A modification in the WES procedures was to place the worms directly in dredged material rather than into an artificial soil mixture to which test chemicals or the dredged material were added. Sixteen buckets of dredged material were used as well as four buckets of the WES reference soil. The reference soil was used only as an index to evaluate the environmental conditions in the growth chamber. Contaminant concentrations in the worms exposed to the dredged material were compared with concentrations in worms from the same lot from the supplier prior to exposure to the dredged material, with concentrations in the Cyperus regrown in the buckets and with concentrations in the dredged material.

4. When the worms were harvested at 28 days, they were weighed. A lesser weight of the 30 g of worms placed in each bucket was recovered (Table 1). This phenomenon was expected as the worms were not fed during the experiment. Eisenia, the bioassay animal used here, as well as other earthworms, feed on the organic material present in the substrate. A net weight loss would be anticipated without the addition of a sufficient amount of the horse manure-chicken mash worm feeding medium; however, addition of a feeding medium to the buckets would have interfered with contaminant availability in the dredged material and consequently would have confounded the results of the bioassay.

5. Although the dredged material had been analyzed for both toxic metal and organic contaminants at the time of the plant bioassay (Jun 81), a second analysis was carried out in Jul 82. The comparison of HNO_3 digestable metals is shown in Table 2. With the exception of arsenic, all parameters were lower in the second analysis. It appears that although some of the toxic metals may have been removed by the several harvests of plants, the dilution of the dredged material by the sand from the Plant Bioassay apparatus probably accounts for the obscured dilution. Even though care was taken to obtain only dredged material from the Plant Bioassay buckets, a small amount of sand inadvertently remained attached to the dredged material and was mixed in with the dredged material. Likewise the concentrations of organic contaminants were found to be lower in the 82 analysis than in the 81 analysis (Table 3). The decrease in concentration of organic contaminants is due in part to volatilization during mixing of air dried sediment as well as the dilution described above.

6. The concentrations of toxic metals in the dredged material, Cyperus regrowth, Eisenia at the initiation of the test, and Eisenia at 28 days are shown in Table 4. Metal contents of Cyperus were similar to those observed in the plant bioassay (MFR, Folsom, 29 Jan 82). In all cases the worms from the supplier contained higher levels of toxic metals than the worms in the sediment at the termination of the experiment. Of particular note is the mean cadmium level of 3.8 $\mu\text{g/g}$ in the worms that is quite close to the 3.3 $\mu\text{g/g}$ of the dredged material. The worm tissue levels appear to equilibrate with that

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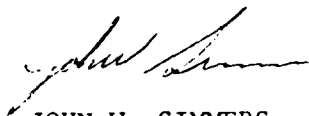
SUBJECT: Interpretive Summary - Evaluation of Availability and Animal Uptake of Contaminants from Dredged Material from the Times Beach Disposal Site, Buffalo, NY

of the dredged material. The range of 2.9-4.3 $\mu\text{g/g}$ for the exposed worms is less than that of the commercially supplied worms but still higher than that of the Cyperus. In addition, zinc levels of 99-122 $\mu\text{g/g}$ for exposed worms are also greater than the levels noted in Cyperus, although well below the 637.5 $\mu\text{g/g}$ mean concentration of the substrate and that of the background worms (145.8 $\mu\text{g/g}$). At this time little data are available to relate the levels of toxic metals in these worms to levels indicating significant dangers of biomagnification through the terrestrial food web. Comparisons of National Bureau of Standards (NBS) certified values and those of the WES Analytical Laboratory for NBS bovine liver, oyster tissue, tomato leaves, and river sediment were used for quality assurance. These data are contained in Incl 2.

7. Analysis of the worms indicated that the 15 most prevalent organic compounds in the dredged material detected during the plant bioassay did not bioaccumulate (Table 5). All organic compounds were found to be below detection limits of 0.65 $\mu\text{g/g}$. Worms do not appear to bioaccumulate contaminants at concentrations higher than those of the existing sediment.

8. While the dredged material in the disposal site at Times Beach contains some toxic metals and organic contaminants, animal uptake of these contaminants appears to approach sediment concentrations and does not appear to bioaccumulate above sediment concentrations. As shown in these experiments the dredged material levels of Cd and Zn present during worm testing were lower than those recorded at the initial plant bioassay analysis. Predictions based on the original analysis in Table 2 would indicate that there is a real potential for worm Cd levels at Times Beach to approximate sediment concentrations of from 10-13 $\mu\text{g/g}$ and Zn levels in the 200-350 $\mu\text{g/g}$ range. The present study results suggest this but do not confirm this potential. Two additional studies appear to be advisable to resolve the question of Cd and other metal contaminant movement through the food web: (1) a study with freshly collected dredged material from Times Beach conducted in the field as well as in the growth chamber simultaneously, and (2) an investigation of actual predator (bird) and prey relationships on site and subsequent analyses of native soil dwelling invertebrates and birds.

2 Incl
as



JOHN W. SIMMERS
Research Biologist



R. GLENN RHETT
Physical Scientist

CF:
Dick Leonard
Buffalo District

Table 1
Comparison of Weights of Eisenia in WES Reference Soil
and Dredged Material Collected at Times Beach
Before and After the Experiment

<u>Initial Weight</u>	<u>Reference Soil</u>	<u>Experimental</u>
30 g	16.48-17.70 (17.15) g n = 4	4.59-19.97 (13.29) g n = 15*

* One bucket of the experimental worms showed an abnormal disappearance of most of the worms to give a final weight of 0.50 g. This bucket was not included in the data analysis.

Table 2
Comparison of HNO₃ Extractible Toxic Metals in Dredged
Material Collected at Times Beach

<u>Toxic Metal</u>	<u>Concentration Range µg/g</u>	
	<u>Original Analysis</u> (June 1981)	<u>Second Analysis</u> (July 1982)
As	2.0-53.9 (22.7)	41.0-90.0 (56.8)
Cd	10.9-13.3 (11.9)	2.5-4.5 (3.3)
Cu	238-269 (251)	129.0-190.0 (152.9)
Pb	156-1037 (497)	238.0-446.0 (300.4)
Zn	1031-1845 (1283)	509.0-889.0 (637.5)
Hg	2.9-9.4 (4.8)	1.8-4.4 (2.4)

Table 3
Comparison of Organic Compounds in Dredged Material
Collected at Times Beach

Organic Compound	Concentration Range $\mu\text{g/g}$	
	Original Analysis (June 1981)	Second Analysis (July 1982)
Chrysene	7.2-26 (14)	0.46-0.70 (0.60)
Benzo-(a)-anthracene	6.2-23 (12)	0.49-0.70 (0.59)
Pyrene	9.8-27 (17)	1.10-1.40 (1.25)
Fluoranthene	10-24 (17)	1.20-1.60 (1.47)
Anthracene	7.0-13 (9.7)	0.63-0.77 (0.72)
Phenanthrene	10-15 (13)	3.20-4.60 (3.77)
Napthalene	11-20 (14)	1.70-1.80 (1.75)
1,4-dichlorobenzene	8.0-22 (12)	0.49-0.73 (0.56)
1,3, dichlorobenzene	1.2-9.5 (3.9)	<0.40
1,2, dichlorobenzene	0.83-9.8 (3.5)	<0.40
Benzo-(a)-pyrene	20-96 (39)	2.60-3.70 (3.15)
p,p'-benzylidene bis (N,N-dimethyl-aniline)	2.6-4.7 (3.3)	0.75-0.88 (0.8)
N-benzyl-N-ethyl-aniline	2.4-7.0 (4.5)	0.74-0.92 (0.82)
Bis (2 ethylhexyl) phthalate	1.5-5.5 (3.0)	<0.40

Table 4
Concentration of Toxic Metals in *Cyperus* and *Eisenia* Grown in
Dredged Material Collected from Times Beach

Toxic Metal	Concentration Range $\mu\text{g/g}$			
	Dredged Material	<i>Cyperus</i>	<i>Eisenia</i> Background	<i>Eisenia</i> at 28 Days
As	41.0-90.0 (56.8)	<0.20	5.0-5.7 (5.3)	<0.40
Cd	2.5-4.5 (3.3)	1.60-1.70 (1.67)	9.7-11.0 (10.4)	2.9-4.3 (3.8)
Cu	129.0-190.0 (152.9)	1.5-14.0 (9.8)	33.0-36.0 (34.8)	6.7-14.0 (8.8)
Pb	238.0-446.0 (300)		8.3-12.0 (10.3)	0.90-2.60 (1.50)
Zn	509.0-889.0 (637.5)	57.0-60.0 (59.0)	139.0-153.0 (145.8)	99.0-122.0 (113.5)
Hg	1.8-4.4 (2.4)	<0.30	0.3-1.5 (0.6)	<0.3

Table 5
Concentration of Organic Compounds in Eisenia Grown in
Dredged Material Collected at Times Beach

<u>Organic Compound</u>	<u>Concentration Range $\mu\text{g/g}$</u>		
	<u>Sediment</u>	<u>Eisenia Background</u>	<u>Eisenia Experimental</u>
Chrysene	0.46-0.70 (0.60)	<0.65	<0.65
Benzo-(a)-anthracene	0.49-0.70 (0.59)	"	"
Pyrene	1.10-1.40 (1.25)	"	"
Fluoranthene	1.20-1.60 (1.47)	"	"
Anthracene	0.63-0.77 (0.72)	"	"
Phenanthrene	3.20-4.60 (3.77)	"	"
Napthalene	1.70-1.80 (1.75)	"	"
1,4-dichlorobenzene	0.49-0.73 (0.56)	"	"
1,3-dichlorobenzene	<0.40	"	"
1,2-dichlorobenzene	<0.40	"	"
Benzo-(a)-pyrene	2.60-3.70 (3.15)	"	"
p',p'-benzylidene bis (N,N-dimethyl-aniline)	0.75-0.88 (0.81)	"	"
N-benzyl-N-ethyl-aniline	0.74-0.92 (0.82)	"	"
Bis (2 ethylhexyl) phthalate	<0.40	"	"

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MEMORANDUM FOR RECORD

SUBJECT: Interpretive Summary, Evaluation of Availability and Plant Uptake of Contaminants from Dredged Material from Buffalo, New York, Toledo, Ohio, and Cleveland, Ohio

Introduction

1. A plant bioassay under greenhouse and field conditions and associated laboratory chemical analyses were performed on dredged material from disposal sites at Times Beach, Buffalo, New York, the new disposal site at Toledo, Ohio, and Disposal Site No. 12 at Cleveland, Ohio. The objectives of the test were to determine the availability and plant uptake of contaminants from dredged material in those disposal sites under a controlled environment greenhouse located at the Waterways Experiment Station (WES) and under field conditions of each disposal site.

Field Test

2. The inner bucket of the double-bucket plant bioassay apparatus was filled with dredged material and embedded in the field at each disposal site. In this procedure, material was removed from the disposal site, part of the material placed into the bucket and set in an excavation at an elevation level with the surrounding surface. The rest of the material was transported to the WES and was subjected to the plant bioassay procedure in the greenhouse as per Folsom et al. (1981).^{*} A bucket filled with prepared WES reference soil was embedded adjacent to each bucket of dredged material at each disposal site. The WES reference soil was watered initially; the disposal site dredged material did not require water. All soil and dredged material was planted with four sprouted tubers of the WES index plant, *Cyperus esculentus*. Four transects consisting of eight embedded buckets per transect (4 of test sediment and 4 of WES reference sediment) were arranged across each of the disposal sites from a wet-flooded situation to a dry-upland situation. The plants were allowed to grow to maximum vegetative growth (45 days after planting) at which time they were harvested and returned to the WES for subsequent processing.

3. Upon arrival at the WES, the plant material was washed in deionized water, separated into component parts - leaves, stems, and seeds, and dried to constant weight at 70°C. The plant leaves were digested in nitric acid-red

* Folsom, B. L., Jr., Lee, C. R., and Bates, D. J. 1981. "Influence of Disposal Environment on Availability and Plant Uptake of Heavy Metals in Dredged Material," Technical Report EL-81-12, US Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

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fuming nitric acid, and subsequently analyzed for zinc, cadmium, copper, iron, manganese, arsenic, mercury, nickel, chromium, and lead.

4. Samples of the field-moist dredged material were subjected to extraction by DTPA and digestion with nitric acid for determination of plant available metals and total metal contents, respectively. Samples of the field-moist dredged material were analyzed for a number of organic compounds (a listing of the organic compounds along with their concentrations are in Tables 1 and 2).

Greenhouse Test

5. The portion of the dredged material taken from each disposal site was transported to the WES and subjected to the plant bioassay. Dredged material moisture was maintained at four levels: flooded, 0.0-0.3 bar, 0.3-0.5 bar, and 0.5-1.0 bar. The flooded dredged material was not allowed to drain or the surface to dry out. A 5-cm depth of deionized water was maintained over the dredged material surface by the addition of water as necessary. A soil moisture tensiometer was inserted into each of the other dredged materials to measure and maintain the above soil moisture levels. Deionized water was added as necessary to maintain each appropriate moisture level.

6. Each of the experimental units was planted with four sprouted tubers of the WES index plant, *Cyperus esculentus*. The plants were allowed to grow to maximum vegetative growth (45 days after planting) at which time they were harvested. All of this plant material was used for toxic metal analysis.

7. The plant material was washed in deionized water, separated into component parts - leaves, stems, and seeds, and dried to constant weight at 70°C. The leaves were digested in nitric acid-red fuming nitric acid, and subsequently analyzed for zinc, cadmium, copper, iron, manganese, arsenic, mercury, nickel, chromium, and lead.

8. In order to have sufficient fresh plant material for analysis of organic contaminants, the experimental units were allowed to regrow for an additional 45 days. This second growth of plants was harvested after 45 days. The plant material was washed in deionized distilled water and separated into component parts - leaves, stems, and seeds. The fresh leaves were then placed into Zip-Loc[®] plastic bags and subsequently frozen at -10°C until time for organic analysis. Fresh leaf tissue was analyzed for the organic compounds shown in Tables 1 and 2 by USEPA method No. 1003.**

** Method for Analysis of Priority Pollutants in Solids and Bottom Sediments. 1979. CRL Method No. 1003. USEPA Chicago, Illinois.

