3.4 Human Health

The Trustees are concerned that following restoration there may be increased human access to the Army Creek watershed. Therefore, the Technical Advisory Committee, relying on the EPA's human health risk assessment, has reviewed and summarized data concerning human health issues.

The 1983, Brown Bullhead contamination data collected by DNREC is not applicable to human health risk assessment, because whole-fish samples were analyzed. Humans do not typically consume whole fish, but rather only eat fish muscle.

On May 23, 1990, DNREC collected 5 carp and 6 American eels from Army Creek. The carp were collected near Route 9 and analyzed as a composite fillet sample (Table 11), while the eels were collected from just below Army Creek Pond and analyzed as a skinned composite sample. Lead concentrations in both samples were below 1.0 ug/g; they may be higher than the FDA-Action Level (<0.3 ug/l), but this could not be determined because the actual level is less than the analytical sensitivity.

A Working Memorandum of Agreement (MOA) between the Delaware DNREC and Delaware Division of Public Health has established an organizational protocol for addressing fish contamination issues in Delaware. Issues that could be considered via this pending MOA include what waters to survey on an annual basis, how to respond to contamination findings, drafting of human health advisories, etc. Additionally, the Delaware DNREC has recently started a study of fish flesh consumption by humans for fish caught in Delaware's estuarine waters. The results of this study might eventually lead to modifications of the inputs and findings for human health risk assessment models used to determine when human health advisories are warranted.

In the Record-of-Decision-2 (June 29, 1990), the EPA presented a public health risk assessment. They considered potential sources of: 1) recovery well water discharge, 2) creek and pond surface water, 3) creek and pond sediments, 4) air in the area of the creek and pond, and 5) fish caught for human consumption. Persons who might be at risk were said to be those trespassing on the site and those residing or working downwind of the site. The potential human exposure routes included: a) inadvertent exposure to groundwater recovery well discharges (e.g., being splashed in the face) and surface water (e.g., falling into the pond), b) inhalation of volatile organic compounds from groundwater recovery well discharges and surface water (e.g., while playing in or near the pond), c) dermal absorption of contaminants from inadvertent exposure to recovered groundwater (e.g., falling into the pond), and d) fish consumption by recreational anglers. The EPA risk assessment for human health focused on carcinogenic and non-carcinogenic risks.

Table 12, Summary of Total Potential Carcinogenic Risks, shows that none of the exposure scenarios at this site, with respect to surface water and sediments, present an unacceptable risk to human health. In Table 12, an excess lifetime cancer risk of 1 x 10E-6 indicates that, as a plausible upper bound, an individual has a one-in-a-million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70 year lifetime under the specific exposure conditions at a site.

The potential for human health effects resulting from exposure to non-carcinogenic compounds is estimated by comparing an estimated daily dose to an acceptable level. If the ratio exceeds 1.0, there is a potential health risk associated with exposure to that particular chemical. The ratios can be added for exposures to multiple contaminants. The sum, known as a Hazard Index, is not a mathematical prediction of the severity of toxic effects, but rather a numerical indicator of the transition from acceptable to unacceptable levels. Since none of the total Hazard Indices (Table 13) exceeds 1.0, there is no cause for concern for non-carcinogenic hazards to human health at the Army Creek site.

The Remedial Investigation found that neither the surface water, nor the recovery well discharges presented an unacceptable risk to human health or welfare; however, the most recent sampling results indicate that discharges may exceed Delaware Surface Water Quality Standard numeric criterion (1.77 ug/l for freshwater and 0.25 ug/l for marine and estuarine waters) for bis(2-chloroethyl)ether, established for protection of human health via the fish consumption exposure route. Note that in Table 7 the concentrations for bis(2-chloroethyl)ether are 4.3 ug/l (0.0043 mg/l) and

6.8 ug/l (0.0068 mg/l) in Pond water and Lower Army Creek, respectively. However, both of these values are below the method detection limit (10.0 ug/l or 0.010 mg/l).

Human Health Summary: Based upon evidence and analyses to date, types or levels of contaminants in Army Creek fish flesh have not warranted issuing a human health advisory against eating Army Creek fish. Examinations of various exposure scenarios to humans for carcinogenic or non-carcinogenic compounds found in Army Creek waters or sediments identified no unacceptable risks to human health. Therefore, restoration of natural resources from a human health perspective can be implemented based upon the EPA's human health risk assessment.

TABLE 11. COMPARISON OF CONTAMINANT CONCENTRATIONS IN BULLHEAD, CARP AND EEL WITH FDA ACTION LEVELS AND EPA PREDATOR-PROTECTION LEVELS.

Contaminant	FDA a Action Level ug/g	EPA b Predator-Protection Level ug/g	1983 Bullhead whole-body ug/g	1990 Carp Fillet ug/g	1990 Eel Skinned ug/g
As			0.6	<2.0	<2.0
Cd		<0.5	<2.0	<1.0	<1.0
Cu		<0.5	5.2	<5.0	<5.0
Hg	>1.0	<0.1	<0.1	<0.1	<0.1
Pb	>0.3	<0.1	5.0	<1.0	<1.0
Zn			18	11.2	14.9
Cr		0.2	5.2	<2.0	<2.0
Ni				<5.0	<5.0
PCB(Total?)	2.0	0.5	1.2		

a Concentration in fresh and saltwater food.
b Concentrations in predator forage items.

Note that the FDA action and tolerance levels should not be used to state that a human health problem exists, but rather to identify potential for a problem depending on the consumption habits of the individuals involved.

TABLE 12. SUMMARY OF TOTAL POTENTIAL CARCINOGENIC RISKS[1]

Media	Scenario	Age Group Exposed: Children 6-11 yrs.	Age Group Exposed: Adults 70 yr.life span
Groundwater Recovery Well Discharges	Inadvertent ingestion	1.2x10E-8	5.3x10E-9
	Inhalation of organics leaving groundwater	7.2x10E-7	3.1x10E-7
	Dermal absorption	9.7x10E-7	9.2x10E-7
Sediment *	Inadvertent ingestion	4.1x10E-9	1.7x10E-9
Surface Water *	Inadvertent ingestion	6.5x10E-9	2.9x10E-9
	Inhalation of organics	1.8x10E-7	7.6x10E-9
	Dermal absorption	6.0x10E-8	5.7x10E-7
Fish **	Ingestion	NC	7.7x10E-7

* Sediment and surface water risks were calculated using the highest pollutant concentrations detected during sampling.

** Estimated using calculated average pollutant concentration during sampling, accepted bioconcentration factor and 5.2 g/day consumption rate. The exposure assessment assumes that 100 percent of the freshwater fish consumed by a receptor are taken from Army Creek/Pond.

NC These values could not be calculated due to a lack of sufficient information regarding fresh fish consumption for children 6-11 years old.

[1]Source: ROD-2 (EPA, 1990)

TABLE 13. SUMMARY OF TOTAL POTENTIAL NON-CARCINOGENIC HAZARD INDICES[2]

Media	Scenario	Age Group Exposed	
		Children 6-11 yrs.	Adults 70-yr.life span
Groundwater Recovery Well Discharges	Inadvertent ingestion	0.000015	0.0000013
Sediment *	Inadvertent ingestion	0.00036	0.000031
Surface Water *	Inadvertent ingestion	0.0008	0.00069
Fish	Ingestion	NC	0.0048

* Sediment and surface water risks were calculated using the highest pollutant concentrations detected during sampling.

NC These values could not be calculated due to a lack of sufficient informaation regarding average fresh fish consumption for children 6-11 years old.

If the Hazard Index exceeds 1.0, there is a potential health hazard associated with exposure to the medium.

[2]Source: ROD-2 (EPA, 1990)

TABLE 11. COMPARISON OF CONTAMINANT CONCENTRATIONS IN BULLHEAD, CARP AND EEL WITH FDA ACTION LEVELS AND EPA PREDATOR-PROTECTION LEVELS.

Contaminant	FDA a Action Level ug/g	EPA b Predator-Protection Level ug/g	1983 Bullhead whole-body ug/g	1990 Carp Fillet ug/g	1990 Eel Skinned ug/g
As			0.6	<2.0	<2.0
Cd		<0.5	<2.0	<1.0	<1.0
Cu		<0.5	5.2	<5.0	<5.0
Hg	>1.0	<0.1	<0.1	<0.1	<0.1
Pb	>0.3	<0.1	5.0	<1.0	<1.0
Zn			18	11.2	14.9
Cr		0.2	5.2	<2.0	<2.0
Ni				<5.0	<5.0
PCB(Total?)	2.0	0.5	1.2		

a Concentration in fresh and saltwater food.
b Concentrations in predator forage items.

Note that the FDA action and tolerance levels should not be used to state that a human health problem exists, but rather to identify potential for a problem depending on the consumption habits of the individuals involved.

TABLE 12. SUMMARY OF TOTAL POTENTIAL CARCINOGENIC RISKS*

Media	Scenario	Age Group Exposed: Children 6-11 yrs.	Age Group Exposed: Adults 70 yr. life span
Groundwater Recovery Well Discharges	Inadvertent ingestion	1.2x10E-8	5.3x10E-9
	Inhalation of organics leaving groundwater	7.2x10E-7	3.1x10E-7
	Dermal absorption	9.7x10E-7	9.2x10E-7
Sediment *	Inadvertent ingestion	4.1x10E-9	1.7x10E-9
Surface Water *	Inadvertent ingestion	6.5x10E-9	2.9x10E-9
	Inhalation of organics	1.8x10E-7	7.6x10E-9
	Dermal absorption	6.0x10E-8	5.7x10E-7
Fish **	Ingestion	NC	7.7x10E-7

* - Sediment and surface water risks were calculated using the highest pollutant concentrations detected during sampling.

** Estimated using calculated average pollutant concentration during sampling, accepted bioconcentration factor and 5.2 g/day consumption rate. The exposure assessment assumes that 100 percent of the freshwater fish consumed by a receptor are taken from Army Creek/Pond.

NC These values could not be calculated due to a lack of sufficient information regarding fresh fish consumption for children 6-11 years old.

Source: ROD-2 (EPA, 1990)

TABLE 13. SUMMARY OF TOTAL POTENTIAL NON-CARCINOGENIC HAZARD INDICES*

Media	Scenario	Age Group Exposed Children 6-11 yrs.	Adults 70-yr.life span
Groundwater Recovery Well Discharges	Inadvertent ingestion	0.000015	0.0000013
Sediment *	Inadvertent ingestion	0.00036	0.000031
Surface Water *	Inadvertent ingestion	0.0008	0.00069
Fish	Ingestion	NC	0.0048

* Sediment and surface water risks were calculated using the highest pollutant concentrations detected during sampling.

NC These values could not be calculated due to a lack of sufficient informaation regarding average fresh fish consumption for children 6-11 years old.

If the Hazard Index exceeds 1.0, there is a potential health hazard associated with exposure to the medium.

* Source: ROD-2 (EPA, 1990)

4.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

4.1 Assessment Problems

Site-specific contamination data for sediment, water or biota, obtained from the Administrative Record and other sources, were used to determine the suitability of restoring Army Creek. These data represent information available before remediation has been completed. As remediation continues toward completion water quality conditions in Army Creek are anticipated to improve. Therefore, data used to make our determination may represent a period when conditions were most degraded.

4.2 Undertake Restoration Of Lower Army Creek Marsh

The Technical Advisory Committee, based upon its technical assessment, concludes that wetland habitat restoration could be undertaken in Lower Army Creek basin, downstream of Army Creek Pond. The landfill impacts on natural resources in Lower Army Creek are not severe enough to prohibit an undertaking of restoration activities in the near future. The restoration efforts in Lower Army Creek Marsh should focus on several multiple-resource objectives: 1) enhancement of tidal exchanges with the Delaware River to help restore functional processes for nutrient cycling and aquatic organism use; 2) enhancement of wetland habitats that serve as spawning, nursery or feeding areas for estuarine/anadromous fishes; 3) enhancement of wetland habitats for waterbirds and other wildlife; 4) reduction in the need for chemical insecticides for mosquito control; 5) potential increase in the use of the area for outdoor recreation or environmental education; etc. A monitoring effort following baseline studies will be needed to determine if the restoration goals are being met and if restoration activities should be adjusted to better meet the goals. Additionally, it would be desirable to determine the effects of the habitat restoration work on contaminant concentrations in sediments, surface water, and biota in the lower marsh.

