United States
Environmental Protection
Agency

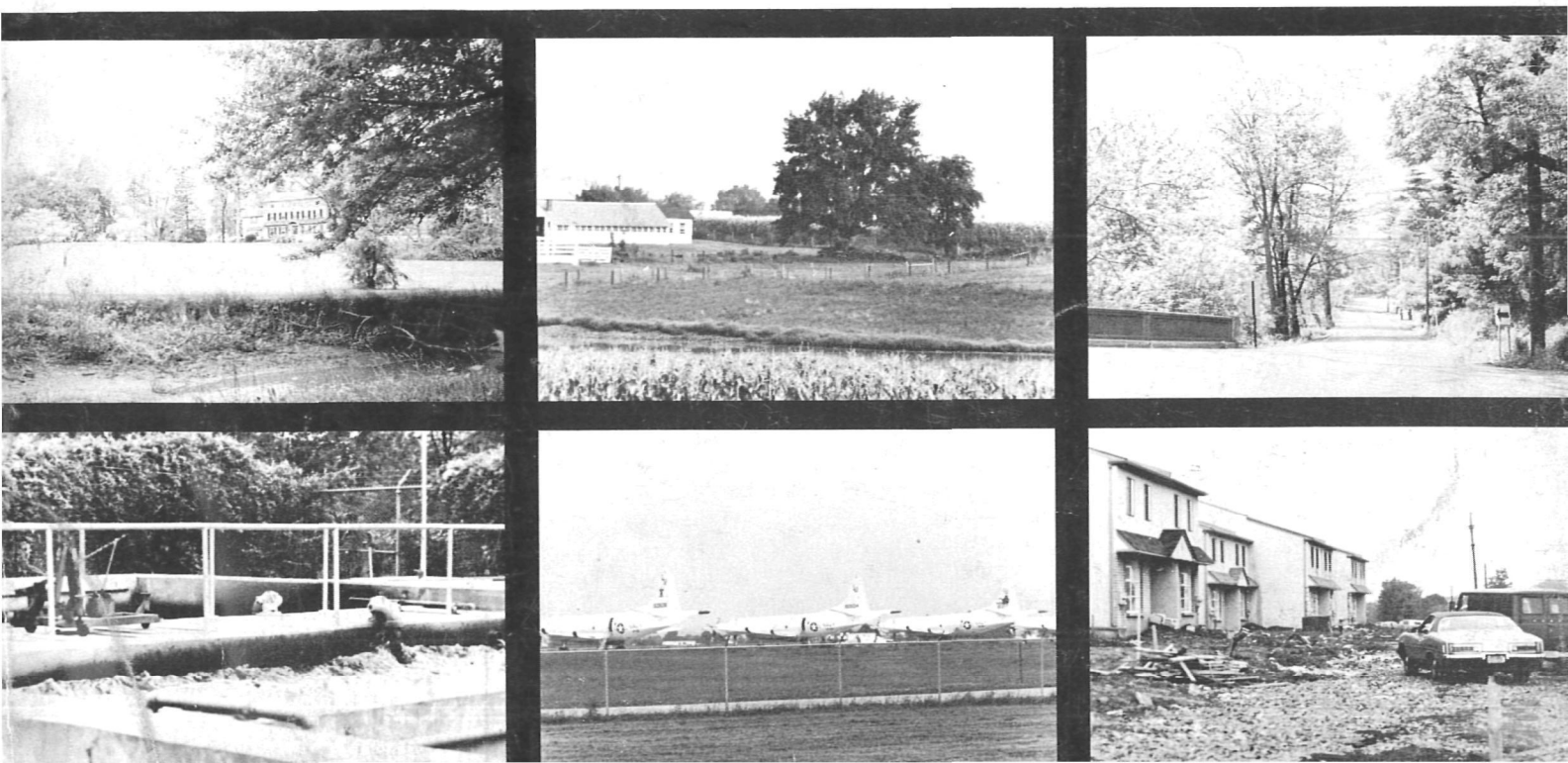
Region 3
6th and Walnut Streets
Philadelphia, PA 19106

September 1979

EPA

Draft Environmental Impact Statement Appendices

Horsham-Warminster-Warrington, Pennsylvania Wastewater Treatment Facilities



Draft Environmental Impact Statement
Appendices

on

Horsham-Warminster-Warrington, Pennsylvania
Wastewater Treatment Facilities

Prepared by:

U.S. Environmental Protection Agency
Region III
Philadelphia, Pennsylvania

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Type of action:

Legislative ( )
Administrative (X)

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APPENDIX A

Septic Tank System Analysis
by
US-EPA Environmental Photographic Interpretation Center (EPIC)

U.S. ENVIRONMENTAL PROTECTION AGENCY
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Date: December 6, 1978

Reply to Attn of: RSD

Subject: Horsham, Warrington, and Warminster EIS

To: Mr. Robert Pickett, 3IR60
EIS Preparation Section
Region III

Enclosed is completed report of the land use/cover inventory and septic tank system analysis for Horsham, Warrington, and Warmister Townships in Pennsylvania (RSD Project 7855)

Inquiries concerning this report should be directed to the Program Manager at the Environmental Photographic Interpretation Center, FTS 557-3110.

David N. McNelis
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Enclosure

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Introduction

The following report was produced at the request of the EIS Preparation Section, EPA Region III for inclusion in an environmental impact statement being prepared by the Regional office for evaluation of alternative sewage collection systems for Warrington, Warminster, and Horsham Townships in southeastern Pennsylvania (see location diagram). The three requested tasks that have been completed by EPIC include:

1) the compilation of photo-mosaics of the three townships,

2) the preparation of land use/cover maps for the three townships, and,

3) a photo-analysis of the area for the purpose of identifying and locating failing on-lot septic tank systems.

Photo-Mosaics and Land Use/Cover

Color aerial photography exposed at a scale of 1:24,000 was utilized to produce the prints used in compiling the photo-mosaics, and also in the analysis of land use/cover categories. The modified Level II land use/cover scheme used included the following categories:

1 Urban and Built-up Land

- 11 Residential
- 12 Commercial/Services/Institutional
- 13 Industrial and Utilities
- 14 Transportation and Communications
- 15 Recreational Areas and Facilities

2 Agriculture

- 21 Cropland and Pasture

3 Rangeland

- 32 Shrub, Brushland and Grassland

4 Forestland

- 41 Mixed Forest

5 Water

- 52 Lakes and Ponds

7 Barren Land

- 76 Transitional Land/Construction

Septic Tank System Analysis

Utilizing normal color, color infrared, and thermal infrared imagery acquired 2 June 1978, an analysis was done on Warrington, Warminster, and Horsham Townships to identify and locate individual home septic tank systems exhibiting signs of failure at the time of the overflight.

Failure of such systems can usually be attributed to one or more of the following causes: 1) the soil used in the absorption field has too slow a percolation rate to allow for adequate assimilation, filtration, and biodegradation of sewage effluent flowing into it, 2) the septic tank system is installed in an area where the seasonal water table is too high for its designed use, 3) the system is installed too close to an underlying impervious layer, 4) the soil used in the absorption field has too high a percolation rate for effective attenuation of sewage effluent prior to its reaching underlying groundwater, 5) mechanical malfunctions or breakage in the septic tank, distribution box, and/or drainage pipes has occurred, 6) caustic, toxic, or otherwise harmful substances which could kill the bacteria in the septic tank or soil and cause clogging have been flushed into the system, and 7) all or part of the system has been improperly installed. Other potential causes for on-lot disposal system malfunctions can be found in Reference (1).

With respect to remote sensing of failing septic tank systems, only those malfunctions which are noticeable on the surface can be detected on aerial imagery. Based upon work done in Nettle Lake (Ohio), Steuben County (Indiana), and the Dayton-Springfield area in Ohio, it has been determined that the primary surface manifestations associated with failing septic tanks and/or absorption fields are: 1) conspicuously lush vegetation, 2) dead vegetation (specifically grass), 3) standing water or seepage, and 4) dark soil where excess organic matter has accumulated. In many cases, the outline of the drainage lines can be distinguished on the aerial photography. This does not always mean, however, that a problem exists.