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Experimental Results

9. Results of the organic analysis of the dredged material from the Buffalo and Toledo disposal sites indicated that most pesticides and some organic compounds were below detectable limits (Table 1). However, there were nine organic compounds that were detected. The concentrations of PCB's reached 1.0 and 2.5 ug/g for Aroclor 1242 and 1254, respectively. While these concentrations were detected, they are not considered to be hazardous levels. One compound that might be of concern is benzo-(a)-pyrene, whose concentration reached 96 ug/g. An additional 10 organic compounds were found and analyzed for in the Buffalo dredged material (Table 2). Each of these compounds is on EPA's priority pollutant list. Even though the compounds were present in the dredged material, only two were found in the plant.

10. Results of organic analysis of plant tissue revealed that only two compounds, bis (2-ethylhexyl) phthalate and phenol, were present in the plants at concentrations above detectable limits. However, plants grown in WES reference soil also contained the phthalate compound. Phenol and Phenolic compounds are considered normal constituents of plants. Therefore, plant uptake of organic contaminants (given in Tables 1 and 2) from dredged material from the three disposal sites does not appear to be out of the ordinary or a problem.

11. Concentrations of toxic metals (especially cadmium) in the dredged material from the three disposal sites were fairly high compared to recent research data collected at the WES. Results of the chemical analysis of the dredged material from each of the disposal sites indicated that the Buffalo and Cleveland sites contained higher total concentrations of most heavy metals than the Toledo site (Table 3). The cadmium concentration was highest in the Cleveland site (24.2 ug/g), less in the Buffalo site (11.9 ug/g), and least in the Toledo site (4.7 ug/g). The Buffalo site contained the highest concentrations of zinc, copper, mercury, chromium, and lead.

12. Results of the DTPA extraction indicated that the heavy metals in the Cleveland site appeared to have more plant available zinc, cadmium, and copper than either the Buffalo or Toledo sites.

13. Plant concentrations (field conditions, Table 4) of heavy metals in plants grown in dredged material from the three disposal sites were no higher than those found in natural marshes around the Great Lakes.*** The cadmium contents of plants grown in dredged material from the Cleveland disposal site were similar to the highest values of cadmium found in these natural marshes.

*** Simmers, J. W. et al. 1981. "Field Survey of Heavy Metal Uptake by Naturally Occurring Saltwater and Freshwater Marsh Plants," Technical Report EL-81-5, US Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

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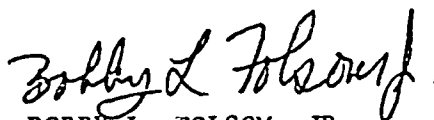
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Plant concentrations of heavy metals in plants grown in the greenhouse (Table 5) in dredged material from the three disposal sites also were no higher than those in the field. Moisture status did not affect plant uptake of heavy metals either in the field or in the greenhouse. In general, plant concentrations of heavy metals were in the same range as those found in natural marshes around the Great Lakes and therefore are not out of the ordinary.

14. There were differences in plant growth between plants grown in dredged material and those grown in WES reference soil. Plant growth in disposal site material was less than that in WES reference soil (Table 6). This indicates that something in the disposal site materials was inhibiting plant growth.

Conclusion

15. While the dredged material in each disposal site studied had some level of contamination with heavy metals and priority organic pollutants, plant uptake of these contaminants was of little consequence. These results suggest that plants should not take up or bioaccumulate contaminants from these disposal sites. Therefore, plants colonizing these disposal sites should not present any environmental contamination problem.



BOBBY L. FOLSOM, JR.
Soil Scientist

Table 1
Concentration of Selected Organic Contaminants in Dredged Material and Plants Grown in Those
Dredged Materials from Buffalo, New York, Toledo, Ohio, and the WES Reference Soil

Organic Compound	Concentration Range, ug/g				
	Sediment		<i>Cyperus esculentus</i>		
	Buffalo	Toledo	Buffalo	Toledo	WES Refer
Bis (2-ethylhexyl) phthalate	1.5 - 5.5 (3.0)*	1.6 - 2.8 (2.5)	0.5 - 1.6 (1.5)	1.1 - 1.9 (1.4)	1.6 - 1.9
PCB (Aroclor 1242)	0.42 - 1.0 (0.75)	<0.2	<1.0	<1.0	<1.0
PCB (Aroclor 1254)	0.62 - 2.5 (1.5)	<0.2	<1.0	<1.0	<1.0
Aniline	1.7 - 2.8 (2.3)	NA*	<0.5	<0.5	<0.5
1 - amino-naphthalene	1.7 - 4.1 (2.7)	NA	<0.5	<0.5	<0.5
N - benzyl-N-ethyl-aniline	2.4 - 7.0 (4.5)	NA	<0.5	NA*	<0.5
4 - (dimethyl-amino) benzo phenone	<0.1	NA	<0.5	NA	<0.5
4,4 - methylene bis (N, N-dimethyl-aniline)	0.54 - 1.4 (0.93)	NA	<0.5	NA	<0.5
N, N, N', N' - tetramethyl benzidine	<0.1	NA	<0.5	NA	<0.5
p, p' - benzylidene bis (N, N-dimethyl-aniline)	2.6 - 4.7 (3.3)	NA	<0.5	NA	<0.5
benzo-(a)-pyrene	20 - 96 (39)	NA	<0.5	NA	<0.5
Chlordane	< 0.2	<0.2	<1.0	<1.0	<1.0
Toxaphene	< 0.2	<0.2	<1.0	<1.0	<1.0
Dimethyl phthalate	< 0.2	<0.2	<0.5	<0.5	<0.5
Diethyl phthalate	< 0.2	0.26 - 0.31 (0.28)	<0.5	<0.5	<0.5
Dibutyl phthalate	< 0.2	0.21 - 0.25 (0.23)	<0.5	<0.5	<0.5
Benzyl butyl phthalate	< 0.2	<0.2	<0.5	<0.5	<0.5
Lindane	< 0.1	<0.1	<1.0	<1.0	<1.0
Heptachlor	< 0.1	<0.1	<1.0	<1.0	<1.0
Aldrin	< 0.1	<0.1	<1.0	<1.0	<1.0
p, p' - DDE	< 0.1	<0.1	<1.0	<1.0	<1.0
Dieldrin	< 0.1	<0.1	<1.0	<1.0	<1.0
Endrin	< 0.1	<0.1	<1.0	<1.0	<1.0
p, p' - DDD	< 0.1	<0.1	<1.0	<1.0	<1.0
p, p' - DDT	< 0.1	<0.1	<1.0	<1.0	<1.0
Methoxychlor	< 0.1	<0.1	<1.0	<1.0	<1.0
Mirex	< 0.1	<0.1	<1.0	<1.0	<1.0
Phenol	< 1.7	<1.7	<1.1	<1.1 - 4.36 (2.01)	<1.1

* Value in parentheses is the mean concentration.

** NA = Not Analyzed For

Table 2
Concentration of Additional Organic Contaminants in Dredged Materials and
Plants Grown in Dredged Materials from Buffalo, New York and the WES
Index Plant (*Cyperus esculentus*)

Organic Compound	Concentration Range, ug/g			
	Buffalo Sediment	<i>Cyperus esculentus</i>		WES Reference
		Buffalo		
1,2 - dichlorobenzene	0.83 - 9.8 (3.5)*	<0.5		<0.5
1,3 - dichlorobenzene	1.2 - 9.5 (3.9)	<0.5		<0.5
1,4 - dichlorobenzene	8.0 - 22 (12)	<0.5		<0.5
Naphthalene	11 - 20 (14)	<0.5		<0.5
Phenanthrene	10 - 15 (13)	<0.5		<0.5
Anthracene	7.0 - 13 (9.7)	<0.5		<0.5
Flouranthene	10 - 24 (17)	<0.5		<0.5
Pyrene	9.8 - 27 (17)	<0.5		<0.5
Benzo-(a)-anthracene	6.2 - 23 (12)	<0.5		<0.5
Chrysene	7.2 - 26 (14)	<0.5		<0.5

* Value in parenthesis is the mean concentration.

Table 3
HNO3 and DTPA Extractable Toxic Metals from Dredged Material from Disposal Sites
at Buffalo, New York, Toledo, Ohio, and Cleveland, Ohio

Toxic Metal	HNO3			DTPA		
	Concentration, ug/g			Concentration, ug/g		
	Buffalo	Toledo	Cleveland	Buffalo	Toledo	Cleveland
Zn	1031 - 1845 (1283)*	138 - 162 (152)	880 - 1300 (1024)	84 - 202 (150)	19 - 25 (21)	181 - 296 (224)
Cd	10.9 - 13.3 (11.9)	4.2 - 5.2 (4.7)	22.0 - 26.6 (24.2)	0.5 - 3.0 (1.76)	1.1 - 1.5 (1.3)	8.9 - 12.7 (11.0)
Cu	238 - 269 (251)	43 - 49 (46)	133 - 171 (150)	10 - 33 (21.4)	17 - 20 (18)	48 - 72 (60)
Fe	54 - 74** (64)	22 - 25** (23)	43 - 47** (44)	0.81 - 1.07** (0.94)	0.75 - 0.97** (0.82)	0.71 - 0.78** (0.74)
Mn	619 - 723 (694)	563 - 593 (581)	683 - 766 (739)	77 - 114 (91)	155 - 166 (159)	146 - 184 (159)
As	2.0 - 58.9 (22.7)	6.4 - 6.7 (6.6)	22.5 - 257 (24.3)	0.09 - 0.29 (0.17)	0.06 - 0.09 (0.08)	0.04 - 0.07 (0.05)
Hg	2.9 - 9.4 (4.8)	<0.01	0.08 - 0.10 (0.09)	<0.05	<0.05	<0.05
Ni	49 - 63 (55)	51 - 56 (53)	94 - 110 (101)	4.2 - 7.0 (5.3)	5.0 - 6.1 (5.4)	6.8 - 7.5 (7.2)
Cr	302 - 393 (332)	44 - 54 (49)	155 - 203 (177)	0.35 - 0.47 (0.40)	0.04 - 0.08 (0.06)	0.17 - 0.34 (0.28)
Pb	156 - 1037 (497)	36 - 58 (44)	177 - 269 (221)	82 - 421 (191)	13 - 15 (14)	47 - 85 (68)

* Value in parenthesis is the mean value.

** Fe is in mg g⁻¹

Table 4
Concentration of Toxic Metals in *Cyperus esculentus* Grown in Dredged
Material from Disposal Sites At Buffalo, New York, Toledo, Ohio,
and Cleveland, Ohio Under Field Conditions

Toxic Metal	Concentration, ug/g		
	Buffalo	Toledo	Cleveland
Zn	34.9 - 83.8 (55.5)*	35.9 - 56.8 (43.5)	54.2 - 67.1 (60.7)
Cd	0.70 - 1.53 (1.04)	0.52 - 0.69 (0.64)	2.22 - 4.21 (3.33)
Cu	6.40 - 18.7 (10.7)	7.73 - 9.10 (8.27)	8.16 - 9.51 (9.07)
Fe	267 - 1751 (983)	172 - 295 (218)	187 - 243 (215)
Mn	129 - 359 (218)	56.0 - 115 (80.0)	18.1 - 61.5 (36.7)
As	0.40 - 4.22 (1.54)	0.06 - 0.09 (0.08)	0.01 - 0.09 (0.04)
Hg	<0.005	<0.005	<0.005
Ni	0.80 - 10.6 (4.85)	0.56 - 2.63 (1.46)	0.58 - 2.69 (1.45)
Cr	4.30 - 38.2 (17.2)	0.1 - 3.58 (2.04)	5.06 - 8.29 (5.78)
Pb	1.91 - 17.9 (6.88)	0.23 - 0.82 (0.55)	0.59 - 1.10 (0.86)

* Concentration in parenthesis is the mean concentration.

Table 5
Concentration of Toxic Metals in *Cyperus esculentus* Grown in Dredged
Material from Disposal Sites at Buffalo, New York, Toledo, Ohio,
and Cleveland, Ohio Under Greenhouse Conditions

Toxic Metal	Concentration, ug/g		
	Buffalo	Toledo	Cleveland
Zn	46.6 - 61.2 (52.9)*	55.5 - 66.4 (61.8)	58.1 - 72.3 (65.9)
Cd	0.79 - 1.16 (0.92)	0.61 - 1.01 (0.75)	2.42 - 3.10 (2.81)
Cu	6.13 - 6.56 (6.44)	6.43 - 7.60 (7.06)	7.95 - 9.78 (8.75)
Fe	98 - 264 (155)	109 - 122 (116)	118 - 348 (200)
Mn	146 - 206 (167)	72.0 - 83.0 (78.4)	76.0 - 129.0 (98.6)
As	0.14 - 0.28 (0.19)	0.04 - 0.08 (0.06)	0.02 - 0.07 (0.03)
Hg	<0.005	<0.005	<0.005
Ni	0.37 - 1.13 (0.81)	0.01 - 0.08 (0.02)	0.63 - 1.75 (1.33)
Cr	1.21 - 1.46 (1.32)	0.18 - 0.62 (0.38)	3.34 - 6.09 (4.60)
Pb	0.32 - 0.55 (0.42)	0.17 - 0.36 (0.23)	0.06 - 0.19 (0.16)

* Concentration in parenthesis is the mean concentration.

Table 6
Yield of *Cyperus esculentus* Grown in Dredged Material from Buffalo,
New York, Toledo, Ohio, and Cleveland, Ohio
Under Field and Greenhouse Conditions

<u>Disposal Site</u>	Yield, g/pot			
	Field		Greenhouse	
	<u>Disposal Site</u> <u>Sediment</u>	<u>Reference</u> <u>Soil</u>	<u>Disposal Site</u> <u>Sediment</u>	<u>Reference</u> <u>Soil</u>
Buffalo	2.0	4.8	10.8	14.0*
Toledo	8.5	11.6	22.4	14.0
Cleveland	3.8	10.9	9.4	14.0

* The same reference soil was used for all three disposal sites in the greenhouse.