4.3 Rationale For Restoration Of Lower Army Creek Marsh

The only feasible restoration work which could be immediately undertaken to help restore the Trustee resources of migratory waterfowl and anadromous/estuarine fish must occur in Lower Army Creek. The Technical Advisory Committee bases its recommendation to restore Lower Army Creek on the following information:

a) In comparison with the sediments of several other relatively uncontaminated creeks in Delaware, Lower Army Creek sediments have higher concentrations of some metals. Compared with sediments of the Delaware River, however, Lower Army Creek sediments have lower levels for many metals.

b) While Hg, Pb, Zn and Cr concentrations in sediments may be high enough to potentially cause adverse biological effects as defined by at least one of the sediment approaches in Long and Morgan (1991), none of the concentrations of the other metals (i.e., Cu and Ni) in Lower Army Creek sediments exceed any of the concentrations defined by the various approaches as potentially causing adverse biological effects. Zinc, Pb, and Hg concentrations are between ER-L (Effects Range-Low) and ER-M (Effects Range-Median) and Cr is below the ER-L, suggesting that there is relatively minimal potential impact to biota in this area. Note that the taxa used in the Long and Morgan (1991) analyses have representatives found in Army Creek. When the concentrations of trace elements in the sediments of Lower Army Creek are compared with the Overall Apparent Effects Thresholds of Long and Morgan (1991), none exceed their Overall Apparent Effects Threshold. Therefore, minimal potential adverse effects would be expected for newly arriving anadromous species should Lower Army Creek be opened to the Delaware River.

c) With the exception of Fe and one Zn sample, none of the surface water concentrations of contaminants in Lower Army Creek exceed Federal AWQC for aquatic life or State of Delaware standards for non-tidal streams. Compared with the Delaware River, heavy metal concentrations in Army Creek surface waters are similar to or only slightly elevated. Thus, opening Lower Army Creek to the tidal influence of the Delaware River would not significantly increase surface water concentrations of heavy metals in Army Creek.

d) Fathead minnow survival and survival and reproduction of water fleas were not adversely affected by exposure to Lower Army Creek water.

e) Species diversity and the number of taxa are higher for Lower Army Creek than for either Upper Creek or the Pond.

f) Only a small percentage of the population of each diadromous species in the Delaware River system is likely to enter Army Creek or be significantly exposed to Army Creek contaminants should Lower Army Creek be opened to the Delaware River.

g) Individuals of diadromous species that do enter Army Creek are likely to be there for a relatively short (e.g., 6 months or less) but unspecified period of time, except for blue crab and American eel. The blue crab and American eel, which associate with bottom sediments, may reside in the creek for considerable periods of time, but most of their populations will be elsewhere.

h) American eels may be exposed to Pond sediments, because they are apparently capable of getting around small obstructions. However, no other diadromous species would be directly exposed to the more contaminated Pond habitat.

i) It is believed that no diadromous species spawn in Army Creek, suggesting that few sensitive life stages are present; however, juveniles may be present. The combination of limited exposure (i.e., relatively small percentage of total population in creek; unlikelihood of eggs or larvae being exposed even though juveniles may be present; and limited time in or near creek) plus relatively low levels of contamination in Lower Army Creek suggest, at worst, limited impacts on individuals and no significant impacts on populations, including those of endangered species, such as the shortnose sturgeon.

j) Species resident to Army Creek (e.g., resident fishes, amphibians, turtles, snakes, birds, mammals) are exposed to chronic, low levels of contaminants, but perhaps not much more so than those species living in or by many other Delaware creeks. Opening Lower Army Creek to tidal flow should result in no increased contaminant exposure or decreased populations (unless change in habitat or competition significantly decreases presence of species), and should improve habitat quality overall. Exchanges and dilutions of Army Creek water with tidal Delaware River water should have a beneficial effect on Army Creek habitat, and not significantly affect Delaware River quality. Opening the Lower Creek to tidal flow should help to restore emergent wetlands vegetation characteristic of tidal, oligohaline wetlands.

k) Any changes in contaminant exposure or population levels of both residents and non-residents probably will not be driven by changes in salinity (both adjacent river and creek are essentially fresh), but perhaps by changes in marsh water levels or tidal exchanges, by changes in habitat (e.g., *Phragmites* replaced by mixed emergents), or by changes in competition caused by arrival of new species (e.g., anadromous fishes).

l) It was estimated that the Delaware River would be minimally affected in terms of water quality by discharges of recovery wells to Army Creek. None of the discharges from the wells exceeds the water quality standards listed in the Delaware River Basin Commissions' July 1978 "Water Code of the Delaware Basin". The State of Delaware Surface Water Quality Standards for Streams, as amended August 27, 1982, states: "All waste discharges shall receive, at minimum, treatment necessary to comply with Federal, Delaware River Basin Commission (DRBC), or Department Regulations Governing the Control of Water Pollution, whichever regulation is applicable or more stringent."

m) After the eventual cessation of groundwater recovery pumping, which will cause decreased flow and lead to stagnation, water quality in Lower Army Creek is anticipated to substantially deteriorate without restoring tidal exchanges with the Delaware River.

n) Based on information to date, no human health advisory for consuming Army Creek fish flesh has been warranted or issued.

o) By working closely with the EPA, it is believed that the activities associated with capping and water treatment remediation efforts at both the Army Creek and Delaware Sand & Gravel (DS&G) Landfills, as well as any bio-remediation activities undertaken at DS&G, will not interfere or adversely affect resource restoration efforts in Lower Army Creek.

p) Highway runoff contaminants, such as Zn or Hg, should be adequately dealt with by the State of Delaware's (DNREC/DWR) pending National Pollutant Discharge Elimination System (NPDES) program requirements for stormwater discharges and by the State's proposed interactions with the Army Creek Trustees in regard to specific road runoff issues at the Army Creek site.

4.4 No Restoration At Present In Army Creek Pond or Upper Creek

Because of contamination levels in the sediments or surface water of Army Creek Pond and upstream reaches, the Technical Advisory Committee does not recommend that natural resource restoration efforts be undertaken in aquatic or wetland habitats in the Pond or upstream area, nor should any effort be made to attract fish and wildlife resources to these areas at the present time. In part, this conclusion is based upon:

a) When compared with the multiple-approaches presented by Long and Morgan (1991), the data suggest Army Creek Pond sediments may be contaminated with heavy metals (Zn, Pb, Hg, Cu, Cr, and Ni) at levels which exceed concentrations thought to potentially cause adverse effects on biota based on one or more of the approaches. Zinc concentrations range from less than those potentially causing adverse biological effects to those that exceed concentrations defined by the Effects Range-Median (ER-M). The highest concentration of Zn in the sediments of the Pond exceeds the Overall Apparent Effects Threshold as defined by Long and Morgan (1991).

b) Concentrations of Cd, Cr, Fe, Hg, and Zn in the surface waters of Army Creek Pond may exceed AWQC for protection of freshwater aquatic life.

c) Abundance and diversity of benthic macroinvertebrates and fishes is lower in Army Creek Pond and upstream areas than in Lower Army Creek.

d) Bioassay tests using ambient surface waters and presence/absence of indicator species also indicate that Army Creek Pond and Upper Army Creek environs are degraded in comparison to Lower Army Creek.

The Technical Advisory Committee has a concern that the sediments of Army Creek Pond may not be satisfactorily cleansed of residual contaminants accumulated prior to initiating groundwater treatment by the water treatment facility. For example, the Fe floc currently in the Pond sediments may not dissipate; the Zn in the sediments which may have come from the landfill or other landscape sources may not decrease. The Trustees will not resolve the issue of restoration for Army Creek Pond and Upper Army Creek until after periodic review by the EPA, no later than approximately 1999, for both the cap and the water treatment facility.

The results of the remediation efforts to reduce or eliminate contamination problems will have to be evaluated to judge if they have reduced contamination. For surface water that would mean that contaminant concentrations were below the Ambient Water Quality Criteria. In the case of sediment, concentrations of contaminants must not exceed EPA sediment criteria protective of natural resources (if they have been established), or the Long and Morgan (1991) sediment guidelines, or other more recent guidelines that may appear in the open literature. There may be other criteria that are examined (e.g., bioassays, criteria to protect wildlife health). As has been done in this report, a deliberative process will occur that will consider the preponderance-of-evidence for multiple factors and their criteria.

The Technical Advisory Committee recommends that future resource management considerations for Army Creek Pond include enhancement of fish habitat. To achieve this goal, the existing contamination levels must first be reduced. Other factors throughout the watershed such as water supply, sediment composition, sedimentation rates, water temperature, channel dimensions, etc. also should be addressed. Much of this effort would be dependent upon funding sources beyond the present damages.

5.0 REFERENCES

Blumer, M., W. Blumer, and T. Reich. 1977. Polycyclic aromatic hydrocarbons in soils of a mountain valley: a correlation with highway traffic and cancer incidence. Env. Sci. Tech. 11: 1082-1084.

Bolton, H.S., R.J. Breteler, B.W. Vignon, J.A. Scanlon, and S.L. Clark. 1985. National perspective on sediment quality. Submitted by Battelle to EPA Criteria and Standards Division, Office of Water Regulation and Standards. EPA Contract #68-01-6986. Wash, D.C.

Bopp, F. and R.B.Biggs. 1972. Trace metal environments near Shell Banks in Delaware Bay. College of Marine Studies, University of Delaware, Newark, DE. NOAA/Sea Grant DEL-SG-9-72.

Britt, S.A. and E.M. Hack. No date. A preliminary assessment of Wilson Contracting Company Landfill. PA/SI Cooperative Agreement Grant No. V-003350-01-0.

Brown, K.W. and Associates, Inc; April 1983. Hazardous Waste Land Treatment. Prepared for the U.S. Environmental Protection Agency.

Byrkit, D.R. 1975. Elements of Statistics. An introduction to probability and statistical inference. New York, NY: D. Van Nostrand Company. 431 pp.

Chapman, P.M. 1986. Sediment quality criteria from the sediment quality triad: An example. Environmental Toxicology and Chemistry 5: 957-964.

Chapman, P.M. 1989. Current approaches to developing sediment quality criteria. Environmental Toxicology and Chemistry. 8: 589-599.

Chapman, P.M., R.N. Dexter, S.F. Cross, and D.G. Mitchell. 1986. A field trial of the sediment quality triad in San Francisco Bay. NOAA Technical Memorandum NOS OMA 25. Rockville, MD: National Oceanic and Atmospheric Administration. 133 pp.

Charters, D.W. 1988. Final Report Army Creek, New Castle, Delaware. U.S. EPA, Environ. Response Branch, Edison, NJ.

Charters, D.W., G. Buchanan, and K. Munney. No date. Final Report Army Creek, New Castle, Delaware. U.S. EPA, Environmental Response Branch, Edison, NJ.

Church, T.M., J.M. Tramontano, and S. Murray. 1986. Trace metal fluxes through the Delaware Bay estuary. Rapp. P.-v. Reun. Cons. int. Explor. Mer. 186: 271-276.

Clean Tech. 1994. Army Creek Treatment Plant Operations and Maintenance Manual. Newark, DE.

Cole, R.V. and T. Fabean. 1992. The Northern Delaware Wetlands Rehabilitation Program: A biotic inventory and environmental evaluation of five candidate wetland restoration sites. Delaware Division of Fish and Wildlife (DCMP), DNREC, Dover, DE 154pp.

Collins, H.H., Jr. 1959. Complete Field Guide to American Wildlife. Harper and Row, New York.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, J. Buckley. 1984. Synopsis of biological data on Shortnose Sturgeon, Acipenser brevirostrum, LeSueur 1818. NOAA Technical Report NMFS 14. 45 pages.