All of these manifestations, or "signatures", are best distinguished on normal color and color infrared film exposed at scales of 1:10,000 or larger. Thermal infrared imagery does not appear to be as valuable in discerning failing systems during this time of the year (i.e. spring or summer). It may be a more effective sensor, however, in either the fall or winter when the importance of vegetation characteristics diminish (e.g. when grass is dormant or light snow-cover is present), and temperature differences between sewage effluent and the ground become greater.

Using the above signatures as "photo-interpretation keys", approximately one hundred and twenty (120) homesites in Warrington, Warminster, and Horsham Townships were chosen for subsequent ground inspection. Of these, sixty-eight (68) were determined to have failing septic tanks or absorption fields at the time of the inspection. An additional twenty-five (25) systems exhibited signs of having failed in the past, or having the potential for malfunctioning during periods of excessive use of moderate to heavy rainfall.

The overestimation of suspect sites was due to the similarity in signatures of failing septic systems and some unrelated ground phenomena, and the possibility that some of these sites were exhibiting signs of malfunctioning systems during the overflight, but were not doing so during the time of the ground inspection. Despite the excess number of suspect sites, most, if not all, of the major failures were believed to have been identified and located. Thus, based upon the photo analysis, and the subsequent ground inspection, it was concluded that there are several residential areas within the three townships that are experiencing problems with on-lot sewage disposal systems which result in visible seepage, break-outs, or other types of wastewater release.

Reference

1) Commonwealth of Pennsylvania, Department of Environmental Resources, Technical Manual for Sewage Enforcement Officers, May 1975.

APPENDIX B

Soil Suitability of Developable Land

Table B-1. Summary of soil suitability of developable residentially zoned land for land disposal of wastewater, by subarea (in acres).

Subarea	Suitable Land Area	Probably Not Suitable Land Area	Not Suitable Land Area
1	8	51	42
2	22	66	131
3	1	2	1
4	50	309	254
5	13	41	13
6	0	28	200
7	32	151	104
8	49	160	82
11 (Warrington only)	88	32	181

APPENDIX C

Quality of Groundwater from Wells in Planning Area

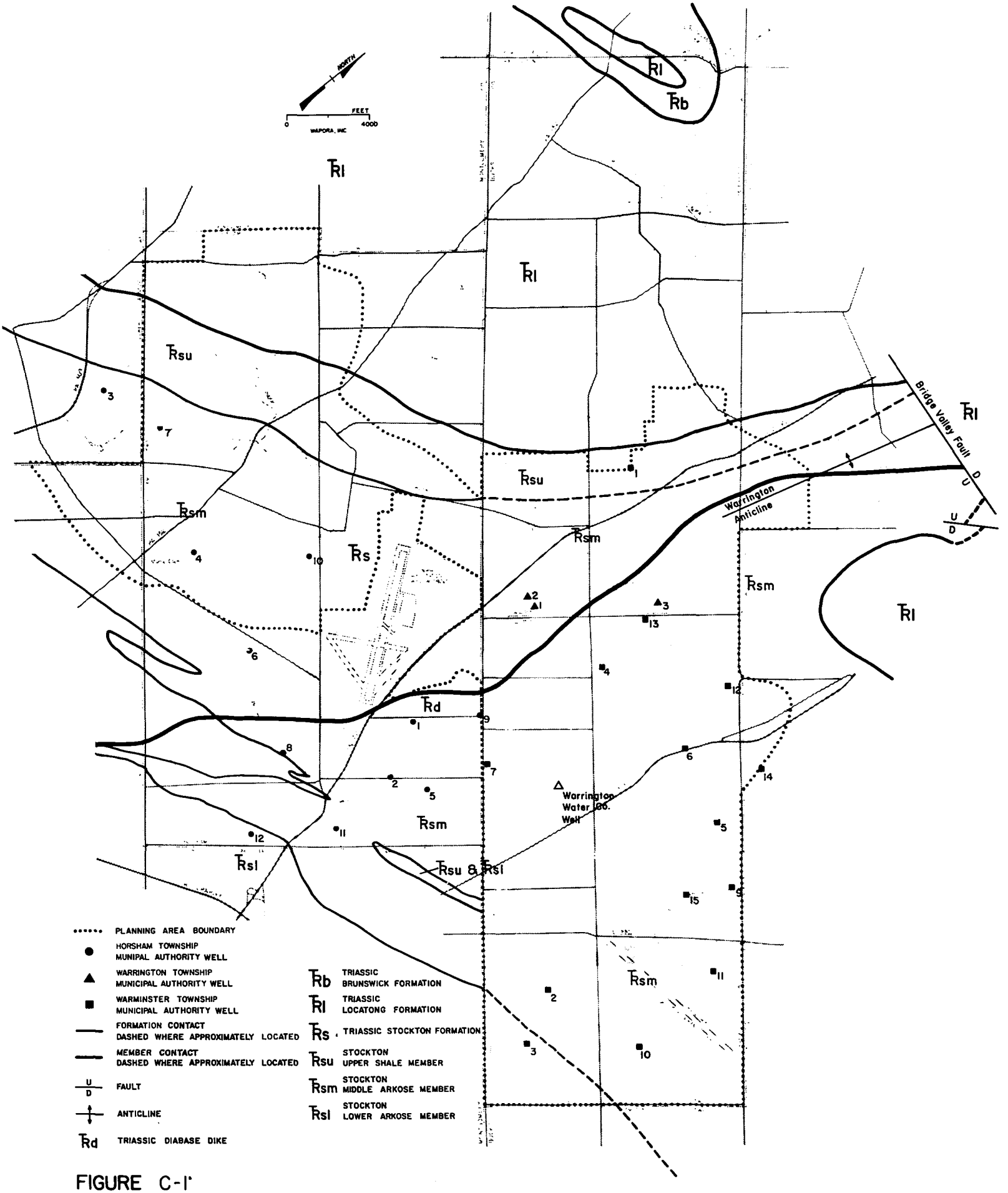


FIGURE C-1

GEOLOGY AND WELL LOCATIONS

Table C-1. Quality of water in public water supply wells located in the Horsham Municipal Authority service area in the Horsham, Warrington, and Warminster planning area. The location of wells is depicted in Figure C-1. Values are expressed in mg/l except where otherwise noted. Blanks indicate that no measurements are recorded (BCDH 1978).

Date	Map Well No.	Turbidity (JTU)	pH (units)	Alkalinity as CaCO3	Hardness	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Chloride	Fluoride	Sulphate	Total Solids	Iron	Manganese	Phosphate
		PARAMETER													
July 1977	H1	1	7.3	152	162	0.030	0.028	5.47	22	10	268	10	10	0.70	0.050
	H2	1	7.6	156	160	0.030	0.028	3.05	22	8	-	30	10	0.08	0.100
	H3	1	7.6	170	190	0.040	0.026	2.18	33	18	296	10	10	0.06	0.035
	H4	1	7.9	100	112	0.040	0.026	4.60	10	10	184	20	10	0.09	0.120
	H5	1	8.0	154	144	0.040	0.026	1.65	18	24	-	10	20	0.05	0.100
	H6	1.5	6.8	126	260	0.040	0.034	1.07	9	145	412	10	80	0.06	0.100
	H7	1	7.8	122	256	0.040	0.026	1.45	13	136	416	80	60	0.04	0.110
	H8	1	7.9	126	156	0.030	0.020	4.38	14	32	268	10	20	0.06	0.050
	H9	1	7.2	116	118	0.030	0.026	2.84	11	14	204	20	10	0.06	0.050
	H10	1	7.8	118	200	0.060	0.050	1.21	8	116	350	10	50	0.03	0.100
	H11	1	7.5	170	196	0.040	0.030	5.47	28	18	-	10	10	0.07	0.180
	H12	1	7.7	136	144	0.040	0.020	6.36	17	14	256	10	10	0.06	0.230

Table C-2. Quality of water in public water supply wells located in Warrington Township Municipal Authority service area in the Horsham, Warrington, Warminster planning area. The location of wells is depicted in Figure C-1. Values are expressed in mg/l except where otherwise noted. Blanks indicate that no measurements are recorded (BCDH 1978).