Comparison of National Bureau of Standards Certified Values
and WES Analytical Laboratory Values for
NBS Standards

<u>Toxic Metal</u>	<u>Concentration Range $\mu\text{g/g}$</u>	
	<u>River Sediment</u> <u>(WES Analysis)</u>	<u>River Sediment</u> <u>(NBS Certified Values)</u>
As	41.00-60.00 (53.75)	66*
Cd	7.70-8.30 (8.00)	10.2 $\pm$ 1.5
Cu	113.00-120.00 (116.50)	109 $\pm$ 19
Pb	679.00-717.00 (706.50)	714 $\pm$ 28
Zn	1570.00-1680.00 (1620.00)	1720 $\pm$ 169
Hg	0.80-1.10 (0.97)	1.1 $\pm$ 0.5

* Non certified

NBS Standards (continued)

<u>Toxic Metal</u>	<u>Concentration Range $\mu\text{g/g}$</u>	
	<u>Tomato Leaves (WES Analysis)</u>	<u>Tomato Leaves (NBS Certified Values)</u>
As	0.20-0.40 (0.32)	0.27 ± 0.05
Cd	2.40-2.50 (2.45)	3*
Cu	11.00	11 ± 1
Pb	3.90-6.20 (5.05)	6.3 ± 0.3
Zn	59.00-60.00 (59.25)	62 ± 6
Hg	0.30-0.40 (0.32)	0.1*

* Non certified

NBS Standards (continued)

Toxic Metal	Concentration Range $\mu\text{g/g}$			
	Bovine Liver (WES Analysis)	Bovine Liver (NBS Certified Values)	Oyster (WES Analysis)	Oyster (NBS Certified Values)
As	0.04-0.04 (<0.04)	0.055 $\pm$ 0.005	8.60-11.00 (10.15)	13.4 $\pm$ 1.9
Cd	0.17-0.32 (0.25)	0.27 $\pm$ 0.04	3.10-3.40 (3.25)	3.5 $\pm$ 0.4
Cu	183.00-200.00 (193.25)	193 $\pm$ 10	61.00-64.00 (63.00)	63.0 $\pm$ 3.5
Pb	<0.90	0.34 $\pm$ 0.08	<0.90	0.48 $\pm$ 0.04
Zn	126.00-129.00 (127.50)	130 $\pm$ 13	794.00-827.00 (805.50)	852 $\pm$ 14
Hg	<0.30	0.016 $\pm$ 0.002	<0.30	0.057 $\pm$ 0.015

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MEMORANDUM FOR RECORD

SUBJECT: Interim Report on Contaminant Mobility Studies at Times Beach,
Buffalo, New York

1. Introduction. The field study, laboratory study, and sample preparation summarized in this Memorandum for Record were conducted by Glenn Rhett, Stratford Kay, Morris Richards, Martin Brodie, Walter Rayford, Don Crawley, and me, Waterways Experiment Station (WES), and by Joop Marquenie, Technology for Society (TNO). Dr. Marquenie was also responsible for interactions with the analytical laboratory of TNO and preparing the data summarized in this report.
2. In 1983 the WES wetland and terrestrial animal bioassay procedure was conducted using freshly collected dredged material from the Times Beach disposal site in the laboratory (growth chamber) and in the field. Soil/sediment cores were collected at each earthworm bioassay station within the disposal site. Samples of the dominant plant species were collected from aquatic, wetland, and upland (terrestrial) sites, and a complete botanical inventory was made within the disposal site and reference site. Native earthworms were collected within the disposal site and in the reference sites. Two species of sport fish were collected from the pond within the disposal site and from the Buffalo River located adjacent to the disposal site. Soil profiles from the disposal site and the reference site were observed and described. The site is illustrated in Figure 1.
3. Analyses for heavy metals, polychlorinated biphenyls (PCB's), and polyaromatic hydrocarbons (PAH's) were performed on soil/sediment cores, field-collected native earthworms, earthworms used in the laboratory bioassays, and fish samples.
4. Preliminary results. Partial results of the growth chamber study are summarized in Table 1. Analyses were carried out for three of the eight points along each transect. These data indicate the presence of bioavailable Cd through both transects. This may be of concern as these levels and those in the native worms collected on the site (Table 2) far exceed literature values. The As is also elevated and may represent a food web biomagnification concern. The total PCB concentration along the transects is relatively uniform as are the concentrations noted in the worm tissue. The indicated biomagnification of PCB's by Eisenia foetida, the earthworm, may be of concern to animals higher up the food web. The PAH concentration of the substrates and the worm tissues is less uniform than that of the Cd, As, or PCB's. The total PAH concentration shown in Table 1 and the break-out of some of the components with the highest concentrations suggests a gradient in distribution and availability with A2 and B2 generally the highest followed by A8 and B8. Prior to the final report, these data will be evaluated statistically. At

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this time, however, there does appear reason to be concerned about the levels of the pyrene groups in the test animals.

5. A comparison of the native worms collected at Times Beach and those from a reference area (Incl 1) indicated an extremely high Cd level at Times Beach as well as elevated levels at the reference area. This may be the result of widespread Cd contamination throughout the Buffalo area. Cadmium levels in worm tissues are generally less than $17 \mu\text{g/g}$ in available literature.

6. The preliminary data from the fish study (Table 4) may indicate potential problems. The USFDA limits for Hg of $0.5 \mu\text{g/g}$ and As of $10 \mu\text{g/g}$, may indicate a potential Hg hazard. FDA guidelines for PCB's are $1 \mu\text{g/g}$ as a limit with $0.5 \mu\text{g/g}$ recommended. This indicates that there may be a potential PCB problem. The fish-eating birds that occupy the peak of the food pyramid may be exposed to relatively large doses of PCB's as they consume whole fish (including livers). The fish PAH concentration given as a total reflects small amounts of 21 compounds, with only one compound, benzo(g,h,i) perylene, consistently in the $0.1 \mu\text{g/g}$ range. The allowable concentrations of PAH's are not known, and the hazard presented by the concentrations shown in Table 4 is not known.

7. The soil profiles of the Times Beach transects from R. P. Leonard's Memorandum for Record are given in Incl 1. These give an indication of the layers in which the dredged material is arranged. The presence of the deep-layer oily material may indicate a pool of organic compounds capable of moving into the ecosystem. The soil profile of the reference site indicates what a typical wetland soil in the area is like, and indicates the differences between the disposal site and a naturally occurring soil.

8. The vegetation of the transects at Times Beach, as well as an overall vegetation survey of Times Beach and the reference area, was summarized by Gerould Wilhelm, Southern Illinois University (Incl 2). This information will be critical in any future contaminant mobility studies addressing food-web effects and later examinations of the plant succession as related to the contaminants in the substrate.

9. Inclosure 3 contains the preliminary data as supplied by TNO. These data will be statistically treated prior to the preparation of a final report when all analyses are completed. These data are preliminary and do not include all the metals or organics found during analysis or all of the duplicate analyses and quality assurance data to be provided in the final report.

10. Recommendations. The samples collected during the Times Beach activities are listed in Table 5. Completed analyses are shown but replicate analyses are not indicated. Based on the information in this table there are several pertinent recommendations that can be made. At this time the preliminary worm study data have yielded some very fine results. It would be very worthwhile to analyze the remaining nine substrate and nine worm tissue samples from the growth chamber study. In order to obtain a field verification it is suggested that approximately 6 of the 13 worm tissue samples from the field portion of

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Buffalo, New York

the study should also be analyzed. These data combined with the data on Cr which were extremely high and other metals and organics would provide a firm statistical background for the site. This information should convincingly demonstrate the bioaccumulation of Cd to levels greater than that in the substrate, as well as PCB's and other metals and organic compounds.

11. The above recommendation does not address the plant-related contaminant problem. An alternative would be termination of the worm analysis at this point and use the approximately 30 remaining analyses to address the plants and substrates related to the plants. Either the worm tissues or the plant tissues could be held for future analysis should funds be available. Funding for FY 84 of \$18-20K would allow the running of the plant program as previously planned and would also allow the continuation of the worm analysis program which is yielding very significant results. The plant program would consist of screening some of the leaf, sediment, seed, and rhizome samples for metals, PAH's and PCB's. Following screening those pertinent samples, if there are only detection level amounts found, no further analysis would be performed and the attention could be turned to the remaining four fish samples (rock bass and carp). The plant analyses could be expected to confirm the results of the WES plant bioassay adding new information primarily in the heavy metal concentrations of seeds, rhizomes, and the aquatic plants. The literature suggest limited movement of PCB's and PAH's from the substrate to plants.

12. Completion of the earthworm and plant analyses in conjunction with the fish data will result in a very good preliminary data base for determining where the emphasis should be placed for future sampling and monitoring efforts. The WES final report will include the deep-layer worm experiment funded by the Dutch Government.



JOHN W. SIMMERS
Research Biologist

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J. M. Marquenie

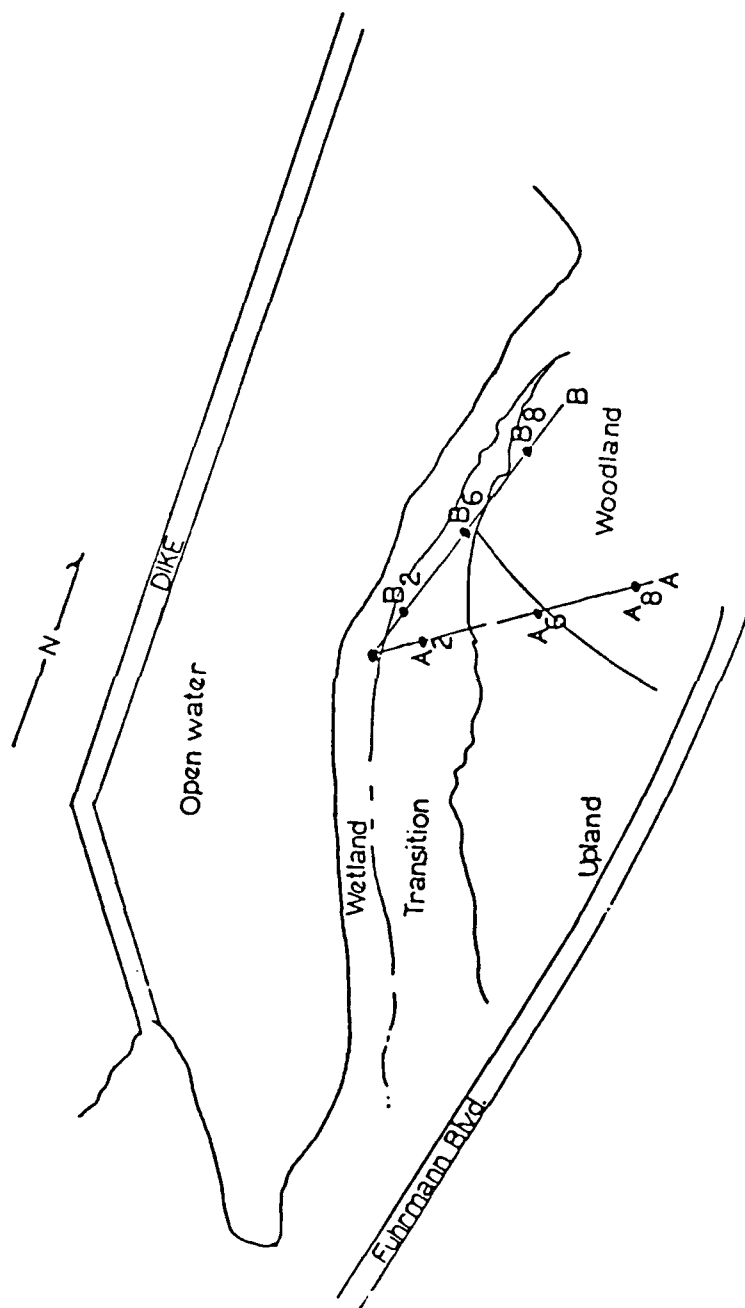


Figure 1. Times Beach Showing Transects A and B

Table 1
Contaminants in Experimental Worm Tissue and Substrates
Summary of Preliminary Data

Transect Location	Component	Concentration $\mu\text{g/g}$			dry weight*		
		Cd	Cu	Hg	As	PCB Total	PAH Total
A8	Substrate	2.10	116.0	2.10	25.0	0.462	40.93
	Tissue	8.86	27.7	0.48	21.1	3.950	21.06
A6	Substrate	0.76	60.0	1.52	20.0	0.712	7.03
	Tissue	6.54	17.3	0.98	17.5	4.426	1.95
A2	Substrate	2.73	148.0	4.22	38.5	1.004	45.52
	Tissue	11.70	32.1	1.39	24.0	4.520	11.78
B2	Substrate	9.61	334.0	8.50	72.4	0.961	63.96
	Tissue	10.80	57.6	0.81	23.9	6.720	38.88
B6	Substrate	5.33	228.0	4.78	58.8	0.743	32.09
	Tissue	17.60	36.2	1.14	35.3	3.620	7.46
B8	Substrate	7.74	269.0	7.45	53.0	0.480	35.10
	Tissue	16.0	46.7	1.77	53.8	3.125	8.49
Worm medium	Substrate	0.39	16.5	0.74	3.40	<0.128	≤ 3.49
	Tissue	3.04	10.1	0.06	8.72	<0.410	≤ 0.77

* Substrates reported as dry weight; tissues reported as ash-free dry weight.

Ash-free dry weight is used in these tables to account for the presence of minute amounts of soil in the digestive tracts of the animals. This is about 1% less than the dry weight.

Each data entry represents one sample.