Delaware River Basin Commission. 1978. Water Code of the Delaware Basin.

deSylva, D.P., F.A. Kalber, and R. Seguin. 1960. Marine Sport Fishing Investigations, Final Rept, 1958-60. Dingell-Johnson Federal Aid to Fish and Wildlife Restoration, Project F-13-R-3, Univ. Del. Marine Labs., Lewes, DE

Dewitt, T.H., G.R. Ditsworth, and R.C. Swartz. 1988. Effects of natural sediment features on survival of the phoxocephalid amphipod, Rhepoxynius abronius. Marine Environmental Research 25: 99-124.

Donaghy, R., L. Bailey, and J. Green. 1988. Aquatic Toxicity Report, Army Creek, Delaware. USEPA, Region III, Wheeling Office, Wheeling, WVA. 7pp.

Dunn Geoscience Corporation, December 1987. Remedial Investigation: Delaware Sand and Gravel Landfill, Final Report.

EPA. 1982. Metals in soils: A brief summary. Exposure Evaluation Division, Office of Toxic Substances, Washington, D.C.

EPA. 1986a. Final report of the Army Creek investigation for ambient stream life survey and series of chronic toxicity tests that were performed on the recovery wells and ambient stations in Army Creek.

EPA. 1986b. Record of Decision-1 for Army Creek Superfund Site. EPA, Region III, Philadelphia, PA.

EPA. 1986c. Water Quality Criteria; Ambient Aquatic Life Water Quality Criteria Documents. 51 Federal Register 47, pp. 8361, et seq.

EPA. 1987. Army Creek sediment analysis of samples taken July 9, 1987.

EPA. 1988a. Final report: Army Creek, New Castle, DE. Environmental Response Branch, Edison, NJ.

EPA. 1988b. Record-of-Decision for Delaware Sand & Gravel Superfund Site. EPA, Region III, Philadelphia, PA.

EPA. 1990. Record of Decision-2 for Army Creek Superfund Site. EPA, Region III, Philadelphia, PA.

EPA. 1992. Sediment classification methods compendium. EPA 823-R-92-006. Office of Water, Washington, DC.

EPA. 1993. Rocord-of-Decision Amendment for Delaware Sand & Gravel Superfund Site. EPA, Region III, Philadelphia, PA.

Feasibility Study for the Army Creek Landfill, New Castle, DE. (including appendix L). 1986. Roy F. Weston, Inc., Weston Way, West Chester, PA 19380.

Focused Feasibility Study (Final Report). 1990. Army Creek Landfill Site, New Castle, DE. EPA Work Assignment No. 37-10-3L34. Contract No. 68-W8-0037. NUS Project No. 1017. NUS Corp. and Gannett Fleming Environmental Engineers, Inc.

Focused Remedial Investigation (Final Report). 1990. Army Creek Landfill site, New Castle, DE. EPA Work Assignment No. 37-10-3L34. Contract No. 68-W8-0037. NUS Project No. 1017. NUS Corporation and Gannett Fleming Environmental Engineers, Inc.

JRB Associates. 1984. Background and review document of the development of sediment criteria. EPA Contract No. 68-01-6388. JRB Project No. 2-813-03-852-84. Washington, DC: U. S. Environmental Protection Agency. 35 pp.

Klapow, L.A. and R.H. Lewis. 1979. Analysis of toxicity data for California marine water quality standards. J. Water Pollution Control Federation 51(8): 2051-2070.

LeBlanc, G.A. 1984. Interspecies relationships in acute toxicity of chemicals to aquatic organisms. Environ. Toxicol. Chem. 3:47-60.

Leland, H.V. 1983. Ultrastructure changes in hepatocytes of juvenile rainbow trout and mature brown trout exposed to copper or zinc. Environ. Toxicology Chem. 2:353-368.

Long, E.R. 1989. The use of the sediment quality triad in classification of sediment contamination. In: Symposium/Workshop on Contaminated Marine Sediments -- Assessment and Remediation. Tampa, FL, May 31- Jun 3, 1988. Washington, DC: National Research Council. pp. 78-93.

Long, E.R. and M.F. Buchman. 1989. An evaluation of candidate measures of biological effects for the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 45. Seattle, WA: National Oceanic and Atmospheric Administration. 105 pp.

Long, E.R. and L.G. Morgan. 1991. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends

Program. NOAA Technical Memorandum NOS OMA 52. Seattle, WA 175pp. plus appendices.

Lytle, T.F. and J.S. Lytle. 1985. Pollutant transport in Mississippi Sound. Sea Grant Publ. No. MASGP-82-038. Ocean Springs, MS: Gulf Coast Research Laboratory. 124 pp.

Mayer, F.L., C.H. Deans, and A.G. Smith. 1987. Inter-taxa correlations for toxicity to aquatic organisms. EPA/600/X-87/332. Environmental Research Laboratory, Gulf Breeze, FL 32561

McKim, J.M., G.F. Olsen, G.W. Holcombe, and E.P. Hunt. 1976. Long-term effects of methylmercuric chloride on three generations of brook trout (Salvelinus fontinalis): Toxicity, accumulation, distribution, and elimination. J. Fish. Res. Bd. Canada 33:2726-2739.

Mitchell, G. and R. Garrow. 1983. Finfish collections at Red Lion Creek, Army Creek, and St. Jones River. State of Delaware, Dept of Natural Resources and Environmental Control, Dover, DE.

National Academy of Science. 1989. Contaminated marine sediments -- Assessment and remediation. Committee on Contaminated Marine Sediments, Marine Board, Commission on Engineering and Technical Systems, National Research Council. National Academy Press, Washington, D.C. 493pp.

Neff, J.M., D.J. Bean, B.W. Cornaby, R.M. Vaga, T.C. Gulbransen, and J.A. Scanlon. 1986. Sediment quality criteria methodology validation: Calculation of screening level concentrations from field data. Work Assignment 56, Task IV. Washington, DC: U. S. Environmental Protection Agency. 225 pp.

Neff, J.M., J.Q. Word, and T.C. Gulbransen. 1987. Recalculation of screening level concentrations for nonpolar organic contaminants in marine sediments. Final Report. Washington, DC: U. S. Environmental Protection Agency, Region V. 18 pp.

NUS Corp. 1988. Site inspection of Wilson Contracting Company Landfill.

NUS Corporation, Superfund Division. TDD No. f3-8707-20. EPA No. DE-145. Contract No. 68-01-7346.

O'Herron, II, J.C., K.W. Able, and R.W. Hastings. 1993. Movements of shortnose sturgeon (Acipenser brevirostrum) in the Delaware River. Estuaries 16(2): 235-240.

PTI Environmental Services. 1988. Sediment quality values refinement: Tasks 3 and 5 -- 1988 update and evaluation of Puget Sound AET. EPA Contract No. 68-02-4341 to Tetra Tech, Inc. Seattle, WA: U.S. Environmental Protection Agency, Region X. 127 pp.

Rand, G.M. and S.R.Petrocelli. 1985. Fundamentals of aquatic toxicology: Methods and applications. Hemisphere Publishing Corporation, Washington.

Schuler, V.J. 1973. An ecological study of the Delaware River in the vicinity of Artificial Island. Ichthyological Associates, Inc., Middletown, DE

Shacklette, H.T., and J.G. Boerngen. 1984. Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geological Survey Professional Paper 1270.

Spehar, R.L. 1976. Cadmium and zinc toxicity to flatfish, Jordanella floridae. J. Fish. Res. Bd. Canada 33:1939-1945.

State of Delaware Water Quality Standards for Streams. August 27, 1982.

State of Delaware, DNREC. 1983. Memorandum - Finfish Collections at Red Lion Creek, Army Creek and St Jones River.

State of Delaware. 1985. Memorandum - Bio-survey at Army Creek.

State of Delaware, DNREC. 1988. 1988 Delaware Water Quality Inventory. Vol II.

State of Delaware. 1989. Surface Water Quality Standards. Development Document Volumes 1 and 2, July 20.

State of Delaware, DNREC. 1992. Unpublished Report on streams with no tidal influence.

Suter, G.W. II and D.S. Vaughan. 1985. Extrapolation of ecotoxicity data: Choosing tests to suit the assessment. Pages 387-399 In K.E. Cowser (ed.) Synthetic fossil fuel technologies: Results of health and environmental studies. Butterworth Publ., Boston, MA.

Swartz, R.C., P.F. Kemp, D.W. Schults, and J.O. Lamberson. 1988. Effects of mixtures of sediment contaminants on marine infauna amphipod, Rhepoxynius abronius. Environmental Toxicology and Chemistry. 7: 1013-1020.

Tessier, A.P. and G.C. Campbell. 1987. Partitioning of trace metals in sediments: Relationships with bioavailability. In: Ecological Effects of In Situ Sediment Contaminants. Aberystwyth, Wales, 1984. R. Thomas, R. Evanms, A. Hamilton, M. Munawar, T. Reynoldson, and H. Sadar, Eds. Dordrecht, Boston, Lancaster: DR W Junk. Developments in Hydrobiology 39. pp. 43-52.

U.S. Department of Interior, Fish and Wildlife Service, Division of Ecological Services. 1988. Ecological Report by Rudis and Andreasen.

Weston, R.F., Inc. 1973. Toxicity study on pumped leachate from Llangollen Landfill area, New Castle Co., DE. Prepared by P. Klose, R.F. Weston, Inc., West Chester, PA.

Weston, R.F., Inc. 1982. Biological assessment of Army Creek Llangollen Landfill, Dec. 30, 1982.

Weston, R.F., Inc. 1986. Feasibility Study for the Army Creek Landfill, New Castle, DE--Final Report. West Chester, PA.

Weston, R.F., Inc. 1992. Operations and Maintenance, Phase I, New Castle County, Delaware, Army Creek Site. West Chester, PA.

Word, J.Q., J.A. Ward, C.W. Apts, D.L. Woodruff, M.E. Barrows, V.I. Cullinan, J.L. Hyland, and J.F. Campbell. 1988. Confirmatory sediment analyses and solid and suspended particulate phase bioassays on sediment from Oakland Inner Harbor, San Francisco, California. PNL-6794 UC-11. San Francisco, CA: Prepared by Battelle for San Francisco District, U.S. Army Corps of Engineers. 250 pp.

ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold Approach
Ag	Silver
Al	Aluminum
As	Arsenic
AVS	Acid volatile sulfides
AWQC	Ambient Water Quality Criteria
Ba	Barium
BCCOA	Bioeffects/Contaminant Co-occurrence Analysis Approach
BMPs	Best Management Practices
Ca	Calcium
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
c.f.s.	Cubic Feet per Second
Co	Cobalt
Cr	Chromium
Cu	Copper
DELDOT	Delaware Department of Transportation
DNHI	Delaware Natural Heritage Inventory
DNREC	Delaware Department of Natural Resources and Environmental Control
DRBC	Delaware River Basin Commission
DS&G	Delaware Sand & Gravel Superfund Site
DWR	DNREC, Division of Water Resources
EPA	U.S. Environmental Protection Agency
ER-L	Effects Range Low
ER-M	Effects Range Median
FDA	Food and Drug Administration
Fe	Iron
FFS	Focused Feasibility Study
FRI	Focused Remedial Investigation

FS	Feasibility Study
FWS	U.S. DOI, Fish and Wildlife Service
FYER	Five Year Evaluation Review/Report
Hg	Mercury
K	Potassium
LC	Lethal concentration
MEK	Methyl ethyl ketone
Mg	Magnesium
mg/kg	ppm
mg/l	ppm
MIBK	Methyl isobutyl ketone
Mn	Manganese
MOA	Memorandum of Agreement
Na	Sodium
ND	Not Detectable
NGVD	National Geodetic Vertical Datum
Ni	Nickel
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSD	Not Sufficient Data
OAET	Overall Apparent Effects Threshold
PAH	Polynuclear Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyls
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
PRP	Potentially Responsible Party
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
ROD	Record-of-Decision
RPM	Remedial Project Manager
S1	State Species of Special Concern [1= most concern]
Sb	Antimony
Se	Selenium
SLC	Screening Level Concentrations Approach
SSB	Spiked-Sediment Bioassay Approach
SWEPT	Sediment-Water Equilibrium Partitioning Approach
TAC	Technical Advisory Committee
TOC	Total organic carbon
ug/g	Microgram per gram (ppm)
ug/kg	Micrograms per kilogram (ppb)
ug/l	Micrograms per liter (ppb)
U.S. DOI	U.S. Department of Interior
Zn	Zinc

ADDENDUM

Since the completion of the Report of the Technical Advisory Committee on Army Creek Contaminant Issues (TAC Report) new information has come available regarding contaminant concentrations in marine and estuarine sediments and their potential biological effects. The purpose of this addendum is to review this new information and update the conclusions and recommendations of this report to reflect this new information. Many of the statements that follow are taken directly from Long et al. (In press) and Long and MacDonald (1992).