		PARAMETER													
Date	Map Well No.	Turbidity (JTU)	pH (units)	Alkalinity as CaCO3	Hardness	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Chloride	Fluoride	Sulphate	Total Solids	Iron	Manganese	Phosphate
March 1977	I & 2	1	8.4	112	208	0.05	0.024	3.06	20		128	394	0.11		0.07
July 1977	1 & 2	<1	7.6	22	168	0.06	0.02	3.5	27				0.09		0.07
July 1975	2	<1	7.5	102	176	0.02	0	1.88	17	<.1	56	280	0.03	<.01	0.1
December 1975	3	<1	7.0	542	156	0.02	0.032	2.13	11				0.26		0.05
December 1976	3	1	7.6	166	205.	0.05	0.018	1.22	19		70	312	0.17	0.01	0.06
August 1976	4	2.5	7.9	158	174	0.04	0.02	2.42	26		16	278	0.44	0.02	2.1
January 1978	5	1.5	7.8	184	200	0.11	0.024	1.74	7				0.049		0.04
January 1977	5	<1	7.9	92	178	0.04	0.024	0.56	26		32		0.02	<.01	0.04
January 1978	5	1.5	7.8	184	200	0.11	0.024	1.74	7		.049				0.04
July 1977	5	< 1	7.9	92	178	0.04	0.024	0.56	26		32		0.02	<.01	0.04

Table C-3. Quality of water in public water supply wells located in Warminster Township Municipal Authority service area in the Horsham, Warrington, Warminster planning area. The location of wells is depicted in Figure C-1. Values are expressed in mg/l except where otherwise noted. Blanks indicate that no measurements were recorded (BCDH 1978).

		PARAMETER													
Date	Map Well No.	Turbidity (JTU)	pH (units)	Alkalinity as CaCO3	Hardness	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Chloride	Fluoride	Sulphate	Total Solids	Iron	Manganese	Phosphate
July	WM1	<1	6.9	46	132	0.05	0.04	4.18	33				0.05		0.16
	WM2	<1	7.1	114	143	0.06	0.05	4.18	22				0.1		0.14
	WM3	<1	7.1	150	154	0.05	0.036	3.96	15				0.04		0.1
	WM4	<1	7.5	112	176	0.09	0.05	3.96	21				0.02		0.11
October 1973	WM4	2	7.2	132	414	0.04	0.016	0.24	7	.11	258	776	0.15	0.12	0.06
February 1975	WM13	1	7.7	124	165	0.02	0.004	3.3	16	.14			0.02		0.1
	WM14	<1	7.6	85	143	0	0.024	1.04	44	.12			0.03		0.1
	WM15	<1	8.1	130	143	0.06	0.03	0.1	13	.13			0.02		0.07
December 1975	WM6	<1	7.6	126	144	0.03	0.05	3.0	19		106	418	0.02	0.01	0.07
	WM8	<1	7.7	126	162	0.02	0.05	4.08	20		70	318	0.04	0.01	0.12
March 1976	WM9	<1	7.8	108	96	0.02	0.034	3.36	16		40	250	0.05	<.01	0.13
December 1976	WM7	1	7.4	148	170	0.07	0.016	3.06	16		20	246	0.02	0.01	0.12

APPENDIX D

PA-DER Criteria for Surface Water Quality

Table D-1. Water quality parameters associated with stream criteria and effluent limitations within the Horsham, Warminster, Warrington Pennsylvania planning area (PA-DER 1978). Stream criteria are extracted from Chapter 93, Title 25 of the Pennsylvania Code; effluent limitations are according to the "Neshaminy C Criteria" issued by PA-DER pursuant to the Pennsylvania Clean Streams Law as amended through 1976. NC means no criterion.

PARAMETER	STREAM	EFFLUENT
Coliform Bacteria	Not more than 5,000/100 ml as a monthly average value nor more than this number in more than 20% of samples collected during any month, nor more than 20,000/ 100 ml in more than 5% of the samples	≤200 fecal organisms/100 ml as the geometric mean
pH (pH units)	6.0 - 8.5	6.0 - 9.0
Dissolved Oxygen (mg/l)	Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l	Same as in-stream
Total Iron (mg/l)	≤1.5	NC
Color (units)	≤50	NC
Turbidity (units)	≤100	NC
Temperature	Not more than a 5°F rise above ambient temperature or a maximum of 87°F, whichever is less; rate of change shall not exceed 2°F per hour	NC
BOD_5 (mg/l)	≤4.0 mg/l	During the period 1 May to 31 October: ≤6 as monthly average ≤15 at any time During the period 1 Novembe to 30 April: ≤12 monthly average ≤30 at any time

Table D-1. Water quality parameters (continued).

PARAMETER	STREAM	EFFLUENT
Suspended Solids (mg/1)	NC	≤30 as monthly average ≤100 at any time
Dissolved Solids (mg/1)	Not more than 500 mg/1 as a Monthly average value; not more than 750 mg/1 at any time	NC
NH_3 - N (mg/1)	≤1.5[a]	During the period 1 June to 31 October: 7 day average ≤3.0
Total Nitrogen (mg/1)	NC	During the period 1 June to 31 October: ≤8 mg/1 During the period 1 November to 31 May: ≤24 mg/1
Phosphate (total soluble)	NC	NC
Chlorine	NC	NC
Heavy Metals (Cd, Cr, Ni, Hg, Pb, Zn, Cu)	NC	NC

[a] Stream criterion from "Neshaminy C Criteria".

Table D-1. Water quality parameters (concluded).

General Water Quality Criteria

(a) Water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

(b) Specific substances to be controlled shall include, but shall not be limited to, floating debris, oil, scum, and other floating materials, toxic substances and substances which produce color, tastes, odors, or settle to form sludge deposits.

APPENDIX E

Baseline Water Quality Conditions

Table E-1. Reported values for water quality parameters in the Horsham-Warminster-Warrington planning area, Montgomery and Bucks Counties, Pennsylvania, 1968-1977. Samples from all stations indicated ambient stream conditions except at Stations 3, 7, 9, and 11, where STP effluent was collected. Station locations are indicated in Figure . NM indicates that the parameter was not measured.

	STATIONS							
	1[a]					5[a]		
CHEMICAL PARAMETER	1967 - 1968	1968 - 1969	2[b]	3[c]	4[b]	1967 - 1968	1968 - 1969	6[b]
Temperature (°C) Avg. (range)	14.3 (0.5-25.0)	12.0 (0.5-22.0)	(19.5-28.5)	NM	(18.5-24.0)	14.5 (0.3-31.0)	13.5 (0.5-26.0)	(18.5-26.0)
Dissolved Oxygen (mg/l) Avg. (range)	11.3 (5.0-13.0)	10.7 (5.0-17.8)	(3.4-10.3)	NM	(2.8-10.9)	11.5 (5.9-16.1)	12.1 (7.0-18.0)	(6.0-10.2)
BOD_5 (mg/l) Avg. (range)	NM	NM	NM	23	NM	NM	NM	NM
pH (pH units) Avg. (range)	7.6 (6.8-8.9)	7.5 (7.1-8.5)	NM	7.0	NM	7.6 (6.5-8.8)	7.7 (6.9-8.8)	NM
Total Dissolved Solids (mg/l) Avg. (range)	217 (176-298)	216 (173-267)	NM	NM	NM	218 (172-272)	250 (204-323)	NM
Total Suspended Solids (mg/l) Avg. (range)	NM	NM	NM	57	NM	NM	NM	NM
Nitrates (as N)(mg/l) Avg. (range)	1.00 (0.07-4.54)	1.01 (0.05-4.54)	(0.04-0.36)	2.45	(0.40-0.48)	0.89 (0.12-3.82)	1.13 (0-3.82)	(1.32-3.08)
Ammonia Nitrogen (as N)(mg/l) Avg. (range)	NM	NM	(0.06-0.12)	11.85	(0.24-0.44)	NM	NM	(0.10-0.20)
Phosphates (as PO_4) (mg/l) Avg. (range)	0.28 (0.13-0.60)	0.40 (0.19-0.72)	(0.24-1.10)	5.7	(0.06-0.14)	0.21 (0.12-0.69)	0.32 (0.16-0.71)	(0.50-1.52)
Turbidity (units not specified) Avg. (range)	5 (1-12)	8 (2-40)	NM	16	NM	11 (1-116)	5 (2-10)	NM
Color (units not specified) Avg. (range)	11 (2-40)	11 (2-30)	NM	NM	NM	9 (3-30)	9 (3-20)	NM
Total Coliform/100 ml Avg. (range)	2,316 (90-28,500)	1,259 (110-3,400)	NM	NM	NM	1,244 (20-5,800)	1,202 (120-3,900)	NM

Table E-1. Reported values for water quality parameters in the Horsham-Warminster-Warrington planning area (continued).