Table 2
Contaminants in Native Worm Tissue at Times Beach and Reference Area
Summary of Preliminary Data

Location	Species	Concentration $\mu\text{g/g}$			ash-free dry weight		
		Cd	Cu	Hg	As	PCB Total	PAH Total
Times Beach	<u>Lumbricus rubellus</u>	98.7	59.0	1.64	41.8	2.747	5.72
Reference Area	<u>L. rubellus</u>	20.0	25.2	0.51	10.32	<0.04	0.69
	<u>Allolobophora chlorotica</u>	23.4	10.9	1.88	10.6	<0.04	0.72
	<u>Octolasion lacteum</u>	43.6	13.65	2.06	8.03	<0.04	0.58

Table 3
Significant PAH's in Worm Tissue and Substrates - Summary of Preliminary Data

Transect location	Component	Concentration $\mu\text{g/g}^*$ pyrene	triphenylene	benzo(e) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	benzo(a) pyrene	benzo(g,h,i) perylene	indeno (1,2,3-c,d) pyrene
A8	Substrate Tissue	2.9 3.9	≤ 0.15 ≤ 0.015	1.8 1.5	3.0 2.1	1.7 1.3	3.8 2.8	3.4 1.5	3.0 1.3
A6	Substrate Tissue	0.53 0.14	≤ 0.15 0.074	0.32 0.099	0.43 0.15	0.25 0.11	0.56 0.16	0.29 0.19	0.47 0.21
A2	Substrate Tissue	2.7 0.53	≤ 0.15 1.6	2.1 0.75	3.5 1.3	1.9 0.65	5.2 1.8	4.5 1.1	3.1 1.1
B2	Substrate Tissue	2.5 ≤ 0.015	≤ 0.15 3.6	4.0 4.2	5.6 5.4	2.9 2.6	8.6 7.4	7.6 3.2	6.7 5.0
B6	Substrate Tissue	1.5 0.093	≤ 0.15 0.57	2.1 0.65	2.3 0.54	1.2 0.24	3.6 0.93	3.7 0.93	2.9 1.6
B8	Substrate Tissue	2.1 0.15	≤ 0.15 0.69	2.1 1.1	2.4 0.67	1.4 0.37	3.6 1.3	3.9 1.5	3.1 0.83
Worm medium	Substrate Tissue	≤ 0.15 ≤ 0.15	≤ 0.15 0.021	≤ 0.2 ≤ 0.02	≤ 0.025 ≤ 0.002	0.032 0.0047	≤ 0.02 ≤ 0.002	0.80 0.160	≤ 0.1 0.029

* Substrates reported as dry weight; tissues reported as ash-free dry weight

Table 4
Contaminants in Fish Tissues from Times Beach and the Buffalo River
Partial List

Location	Fish	Concentration $\mu\text{g/g}$			ash-free dry weight		
		Cd	Cu	Hg	As	PCB Total	PAH Total
Times Beach	Yellow Perch						
	muscle	<0.01	2.44	1.16	0.21	0.905	0.55
	liver	0.04	1.32	0.10	0.94	15.400	3.31
	Pumpkin Seed						
Buffalo River	Yellow Perch						
	muscle	<0.02	1.92	0.43	0.16	0.327	0.42
	liver	0.28	3.96	0.05	0.58	5.397	0.93
	Pumpkin Seed						
	muscle	<0.03	1.99	0.73	0.53	≤ 0.265	0.40
	liver	1.26	10.90	0.36	1.82	0.637	1.00

Table 5
Samples Resulting from Times Beach Related Activities

Activity	Samples Collected		Samples Analyzed	
	Tissue	Substrate	Tissue	Substrate
Growth chamber tests	15	15	6	6
Growth chamber control	4	4	4	4
Background	<u>5</u>	<u>0</u>	<u>5</u>	<u>0</u>
Subtotals	24	19	15	10
Field tests	13	13	0	0
Field control	6	6	0	0
Native worms	2	0	2	0
Background	5	0	0	0
Reference site	<u>3</u>	<u>0</u>	<u>3</u>	<u>0</u>
Subtotals	29	19	5	0
Fish samples	18	0	14	0
Aquatic plants	2	2	0	0
Wetland plant	16 leaf	16	0	0
	15 stem		0	0
	12 seed		0	0
	15 dead leaf		0	0
	<u>4 rhizomes</u>	<u>—</u>	<u>0</u>	<u>0</u>
Subtotals	<u>64</u>	<u>18</u>	<u>0</u>	<u>0</u>
Totals	135	56	34	10

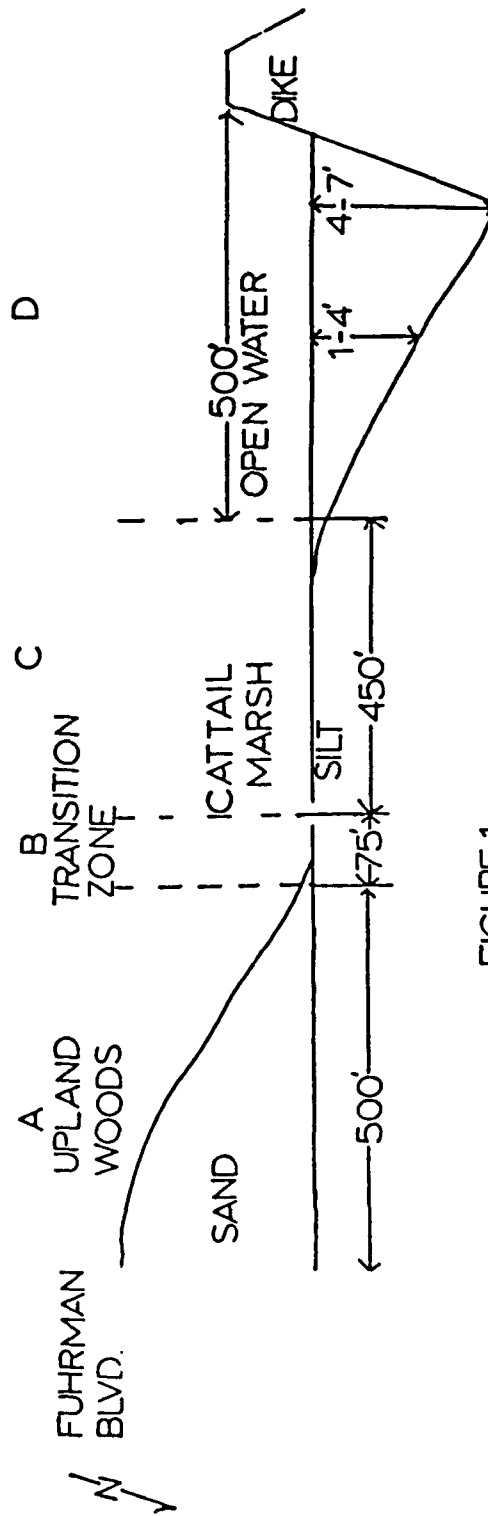


FIGURE 1

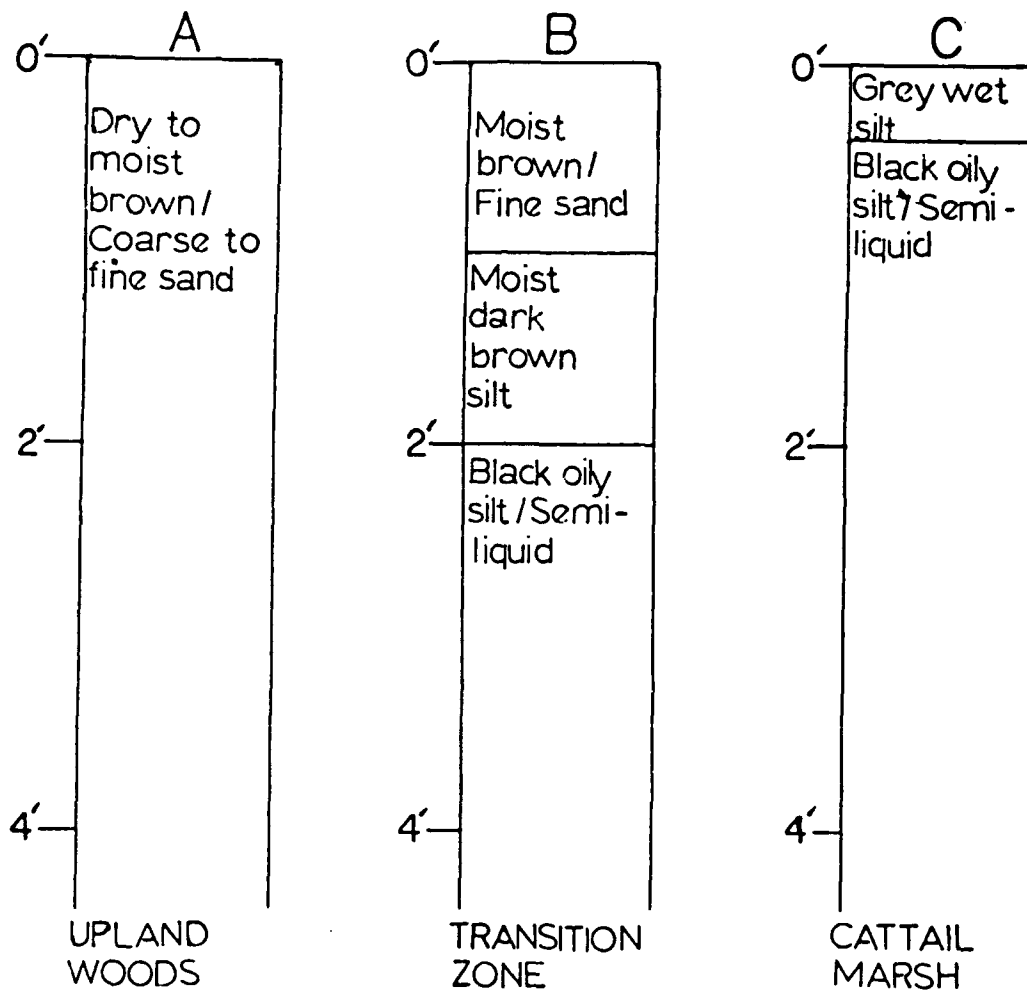


FIGURE 2

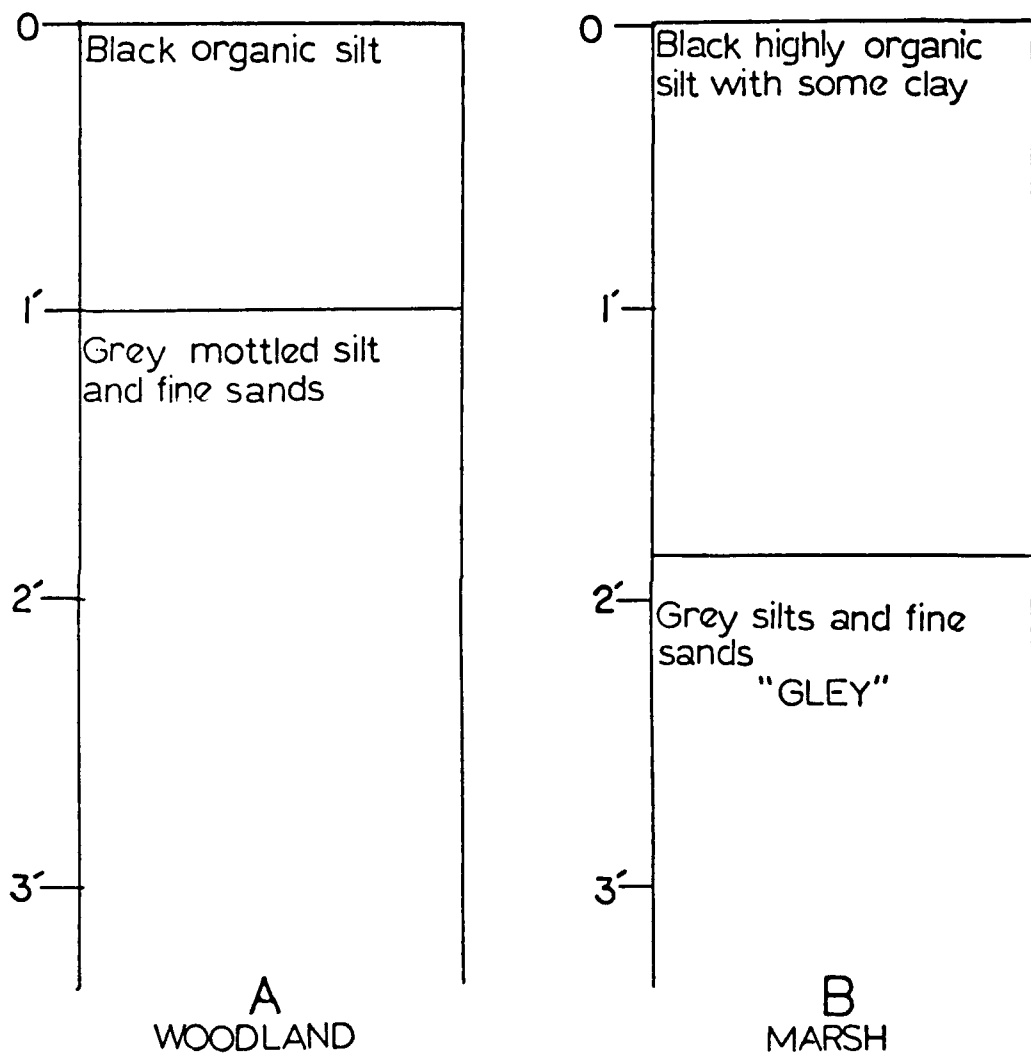


FIGURE 3

Soil Profiles--Times Beach Disposal Area and Control Wetland Area at Grand Island, New York

1. The following information was taken from MFR's of 9 and 10 August 1983 written by Richard P. Leonard of the Buffalo District.

2. In August 1983, a number of hand auger soil borings were made at the Times Beach disposal area and at the Control Wetland Site located on the east side of the East River Rd. near the River Oaks Golf Course and adjacent to the east branch of the Niagara River. Borings were made to depths of 2-4 ft at the Times Beach Disposal Area and to 3 ft at the Control Wetland Area.

3. Results from Times Beach Disposal Area

A. Borings showed that in the higher elevated and wooded portions of the site, nearer Fuhrman Boulevard, sandy sediments were prevalent. As one proceeded into the wetter areas of cattails, sand deposits graded into predominantly silts. This would be expected since the pipe discharge occurred at the north eastern end of the site and heavier sandy material was deposited quickly, whereas fine silts were carried out towards the dike. A typical east to west profile is shown in Fig 1.

B. Borings revealed that the deeper sandy deposits have dried out considerably since disposal was discontinued some 7 years ago. This material would support heavy equipment and probably light structures. As the site is traversed from east to west towards the lake, sand deposits become thinner. Where sand deposits become less than about 3 ft thick, the lower sand layers and underlying silt are apparently permanently saturated (i.e., water table).

C. The sand and predominantly silt layers which are saturated have undergone little or no change since they were deposited. This material is grey to black with a semi-liquid consistency and a strong oil odor. This underlying material is in marked contrast to drier top layers which have a dark brown color with faint oil odor. In the silty material of the transition zone and in the cattail zone, only the top 1 to 2 ft has been changed by oxidation, due to plant root and microbiological activity. These areas would not support vehicles or structures. Typical profiles for the various zones are shown in Fig 2.

D. It is obvious that the most important factor controlling soil development and organic contaminant degradation in the Times Beach disposal area (and other dike disposal areas) is the location of the water table. Apparently reducing conditions in sediments below the water table hinder microbiological and plant root activity which could enhance the breakdown of oil, grease, and other organic contaminants. Thus, while a wetland can thrive, soil development and stabilization of dredge material will occur more rapidly in sediments deposited above a water table.