Using data available from all the major approaches to the development of effects-based criteria, Long and Morgan (1991) prepared informal guidelines for use by the National Oceanic and Atmospheric Administration (NOAA) to identify chemicals that occurred in concentrations that were sufficiently high to warrant concern and to identify sampling sites and areas in which there was a potential for toxicity. These guidelines also have been used to provide an estimate of the potential for adverse biological effects of sediment-associated contaminants on benthic organisms, based on a weight of evidence from analyses performed with multiple species and/or biological communities (Squibb et al., 1991; Mannheim and Hathaway, 1991; Soule et al., 1991). The use of these (Long and Morgan, 1991) guidelines was included in the report in Section 3.1 and is reflected in the conclusions and recommendations (Section 4.3). Subsequently, the database from which these guidelines were prepared has been updated and expanded and the approach refined (Long and MacDonald, 1992; MacDonald, 1992; Smith and MacDonald, 1992). The update and refinement were not included in the TAC Report and is the focus of this addendum.

The update and refinement of Long and Morgan (1991) has resulted in the development of a Biological Effects Database for Sediments (BEDS) which integrates chemical and biological data from numerous studies conducted throughout North America to support the derivation of the updated guidelines. The database used by Long and Morgan (1991) was refined by excluding data from freshwater studies and including data from additional sites, biological test endpoints, and contaminants. Nearly 350 publications were reviewed and screened for possible inclusion in the

BEDS. Data from equilibrium-partitioning modelling, laboratory spiked-sediment bioassays, and field studies of sediment toxicity and benthic community composition were critically evaluated. Only matching, synoptically-collected biological and chemical data from marine and estuarine studies were included in the database. Data were excluded if: 1) methods were not clearly described, 2) sediments were frozen before toxicity tests, 3) toxicity of controls were higher than commonly acceptable, 4) there was less than a 10-fold difference in the concentrations of all contaminants among sampling stations, 5) chemical analytical procedures were inappropriate, and 6) either no biological data or chemical data were reported.

Each concentration value entered in the BEDS was placed in ascending order and assigned an "effects/no effects" descriptor. An entry was assigned an "effects" descriptor if: 1) an adverse biological effect was reported and 2) concordance was apparent between the observed biological response and the measured chemical concentration. For broad applicability, the kinds of adverse effects included: 1) measures of altered benthic communities (depressed species richness or total abundance), significantly or relatively elevated sediment toxicity, or histopathological disorders in demersal fish observed in field studies; 2) EC_{50} or LC_{50} concentrations determined in laboratory bioassays of sediment spiked with single compounds or elements; and 3) toxicity predicted by equilibrium-partitioning models. These ascending data tables, as reported by Long and Morgan (1991) and updated by Long and MacDonald (1992), MacDonald (1992), and Smith and MacDonald (1992), summarized the available information for each chemical or chemical group that was considered.

With Long and Morgan (1991) the distributions of the effects data were determined using percentiles (Byrkit, 1975). Two values were derived for each chemical or chemical group. The lower 10th percentile of the effects data for each chemical was identified and referred to as the Effects Range-Low (ER-L). The median, or 50th percentile, of the effects data was identified and referred to as the Effects Range-Median (ER-M). The concentrations below the ER-L value represent a "Minimal-Effects" range; a range intended to estimate conditions in which effects would be rarely observed. Concentrations equal to and above the ER-L, but below the ER-M represent a "Possible-Effects" range within which effects would occasionally occur. Finally, the concentrations equivalent to and above the ER-M value represent a "Probable-effects" range within which effects would frequently occur.

The method used by MacDonald (1992) considered both the "effects" and "no effects" data, whereas that of Long and Morgan (1991) used only the "effects" data. For the MacDonald (1992) data, a threshold effects level (TEL) was calculated first as the square root of the product of the lower 15th-percentile concentration associated with observations of biological effects (the ER-L) and the 50th-percentile concentration of the no-observed-effects data (the NER-M). A safety factor of 0.5 was applied to the TEL to define a No-Observable-Effects-Level (NOEL). MacDonal has since dropped the calculation of NOELs as one-half of the TEL values (Long, pers. Comm.). Next, a Probable-Effects Level (PEL) was calculated as the square root of the product of the 50th-percentile concentration of the effects data (the ER-M) and the 85th-percentile concentration of the no effects data (the NER-M). Despite the differences in methods, the agreement between Long and Morgan (1991) and MacDonald (1992) is very good (Long and MacDonald, 1992). MacDonald (1992) also calculated guidelines only for those chemicals for which there was a minimum of 40 data points, after determining the minimum amount of data necessary to calculate reliable and consistent values. These minimum data requirements were established by iteratively calculating guidelines using data sets of increasing size and determining when the estimate of the guidelines stabilized.

Neither Long and Morgan (1991) nor MacDonald (1992) is preferred or advocated over the other (Long and MacDonald, 1992). According to Long and MacDonald (1992), the significant feature is the use of a weight of evidence developed in the ascending tables, not the specific method of using the data tables. The overall approach used by Long and Morgan (1991) and MacDonald (1992) to develop such guidelines is being used by Environment Canada and Florida Department of Regulation. It also has been adopted by a committee of the International Council for the Exploration of the Sea for use by member nations (Long and MacDonald, 1992).

Results

When compared with the multiple-approaches presented by Long and Morgan (1991), the data suggest Army Creek Pond sediments may be contaminated with heavy metals (Zn, Pb, Hg, Cu, Cr, and Ni) at levels which exceed concentrations thought to potentially cause adverse effects on biota based on one or more of the approaches (Table 2A). Zinc concentrations range from less than those potentially causing adverse biological effects to those that exceed concentrations defined by the Effects Range-Median (ER-M), the Apparent Effects Threshold (AET), the Bioeffects/Contaminant Co-occurrence Analysis (BCCOA), and the Spiked-Sediment Bioassay (SSB) as potentially causing adverse biological effects. Additionally, zinc at the highest concentration observed exceeded the Overall Apparent Effects Threshold. Lead concentrations range from less than those of concern to those that exceed the Effects Range-Low (ER-L) and BCCOA. Mercury concentrations range from less than those of concern to those that are approximately equal to the ER-L, and exceed the Sediment-Water Equilibrium Partitioning Threshold (SWEPT), and the BCCOA. Copper concentrations range from less than those of concern to those that exceed the BCCOA and SSB. Chromium concentrations range from less than those of concern to those that exceed the SWEPT. Nickel concentrations range from less than those of concern to those that exceed BCCOA and SWEPT.

However, Long and MacDonald (1992) only consider "No-Observable-Effects Levels" (approximately equivalent to Long and Morgan's ER-L) and "Probable-Effects Levels" (approximately equivalent to Long and Morgan's ER-M). Thus, the only comparisons to be made are between the ER-L and ER-M values of Long and Morgan (1991) and those equivalents of Long and MacDonald (1992).

For the sediments Army Creek Pond, zinc exceeds the ER-M of Long and Morgan (1991), but not the equivalent ER-M of Long and MacDonald (1992) [See Addendum Table 1a]. Lead concentrations in the bottom sediments of Army Creek Pond exceed the ER-L for Long and Morgan (1991) and the equivalent ER-L of Long and MacDonald (1992). Copper and nickel concentrations in the bottom sediments of Army Creek Pond did not exceed the ER-L of Long and Morgan (1991), but did the equivalent ER-L of Long and MacDonald (1992). Using the guidelines of Long and Morgan (1991), lead exceeds the ER-L value and zinc exceeds the ER-M value. Using the guidelines of Long and MacDonald (1992), copper, lead, nickel, and zinc concentrations in the bottom sediments of Army Creek Pond exceed the ER-L values. In addition to lead and zinc, copper and nickel are placed into the "Possible-Effects" range by Long and MacDonald (1992).

For Lower Army Creek, the data suggest the sediments there may be contaminated with heavy metals (Zn, Pb, Hg, and Cr) at levels which exceed concentrations thought to potentially cause adverse effects on biota based on one or more of the approaches presented in Long and Morgan (1991) (Table 2A). Lead and Hg exceeded such concentrations at two stations (sites 1 and 4), Zn at one station (site 4) near Route 9 bridge, and Cr only at site 4 (Tables 2A and 3). Concentrations of Pb, Hg and Zn range from less than those potentially causing adverse biological effects to those approximately twice the ER-L but less than the ER-M. Lead concentrations also exceeded the BCCOA. Mercury concentrations also exceeded the AET, BCCOA, and SWEPT. Zinc concentrations also exceeded the BCCOA and SSB. Chromium concentrations do not exceed the ER-L at any of the sites, but do exceed the SWEPT once (site 4). When the concentrations of the above trace elements in the sediments of Lower Army Creek are compared with the Overall Apparent Effects Thresholds of Long and Morgan (1991), none exceed their Overall Apparent Effects Threshold (Table 2C).

For comparative purposes here, concentrations of lead, mercury, and zinc in the bottom sediments of Lower Army Creek range from less than those potentially causing adverse effects to those approximately twice the ER-L but less than the ER-M, based on the guidelines of Long and Morgan (1991). Based on the guidelines of Long and MacDonald (1992), arsenic, lead, mercury, and zinc concentrations in the bottom sediments of Lower Army Creek exceed the equivalent ER-L, but not the equivalent ER-M. Thus, the only difference in Lower Army Creek between the previous conclusions and modifications prompted by the newer Long and MacDonald (1992) data is the addition of arsenic as a "Possible Effects" problem. This addition is caused by a reduction in the ER-L value for arsenic from 33 ppm (Long and Morgan, 1991) to an equivalent ER-L of 8.2 ppm (Long and MacDonald, 1992), which is now lower than one of the three known arsenic sample concentrations from the bottom sediments of Lower Army Creek (arsenic sample concentrations from Lower Army Creek were 13.5, 5.4, and 2.3 ppm).

Summary and Conclusions

The application of the Long and MacDonald (1992) guidelines additionally identified copper and nickel in the sediments of Army Creek Pond as having "Possible-Effects" (i.e., greater than ER-L, but less than ER-M), and added arsenic as a metal having "Possible-Effects" in sediments of Lower Army Creek. The refinement of Long and Morgan's (1991) values by Long and MacDonald (1992) changed the category of these metals from "No-Observable-Effects" or "Minimal-Effects" (i.e., less than ER-L) to "Possible-Effects". In addition, the only other modification based upon Long and MacDonald (1992) is a change in the category of zinc in the sediments of Army Creek Pond from "Probable-Effects" (i.e., greater than ER-M) to "Possible-Effects".

For interpretive purposes Long et al. (In press) report that for most trace metals, biological effects were observed in 5-10% of the studies (depending on the particular metal involved) where concentrations were below the ER-L. For concentrations above the ER-M values, from 63-95% of the studies (depending on the particular metal involved) showed effects. According to Long (pers. comm.), "We interpret these data as saying that, based upon previous studies, there is about a 5.0% probability of toxicity at, say, arsenic concentrations of 8.2 ppm (the ER-L value) or less and about a 63% probability of effects at arsenic concentrations above the ER-M value." At concentrations in between, the probability of effects would range between 5% and 63%. "There are several exceptions to this pattern, the most notable of which is nickel. The incidence of toxicity above and below the ER-M and ER-L [respectively] are virtually the same. Therefore, we have no confidence in the guidelines for nickel" (Long, pers. comm.).