	7		8[a]		9			11	
CHEMICAL PARAMETER	7[c]	7[b]	1967 - 1968	1968 - 1969	9[c]	9[b]	10[b]	11[c]	11[b]
Temperature (°C) Avg. (range)	NM	21.0	12.7 (0.3-26.5)	11.0 (0.5-24.5)	NM	24.0	(19.0-28.5)	NM	23.0
Dissolved Oxygen (mg/l) Avg. (range)	NM	(4.8-6.4)	10.4 (7.6-15.0)	10.8 (6.0-15.)	NM	(4.0-4.9)	(3.4-10.7)	NM	(4.0-8.2)
BOD_5 (mg/l) Avg. (range)	23	14.0	NM	NM	19	(18.0-54.4)	NM	17	12.0
pH (pH units) Avg. (range)	NM	6.8	7.2 (6.7-8.2)	7.3 (6.8-8.2)	72	NM	NM	72	NM
Total Dissolved Solids (mg/l) Avg. (range)	NM	NM	199 (172-226)	263 (202-373)	NM	NM	NM	NM	NM
Total Suspended Solids (mg/l) Avg. (range)	NM	50	NM	NM	39	NM	NM	37	NM
Nitrates (as N)(mg/l) Avg. (range)	(1.32-3.08)	1.29	1.74 (0.69-5.89)	1.56 (0.49-5.39)	3.14	7.26	(1.24-3.52)	10.3	11.00
Ammonia Nitrogen (as N)(mg/l) Avg. (range)	(0.10-0.20)	5.52	NM	NM	8.84	1.32	(0.38-2.53)	6.28	9.24
Phosphates (as PO_4) Avg. (range)	(0.50-1.52)	3.93	0.81 (0.31-1.91)	0.87 (0.34-2.24)	7.77	11.00	(1.00-4.29)	11.3	8.03
Turbidity (units not specified) Avg. (range)	NM	27	7 (1-21)	9 (5-18)	17	NM	NM	18	NM
Color (units not specified) Avg. (range)	NM	NM	14 (5-30)	12 (6-25)	NM	NM	NM	NM	NM
Total Coliforms/100 ml Avg. (range)	NM	NM	2,112 (40-11,000)	2,343 (350-11,000)	NM	NM	NM	NM	NM

Table E-1. Reported values for water quality parameters in the Horsham-Warminster-Warrington planning area (continued).

CHEMICAL PARAMETER	12[a] 1967 - 1968	12[a] 1968 - 1969	12[b]	13[b]	14[a] 1967 - 1968	14[a] 1968 - 1969
Temperature (°C) Avg. (range)	13.8 (2.0-26.5)	12.0 (0.5-26)	(19.0-26.0)	(19.5-24.0)	13.6 (0.5-28.0)	12.0 (0.5-26.5)
Dissolved Oxygen (mg/l) Avg. (range)	8.5 (4.1-13.6)	8.6 (2.2-13.0)	(5.5-8.7)	(3.0-5.2)	9.1 (4.9-13.2)	9.8 (4.9-17.0)
BOD_5 (mg/l) Avg. (range)	NM	NM	NM	NM	NM	NM
pH (pH units) Avg. (range)	7.0 (6.8-7.3)	7.1 (6.9-7.3)	NM	NM	7.1 (6.8-7.5)	7.3 (7.0-7.8)
Total Dissolved Solids (mg/l) Avg. (range)	260 (218-302)	344 (238-452)	NM	NM	256 (202-314)	316 (232-424)
Total Suspended Solids (mg/l) Avg. (range)	NM	NM	NM	NM	NM	NM
Nitrates (as N)(mg/l) Avg. (range)	2.87 (0.89-11.1)	2.96 (0.95-11.06)	(6.38-14.08)	(0.46-9.68)	3.2 (0.55-12.7)	3.50 (0.83-12.72)
Ammonia Nitrogen (as N)(mg/l) Avg. (range)	NM	NM	(5.39-5.72)	(4.4-5.17)	NM	NM
Phosphates (as PO_4) Avg. (range)	10.8 (2.28-49.4)	16.7 (2.07-49.4)	(7.81-8.69)	(7.34-8.25)	9.55 (1.59-41.2)	15.45 (2.08-41.2)
Turbidity (units not specified) Avg. (range)	9 (2-18)	15 (5-100)	NM	NM	7 (1-30)	14 (5-115)
Color (units not specified) Avg. (range)	20 (8-40)	19 (10-60)	NM	NM	24 (5-40)	15 (7-60)
Total Coliforms/100 ml Avg. (range)	1,386 (0-5,800)	1,954 (0-7,400)	NM	NM	2,122 (90-5,700)	2,025 (160-5,500)

Table E-1. Reported values for water quality parameters in the Horsham-Warminster-Warrington planning area (concluded).

[a] Data from Broadfoot et al. 1969, 1970. Duplicate samples were taken at three week intervals during the period September 1967 to September 1968 and during the period September 1968 to August 1969.

[b] Data from Water Resource Engineers 1976. All in-stream samples were collected on 4 August 1976. At each station the in-stream samples were collected during the early morning (0400 to 0630) and during the midday (1230 to 1420). Effluent sample values were taken from the monthly operating reports of the respective STP's.

[c] Data from Bucks County Planning Commission 1977. The values for each STP are yearly averages (1974-1975) computed from the monthly operating reports of the respective STP's.

APPENDIX F

Peak Discharge for Little Neshaminy Creek and Park Creek

Table F-1. Peak discharges of Little Neshaminy Creek and Park Creek during the 10, 50, 100, and 500 year storm events (US-HUD 1978).

	Drainage Area (sq mi)	Peak Discharges (cfs) 10 Year	50 Year	100 Year	500 Year
Little Neshaminy Creek					
Downstream of Warrington Corporate Limits	25.4	2,437	4,225	5,489	10,850
Downstream of Warminster Corporate Limits	28.7	2,492	4,334	5,851	11,350
Park Creek					
Confluence with Little Neshaminy Creek	11.6	1,780	2,747	3,104	3,824

APPENDIX G

Population Estimates by Subarea

Table G-1. Population estimates for the Horsham, Warminster, and Warrington Pennsylvania, planning area, 1975 - 2020, by subarea.

Subarea	1975	1980	1985	1990	1995	2000	2010	2020
1	498	732	861	975	1,114	1,253	1,322	1,388
2	1,471	2,229	2,591	2,909	3,712	4,523	4,930	5,335
3	46	46	46	46	93	142	164	191
4	589	656	744	799	859	919	1,103	1,287
5	380	404	435	456	484	512	599	688
6	305	336	377	402	526	650	1,209	1,406
7	762	807	865	897	1,010	1,123	1,465	1,806
8	608	904	1,270	1,475	1,586	1,661	1,946	2,231
9	1,119	1,188	1,298	1,329	1,344	1,361	1,369	1,376
10	145	145	145	145	171	196	273	350
11	43,371	46,657	47,565	48,357	48,834	49,343	49,517	49,690
Total Planning Area	49,294	54.104	56,197	57,790	59,715	61,683	63,717	65,748

APPENDIX H

Distribution of Land Uses by Subarea

Table H-1. Land use in the Horsham, Warminster, and Warrington, Pennsylvania planning area, by subarea , 1978.