E. The soil investigations at Times Beach also revealed the unsoundness and futility of any plans to excavate sediments for any development in the wetland transition zone or cattail marsh. Excavation would uncover saturated, possible highly contaminated material. The deep sandy deposits nearer Fuhrman Boulevard may support limited development.

4. Results from the Control Wetland Area

A. Profiles were examined in the very poorly drained wet marsh areas containing cattails, sedges, and rice cutgrass and in the slightly better drained (i.e., poorly drained to somewhat poorly drained) and drier (moist) surrounding deciduous woodland. All the soils examined have developed from glacial lakeland (Lacustrine) silt and fine sand deposits. The woodland borings indicate that compact glacial till underlies the areas at depths of 3 ft or greater. Typical profiles for the marsh and woodland are shown in Fig 3.

B. The soils at this site are temporarily saturated to permanently saturated natural wetland soils. Although the surface soils are high in organic matters, they are not peat. The grey, unmottled marsh subsoil (B) has a typical "Grey" color indicating permanently saturated and reduced conditions. The reddish brown mottling in the woodland soil indicates that this layer is seasonally dried out with some oxidation of iron compounds occurring.

VEGETATION OF THE TIMES BEACH DISPOSAL AREA
Buffalo, New York

(This report is provided in Appendix A, pp A3-A21.)

APPENDIX NOMENCLATURE OF PCB AND PCA COMPONENTS

PCB components

28	2,4,4'	-	trichlorobiphenyl
52	2,5,2',5',	-	tetrachlorobiphenyl
49	2,4,2',5'	-	"
70	2,5,3',4'	-	"
101	2,4,5,2',5'	-	pentachlorobiphenyl
87	2,3,4,2',5'	-	"
153	2,4,5,2',4',5'	-	hexachlorobiphenyl
138	2,3,4,2',4',5'	-	"
180	2,3,4,5,2',4',5'	-	heptachlorobiphenyl

PCA components

1	phenanthrene
2	anthracene
3	fluoranthene
4	pyrene
5	3,6-dimethylphenanthrene
6	triphenylene
7	benzo(b)fluorene
8	benzo(a)anthracene
9	chrysene
10	benzo(e)pyrene
11	benzo(j)fluoranthene
12	perylene
13	benzo(b)fluoranthene
14	benzo(k)fluoranthene
15	benzo(a)pyrene
16	dibenzo(a,j)anthracene
17	dibenzo(a,l)pyrene
18	benzo(g,h,i)perylene
19	indeno(1,2,3-c,d)pyrene
20	3-methylcholanthrene
21	anthanthrene

Table 1 Metal concentrations ($\mu\text{g.g}^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure)

<u>station</u>	Cd	Cu	Hg	As
A8	2.10	116	2.10	25.0
A6	0.76	60	1.52	20.0
A2	2.73	148	4.22	38.5
B2	9.61	334	8.50	72.4
B6	5.33	228	4.78	58.8
B8	7.74	269	7.45	53.0
Man	0.39	16.5	0.74	3.40

Table 2 Metal concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in experimental worms exposed to sediments described in Table 1

<u>station</u>	Cd	Cu	Hg	As
A8	8.86	27.7	0.482	21.1
A6	6.54	17.3	0.981	17.5
A2	11.7	32.1	1.39	24.0
B2	10.8	57.6	0.805	23.9
B6	17.6	36.2	1.14	35.3
B8	16.0	46.7	1.77	53.8
Man	3.04	10.1	0.059	8.72

Table 3 Metal concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area

area	species	Cd	Cu	Hg	As
Times Beach	<u>Lumbricus rubellus</u>	113.0	59.7	1.33	30.8
	" "	84.4	58.3	1.95	52.9
Reference	<u>L. rubellus</u>	17.6	20.2	0.469	8.84
	" "	22.4	30.2	0.549	11.8
	<u>Allolobophora chlorotica</u>	24.3	11.4	1.76	10.8
	" "	22.5	10.4	2.00	10.4
	<u>Octolasion lacteum</u>	36.5	12.5	1.77	6.47
	" "	50.7	14.8	2.34	9.59

Table 4 Metal concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in fishes at Times Beach and the adjacent mouth of Buffalo River

area	species	organ.	Cd	Cu	Hg	As
Times Beach	Yellow Perch	muscle	<0.013	2.44	1.16	0.214
		liver	0.042	1.32	0.102	0.936
	Pumpkin Seed	muscle	<0.019	3.30	0.717	0.579
		liver	0.316	8.00	0.355	1.89
Buffalo River	Yellow Perch	muscle	<0.020	1.92	0.428	0.161
		liver	0.280	3.96	0.053	0.575
	Pumpkin Seed	muscle	<0.028	1.99	0.730	0.534
		liver	1.26	10.9	0.363	1.82

Table 5 PCB concentrations ($\mu\text{g} \cdot \text{kg}^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure)

station	PCB component								
	28	52	49	70	101	87	153	138	180
A8	43	93	64	78	58	40	34	32	20
A6	110	160	120	160	70	55	15	18	4
A2	130	220	160	210	110	76	42	41	15
B2	55	220	150	120	140	100	71	71	34
B6	50	170	110	120	110	70	46	45	22
B8	22	93	55	42	83	50	53	52	30
Man	<10	<15	<14	<16	<17	<15	<12	<13	<16

Table 6 PCB concentrations ($\mu\text{g.kg}^{-1}$ ash-free dry weight) in experimental worms exposed to disposed materials mentioned in Table 5

station	PCB component								
	28	52	49	70	101	87	153	138	180
A8	230	800	460	600	680	310	420	330	120
A6	530	1000	760	990	520	310	140	130	<46
A2	400	1000	690	830	630	360	280	230	100
B2	260	1700	1100	870	1100	680	470	430	150
B6	150	870	540	430	630	360	290	250	100
B8	60	680	340	<45	730	350	420	350	150
Man	<32	<48	<45	<51	<54	<48	<39	<42	<51

Table 7 PCB concentrations ($\mu\text{g.kg}^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area

area	species	PCB component								
		28	52	49	70	101	87	153	138	180
T.B.	<u>L. rubellus</u>	126	460	220	330	320	160	130	130	50
		207	900	460	590	560	280	200	210	160
Ref.	<u>L. rub.</u>	all values below detection limits = $< \sim 40$								
	<u>A. chl.</u>	"	"	"	"		"			
	<u>O. lac.</u>	"	"	"	"		"			

Table 8 PCB concentrations ($\mu\text{g.kg}^{-1}$ ash-free dry weight) in fishes at Times Beach and the adjacent mouth of Buffalo River

area	spec.	org.	PCB component								
			28	52	49	70	101	87	153	138	180
T.B.	Y.P.	m	100	180	130	160	130	59	68	56	<22
		l	1800	3400	2500	2900	2300	840	750	580	330
	P.S.	m	150	290	210	290	210	110	120	100	50
		l	420	750	590	780	600	360	370	330	190
B.R.	Y.P.	m	26	38	26	27	41	<23	63	50	33
		l	530	900	650	600	920	87	900	580	230
	P.S.	m	<18	<26	<25	<28	33	<26	47	34	<28
		l	42	70	50	64	90	<25	130	93	73

Table 9 PCA concentrations ($\mu\text{g}\cdot\text{g}^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure). Approximate detection limits are indicated (d).

station	PCA component									
	1	2	3	4	5	6	7	8	9	10
A8	3.8	1.1	3.4	2.9	0.52	d	0.58	2.8	3.0	1.8
A6	0.54	0.18	0.59	0.53	0.068	d	0.075	0.37	0.33	0.32
A2	2.0	0.64	2.0	2.7	0.41	d	6.1	2.5	2.2	2.1
B2	3.2	0.96	2.8	2.5	0.72	d	1.1	3.1	3.2	4.0
36	1.9	0.81	1.9	1.5	0.38	d	0.45	1.5	1.5	2.1
B8	2.3	0.92	2.3	2.1	0.41	d	0.49	1.7	1.9	2.1
Man	0.43	0.021	d	d	d	d	d	d	d	d
d			0.080	0.15	0.04	0.15	0.06	0.05	0.09	0.2

Table 9 PCA concentrations ($\mu\text{g}\cdot\text{g}^{-1}$ dry weight) in Times Beach surface disposed materials and a control (manure). Approximate detection limits are indicated (d) (cont'd).

station	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
A8	d	1.1	3.0	1.7	3.8	0.67	1.3	3.4	3.0	0.81	1.1
A6	d	0.15	0.43	0.25	0.56	0.14	0.43	0.29	0.47	d	0.13
A2	d	1.2	3.5	1.9	5.2	1.4	1.7	4.5	3.1	d	1.2
B2	d	2.8	5.6	2.9	8.6	1.9	2.6	7.6	6.7	d	2.5
B6	d	1.3	2.3	1.2	3.6	0.97	1.8	3.7	2.9	d	1.1
B8	d	1.4	2.4	1.4	3.6	1.1	1.6	3.9	3.1	d	1.2
Man	d	d	d	0.032	d	d	d	0.80	d	d	d
d	1.0	0.01	0.025		0.02	0.1	0.09		0.1	0.025	0.02

Table 10 PCA concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in experimental worms exposed to Times Beach disposed materials. Approximate detection limits are indicated (d).

station	PCA component									
	1	2	3	4	5	6	7	8	9	10
A8	0.68	0.26	0.85	3.9	0.22	d	0.49	1.2	1.0	1.5
A6	0.091	0.0076	0.099	0.14	0.018	0.074	d	0.099	0.17	0.099
A2	0.28	0.062	0.41	0.33	0.11	1.6	0.17	0.17	0.41	0.75
B2	0.57	0.066	0.19	d	0.51	3.6	0.68	0.35	0.47	4.2
B6	0.10	0.014	0.065	0.093	0.10	0.57	d	0.48	0.15	0.65
B8	0.14	0.024	0.090	0.15	0.090	0.69	0.058	0.10	0.15	1.1
Man	0.043	0.0016	0.12	d	d	0.021	d	0.16	d	d
d				0.015	0.0040	0.015	0.050		0.0085	0.02

Table 10 PCA concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in experimental worms exposed to Times Beach disposed materials. Approximate detection limits are indicated (d) (cont'd).

station	PCA component										
	11	12	13	14	15	16	17	18	19	20	21
A8	d	0.41	2.1	1.3	2.8	0.71	0.58	1.5	1.3	d	0.14
A6	d	0.043	0.15	0.11	0.16	0.050	0.076	0.19	0.21	d	0.0084
A2	d	0.37	1.3	0.65	1.8	0.32	0.43	1.1	1.1	d	0.11
B2	d	1.8	5.4	2.6	7.4	0.73	1.4	3.2	5.0	d	0.60
B6	d	0.18	0.54	0.24	0.93	0.24	0.37	0.93	1.6	d	0.057
B8	d	0.26	0.67	0.37	1.3	0.32	0.45	1.5	0.83	d	0.090
Man	d	d	d	0.0047	d	d	d	0.160	0.029	d	d
d	0.1	0.0008	0.002		0.002	0.01	0.009			0.003	0.0025

Table 11 PCA concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area. Approximate detection limits are indicated (d).

area	species	PCA component									
		1	2	3	4	5	6	7	8	9	10
T.B.	<u>L. rubellus</u>	0.36	0.13	0.62	0.37	0.013	0.94	0.13	0.53	0.48	0.32
		0.20	0.059	0.24	0.17	0.014	0.56	0.038	0.22	0.23	0.23
Ref.	<u>L. rubellus</u>	0.11	0.0048	0.051	d	d	d	d	0.012	0.020	d
		0.17	0.0090	0.086	d	d	d	d	0.022	0.040	d
	<u>A. chlorotica</u>	0.20	0.0064	0.090	d	0.0071	0.045	d	0.012	d	d
		0.13	0.0042	0.066	d	d	0.023	d	0.0070	0.014	d
	<u>O. lacteum</u>	0.088	0.0040	0.039	d	0.0040	0.013	d	0.0074	d	d
		0.11	0.0051	0.057	d	d	0.020	d	0.0072	0.027	d
				0.002	0.0055	0.02	0.01		0.01	0.0035	

Table 11 PCA concentrations ($\mu\text{g.g}^{-1}$ ash-free dry weight) in native worms at Times Beach and a reference area. Approximate detection limits are indicated (d) (cont'd).

area	species	PCA component										
		11	12	13	14	15	16	17	18	19	20	21
T.B.	<u>L. rubellus</u>	d	0.19	0.45	0.27	0.59	0.16	0.15	0.76	0.48	d	0.14
		d	0.13	0.27	0.14	0.31	0.086	0.13	0.64	0.30	d	0.086
Ref.	<u>L. rubellus</u>	d	0.0048	0.024	0.010	0.011	d	d	0.10	d	d	d
		d	0.0027	0.034	0.015	0.018	d	d	0.14	d	d	d
	<u>A. chlorotica</u>	d	d	0.0083	0.0051	d	d	d	0.17	d	d	d
		d	d	0.0085	0.0049	0.0028	d	d	0.18	d	d	d
	<u>O. lacteum</u>	d	d	0.0074	0.0047	d	d	d	0.14	d	d	d
		d	0.0015	0.019	0.0080	0.0065	d	d	0.13	d	d	d
d		0.15	0.0015			0.003	0.015	0.015		0.015	0.004	0.003

Report no. : R 85/215
Order no. : 14192
Date : 1985-08-28

WES-TNO CONTAMINANT MOBILITY RESEARCH
First and second interim report

Drs J.M. Marquenie



p.o. box 217
2600 AE delft

address
schoemakerstraat 97

telex 38071 zptno
phone 015 - 56 93 30

Sponsor :

Department of the Army
Commercial Accounts Branch
56th Finance Section
P.O. Box 160
WARRINGTON, Cheshire WA 5
U.K.