Based on this analysis, the changes noted above are viewed as minor since none involve a change to a "Probable-Effects" category. Concerning organics in sediments, no additional statements can be made, because the data are too sparse (See Addendum Table 1b). Therefore, the general conclusions and recommendations of the TAC Report remain unchanged.

Summary Table for Army Creek Pond and Lower Army Creek of exceedances of heavy metal concentrations thought to potentially cause adverse effects on biota based on one or more of the approaches in Long and Morgan (1991) and MacDonald (1992). See body of report (Section 3.1) or Acronyms and Abbreviations and text following Tables 2a and b for explanation of approaches.

	Approaches in Long and Morgan (1991)						
Metals	SWEPT	SSB	AET	BCCOA	ER-L	ER-M	OAET
Zinc		*+	*	*+	*+#@	*	*
Lead				*+	*+#@		
Mercury	*+		+	*+	=+ @		
Copper		*		*	#		
Chromium	*+						
Nickel	*			*	#		
Arsenic					@		

* Army Creek Pond exceeds based on Long and Morgan (1991)
+ Lower Army Creek exceeds based on Long and Morgan (1991)
= Pond equals ER-L based on Long and Morgan (1991)
Army Creek Pond exceeds based on MacDonald (1992)
@ Lower Army Creek exceeds based on MacDonald (1992)

and Harbors, County of Los Angeles. University of Southern California, Los Angeles, CA. 206pp.

Squibb, K.S., J.M. O'Connor, and T.J. Kneip. 1991. New York/New Jersey Harbor Estuary Program. Module 3.1: Toxics characterization report. Prepared for U.S. Environmental Protection Agency, Region 2. NYU Medical Center, Tuxedo, NY. 65pp.

APPENDIX B

NEPA COMPLIANCE

NEPA COMPLIANCE CITATIONS: In an abbreviated fashion we refer to sections within the restoration plan where details of compliance can be found.

1.0 Purpose of and Need for Action

The purpose and need for action is specified in section 1.2 in the restoration plan. The Army Creek Natural Resources Trustees want to increase suitable habitat for natural resources under their Trusteeship as a Superfund (CERCLA) restoration activity. A general description on the background of the Army Creek site can be found in the introduction of the restoration plan, section 1.3.

1.1 Significant issues identified.

The Restoration Plan, section 2.0, identifies the lack of tidal inflows, and to a lesser extent, upstream water withdrawals and diversions, as a significant problem at the Army Creek Site.

The Environmental Assessment, Appendix A, section 2.1, details the potential environmental impacts at the Army Creek Site. Such impact considerations include the evaluation of contaminant levels that can cause continued injury to Trust resources, alterations of the water table level, road runoff problems and impacts on mosquito control.

2.0 Federal permits, licenses, and entitlements necessary to implement the project.

The Restoration Plan, section 2.0, explores possible State and Federal permit requirements, including the consideration of Federal wetland permit section 404.

No Federal or State threatened or endangered species have been found at Army Creek. Rare species, as classified by the Natural Heritage

Foundation, are discussed in the Restoration Plan section 2.1.2 and Appendix A, Attachment II.

Land acquisition activities are discussed in section 2.2 Upland Restoration.

3.0 Alternatives Including the Proposed Action

The Restoration Plan, section 2, details the water and vegetation plans with associated alternative proposals. The water management plan contains several proposals for tidal exchange: no action, unmanaged tidal exchange, maximize marsh surface inundation and the proposed action of controlled tidal exchanges. The vegetation plan addresses the alternatives for restoring desirable tidal marsh species. These alternatives encompass no action, flooding, mowing, burning, mow and burn, herbicide, and the proposed action herbicide and burn treatment.

4.0 List of Preparers

State of Delaware,
Department of Natural Resources and Environmental Control
William H. Meredith

U.S. Department of the Interior,
Fish and Wildlife Service
Robert E. Foley

U.S. Department of Commerce,
National Oceanic And Atmospheric Administration
James P. Thomas, Timothy E. Goodger, Peter Leigh

5.0 List of Agencies, Organizations, and Persons to Whom Copies of the Statement are Sent.

State of Delaware,
Department of Natural Resources and Environmental Control

U.S. Department of Interior,

Fish and Wildlife Service

U.S. Department of Commerce,
National Oceanic and Atmospheric Administration

APPENDIX C

WATER CONTROL STRUCTURE AND SCHEDULE

Required Changes to Existing Structure for the Proposed Action

1) Existing Structure -- Meeting many of the environmental objectives will necessitate increasing tidal exchanges and marsh water levels. In order to achieve the desired tidal exchanges and marsh water levels in a controlled fashion, while also preventing excessive floodings, it will be necessary to modify and then manage the existing water control structure located at the mouth of Army Creek, adjacent to the Delaware River. The water control structure currently consists of five 48"-diameter pipes each fitted with one-way flapgates on the riverside, allowing only outflow of upland runoff and prohibiting tidal inflow.

The structure is equipped with slots for installing riserboards to control marsh water levels (using water derived from accumulated upland runoff), but to date managing Army Creek water levels using riserboards has not been done. Potential use of riserboards would primarily be to set and try to maintain minimum marsh water levels. Because the existing riserboard slots may not be high enough to achieve some of the desired management levels, it may also be necessary to modify the structure to allow higher riserboard settings. Problems with relying solely upon riserboards for marsh water management include the need for constant checking and manual manipulations of the riserboards in response to management objectives or storm events; very limited flexibility for managing tidal inflow in association with varying marsh water levels; inhibition of the frequency or duration of tidal inflows; diminished marsh water volume discharge capacity; and reliance upon upland runoff to meet most wetland water supply needs.

2) New Needs and Costs for the Water Control Structure -- In order to help achieve the water management goals necessary to restore and then maintain high quality wetlands habitat in Lower Army Creek Marsh, it will be necessary to retrofit one or more of the existing 48"-diameter pipes in the Army Creek water control structure with automated tidegates, thereby allowing controlled tidal exchanges. The automated gates could be either mechanical floatgates (which operate in response to water

levels on the river side) or electronic slidegates (which operate in response to sensing water levels on both sides of the structure). Any of the remaining one-way flapgates would continue to operate as in the past, and the desirability of using various configurations of riserboards in association with the new and old tidegates would be assessed.

The cost of an automated mechanical floatgate, such as the Steinke Self-Regulating Tidegate (SRT) is about $22,000 for one gate, or $20,000 per gate for two or more SRT's. The SRT is a mechanically-operated gate using floats on the structure's river side to automatically open the gate at a preset river height and to automatically close the gate at a preset river height, thereby controlling when flood waters can enter the marsh. These height settings are adjustable. This opening and closing occurs regardless of marsh water levels, presenting potential problems under certain conditions. The SRT discharges water from the marsh to the river on a gravity basis, whenever marsh water levels exceed river water heights; this also can present a potential problem in terms of excessively dewatering the marsh. Stoplogs or riserboards may be used in the structure's existing channels to partially offset this problem. If all five existing flapgates were replaced with SRT's, material costs will be about $100,000. To take off one existing flapgate and replace it with a SRT will involve about 1-1/2 days of labor for a 3-man crew with crane, costing about $2,000 per gate, or $10,000 for all 5 gates. Thus, the total cost for material and installation for replacing all five gates with SRT's would be about $110,000. It is not yet known if 1, 2, 3, 4 or all 5 gates will need SRT's (this awaits outcome of a hydrological engineering study).

If we want or need a structure enabling more responsive changes in marsh water levels under a wider range of conditions than achievable with SRT's, one or more of the existing flapgates could be replaced with an automatic Vertical Lift Gate (VLG) having water level electronic sensors on both marsh and river sides; this would enable control of the duration or amount of river flooding and the duration or extent of marsh discharge based on marsh water levels. The material cost of a single VLG is about $11,300. However, installing the first VLG would incur a total cost of about $39,300; beyond the VLG's material cost of $11,300, there would also be cost to remove the old flapgate ($2000), install the new VLG ($3500), add electronic water level sensors and computerized integration ($7500), install electric power lines and transformers running to the site ($5000), and provide for a secured control cabinet and electrical connections ($10,000). However, many of the above costs would not have to be repeated in order to add a second or more VLG's; it's estimated that each additional VLG could be installed for a total cost of $18,800 per gate. If all five existing flapgates were replaced with VLG's, the total cost could be $114,500.

The difference between the costs for five VLG's($114,500) vs. five SRT's ($110,000) is only $4500, so initial costs should not be a major factor in determining which type of gate to use. Rather, questions about the ability to achieve or maintain desired water level settings under variable conditions, about the ability to finely adjust marsh water level heights, about the ability to rapidly make adjustments, about the reliability of the gates to function as designed, about the gates' short-term and long-term maintenance and repair needs, and about other similar practical concerns will all enter into making the final choices. Depending upon the outcome of a hydrological engineering study and analyses of the above factors, the final water control structure design might be a mixture of VLG's, SRT's, and the flapgates.

The estimated total cost of about $150,000 is based on doing some type of replacement for all five existing flapgates, plus an additional $35,000-$40,000 as a buffer to accommodate what are usually inevitable unanticipated expenses. Of course, if one or more existing flapgates are left as is, the total estimated cost decreases. Efforts should also be made to incorporate practicable security or anti-vandalism features into the structure's design, which will also increase the structure's costs.

3) Hydrological Engineering Study -- In order to determine what types of structural modifications should be made to Army Creek's water control structure to achieve the water management objectives for wetlands restoration and maintenance, the Trustees will approve a contract with an engineering consulting firm to assess what the proposed water management schedule entails, and to plan and design a structure that will achieve the water management objectives. The engineering consultant will be contacted as soon as possible after the restoration plan is approved and funds are released to start the restoration work. It is estimated that the consultant's cost will be about $30,000 for a 6-12 month project. The consultant will be performing several tasks, which include in part:

1) Modeling of surface hydrological patterns in Army Creek's watershed, with an emphasis on how the current water control structure now discharges upland runoff, and on how future structural modifications would affect this discharge capacity.

2) Determination of how new, and unusually high, marsh water levels will affect potential for flooding problems on Rt. 9 or on developed properties around the wetlands periphery, and how the new marsh water levels will affect stormwater detention and discharge capacities.

3) Design of structural modifications to the existing water control structure in order to achieve the varying tidal exchange and marsh water level objectives that are desired, addressing issues such as:

a) Use of mechanical floatgates vs. electronic slidegates;

b) Number of existing flapgated pipes to be retrofitted with new tidegates (from 1 to 5);

c) Potential role of riserboards in future management schemes;

d) Management settings and schedules for operation of the new (modified) water control structure;

e) Reliability, security and maintenance considerations regarding the structure;

f) Economic costs of installing and maintaining the structure.

Additionally, the Trustees will have to address who are the responsible parties for the long-term operation and maintenance of the water control structure, which is examined in the Operations and Maintenance section of this plan.

Proposed Water Management Schedule

The proposed water management schedule is given in Table C-1, as part of the proposed action to accomplish the multiple environmental objectives. Based upon preliminary topographic surveys, accompanying Figures 5-1 and 5-2 show the relationships between tidal datum elevations, marsh surface elevations, structural elevations, and proposed water level management elevations (all important in understanding the proposed water management plan). A general picture of Lower Army Creek Marsh's wetlands vegetation cover, water cover, and surface water flows BEFORE implementing the proposed action (i.e. the existing conditions) is presented in accompanying Figure C-1. Essentially, this "before" condition consists of a wetland dominated almost exclusively by a thick, robust monoculture of phragmites; surface water cover confined primarily to deeper channels and guts; and surface water movements in only an outflow or discharge direction. A general picture of Lower Army Creek Marsh's wetlands vegetation cover, surface water cover (at a maximum managed pool level), and surface water flows AFTER implementing the proposed action is presented in accompanying Figure C-2. This "after" condition will have a diverse cover of emergent, brackish-water wetlands plants; surface water cover of varying heights, from full pool to channel waters only, as temporally prescribed in a water management schedule; and surface water tidal movements in both flood and ebb directions.