Subarea	Total Land (Acres)	Residential	Commercial, Services, and Institutional	Industrial	Utility	Recreational	Transitional	Cemetery	Railroad	Military Installation	Undeveloped	Total
1	346	45.1	5.5	0.0	5.5	0.0	1.4	0.0	0.0	0.0	42.5	100
2	1,275	28.3	10.0	3.6	1.2	0.3	0.4	0.0	0.0	0.0	56.2	100
3	84	7.1	0.0	36.9	0.0	0.0	0.0	0.0	0.0	0.0	56.0	100
4	1,807	11.8	1.1	3.6	4.6	14.4	0.0	6.3	0.0	0.0	58.3	100
5	784	12.4	7.3	2.8	1.3	29.7	0.0	0.0	0.0	0.0	46.6	100
6	458	23.6	0.0	0.0	5.0	3.5	0.0	0.0	0.0	0.0	67.9	100
7	936	22.6	0.1	0.0	4.1	28.0	0.0	0.0	0.0	0.0	45.2	100
8	766	29.6	2.7	0.0	3.0	0.0	0.0	0.0	0.0	0.0	64.4	100
9	414	72.0	5.6	0.0	0.0	1.2	0.0	0.0	0.0	0.0	21.3	100
10	158	10.8	34.8	0.0	0.0	11.4	0.0	0.0	0.0	0.0	43.0	100
11	7,944	50.5	9.0	5.0	0.8	2.6	2.4	0.7	0.9	7.3	20.8	100
Total Planning Area	14,971	38	7	4	2	7	1	1	0.5	3.5	36	100

Table H-2. Land use categories used for land use mapping of the Horsham, Warminster, and Warrington, Pennsylvania planning area.

Land Use Category	Definition
Residential	Land in residential use, ranging from high density multiple-unit structures to low density estates on large lots.
Commercial, Services, and Institutional	Land used predominantly for the sale of products and services, as well as institutions such as schools or churches, public buildings, professional and office buildings, health facilities, and the grounds and parking areas that are related to such uses.
Industrial	Light to heavy manufacturing plants, industrial parks, and the grounds and parking areas that are related to such plants.
Utilities	All public service utilities, including sewage treatment plants, high-tension electric power lines, underground gas pipelines and associated rights-of-way.
Recreational	Parks, playgrounds, and public recreation areas; public and private golf courses and driving ranges.
Transitional (Under Construction)	Land undergoing change, such as construction of structures, during preparation of land use map.
Cemeteries	Cemeteries
Military Installation	The entire properties of the Willow Grove Naval Air Station (Horsham Township) and the Naval Air Development Center (Warminster Township).
Railroad	Railroad tracks and associated rights-of-way.
Underdeveloped	Non-urbanized land including forests, oldfield and scrub, cropland, pasture, and other agriculturally related uses not included in any previous category.

APPENDIX I

Institutional Responsibilities in Land Use Management

Table I-1. Public institutional responsibilities in land use management in southeastern Pennsylvania.

LEVEL OF GOVERNMENT	AGENCY	MAJOR RESPONSIBILITIES
Federal	US-EPA	No direct responsibilities except through funds provided for water and air quality management planning; review of NPDES and PSD permits.
	US-HUD	Provides 701 planning funds to counties and eligible municipalities
State	Department of Community Affairs	Implementation and enforcement of Municipalities Planning Code (PA Act 247)
		Review of Federal and State funded redevelopment and renewal plans
		Provision of technical services to counties and municipalities
	Department of Envi-	Issues land development-related permits (erosion and sedimentation control, dams and encroachments, water supply, sewage facilities)
		Reviews and approves sewage facility plans, revisions, and supplements (as required by PA Act 537)
		Reviews, prioritizes, and approves Federally-funded construction grants applications and plans for sewage facilities
		Issues NPDES permits
Regional	Delaware Valley Regional Planning Commission	A-95 Areawide Clearinghouse
		Designated 208 water quality management agency for continuing planning under CWA
		Responsibilities for inter-county coordination on a multitude of planning matters
		Regional planning responsibilities in transportation, housing, and air quality

Table I-1. Public institutional responsibilities in land use management (concluded).

LEVEL OF GOVERNMENT	AGENCY	MAJOR RESPONSIBILITIES
Regional	Delaware River Basic Commission	Review and recommendations on sewage facility plans and state-issued permits
County	Bucks County and Montgomery County Planning Commission	Review of all land development proposals as required by PA Act 247
		Original preparation of official sewage facility plans (as required by PA Act 537) and review of plan revisions
		Coordination among municipalities for Federally-funded 201 sewage facility planning and other planning efforts
		Development of county plans addressing housing, transportation, open space, land use, and other concerns
		Technical planning assistance to municipalities
	Bucks County and Montgomery County Conservation Districts	Review of major subdivision plans and permit applications for erosion and sedimentation control
Municipal	Planning Commissions	Prepare zoning and sub-division ordinances, master plans, and official maps
		Review and make recommendations on land development proposals, zoning variances and special exceptions, and other land management decisions
	Zoning Hearing Board	Hear and decide on requests for zoning cnanges, variances, and special exceptions (judicial function)
	Governing body	Adoption of all ordianances, plans, and official maps (legislative function)
		Approval of all land development proposals
		Provision of municipal services, including police, recreation, libraries, and financial assistance to fire companies

APPENDIX J

AICUZ Recommendations for Land Use Changes

AIR INSTALLATION COMPATIBLE USE ZONE
NAVAL AIR STATION WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

CONTRACT NO.
N62467-76-C-0149

Prepared by
CH2M HILL
RESTON, VIRGINIA
For
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