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1	Scirpus atrovirens	2	leaves	0.059	0.430	0.210
2	Scirpus atrovirens	4	leaves	0.031	1.850	0.087
3	Scirpus atrovirens	2	seeds	0.150	3.210	0.850
4	Scirpus atrovirens	4	seeds	0.160	4.980	1.170
5	Carex stipata	1	leaves	0.088	2.090	0.290
6	Carex stipata	3	leaves	0.034	1.230	0.190
7	Carex stipata	1	seeds	0.340	4.670	2.810
8	Carex scipata	3	seeds	0.390	11.510	3.290
9	Elodea spec.		aquatic plant	2.000	7.400	10.960
10	Potamogeton spec.		aquatic plant	0.200	2.100	1.140
11	Typha latifolia	1	rhizomes	0.610	-0.010	0.390
12	Typha latifolia	2	rhizomes	0.530	1.660	0.360
13	Typha latifolia	1	leaves	0.220	-0.010	0.350
14	Typha latifolia	2	leaves	0.110	-0.010	0.320
15	Typha latifolia	1	seeds	0.320	8.730	1.900
16	Typha latifolia	2	seeds	0.480	8.910	2.130
17	Phragmites australis	2	leaves	1.350	2.000	0.900
18	Phragmites australis	3	leaves	4.990	62.190	4.770

PCB-52	PCB-49	PCB-44	PCB-70	op-DDE	PCB-101	PCB-87	pp-DDE
-0.010	0.200	0.160	0.140	-0.010	0.210	0.110	0.110
0.120	0.039	-0.010	-0.010	-0.010	0.110	0.058	0.048
2.090	0.640	-0.010	0.920	0.300	1.220	0.320	0.150
3.890	0.960	1.760	1.410	0.110	0.420	0.320	0.180
0.360	0.120	0.180	0.150	-0.010	0.250	0.110	0.210
0.200	0.120	0.130	0.110	-0.010	0.130	0.046	0.120
12.010	3.530	4.800	5.740	-0.010	1.530	3.340	-0.010
9.260	2.390	4.420	3.370	1.340	5.250	0.290	0.400
18.090	13.130	14.590	18.520	4.370	10.190	5.550	-0.010
2.150	1.370	-0.010	-0.010	0.420	1.100	0.490	0.250
1.560	0.840	1.210	0.920	0.290	0.620	0.380	-0.010
1.330	0.700	0.950	0.890	0.290	0.650	0.370	-0.010
-0.010	0.510	0.510	0.260	-0.010	0.450	0.180	0.290
-0.010	0.240	0.180	-0.010	-0.010	0.310	0.140	0.210
6.580	1.630	3.290	2.410	1.040	3.140	0.970	0.430
8.430	2.210	4.270	3.530	1.660	4.420	1.400	0.450
1.860	0.770	-0.010	-0.010	0.220	1.170	0.540	1.640
-0.010	5.000	4.540	4.610	1.250	5.960	2.900	7.160

PCB-153	PCB-138	PCB-180	1	2	3	4	5
-0.010	0.330	0.170	9.40	0.29	2.00	6.90	-1.30
-0.010	0.150	0.084	7.30	0.30	1.50	6.30	-1.10
0.370	0.660	0.400	29.00	2.20	8.10	11.00	-1.00
0.940	0.870	0.550	14.00	0.70	3.50	3.10	-1.20
0.320	0.320	0.130	8.80	0.38	3.17	6.90	-1.10
0.180	0.160	0.087	32.00	1.40	7.70	6.00	-1.20
2.150	2.240	0.650	140.00	7.30	51.00	35.00	-6.20
2.540	2.860	1.200	47.00	1.80	12.00	21.00	-4.60
3.230	3.860	1.070	16.00	2.60	47.00	37.00	2.40
0.590	0.620	0.310	21.00	4.90	59.00	41.00	-1.00
0.230	0.250	0.094					
0.270	0.290	0.170					
6.390	0.470	0.250	34.00	0.44	1.80	1.70	-1.10
-0.010	0.740	0.230	6.90	0.48	0.89	-1.50	-1.00
1.120	1.450	0.450	120.00	5.20	24.00	21.00	-2.40
1.450	1.600	0.830	140.00	6.50	34.00	33.00	3.90
-0.010	2.180	0.660	11.00	0.81	2.90	7.70	-1.00
6.250	6.510	3.080	12.00	0.89	4.10	6.60	-1.00

-3.70	-3.20	-0.90	-2.30	-4.70	-6.20	-0.20	0.82
-3.30	-2.90	-0.80	-2.00	-4.10	-5.50	-0.20	-0.30
-2.90	-2.60	2.70	1.90	-3.70	-5.10	-0.20	0.41
-3.30	-2.90	-0.80	-2.10	-4.20	-5.70	-0.20	-0.40
-3.00	-2.60	0.72	1.80	-3.80	-5.10	0.25	1.20
-3.40	-3.00	2.20	-2.10	-4.30	-5.80	-0.20	1.10
-17.00	-15.00	9.20	-11.00	-22.00	-30.00	1.10	6.20
-13.00	-11.00	3.40	-8.00	-16.00	-22.00	0.90	4.20
-2.20	-1.90	20.00	18.00	13.00	-3.80	3.40	19.00
-2.90	-2.50	21.00	22.00	13.00	-5.00	2.10	21.00

-3.20	-2.80	-0.80	-2.00	-4.00	-5.40	-0.20	-0.30
-2.90	-2.60	0.85	-1.80	-3.70	-5.10	-0.20	-0.30
-6.80	-5.90	6.70	9.20	-8.50	-12.00	-0.40	1.20
8.90	-6.30	7.90	5.20	-9.10	-12.00	-0.40	-0.80
-2.80	-2.50	1.50	-1.70	-3.60	-4.90	0.68	1.30
-2.80	-2.50	1.40	-1.70	-3.60	-4.90	0.22	0.83

14	15	16	17	18	19	20	21
0.36	0.59	-1.90	-1.30	-3.10	-0.90	-0.50	-0.40
-0.10	-0.30	-1.60	-1.20	-2.70	-0.80	-0.40	-0.30
0.22	0.27	-1.50	-1.10	-2.40	-0.80	-0.40	-0.40
-0.10	-0.30	-1.70	-1.20	-2.80	-0.80	-0.40	-0.30
0.60	0.92	-1.50	-1.00	-2.40	1.60	-0.40	-0.30
0.50	0.70	-1.70	-1.20	-2.80	-0.90	-0.40	-0.40
2.80	3.60	-8.70	-6.10	-14.00	-4.40	-2.20	-1.80
2.00	3.30	-6.50	-4.60	-3.50	-3.30	-1.60	-1.30
10.00	9.90	-1.10	7.70	-1.70	14.00	-0.30	1.10
11.00	7.50	-1.50	-1.00	-2.30	13.00	-0.40	0.65

-0.10	-0.30	-1.60	-1.10	-2.60	-0.80	-0.40	-0.30
-0.10	-0.30	-1.50	-1.10	-2.40	-0.80	-0.40	-0.40
-0.70	-1.60	-3.40	-2.40	-5.40	-1.70	-0.80	-0.70
-0.30	-0.70	-3.60	-2.60	-5.80	-1.90	-0.90	-0.90
0.65	1.60	-1.40	-1.00	-2.30	-0.70	-0.40	-0.40
0.41	0.69	-1.40	-1.00	-2.30	-0.70	-0.40	-0.40

APPENDIX D: PROCEEDINGS OF THE 1984 CONTAMINANT MOBILITY
WORKING GROUP (WORKSHOP), BUFFALO, NEW YORK

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WES

MEMORANDUM FOR RECORD

SUBJECT: Proceedings of the Contaminant Mobility Working Group - 1985

1. The following is a collection of the reports of the Task Groups formed from the participants of the Working Group. The meeting conducted in Buffalo, NY, 13-17 May 1985, served to identify the research pathways followed during 1985.
2. Dr. Joop Marquenie of TNO Laboratories and I feel that the joint WES-TNO Working Group meeting was immeasurably successful and we would like to extend our thanks to all participants and observers for their enthusiastic exchange of ideas.
3. We hope that this summary document will be useful to you and that it will serve as a reference or model for the next Working Group Meeting and the subsequent, more structural proceedings.

John W. Simmers, PhD
Research Biologist

1985 ANIMAL BIOASSAY WORKING GROUP
Attendance Roster

<u>Name</u>	<u>Organization</u>
John Simmers	WES
Dick Lee	WES
Glenn Rhett	WES
Don Crawley	WES
Stratford H. Kay	WES
Robert Lazor	WES
Alena Mudroch	Environment Canada
Gerould Wilhelm	Morton Arboretum, Lisle, Illinois
Wilfrech H.O. Ernst	Free University, Amsterdam
Wim Ma	Res. Institute for Nature Management, Arnhem, NL
Rob H.D. Lambeck	Delta Institute of Hydrobiological Research, Yerseke, NL
Ed Neuhauser	Cornell University
Brian Hunter	British Petroleum International
Chuck Garten	ORNL, Oak Ridge, TN
Hans Gielen	TNO, Delft, The Netherlands
Bill Stickle	Louisiana State Univ., Baton Rouge
Norm Rubinstein	EPA Res. Lab. - Narragansett
Bill Langston	Marine Biological Association, Plymouth, U.K.
Mike Ireland	University of Heidelberg, FRG
Jim Mansky	USACE, NY District
Ludwig Tent	Port of Hamburg
Clive Edwards	Rothamsted Expt. Station, U.K.
Clarence A. Callahan	USEPA, Corvallis, Oregon
Elizabeth Stafford	Rothamsted Expt. Station, U.K.
Nelson Beyer	Patuxent Wildlife Res. Ctr.
Joop Marquenie	TNO, Den Helder, NL
Frank Snitz*	USACE, Detroit District
Anthony Kizlauskas*	USEPA, Great Lakes Nat'l Program
Lex MacCubbin*	Roswell Park Memorial Institute
Todd Higgins	WES
Steve Yaksick*	USACE, Buffalo District
Harish Sikka	Great Lakes Lab, State Univ. College

* Observer

TASK GROUPS

Plant Life

Ernst
Wilhelm
Mudroch
Lazor
Lee

Per Habitat:

- Structural important species
- Abnormalities, lacking species
- Future development
- Needs for research

Soil Invertebrates

Beyer
Stafford
Edwards
Callahan
Hadiman
Kay/Marquenie

Per Habitat:

- Structural important species
- Abnormalities, lacking species
- Future development
- Needs for research

Chemical and Data Analysis

Gielen
Garten
Brandon
Black
Leonard
Adams
Rhett

General impression of the site:

- Important processes
- Which chemicals, how to decrease analysis
- Sample storing for future use
- Impact on water quality

Aquatic/Wetland

Prosi	Aquatic
Ireland	
Langston	
Rubinstein	
Sikka	Wetland
Stickle	
Pfeiffer/Roper	
Marquenie/Kay	

- Importance of aquatic food chains
- Effects
- Basic food sources in the wetland
- Needs for research

Management

Tent
Mansky
Higgins
Simmers

- Potential user
- Needs for monitoring
- Needs for criteria
- Interaction with socio-economics

Food Chains (not aquatic)

Hunter	
Ma	Mammals
Andrle	
Lambeck	
Neuhauser	Birds
Crawley	

- What are the species
- Expected percentage of usage of the site
- Expectance of effects on population level
- Needs for research

CONTAMINANT MOBILITY IN FOOD CHAINS - FOOD CHAINS FISH GROUP

INTRODUCTION

The team set the following objectives:

- i) to investigate the physical process involved in the creation of the site
- ii) assess how this affects the distribution of contaminants
- iii) develop understanding of community/food chain development in space and time over the site
- iv) examine food chain mobility of contaminants at Times Beach
- v) collect information in a way that it can be used to predict the effects of proposed new dredged material disposal sites elsewhere, and that can be used in the evaluation of management options for disposal sites.

To do this, it is realized that our discussions would overlap considerably with those of other groups.

1. Physical factors in description of site

- point source for dredge pumping
- differential particle size deposition
- possible uneven distribution of contaminants linked to particle size deposition: eg. metals and clays; organic and oils/colloidal material.

2. Transect locations (Figure 1)

- start at dredge pipe input point
- cross major habitat types
- incorporate one central point from the previous study
- located in central area to minimize edge effects (immigration)

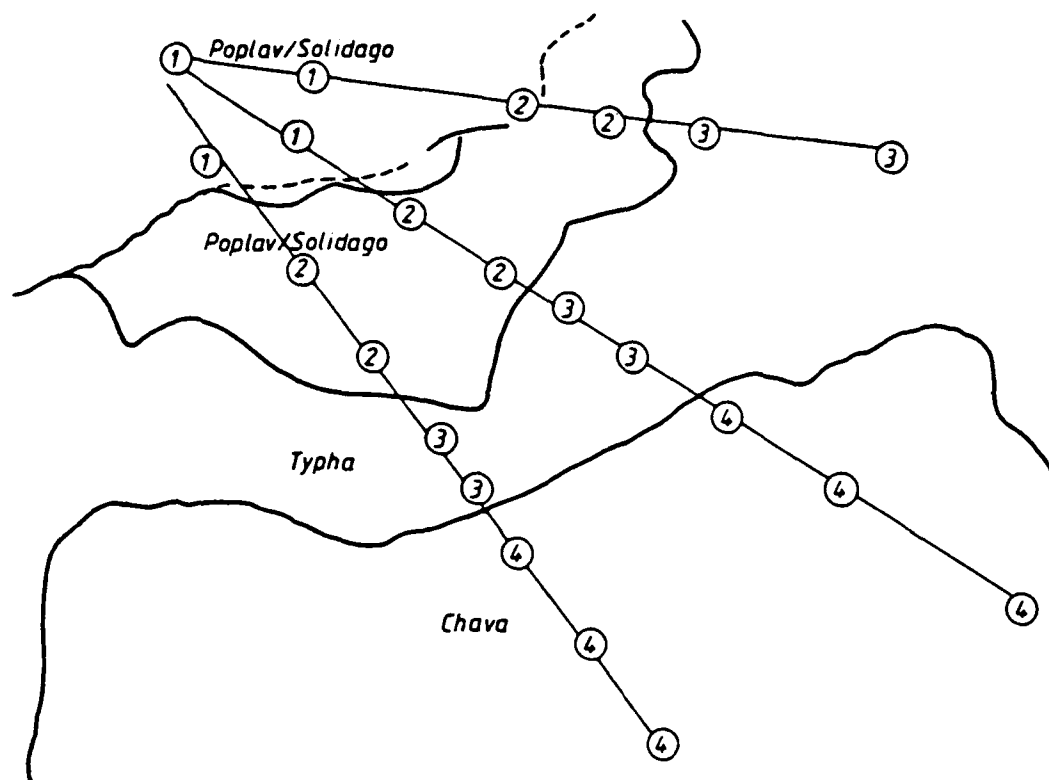


Figure 1

3. Major Habitat Types

- i) Non-dredged material/old beach coastline
 - ii) Poplar/Solidago woodland
 - iii) Typha marsh
 - iv) Aquatic
- dredged material habitats