TABLE C-1. Proposed Water Management Schedule

Date	Manipulation	Rationale
March-April	Reduce pool level to 0% at LT, but do not exceed 100% pool at HT (approx. +0.2 ft. NGVD); allow semi-daily tidal floods until 100% pool is reached, and semi-daily maximum ebbs.	Promote maximum flushing of accumulated overwinter detritus and sediment; permit anadromous fish egress; allow regrowth of marsh emergents.
May	Manage for an average 50% pool level, with a 40-60% range per tide cycle; allow about 4 hrs. of flood near HT and 4 hrs. of ebb near LT.	Increase pool level and stability for waterfowl breeding without inundating nests; permit fish movements; continued regrowth of high marsh emergents
June-July	Manage for an average 75% pool level, with a 70-80% range per tide cycle; allow about 2 hrs. of flood near HT and 2 hrs. of ebb near LT.	Provide habitat for waterfowl brood rearing; increase aquatic invertebrate populations; encourage SAV growth, discourage phragmites; permit fish movements.
Aug.-Sept.	Manage for an average 50% pool level, with a 40-60% range per tidal cycle; allow about 4 hrs. of flood near HT and 4 hrs. of ebb near LT.	Provide exposed mudflats for migrating shorebirds; increase egress for estuarine fishes; promote growth of late season annuals.
Oct.-Feb.	Manage for an average 95% pool level, with a 90-100% range per tidal cycle; allow about 2 hrs. of flood near HT and 2 hrs. of ebb near LT.	Provide habitat for migratory and overwintering waterfowl; maintain water quality thru tidal.exchanges.

*** See notes on next page for further explanation.

Notes:

1) "Pool level" refers to the percent of the general marsh surface area that is inundated with water, as a portion of the managed maximum 100% surface inundation that is desired.

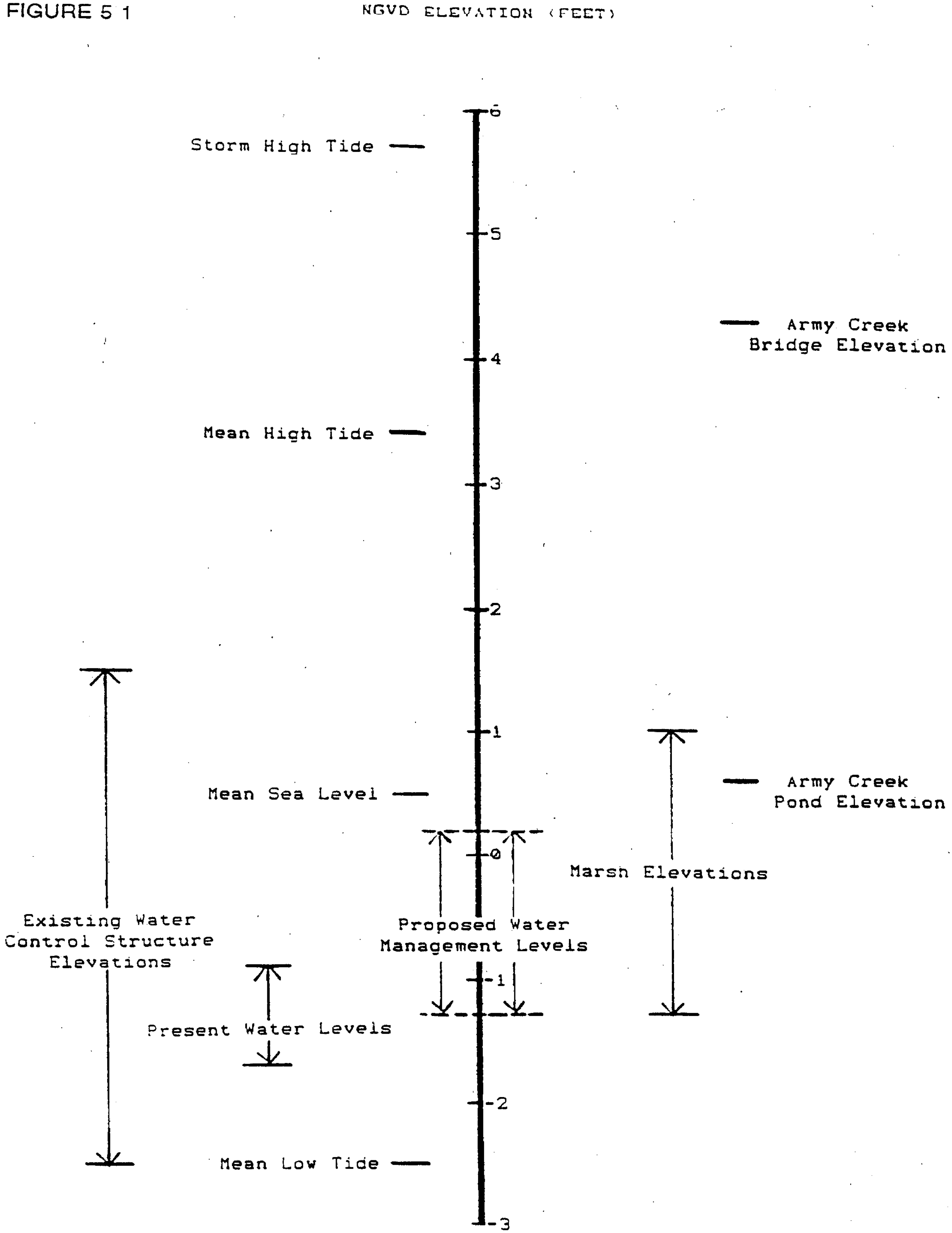
2) 0% pool level is no water over general marsh surface, although shallow ponds, channels and ditches may still have water. This is the typical existing condition for lower Army Creek Marsh.

3) 100% pool level is "full pool" at about +0.2 ft. NGVD, inundating about 80-90% of the general marsh surface of lower Army Creek Marsh, at depths ranging from only a few inches to 18" deep; waters deeper than 18" could occur in shallow ponds, channels and ditches.

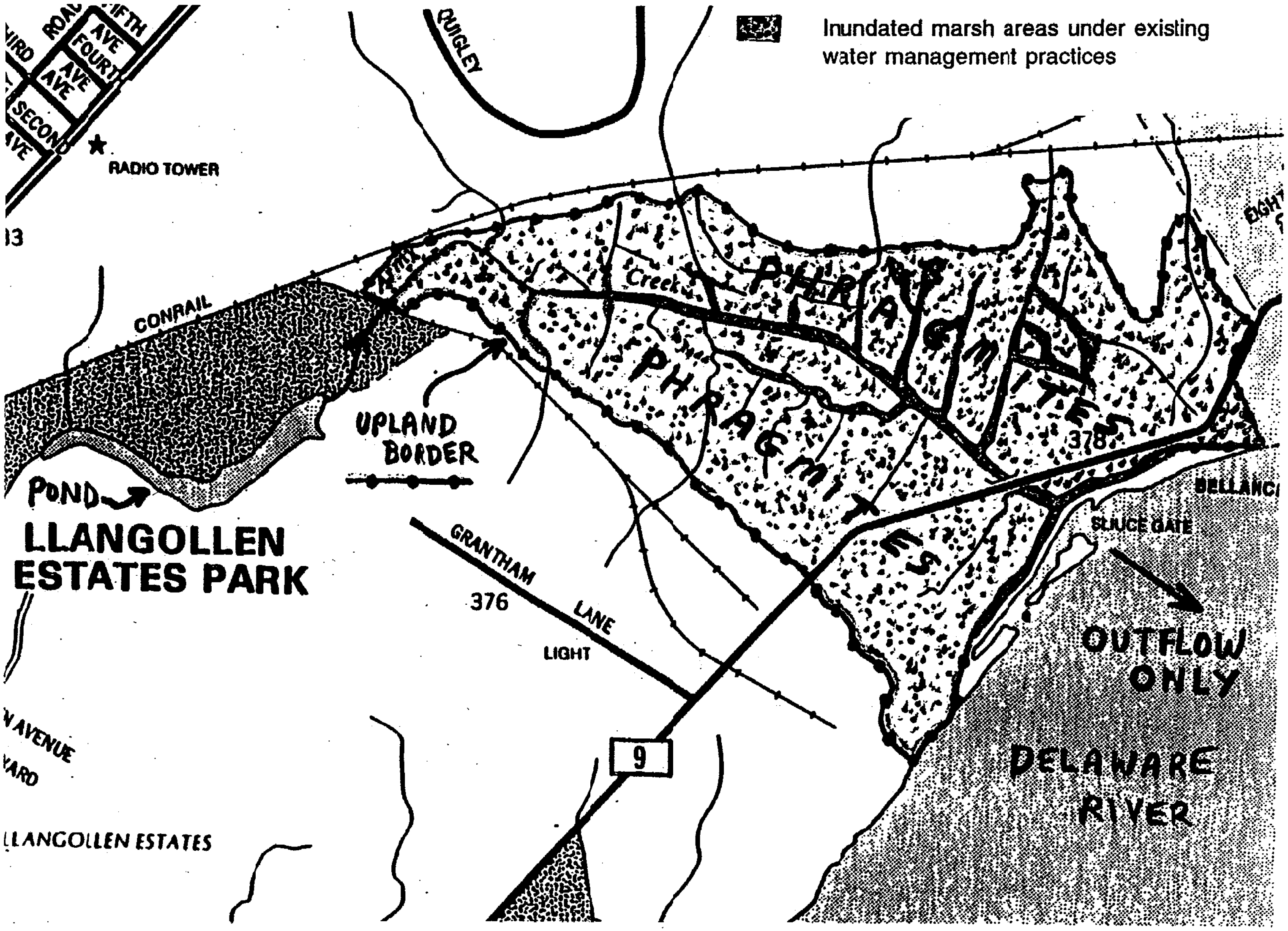
4) Water level elevation upstream in Army Creek Pond is above +0.6 ft. NGVD, so the maximum managed water level in the lower basin (+0.2 ft. NGVD) should not affect the Pond. If it's desirable to insure that lower basin water doesn't enter the pond on flooding tides, it may be necessary to construct a small spillway, with crest elevation = +0.6 ft. NGVD, on Pond's downstream end.

5) The proposed water management schedule is subject to future modifications dependent upon: a) ecological responses of the marsh system following implementation of the initial water management schedule; b) changed environmental objectives; c) future hydrological or topographic findings; d) engineering factors or constraints; e) commitment limitations for operation and maintenance; f) economic costs; g) landowner cooperation.