TABLE V-5

LAND USE COMPATIBILITY MATRIX

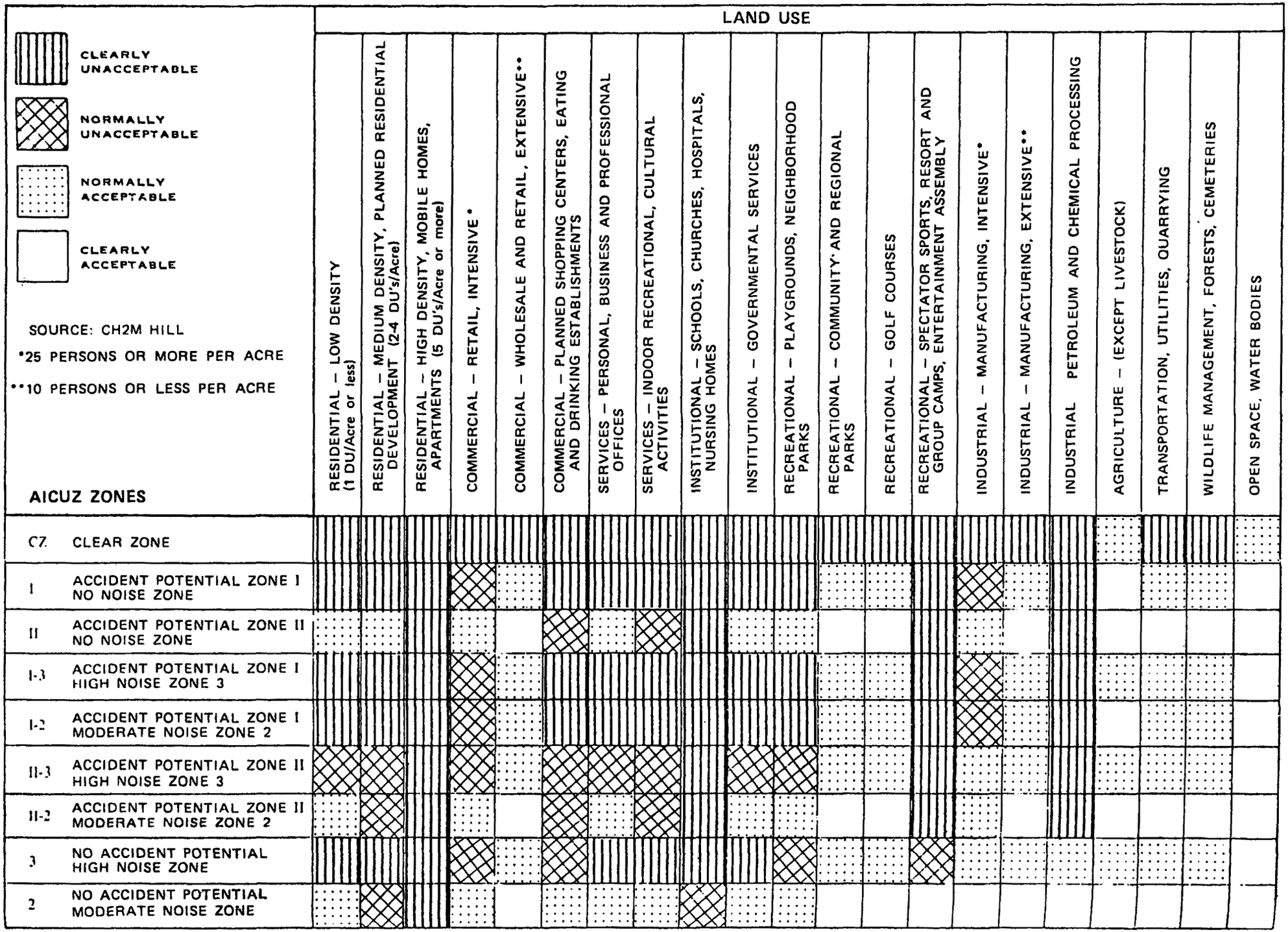
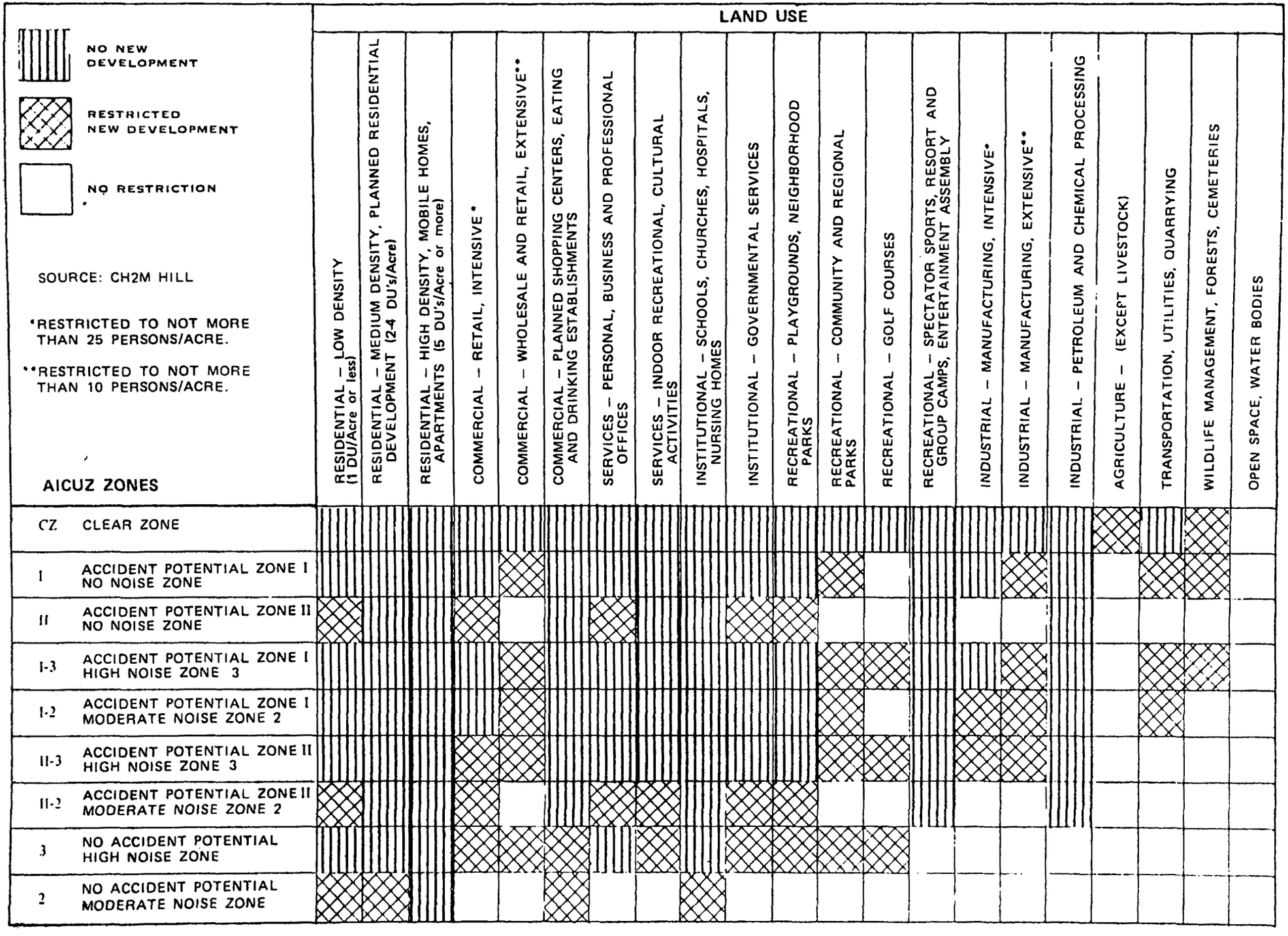


TABLE V-6

LAND USE OBJECTIVES MATRIX



COMPATIBLE LAND USE PLAN RECOMMENDATIONS

The objectives recommending compatible development are incorporated in Tables V-5 and V-6. These compatibility matrices specify land use categories as acceptable or unacceptable in terms of the AICUZ principle. An application of these recommended land uses to the existing and proposed developments within the AICUZ can provide a basis to guide land use decisions for this area.

An objective evaluation on the part the area planning agencies within and near the AICUZ regarding the review and approval of development proposals and/or zoning changes is necessary to achieve and promote compatibility.

The existing location of the Air Station serves to bridge the developed eastern and southern parts of Horsham Township with the western and northern rural parts of the Township. This situation establishes an AICUZ with three separate areas for land use management:

1. The eastern and southern area should be restricted to further development with residential densities maintained at a medium level (not more than 2 to 4 dwellings per gross acre). Commercial areas should be restricted to limit new eating and drinking establishments, theaters, amusements, gasoline service stations and similar people attractions. Schools, churches and any public service institutions should not be permitted.

2. The central area of NASWG includes the properties to the west of the facility which is under present development pressure. Since this area is also the most impacted by the activities at the Station, extreme concern to limit residential use activity is recommended. Present trends and adjacent land use development tend to suggest that much of this central area should expand as an industrial complex within the guidance of the I-1 zoning criteria ("selected, large scale, non-nuisance industrial type establishments which require large sites and land areas"). Such developments would serve to protect the Navy's mission and to add to the Township's growth without jeopardizing the health, safety and welfare of future Township residents. Provided, however, that accessory uses permitting concentration or large assembly of people are disallowed in the AICUZ.

3. The northern AICUZ area is sparsely developed and currently lacks the public services that could change its present character. Therefore, it is recommended that this impact area be retained in its present residential-conservation zoning category limiting housing to lot sizes of 3 acres or more for each dwelling unit. Schools, churches and convalescent or nursing homes should not be permitted. Open space uses, golf courses, agricultural or conservation uses should be encouraged.

Particular attention should be given to the areas adjacent to the runway ends designated as "clear zones." These areas require special restrictions to provide aircraft overrun areas and unrestricted visibility of airfield approach lighting. Due to the critical safety

problem in these areas, Navy policy requires that they be completely free of any type of development.

The clear zone at runway 33 has 69 acres of this zone in heavy development, another 20 acres are undeveloped and could be obtained. Presently the Navy owns 39 acres in this clear zone. In the northerly clear zone (runway 15), the Navy owns over 84 acres, the Township owns 18 acres and 26 acres are held privately and are not yet developed.

Any proposal to add, change or alter private developments in these clear zones should be reviewed by both Township and Navy officials prior to deciding any proposed action. Similar consideration should be given to the land areas within the high noise zone 3 and accident potential zone I.

As a matter of general policy, Navy officials at NASWG should maintain communications with each of the adjacent municipal and county agencies regarding growth policy, planning and development actions. Navy participation in the local government and planning process is necessary to demonstrate good faith and cooperation with civilian agencies.