4. Sample Points

- i) Six points per dredged material habitat (4 for non-dredged material)
- ii) Points positioned to minimize edge effects between habitat types and to include representative flora

5. Substrate samples (Figure 2)

- sample depth profiles for each zone
- all transect points sampled
- at each point 3 cores, depth divided, bulked and subsampled

6. Substrate analysis (Figure 3)

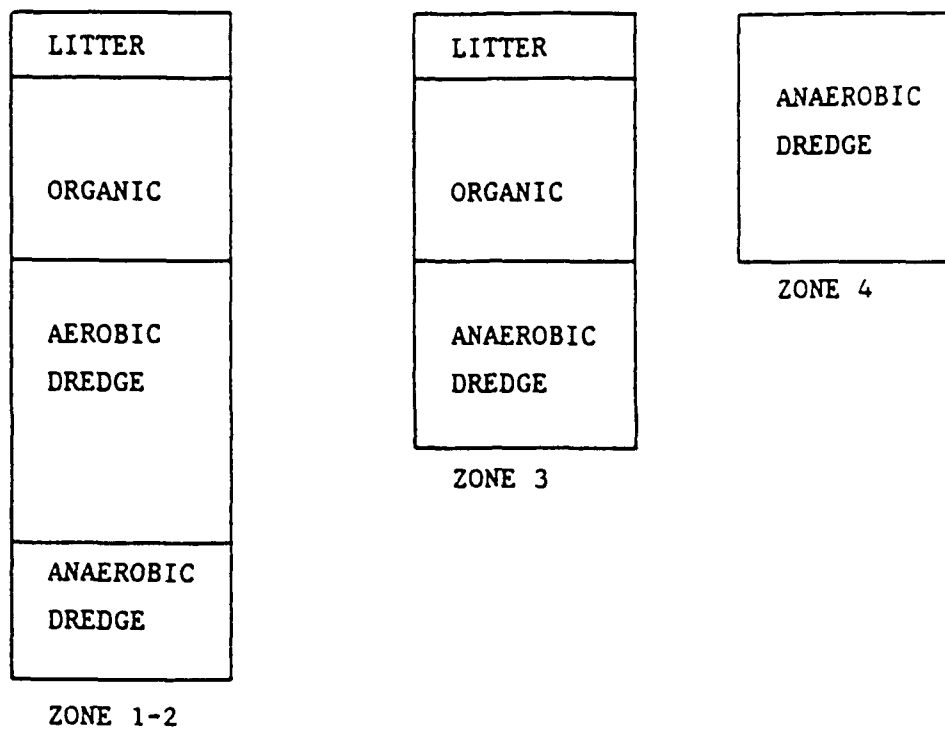


Figure 2

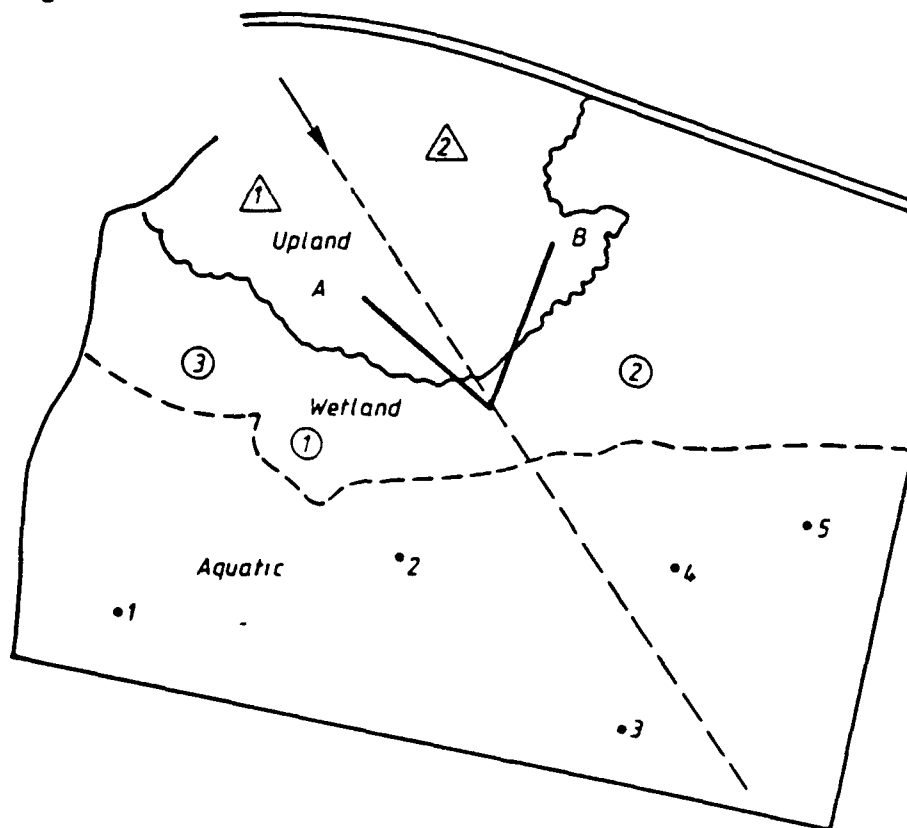


Figure 3 - Aquatic .10 random samples (5 chemical analysis)

- Wetland aside the new transect *
- Upland aside the new transect *
- Old land composite sample

* Humus layer take at same site as sediment

7. Groundwater: boreholes - record depth - unstuff groundwater monitoring wells
 - collect chemical data - organics and metals
8. Plants
 - identify major habitat types
 - identify dominant species
 - 1 Poplar/Solidago
 - 2 Willow
 - 3 Typha
 - 4 Chara
 - restrict collection/analysis to dominants
 - account for seasonal variation
 - sample spring, summer, and fall
 - samples include green leaves (poplar) and whole plants (Solidago/Chara)
 - bulked samples from 10 individuals at each point and subsample
 - one a year in fall collect Poplar twigs: major litter input.

Substrate analysis on each subsample.

1. Physical
 - particle size analysis
 - organic matter content
 - water content
2. Chemical
 - pH and redox
 - plant nutrients - NPK
 - contaminants - metals : plants Cu Ni Zn; animals Cd Pb (Cr, Hg)
 - organics: PCBs, PAHs etc.
3. Groundwater
 - i) depth measurement
 - ii) chemical data
 - metals
 - organics

4. Plants

- i) identify major habitat types
- ii) identify dominant species
- iii) seasonal variation

Zone 1 Poplar and Solidago

2 sampled spring, summer, and fall

3 Tyoha Equisetum

4 Elodea and Chara

9. Earthworms

- only of complexity
- sample zones 1, 2, 3
- sample adults in fall; analyze 10 individuals, unpurged guts

10. Small mammals (Figure)

Figure - sample zones 1, 2, 3

- one collection in fall

Figure - collect older specimens

species -- diets

- tissues KL

specific target organs

11. Birds - identify large us species using site; NO analysis yet (year 1)

- must assess which species most at risk

To do this study - occurrence

- numbers
- feeding areas
- residence time

Year 2 - select species for study

- possible sample young from nest of common bird - fixed diet, age etc.

Overhead Photo

Oblique from 300 ft

To delineate 8 vegetation types

To delineate upper debris zone

1. Four linear transects radiate from the distal portion of ten year old dredged material disposal pipe, to end at dike (Figure 4).
 - (a) To follow elevation gradient, (particle density and contamination level gradients).
 - (b) Each transect should be selected to include as many as possible of each of the eight vegetational zones.
 - (c) For each transect at each vegetational zone there shall be an approximately 25 m² sampling station, within which shall be established 6 permanent subplots, each 1 m².

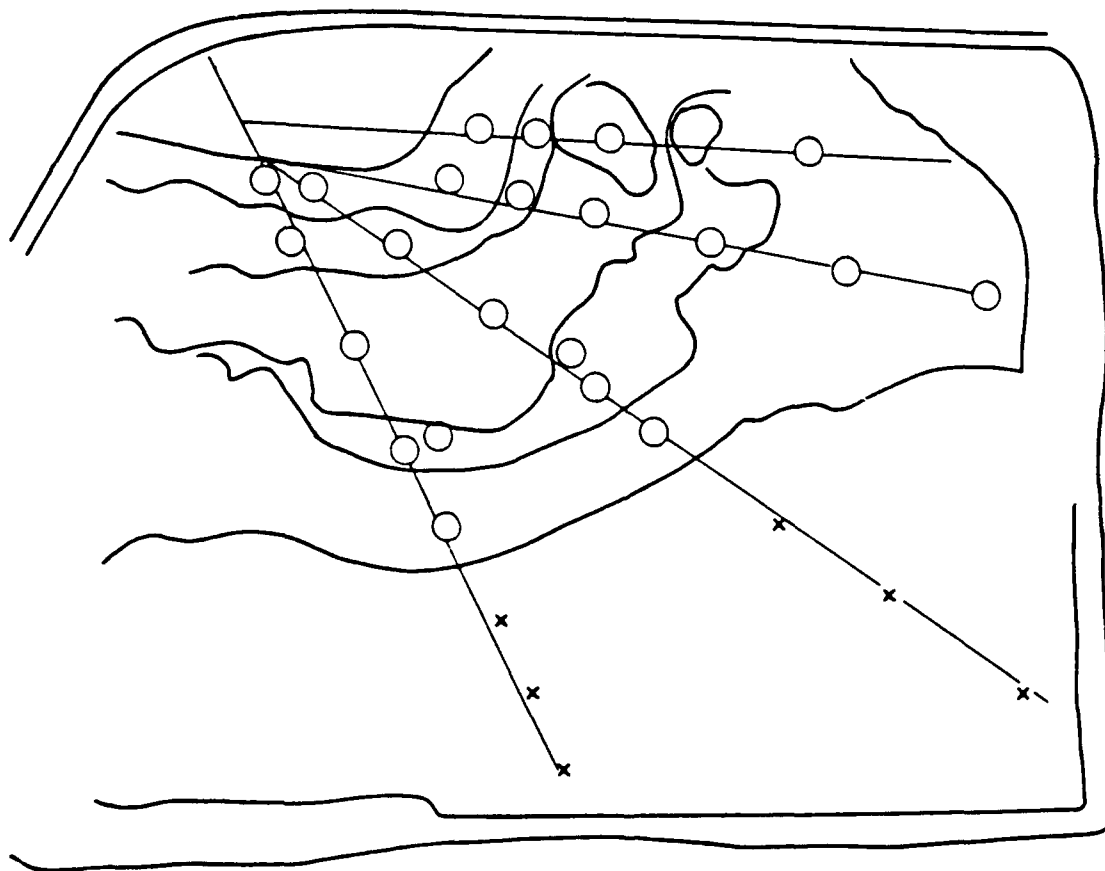


Figure 4

2. Items sampled

Surface plants (for analysis)

Root/rhizome sample for specific species (for analysis)

Soil fractions, plant and animal bioassay

Invertebrates

Plant survey (for cover/basal area and abundance)

Thru - fall and leaf catchment

3. Time phasing

a) Plants (for analysis phyto/root mass)

Early summer

Poa spp. leaves, roots (no flowers)

Mid-summer

<i>Typha latifolia</i>	Roots, rhizomes, seeds

<i>Leersia oryzoides</i>	Roots, leaves

<i>Lythrum salicaria</i>	Roots, lower leaves

<i>Phalaris arundinacea</i>	Roots, leaves

Late summer

<i>Impatiens capensis</i>	Roots, leaves

<i>Solidago altissima</i>	Rhizomes, seeds, leaves

<i>Solidago gigantea</i>	Rhizomes, seeds, leaves

<i>Populus deltoides</i>	Leaves, seeds

<i>Cornus stolonifera</i>	Finer roots, leaves

<i>Salix interior</i>	Finer roots, leaves

b) Soil fractions - early summer

Depth will depend on nature of vegetation zone

c) Plant survey

Trees - early summer

d) Thru - fall, leaf catchment

4. Major zones

Upper cottonwood

Cornus/cottonwood

Lower cottonwood

Willow

Phragmites

Rice cut grass

Typha

Aquatic

SOIL INVERTEBRATES - TASK GROUP

I. PREDICTIVE TEST - EARTHWORM TESTING METHODS

Both toxicity and bio-accumulation need to be assessed in this procedure. The test needs further improvement and standardization. The dredged material must be brought to a condition in which the worms can survive and this can be done by the following methods:

- i) Dilution with uncontaminated material
- ii) Aging dredged materials naturally (until earthworms find the dredged materials acceptable and survive within them. The bioassays should then be carried out).
- iii) Leaching and irradiating thin layers of dredged material held in trays with U.V. light¹. This should be carried out indoors and under controlled environmental conditions. Methods should be aimed at accelerating natural weathering processes and not expose sediments to treatments they would not encounter under natural conditions.

The group greatly favored method (iii) as a standard method for the pre-treatment of all dredged materials but emphasize that experimental tests need to be run with a range of dredged materials. These would be exposed to the conditions in (iii) and periodically tested until they all reach a condition when the earthworms burrow into the material and remain within it. At this point a full bioassay as previously developed should be run to assess toxicity and principally bioavailability.

The value of the bioassay is to rank dredged materials in order of potential toxicity and bioavailability. Materials used in a full laboratory experiment should include dredged materials from sites that could be used in a field verification experiment.

II. VALIDATION AND FIELD VERIFICATION OF EARTHWORM TEST ON NEW SITES

Ideally, it would be preferable to set up a new field experiment on a single site which would test the ecological effects of field applications of dredged material. These material should be a subset of those dredged materials used in Section I (iii). The validation procedure would involve several steps including:

- a) periodic sampling of dredged material for earthworm bioassay in the laboratory to compare bioavailability of contaminants after field aging of dredged material. These data can be compared to laboratory bio-accumulation data obtained in Section I (iii).
- b) periodic sampling and analysis of earthworms that colonize the site naturally for bio-accumulation of contamination to assess the potential of different species.
- c) relation of bio-accumulation of contaminants by earthworm to bio-accumulation by other key soil invertebrates colonizing the site naturally. These key individual species should be selected on the basis of their abundance and potential for bio-accumulation of contaminants.

If the ideal situation described above is not feasible (i.e. all sediments applied to a single site) then an equal number of individual sites where dredged material is scheduled to be applied should be selected. Again, these site should include those materials evaluated in Section I (iii).