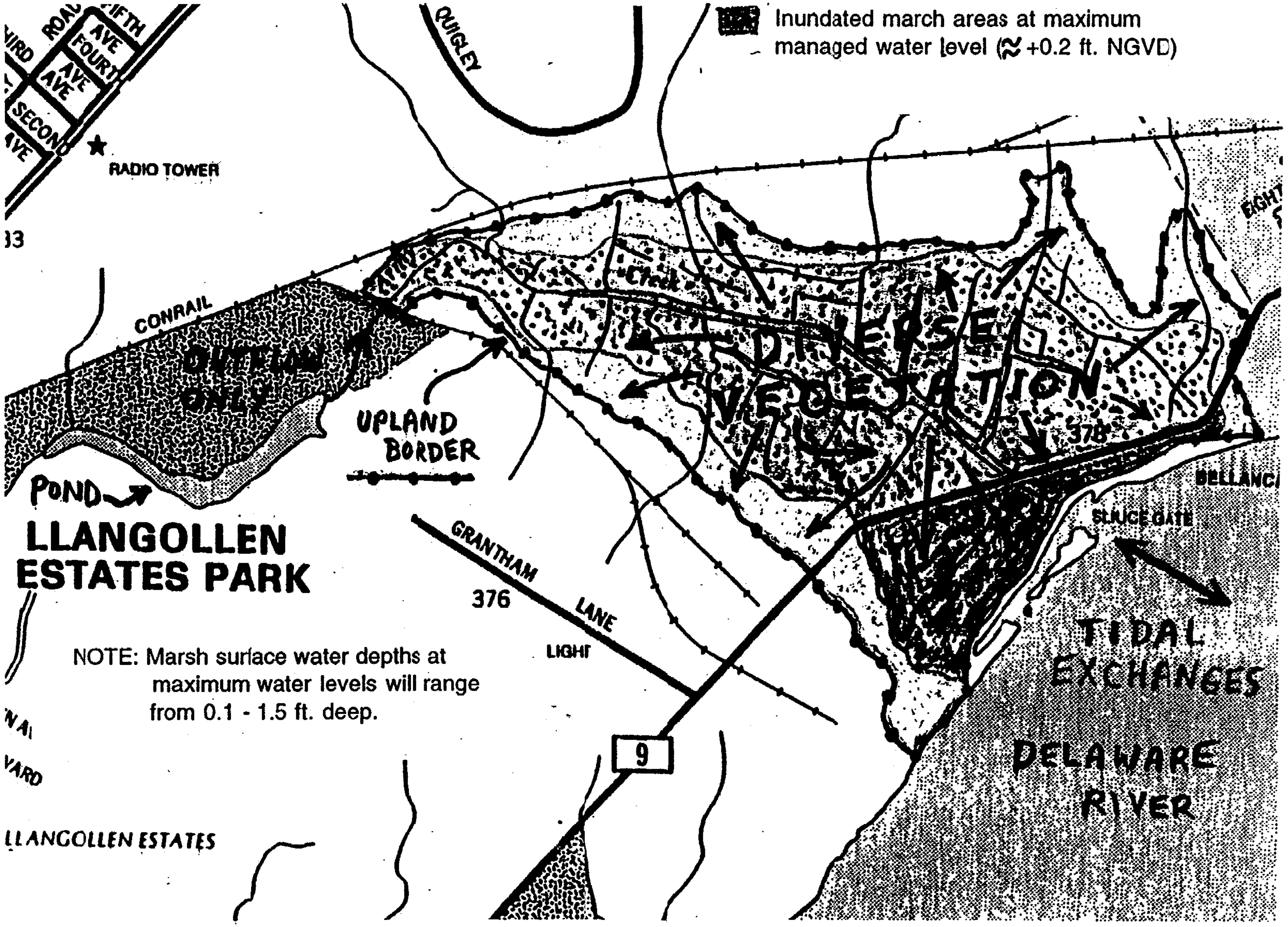
FIGURE 5 1


NGVD ELEVATION (FEET)
6
5
4
3
2
1
0
-1
-2
-3
Storm High Tide
Army Creek
Bridge Elevation
Mean High Tide
Army Creek
Pond Elevation
Mean Sea Level
Marsh Elevations
Existing Water
Control Structure
Elevations
Proposed Water
Management Levels
Present Water Levels
Mean Low Tide

Map C-1 Lower Army Creek Marsh Before Restoration



Map C-2 Lower Army Creek Marsh After Restoration



NOTE: Marsh surface water depths at maximum water levels will range from 0.1 - 1.5 ft. deep.

APPENDIX D

Proposed treatment process for phragmites control.

The phragmites treatment process proposed for Army Creek Marsh has been developed by DNREC's Division of Fish and Wildlife, and has been in operational use since the mid-1980's on a statewide basis, sometimes involving a 50:50 cost-share program between the State and private landowners. The treatment involves the use of a systemic herbicide, glyphosate (Rodeo), aerially applied by helicopter during the late summers of two consecutive years, at a time when maximum aboveground photosynthate is being translocated to roots and rhizomes in preparation for winter dormancy; in controlling phragmites, it is necessary to kill the underground portions. Where possible, it is also highly desirable to follow each herbicide application in the subsequent early spring (i.e. March) with prescribed burning of the standing dead phragmites culms. This removes the negative shading effect of dead culms, thereby allowing sunlight to reach the marsh surface to release the seedbank of more desirable plants. Increased insolation of the marsh surface following burning also increases soil and water temperatures to promote plant growth, and may also increase nutrient releases to marsh waters. Burning allows for more effective follow-up herbicide coverage of resprouting phragmites, by eliminating intercepting debris during spray applications. The prescribed burns done in the early spring will be organized by the Division of Fish and Wildlife in cooperation with local fire authorities. During the two-year phragmites treatment phase of Army Creek Marsh's restoration, the marsh will be kept as dry as possible during February and March (i.e. 0% pool level, no tidal inflow) in order to create better burning conditions. Mowing and physical removal of the dead culms might also accomplish some of these desired effects, but soft marsh soils and the scale of removal do not usually make this a practical option for an area the size or nature of Army Creek Marsh.

After the two-year herbicide-and-burn treatment is completed, it is desirable to monitor over several years any future regrowth or reinvasion of phragmites, and to spot-treat with glyphosate any unacceptable incursions. In particularly robust stands of phragmites, such as what is found in Lower Army Creek Marsh, it is sometimes necessary to perform a third or even fourth year of the intensive herbicide-and-burn treatment (as part of the initial control effort).

Treatment costs.

The Trustees will contract with DNREC's Division of Fish and Wildlife to undertake the initial two-year phragmites treatment process; the Division may be able to recover a portion of the treatment costs through the 50:50 cost-share program, applicable to cooperative landowners within lower Army Creek Marsh. During the first year of herbicide treatment, glyphosate is applied at the rate of 4 pts/acre, yielding a total application cost (product + helicopter) of $60/acre; during the second year of treatment, glyphosate is used at a rate of 2 pts/acre, decreasing total application costs to $38/acre. Budgeting for a two-year program to treat about 200 acres will cost about $20,000. If a third year of initial intensive treatment is needed, another $5000 would be required. Spot-treatments of reinvading phragmites, following the 2-3 year intensive treatment phase, will probably necessitate $5000 more, spread over a 5-10 year period (or from 7-8 years, up to 12-13 years, after the start of restoration work). Thus, the maximum total costs for phragmites treatment, in today's dollars, will be about $30,000.

APPENDIX E

LOWER ARMY CREEK WETLANDS MONITORING PLAN

This monitoring plan will provide information to the Trustees as to whether the projects are functioning and providing services consistent with restoration goals. The design of this monitoring plan will permit detection of, and response to, significant changes in the community structure.

1.0 Restoration Benefits:

1.1 Increased acreage of available, suitable habitat for Trust Natural Resources.

1.2 Improved habitat quality via increased emergent plant diversity, shallow water pools, and substantially reduced Phragmites cover.

1.3 Increased species diversity, particularly for anadromous and estuarine fish species and blue crabs.

1.4 Increased numbers of birds using area, particularly waterfowl, wading birds, and shorebirds.

1.5 Reduced use of chemical insecticides for mosquito control.

2.0 Measures of Restoration Success:

2.1 Approaches

2.1.1 Comparison before and after restoration, e.g., some baseline to after restoration (requires pre-restoration survey of Lower Army Creek).

2.1.2 Comparison of after restoration to adjacent systems (i.e., convergence toward Gambacorta or Broad Dyke restored marshes). May also compare species presence with that of adjacent Delaware River.

2.2 Measures of success

2.1.1 Increase in area available to anadromous species.

2.2.2 Increase in volume and diversity of habitat available (i.e., tidal amplitude, shallow water pools, and marsh habitat).

2.2.3 Altered present dominant plant community.

2.2.4 Change in faunal composition and abundance to more anadromous and estuarine species (fish and blue crabs) and maintenance of or increase in bird and other faunal use.

2.2.5 Decrease in need for chemical control of mosquito.

3.0 **Monitoring**

3.1 Pre-restoration baseline (Do one year before implementing restoration).

3.1.1 Determine areal extent of suitable habitat available to aquatic plants and animals, particularly riverine, estuarine, and anadromous fish.

3.1.1.1 Undertake aerial photography of Army Creek Pond, Lower Army Creek and associated marsh during February-March and August-September of year before implementing restoration. Photographic missions will be flown to identify physical features (e.g., vegetated areas, shallow-water pools, drainage ditches, dikes, pannes, mudflats, rocky or concrete covered areas, etc.), upland-wetland boundaries, and degree of habitat diversity. Features are to be nested within the classification schemes of Cowardin et al. (1979) and Dobson et al. (1995).

3.1.2 Determine plant species composition via field survey and relate to vegetative coverage and aerial photography for Lower Army Creek.

3.1.2.1 August-September field survey will be performed at eight 1 m^2 quadrat stations on two transects; one positioned parallel to the main stem of the creek and the other perpendicular to the main stem but parallel to a secondary channel in the middle portion of the marsh system.

The intent of the two transects is to measure the potential changes in the plant communities with the introduction of Delaware River water through tidal flow. The transect parallel to the main stem will measure changes as a function of the flow penetration to the head waters, and the transect perpendicular to the main stem, but in the middle portion of the marsh, will measure changes relative to elevation along a secondary ditch. Stations/quadrats along the transects will be located using the following:

a) Number and location of existing plant communities during the pre-restoration survey,

b) Variations in elevation,

c) Accessibility.

3.1.2.2 Vegetative coverage.

February-March and August-September quantitative areal coverage will be determined for aerial photographs taken as described above. Plant species composition will be related to the areal coverage.

3.1.3 Determine faunal composition and abundance (i.e., number per unit area), particularly for anadromous, estuarine, and riverine fish species in Lower Army Creek.

3.1.3.1 Fishes and Blue Crabs

April sampling to consist of two 24-hr gillnet sets in upper and lower main channel to determine access and penetration of adult anadromous and estuarine fishes.

August-September to consist of two sampling experiences in upper and lower main channel, secondary guts and tertiary ditches using trap-nets, popnets, seines, back-pack electroshocker or other appropriate gear to determine utilization by resident, anadromous and estuarine species.

August-September sampling of blue crabs in upper and lower main channel, secondary guts and tertiary ditches using standard crab pots to determine the extent of use of the area by blue crabs. Numbers and size of collected crabs will be noted. Analysis should be done on site and all live blue crabs should be returned. The actual site selection will be random during the pre-restoration period. During the post-restoration phase, these previously sampled sites will be revisited and changes in relative abundance and sizes compared to pre-restoration samples will be noted.

Study design recognizes substrata or different habitat types within Army Creek, i.e., main channel, secondary guts, and tertiary ditches, as the basis for characterization during the pre- and post-restoration periods. The physical attributes of these different habitats dictate the use of collection gear of different types. Comparisons will be made only between like habitat types sampled with like collection gear. The site characterization will necessarily be only a semi-quantitative/qualitative composite of habitat types. A standardized unit of collection effort, such as number per unit volume of water sampled, would enhance comparisons between habitats. Ongoing work by DNREC includes the calculation of density from various pieces of equipment, but the volumetric methods are not described in the available reports. Use of such methods would be desirable. However, the density data from different gear would not be totally comparable because of varying degrees of collection efficiency related to an organisms avoidance of sampling equipment.

A push-trawl will be used in the main channel during both pre- and post-restoration periods. The blocking net/seine technique, as described by DNREC, does not depend on tidal flow; therefore, it will be used in the tertiary ditches during both pre- and post-restoration periods.

The choice of gear for the secondary guts is more difficult. The physical attributes, e.g., relatively vertical banks, narrow channels, and sometimes bottomless substrate, of these guts make an active technique like seining hard to employ. A less active technique, such as electro-shocking, would work well during the pre-restoration survey, but would be less effective and possibly inappropriate in the post-restoration surveys. As a compromise for the pre-restoration survey without tidal flow to push the fish into the gear, a channel net will be used along with techniques to scare, herd, and crowd fish into the net via the use of dip nets and small seines. In the post-restoration phase with tidal flow restored, the channel net as used by DNREC and others is the gear of choice and will be used.

3.1.3.2 Determine presence/absence of other aquatic-associated species (e.g., reptiles, amphibians, and mammals) in Lower Army Creek using appropriate techniques.

3.1.3.3 Determine species and numbers of birds using Lower Army Creek area, with emphasis on waterfowl, wading birds, and shorebirds. Conduct avian surveys in January, May, June, September and October during the morning hours of one day at observation points around or within Lower Army Creek marsh to be determined by avian expert.