VII. IMPLEMENTATION

The implementation of the compatible land use plan can be achieved by a variety of actions available through the functions of local government and through official Navy policies.

LOCAL GOVERNMENT ACTION

First and foremost is the cooperation of local government through their planning and land use control authority. This authority is given to the local planning commission which has the responsibility of regulating future development through a wide range of land use controls including land use planning, zoning, subdivision regulation, official map preparation, cluster housing ordinances, and site plan review. These controls provide local officials with the tools necessary to be able to guide and direct various land use types and their extent throughout the municipality.

The authority to exercise these controls is provided by state legislation under the police powers which broadly establish protection for public health, safety, and general welfare. These powers can be applied to achieve compatible land use within the AICUZ; however, they must be directed through the public process. It is within this process that the Navy can be effective in explaining its mission and these AICUZ objectives.

NAVY ACTION

It is important that the Navy personnel also take an active role to assure implementation of its

recommendations for compatible land use. Several programs and policies are available to the Navy as described below.

Acquisition

One of the simplest and most direct is the outright acquisition of restrictive easements on or title to all land in the AICUZ area through purchase in fee simple, purchase of development rights or land exchange. However, this action on the Navy's part is not in the best interests of all concerned since it is expensive, it would remove productive land from the tax roles and it would have a strong tendency to restrict development in the vicinity. While an acquisition policy is recommended for the securing of runway clear zones, it is not the most feasible way to obtain compatible land use. The general policy of the Navy is not to pursue acquisition due to funding limitations and to avoid unpopular condemnation procedures.

Public Awareness

Another action on the part of the Navy is to establish public awareness through information programs, participation in public affairs and activities. Such participation is effective and inexpensive. Since an informed public is an understanding public, the following methods should be used:

1. Make public speakers available to public and service club functions. The AICUZ slide show, NAVFAC movies and presentations on the purpose and function of the Navy's mission are of general interest and well accepted by the public.

2. Use the newspapers, radio and TV to inform the public on activities occurring at the NAS. Initial information on the completed AICUZ study should be given in a news release and followup releases made as adjustments to the AICUZ are made. Information should also be released to alert the public of forthcoming periods of intense or unusual aircraft operations.

3. Make copies of the AICUZ study report available to each adjacent municipality, the County and to area libraries. Maintain copies of the public information summary on the AICUZ for ready distribution. Copies should be made available through the Chamber of Commerce, the county economic development organization and others.

4. A public information officer should be made responsible for issuing these data and providing other information outlets such as newsletters, news releases and media announcements. Another responsibility would be to provide a liaison with major land holders and developers in the adjacent areas.

Command level Naval personnel should become active participants in local government affairs. Membership on planning and zoning boards, school boards, and governing bodies would be effective areas for making the Navy's interests known and in gaining public awareness. It is also a very visible means to show that the Navy is a good neighbor and an integral part of the community.

Noise complaints should be directly referred to the AICUZ officer and/or a designated noise complaint officer. A "hotline" for this purpose could be established and publicized for maximum effectiveness. Followup letters of action taken should be sent to the complaintant with copies sent to the adjacent area governing body.

PUBLIC POLICY FORMULATION

Public policy constitutes the starting point for initiating positive courses of action with respect to pending issues and concerns. Policy is the first step in the preparation of program standards, and regulations to achieve intended results.

In the context of the AICUZ, public policy is formulated by public officials to provide a general guide for day-to-day decision making regarding land use and environmental quality. To the extent practical, the Navy's role is to augment existing and proposed public policy in order to influence adequate consideration of AICUZ objectives.

In general, this approach to implementing AICUZ objectives is advantageous in that its only requirements are thorough preparation and diligent effort on the part of the Navy. However, the advantages of placing the responsibility for achieving objectives in the hands of public officials are sometimes outweighed by the disadvantages. The basic disadvantage is that full effect of the definitive policies that are needed can be diluted in the political arena of policy formulation. This not only results from the fact that policy-makers change office, but also because public policy is directed at creating a balance among various interest groups for

the public's good. Therefore, the government actions necessary to achieve the Navy's AICUZ objectives may be compromised in order to adequately account for other public interests. It should be in the Navy's interest to keep the AICUZ policy current within the government process.

Local Land Use Control Policy. Land use control policy on the local level includes comprehensive planning, zoning, subdivision and land development regulation, official map, planned residential developments, and airport zoning.

Once established as local policy, each of the above provide local government with effective tools in which to shape and control their environment.

Any proposed development or major land use must be presented to the planning commission and/or governing body for review and approval prior to development. In each case, public hearings are held by the municipality giving the public an opportunity to be heard.

These hearings provide the Navy with the opportunity to give testimony and to go on record regarding AICUZ objectives in those areas which may be subject to incompatible development. It is the required policy of the municipality to publish a formal notice of these hearings and to specifically inform adjacent land owners of action that may effect their interests.

The Navy's coordination with this planning process should include the following:

1. To be an initial part of the planning process by being active participants in local planning policy.

2. To have on record as official Navy policy a copy of the AICUZ plan.

3. To always make presentations at appropriate public hearings as a means to firmly establish the AICUZ objective.

Development Proposals and Official Review Agencies. Every level of government; federal, state, regional, county and local have review powers regarding major developments. Federal and state agencies become involved where federal grants or loans are made to assist in public works, parks, transportation networks and housing. State agency concerns regarding the environment, water rights and human rights mandate preliminary review; county and regional agencies review land development proposals, drainage requirements and capital improvements programs; and local governments initiate, contribute, and participate in this review process. In each case, the Navy can influence the review process to include the compatibility objectives of the AICUZ by presenting supporting documentation to the appropriate agency.

Federal Level Review.

1. National Environmental Policy Act (NEPA) requires a review of alternative courses of action in an

environmental impact statement where federal funds are involved for housing, utility systems, highways, airports, etc. These alternatives must evaluate environmental impacts generated by the proposed project such as noise, safety and health. Federal EPA approval is contingent on environmental compatibility as determined by this analysis and review.

2. Project Notification and Review System (A-95). As established by the Federal Office of Management and Budget, Circular No. A-95 requires that all federal aid for development purposes be consistent with local, regional, and state objectives and plans. To accomplish this objective, all applications for federal grants and aids for public works must be first submitted for review and comment by the areawide comprehensive planning agency. This agency reviews the project proposal in terms of the existing and planned development within the area as a "clearinghouse" process. The Deleware Valley Regional Planning Commission (DVRPC) has been designated as a clearinghouse charged with the A-95 review requirement. The Montgomery County Planning Commission assists the DVRPC in this process for projects located in the County. Submitting the AICUZ compatibility objectives and plan with these agencies can effectuate this review process.

3. Federally Assisted Housing. The Department of Housing and Urban Development (HUD) reviews both VA and FHA loan applications. Approval of these applications is contingent upon factors such as

noise, safety, flooding and other features as part of the review process. HUD has established safety limits regarding noise exposure expressed in terms of CNR, NEF and Ldn and can withhold mortgage approval on sites exceeding recommended tolerances.

State Level Review. Development controls and restrictions receiving state level attention include the Pennsylvania Sewage Facilities Act (Act 537), Department of Environmental Resources, and Department of Community Affairs.

County Review. The county planning commission play an important role in reviewing countywide developments and planning proposals. This activity extends to subdivision review, planned residential developments, site plans, A-95 review, environmental impact statements and municipal comprehensive plans and zoning ordinances. This responsibility can be employed to the benefit of Navy AICUZ objectives and it is recommended that a liaison between the command level and county planning agencies be established for this purpose.

Local Level Review. This is the action level where plans, programs and proposals get resolved. The Navy's role in this process should be a foremost requirement as discussed above under Local Land Use Control Policy.

OTHER STRATEGIES

Noise Abatement. A number of noise abatement strategies can be applied to known sources and location of noise impact areas. The baseline AICUZ defines the noise sources and impact areas for NASWG. The principal

strategy for controlling significant noise sources at Willow Grove is primarily to mitigate the A-4 static runup noise by installing sound suppressors and to alter the directional flight path to the southeast of runway 33. These efforts reduced both the APZ I and noise zone 2 areas over portions of Horsham and Upper Moreland Townships and Hatboro Borough to the east and an area around Norristown Road to the west.