The same steps - a, b, c should be followed regardless of the overall design.

Those invertebrates that are selected as key indicator species should be those used as food for predators in food chain studies.

III. WORK ON TIMES BEACH AND OTHER EXISTING SITES

a) Times Beach

It was decided that the main aim of future work should be aimed at identifying those plants and animals that have accumulated the largest (or most ecologically significant) concentration of contaminants. Samples should be carried out in spring or fall. Identification of such animals would include trapping or sampling invertebrate or vertebrate and analyzing the levels of contaminants in their tissues. This would yield important results in identifying key indicator species of animals.

Previous work done on the site has shown that variability in levels of contaminants in earthworms (from the bioassays) has not been great, so future sampling could be confined to bulk samples with only adequate replication.

Since most animals are mobile it would not seem necessary to do further detailed analysis in terms of spatial distribution.

We do not recommend work on another reference site because this information in our opinion would not yield a great deal of useful information for this evaluation especially in view of the amount of work required.

Because we have no initial reference point for the toxicity or potential for bio-accumulation of the dredged material originally applied to Times Beach we suggest that material obtained from deep cores (unconsolidated and reduced material at depths of > 1 m) be used for laboratory bioassays. This could yield data which could link laboratory toxicity to earthworms to recent bioassays and the present status of Times Beach.

b) Other sites

Similar operations should be carried out on a selection of other existing sites of different ages. Attention to sites that have not become as ecologically desirable as Times Beach could yield useful data.

IV. FUTURE DEVELOPMENT AND MANAGEMENT OF SITES

We recognize that when serious contamination has been indicated by the previous evaluations then sites can be managed in various ways which include:

- a) Limited access by public
 - b) Physical alterations and modifications, such as cultivation, vegetation control, drainage etc.
 - c) Change in image such as filling and capping.
- * The work described in these sections is envisaged as being carried out within the next year/6 months.

CONTAMINANT MOBILITY WORKSHOP - REPORT OF CHEMICAL ANALYSES GROUP

1. Sampling and analyses of aquatic sediments not previously done needs to be done. Data from Corps drilling investigations indicates top 2-5 feet is uniform organically enriched silts and clays. Therefore five random samples throughout aquatic area should be sufficient.
2. Since wetland and upland have previously been sampled, two additional samples from upland and 3 from wetland should be sufficient. Organic (Humus) layers in woodland and wetland should be sampled and analyzed (same sites as sediments). Dr. Black (Roswell Park Memorial Institute) will need 3 samples of sediment analyzed by GCMS.
3. Parameters
 - A. Soils - Heavy Metals - Zn, Cd, As, Pb, Hg, Cr
Organics - PCBs, PAHs, chlorinated benzenes, aromatic amines, oil and grease (or organic carbon particle size), nutrients; complete GCMS scan for 2-3 samples
 - B. Plants - Metals as above - since organics have not been found previously, or found at very low levels, further organic analysis does not appear necessary
 - C. Animals - Metals and organics as in A above
and Fish Note - Lipid analyses on all animal and fish samples strongly recommended at summary meeting
4. The Buffalo District is especially interested in analyses of higher food chain organisms including mammals, fish, birds.
5. Quality Assurance - Reports should contain quality assurance data including spikes, replicates, standards.
6. Sample Storage - Store at -20°C
7. Data Format - Percent Ash and percent moisture of samples should be given to enable conversions.
8. Data Management - John Adams of Buffalo District, COE will develop computer system for treatment, storage, and retrieval of Times Beach chemical data (plants, animals, fish, sediments).

REPORT - AQUATIC AND WETLAND TASK GROUP

Objective: Develop a research strategy to assess ecological impacts of contaminated dredged material at the Times Beach containment site: That effect the Wetland and Aquatic habitats.

A comprehensive ecological survey should be conducted to determine community structures and trophic relationships. Key species should be identified to ensure appropriate selection for biomonitoring. Contaminant concentrations in sediments, detritus and major components of the food chain should be measured. Food sources and contaminant transfer should be determined. Contaminants to be analyzed must included PCBs, HCB, Hg, Cd and other compounds as determined by the chemistry task group.

Organisms from the site should be collected for analysis and transplant experiments should be conducted with "pristine" organisms to determine the potential for bioaccumulation and transfer. Concurrent laboratory studies should be conducted to gain further understanding of processes pertinent to contaminant uptake, transformation and transfer between trophic levels. The following species are recommended for transplant studies:

- *Lampsilis* sp. (suspension feeder)
- Tubificids (deposit feeders)
- *Lymnaea* sp. (grazer)
- selected fish species (omnivores/carnivores)

Because of the difficulty in isolating anthropogenic sources from naturally occurring processes field and laboratory studies should address the redox conditions which exist in the wetland and aquatic habitats of the disposal site. In addition changes in pH caused by plant productivity must be considered.

Because the most significant impact could be long-term and sublethal the following physiological, developmental, mutagenic and population responses should be considered:

- physiological - bioenergetics
- immune response

- developmental - life cycle testing (i.e. Hexagenia)
 - larval abnormalities (i.e. tadpoole) lymnaea
- mutagenic
 - Ames testing
 - chromosome abnormalities
(i.e. mud minnow)
 - gross morphology/histopathology
- population/
community
 - size frequency distribution
 - productivity/biomass

Due to the lack of adequate control sites, we suggest a literature review of key species and contaminants of concern be conducted to provide baseline data with which to compare measured values from field and laboratory studies.

We recognize the limitations of time and resources and therefore recommend the following prioritization of the aforementioned tasks:

- 1) Faunal survey
- 2) Bioaccumulation (Transplant Experiments)
- 3) Food chain dynamics
- 4) Sublethal effects

REPORT-MANAGEMENT TASK GROUP

Potential Use: The future use of Times Beach will depend on the needs of the City of Buffalo. The group identified three primary potential uses for the site. These are commercial/industrial/residential (CIR) use, use as a recreational park or use as wildlife habitat.

The CIR use could be desirable since the site consists of more than 7500 ft of frontage to navigable channel. In addition it could lead to improve economic development. However alternative areas for this kind of use are available and Times Beach needs substantial modifications for development.

A recreational park provides intensive public use like picnicking, boating, jogging, bicycling. These uses normally are accompanied by undesirable activities like littering, noise, vandalism. Modifications of the site (placement of fill, construction activities) will be necessary. Alternative sites are available.

Currently the Times Beach area is primarily used as wildlife habitat. It seems to be unique to this area of Buffalo. Within the uses of this site are resting/nesting of migratory waterfowl and other organisms. The ongoing succession taking place at this area can serve for scientific studies and with only minor modifications could be developed as a nature study-observation area. One major detriment to this usage might be the contaminants within the site. The intensity of the last mentioned use will be the least intensive usage by the people of Buffalo of the three. Taking all these factors into consideration the group recommends the site to be maintained as a wildlife habitat at the present state of knowledge on contamination.

Monitoring/criteria

With the assumption that the site will be maintained as a wildlife habitat area the following are the monitoring/criteria considerations. An intensive multiple-year study should be undertaken to provide appropriate background data. Afterwards there is needs to conduct additional monitoring to detect changes on the long term in the ecology of the area.

To improve sampling and monitoring a grid system should be developed for the site. This will help to increase precision and coordinate the work of different groups. Chemical, physical and biological properties of the site should be evaluated extensively (see reports of the other task groups).

Monitoring of the water exchange through the dike (including flow rate, direction, variable permeability and contaminant exchange capacity of the dike) would provide information of the impact of contaminants in the site to the surrounding area.

Monitoring the airborne pollutants is necessary to determine the relative influence of these to the overall contamination of the area.

Determine species usage and food chains involved within the Times Beach ecosystem. This information is vital for a contaminant budget for the site.

Data on gas formation in the substrate could be determined because primary or secondary adverse effects could result (mortality of plants, cycling of nutrients in the open water section etc.).

Criteria should be developed to allow decisions as to when active management should be conducted (e.g. capping of the total or part of the site).

Succession and population dynamics of resident species should be monitored. Physiological impact on species as well as communities should be evaluated as a sensitive indicator of impact due to contamination.

Long term management

Should active management be required to enhance or eliminate certain species, these must be defined for the differing habitats. To keep the site stable and productive, management techniques such as burning may be necessary.

To avoid adverse effects on the biota, the access to the site should be limited, and research work must be coordinated to avoid unnecessary disruption.

If established contaminant criteria are exceeded appropriate, remedial options must be implemented.

SUMMARY (C.R. Lee)

1. Three transects across vegetative zones (similar to Figure 1)
2. Eight vegetative zones (Figure 4)
3. 24 sampling stations (upland-wetland)
 1 aquatic station
 25 sampling stations
4. Vegetative sampling
 - 3 samples per station for upland and wetland areas
 - 9 samples in aquatic zone per plant species
5. Soil samples cores
 - 3 cores per station for upland and wetland areas
 - 9 cores in aquatic zone (3 along each transect that passes through aquatic zone); 3 additional cores are separated into litter, organic layer, mid layer (A2), anaerobic bottom layer (Hunter's overhead)

May decide 9 samples from

$\frac{x4}{36}$ samples

Depth

woodland	3 x 27 + 9 litters =	36
upland	3 27 + 9 litters =	36
wetland	2 18 + 9 litters =	27
aquatic	2 <u>18</u> + 9 litters =	<u>27</u>
	90 samples total	126

6. Soil invertebrates:
 - 3 determinations per station or
 - 6 determinations (samples) per zone (woodland, upland, wetland, aquatic)

7. Earthworms:
 - 6 samples (composites) per zone (woodland, upland, wetland, aquatic)
 - Hunter's overheads
8. Plant and earthworm bioassays
 - Plant bioassays relate to 8 zones; earthworm bioassays relate to soil samples cores.

Report: R 87/15 WES-TNO Contaminant Mobility Research
Final Technical Report

Appendices 1: R 87/023 Proceedings of the 1984 Workshop, held at Buffalo, USA
2: R 86/199 Musselwatching in the Buffalo River, Times Beach and Lake Erie
3: R 86/220 Preliminary inventory of planktonic and benthic organisms at Times Beach
4: P 85/50 Animal bioassays of black rock harbor sediments - Field verification at an experimental wetland-creation disposal site
5: P 87/007 Morton Arboretum Bioassays.

ANNEXE A

Participants that were reimbursed for travel to and from Buffalo (N.Y.) - Europe and for per diem.

J.W.J. Gielen
C.A. Edwards
W.H.O. Ernst
B.A. Hunter
M.A. Ireland
R.H.D. Lambeck
W.J. Langston
W.C. Ma
J.M. Marquenie
F. Prosi

Participant who was reimbursed for travel only.

L. Tent

Invited participants that were unable to attend the work shop.

M.S. Johnson
H. Nijssen

APPENDIX E: SCIENTIFIC AND COMMON NAMES OF PLANTS
AND ANIMALS MENTIONED IN TEXT

Scientific NameCommon Name

<i>Acarina</i>	Mites
<i>Agelaius phoeniceus</i>	Red-winged Blackbirds
<i>Allolobophora longa</i>	Earthworms
<i>Allolobophora caliginosa</i>	Earthworms
<i>Allolobophora chlorotica</i>	Earthworms
<i>Ambloplites rupestris</i>	Rock Bass
<i>Anas platyrhynchos</i>	Mallard Ducks
<i>Arachnida</i>	Spiders
<i>Araneida</i>	Spiders
<i>Armadillidiidae Armadillidium</i>	Pillbugs/Woodlice
<i>Bufo americanas</i>	American Toad
<i>Carabidae</i>	Tiger Beetles
<i>Chilopoda</i>	Centipedes
<i>Chrysomelidae</i>	Leaf Beetles
<i>Coleoptera</i>	Beetles
<i>Collembola</i>	Springtails
<i>Cornus stolonifera</i>	Red Osier Dogwood
<i>Cyperus esculentus</i>	Yellow Nut Sedge
<i>Cyprinus carpio</i>	Carp
<i>Diplopoda</i>	Millipedes
<i>Diptera</i>	Flies
<i>Eisenia foetida</i>	Red Wiggler Earthworms
<i>Elliptio dilatata</i>	Freshwater Mussels
<i>Elateridae</i>	Click Beetles
<i>Gamasina</i>	Mites
<i>Impatiens capens</i>	Common Jewel Weed
<i>Insecta</i>	Insects
<i>Isopoda</i>	Pillbugs/Woodlice
<i>Isotomidae</i>	Springtails
<i>Leersia oryzoides</i>	Rice Cutgrass
<i>Lepomis gibbosus</i>	Pumpkinseed
<i>Lumbricus rubellusa</i>	Earthworms
<i>Lumbricus terrestris</i>	Earthworms
<i>Lythrum salicaria</i>	Purple Loosestrife
<i>Microtus pennsylvanicus</i>	Meadow Voles
<i>Morone americana</i>	White Perch
<i>Moxostoma macrolepidotum</i>	Northern Rednose
<i>Myriapoda</i>	Millipedes and Centipedes
<i>Natrix sipedon</i>	Northern Water Snakes
<i>Nitidulidae</i>	Sap Beetles
<i>Notomigonus crysolencus</i>	Golden Shiners
<i>Onchiuridae</i>	Springtails
<i>Ondatra zibethicus</i>	Muskrats
<i>Oniscidae Oniscus</i>	Pillbugs/Woodlice
<i>Opiolones</i>	Harvestmen
<i>Oribatidae</i>	Mites
<i>Orthoptera</i>	Grasshoppers
<i>Oxytelinidae</i>	Carion Beetles
<i>Perca flavescens</i>	Yellow Perch
<i>Peromyscus leucopus</i>	White Footed Mice
<i>Phalaris arundinacea</i>	Reed Canary Grass
<i>Phragmites australis</i>	Common Reed

Plethodon
Populus deltoides
Porcellionidae *Porcellio*
Procyon lotor
Rana catesbeiana
Rhodacidae
Salix
Solidago altissima
Sorex
Sylvilagus floridanus
Tachyporidae
Thamnophis sirtalis
Trichoniscidae *Trichoniscus*
Typha angustifolia

Salamanders
Cottonwood Trees
Pillbugs/Woodlice
Raccoons
Bullfrogs
Mites
Willows
Goldenrod
Shrews
Eastern Cottontails
Carion Beetles
Garter Snakes
Pillbugs/Woodlice
Cattail