3.2 Post-Restoration sampling (+3, 4, 6, and 10 years after initiating restoration). Beyond 10 years shift effort to Operations and Maintenance components of Restoration Plan. This sampling scheme is recommended, because years +3 and 4 are anticipated to show the most rapid recovery trends, while years +6-10 will provide a measure of stability and long-term success. All post-restoration sampling must match pre-restoration sampling relative to seasons, frequency, methods and locations.

3.2.1 Determine and compare areal extent of suitable, wetland habitat in Army Creek Pond, Lower Army Creek and associated marsh available to aquatic plants and organisms (particularly anadromous, estuarine, and riverine fish) with pre-restoration baseline.

Obtain aerial photography of Army Creek Pond, Lower Army Creek and associated marsh at high and low tide in February-March and August-September and compare with pre-restoration aerial photography. Identify physical features (e.g., vegetated areas, shallow-water pools, drainage ditches, dikes, pannes, mudflats, rocky or concrete covered areas, etc.), upland-wetland boundaries, and degree of habitat diversity. Nest identified features within the classification schemes of Cowardin et al. (1979) and Dobson et al. (1995). Do years +3, 4, 6, and 10.

3.2.2 Determine and compare plant species composition and areal coverage in Lower Army Creek with pre-restoration baseline. Match pre-restoration sampling methodology. Post-restoration sampling should occur at tidal stages that approximate pre-restoration water levels where feasible. Do years +3, 4, 6, and 10.

3.2.3 Determine and compare faunal composition in Lower Army Creek with pre-restoration baseline.

3.2.3.1 Determine and compare fish and blue crab species and abundance (particularly anadromous, estuarine, and riverine fish) in Lower Army Creek with pre-restoration baseline. Match pre-restoration sampling. Do years +3, 4, 6, and 10.

Additionally: At tide gate - Sample 6 tidal cycles per season by sampling a few minutes each 1/2 hour during entire flood and ebb cycles. Methods and equipment used will be similar to those of DNREC. Do years +3, 4, 6, and 10.

3.2.3.2 Determine and compare presence/absence of species of reptiles, amphibians and mammals in Lower Army Creek with pre-restoration baseline. Match pre-restoration sampling. Do years +3, 4, and 6.

3.2.3.3 Determine and compare with pre-restoration baseline the presence/absence of bird species, particularly waterfowl, wading birds, and shorebirds. Match pre-restoration sampling. Do years +3, 4, 6, and 10.

3.2.4 Compare pre and post restoration mosquito brood and control records.

3.2.5 Assess composition data for possible shifts in trophic structure.

3.2.6 Obtain and compare applicable results of sampling being accomplished in Gambacorta or Broad Dyke Marshes to determine degree of convergence by Lower Army Creek.

3.2.7 Compare lists of anadromous and estuarine fish present in Lower Army Creek based on post-restoration sampling with species present in adjacent Delaware River (e.g., see Contaminants Report appendix A attachment 2 section 2.4.2.6 and referenced citations) to determine degree of convergence.

4.0 Analyses

4.1 Analytical procedures - to be described by contractor and reviewed by Natural Resources Trustee Committee. All methods should be state-of-the-art, scientifically valid, and as quantitative as possible. Statistical validity should be invoked wherever possible.

4.2 Quality Assurance and quality control - Each technique must be used in a consistent manner from time to time and place to place from pre-restoration sampling to the termination of monitoring. As much consistency as possible in timing and approach is highly recommended. Methods used and quality assurance procedures instituted must be supplied in written form prior to contract and included with each progress and summary report.

4.3 Data presentation (graphs, overlays, etc.) - Data are to be presented in tabular and graphical form and as photographs and maps.

4.4 Mid-Course Corrections - Data on water related parameters and plant composition will be used at the end of 3 - 4 years following initial restoration to determine the need for mid-course corrections as described in section 2.1.2, page 2-24.

5.0 Review and approval for release. The Natural Resources Trustee Committee for Army Creek will determine appropriate review and release of data.

6.0 Storage and maintenance of data. The State of Delaware, Department of Natural Resources and Environmental Control will store and maintain the data resulting from this monitoring. Such data will be placed in the Natural Resources Trustee's Administrative Record for Army Creek.

7.0 Periodic reporting.

7.1 Progress Reports - Pre-restoration (Year 0), and years 3,4,6 and 10.

These are to be submitted to the Natural Resources Trustee Committee for Army Creek within 3 months of the end of sampling for a particular year. The reports will include sampling, analytical, and quality assurance methods used, and present all data for the particular year in tabular form with dates, times, tidal stage, and locations associated with each data point. Appropriate maps should be included to show not only where Army Creek is located, but also to show overall and detailed sampling locations. In short, enough information should be appended to the data so that someone other than the contractor could repeat the sampling or verify a location.

7.2 Summary Reports - Within 4 months of the end of sampling in years 6 and 10 a summary report including all previous sampling will be submitted to the Natural Resources Trustee Committee for Army Creek. The Summary Reports, in addition to what is included in the progress reports, will include trend information and discuss progress, or lack thereof, toward successful restoration.

8.0 Duration of Monitoring. Monitoring will continue for a period of at least ten years after the implementation of restoration.

9.0 Public access to data. All data shall be available to the public after it has been reviewed and approved by the Natural Resources Trustee Committee for Army Creek. The Coordinating Trustee, State of Delaware Department of Natural Resources and Environmental Control, will maintain these data as part of the Natural Resources Trustee's Administrative Record for Army Creek.

10.0 Schedule

Pre-survey year 0. - Sampling and analysis (vegetation, fish, blue crabs), Progress Report.

Post Restoration Year +3 - Sampling and analysis (vegetation, fish, blue crabs), Progress Report.

Year +4 - Sampling and analysis (vegetation, fish, blue crabs), Progress Report.

Year +6 - Sampling and analysis (vegetation, fish, blue crabs), Summary Report.

Year +10 - Sampling and analysis (vegetation, fish, blue crabs), Summary Report.

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRue. 1979. A classification of wetlands and deepwater habitats of the United States. Office of Biological Services, U.S. Fish and Wildlife Service. FWS/OBS-79/31.

Dobson, J.E., R.L. Ferguson, D.W. Field, L.L. Wood, K.D. Haddad, H. Iredale III, J.R. Jensen, V.V. Klemas, R.J. Orth, and J.P. Thomas. 1995. NOAA Coastal Change Analysis Project: guidance for regional implementation. NOAA Coastal Ocean Program, NOAA Technical Report. NMFS 123. 93pp.

APPENDIX F

AGREEMENT FOR ARMY CREEK MARSH BETWEEN ARMY CREEK NATURAL RESOURCES TRUSTEES, DELAWARE DIVISION OF FISH AND WILDLIFE, DELAWARE DEPARTMENT OF TRANSPORTATION, AND NEW CASTLE CONSERVATION DISTRICT.

This **AGREEMENT**, made this ____ day of ____________, 1994, by and between Army Creek Natural Resources Trustees (**TRUSTEES**), as party of the first part; and the Delaware Division of Fish and Wildlife (**DIVISION**), as party of the second part; and the Delaware Department of Transportation, (**DELDOT**), as party of the third part; and the New Castle Conservation District (**NCCD**), as party of the fourth part.

WITNESSETH:

WHEREAS, TRUSTEES desires to establish a new modified water control structure for the Army Creek Marsh, and

WHEREAS, TRUSTEES, DIVISION, DELDOT, and **NCCD** have an interest in the construction of the facility which is the subject of this agreement, and

WHEREAS, NCCD has a role of carrying out programs as a party in cooperation with State, County, municipal and other private and public interests,

NOW THEREFORE, TRUSTEES, DIVISION, DELDOT, AND **NCCD**, for and in consideration of the mutual covenants hereinafter stipulated to be kept and performed, agree as follows:

SECTION I - FUNDING: - **TRUSTEES** agree to provide all funding for construction of the proposed water control structure in the amount of $

SECTION II - CONSTRUCTION:

1. **NCCD** in cooperation with **TRUSTEES, DIVISION,** and **DELDOT** will manage the planning, construction, and administration of the project as follows:

   A. Be fully responsible for undertaking and supervising all phases of the necessary job planning, design, construction, supervision, and administration of this project with all aspects complying fully with State Laws.

   B. Secure the services of a qualified contractor to construct the planned works of improvement.

   C. Keep accurate records of the expenditure of these funds and will advise **TRUSTEES, DIVISION,** and **DELDOT** in writing when project is completed.

   D. Submit progress billings as work progresses on the project.

   E. **DELDOT** agrees to grant rights-of-way to the **NCCD** for construction and maintenance purposes as follows:

      a. **NCCD** shall construct the planned water control structure using **NCCD** or contractor resources to the limit of the projected cost of the project.

      b. **DELDOT** is responsible for removal or replacement of structures, fences, plantings, or other items they desire to salvage prior to construction.

      c. **DELDOT** is responsible to point out and clearly mark any property markers that are located in the rights-of-way. Property markers removed from excavated areas will not be replaced by the **NCCD**.

      d. **DELDOT** shall grant ingress and egress to the construction site for the personnel necessary to survey, plan, construct, and inspect installation of the water control structure.

SECTION III - MAINTENANCE:

1. **NCCD** shall have no maintenance responsibilities whatsoever for the completed structure.

2. **DIVISION** shall be responsible for the payment of any electrical service required for the operation of the proposed structure, and the maintenance and repair/replacement of any proposed electrical service to the structure.

3. **DIVISION** shall be responsible for the repair/replacement of any electrical facilities utilized in the operation of the proposed structure, including: water level sensors, vertical lift motor, and control panels.

4. **DIVISION** shall be responsible for the replacement of any floats required for the operation of the proposed structure.

5. **DELDOT** shall be responsible for the repair/replacement of all non-electrical facilities associated with the existing and proposed structure, excluding floats. These non-electrical facilities include but are not limited to the dike, pipes, concrete culverts, water control gates, and housings containing the water control gates.

6. **DELDOT** shall be responsible for annual inspections of the proposed water control structure.

7. **DIVISION** shall be responsible for weekly inspections of the proposed water control structure and the removal of any trash or debris from the structure. When requested, **DELDOT** shall assist the **DIVISION** in removing any large debris from the structure that requires special equipment or assistance.

8. **DIVISION** shall be responsible for: lubricating any electric motor, lift screw, or gate linkage; maintaining any water level sensors, and repairing any float required to operate the proposed structure.

9. **NCCD** will provide technical assistance to **DIVISION,** or **DELDOT** at their request.

SECTION IV - OPERATION:

1. **DIVISION** shall implement the "Water Management Plan" approved by the**TRUSTEES**, and shall be responsible for adjusting any floats, sensors, or computer programs to implement this plan. This "Water Management Plan is subject to adjustments and change based on the availability of additional information, climatic conditions, and in order to better achieve all biological and hydrological objectives.

2. **DELDOT** shall be responsible for maintaining a gate or barrier to restrict public access to the structure, but shall grant ingress and egress to the **TRUSTEES, DIVISION,** and **NCCD** for activities associated with the maintenance, operation, and inspection of the proposed structure; and to conduct biological and hydrological surveys of the surrounding area.

TRUSTEES, DIVISION, DELDOT and **NCCD** agree that this **AGREEMENT** is the entire and completed **AGREEMENT** between the parties and that no alternations, modifications, or amendments of this said **AGREEMENT** shall be made or deemed valid unless in writing and signed by all parties.

IN WITNESS THEREOF, the parties hereunto have caused this **AGREEMENT** to be executed in quadruplicate, the day and year first above written.

ARMY CREEK NATURAL RESOURCE TRUSTEES

By: ____________ ____________ ____________

Title: ______________ ______________ ______________
Date: ______________

NEW CASTLE CONSERVATION DISTRICT DIVISION OF FISH & WILDLIFE

By: ______________ By: ______________

Josef A. Burger
Title: Chairman

Andrew T. Manus
Title: Director

Date: ______________ Date: ______________

DEPARTMENT OF TRANSPORTATION

By: ______________

Title: ______________

Date: ______________