New housing constructed within the remaining AICUZ area should be soundproofed. The local building codes should be amended to provide for approved soundproofing materials and improved standards.

Other strategies to achieve the AICUZ objective include the following:

1. Municipal adoption of the AICUZ footprint. The local governing bodies and planning commissions should review and adopt, after public hearing as required under Act 247, the AICUZ footprint. The data incorporated in the final report should be used to support planning and zoning decisions by the municipal and county agencies. Municipal agencies should include Horsham, Upper Moreland and Warrington Townships, Hatboro Borough, and Montgomery and Bucks Counties.

2. A-95 Review. Following local adoption of the AICUZ, a copy of the final report should be filed with the Montgomery and Bucks County A-95 clearinghouse agencies for carrying out their respective review responsibilities.

3. Fair Disclosure Ordinance. Regulations similar to Act 89, Information Disclosure, (P.L. 288, No. 104) should be adopted by each local government. Such regulations should require the disclosure by the seller of any property in the AICUZ of the accident potential zone and noise impact zone in which such property is located.

4. Airport Zoning. The provisions to establish airport zoning should be adopted as an ordinance in Horsham and Upper Moreland Townships and Montgomery County. Every political subdivision in the State having an airport hazard area may adopt, administer and enforce, under the police power, airport zoning regulations regarding the regulation of land use and height of structures. A copy of the Airport Zoning Act is included as Appendix E.

5. Subdivsion and Land Development. Ordinances for the regulation of subdivisions and land development have been adopted by each of the municipalities adjacent to NASWG. It is recommended that the review process be amended to include the following for new developments within the AICUZ.

   a. Subdivisions intended for uses not compatible with AICUZ objectives will not be approved.

   b. Subdivision plats within the AICUZ will show the AICUZ accident potential and noise zones.

6. Capital Improvements Programs. Public investments for public works projects, schools, institutions

and other public investments within the AICUZ area should adopt the following policy.

a. Public buildings should not be located in conflict with AICUZ objectives.

b. Capital Improvements Programs should be developed to encourage growth in areas not impacted by noise and accident potential.

c. Utility extension policies should discourage incompatible land use patterns.

7. Citizen Participation. In the implementation of the AICUZ objectives, public understanding and citizen participation should be encouraged.

8. Land Acquisition. Where necessary and in the public interest, acquisition of land to achieve the AICUZ objectives can sometimes be the only means to benefit public health and safety.

IMPLEMENTATION PLAN

The strategies described above can be applied to achieve implementation of the recommended Compatible Land Use Plan. Five basic goals are identified and make up the Implementation Plan as shown on Figure VII-1. These goals relate to the various defined strategies and are outlined as follows:

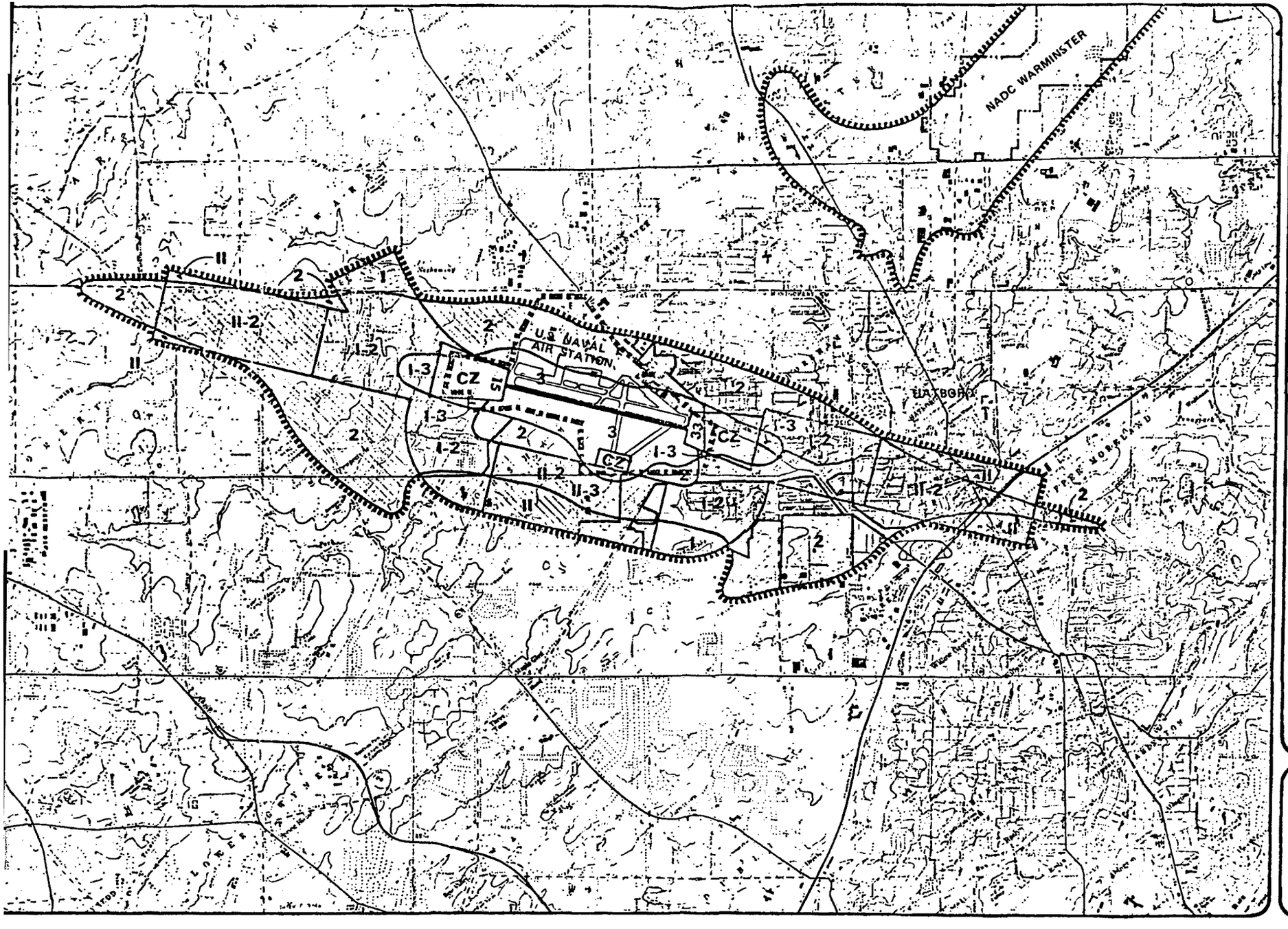
A. Maintain the runway clear zones as open area - restrict all development. Strategies applicable to implement this goal include both airport hazard zoning and standard zoning processes and sub-division regulations,.

B. Restrict any proposed development in Noise Zone 3 areas. Applicable strategies include zoning, airport hazard zoning, capital improvements programming, fair disclosure, and building code enforcement.

C. Maintain established zoning categories where appropriate. Strong zoning administration of existing zoning ordinances can help maintain compatible areas from being changed to incompatible zoning categories. Objective subdivision and land development review, capital improvements programming, and information disclosure should be applied as additional management strategies. Attention should be paid to the Land Use Objectives Matrix for guidance in the issuing of building permits (see Tables V-5 and V-6) and conformance to the Horsham Township "Air Transportation District" as proposed in its revised comprehensive plan.

D. Lower residential density - limit new or expanded development. These defined areas within the AICUZ are predominantly developed. Therefore, any change in development should be to reduce the magnitude of the area impacted. The goal toward limiting new or ("zero") or expanded development should be controlled by zoning and subdivision regulations. Building code enforcement to assure that soundproofing measures are added to renovated structures and new construction. "Zero" development goals will require controlled zoning and building permit allotment by the local government agency involved to help regulate expansion and to achieve lower densities. Public building development and/or expansion should be monitored through capital improvements programming.

E. Expand I-1 Industrial Zoning. The area to the west of the Station is impacted by both accident potential and noise. This environment is not suited to residential development, and therefore, should be discouraged. Since industrial development trends are prevalent in this area, these trends should be allowed to continue. Strategies would include zoning, subdivision regulations, and capital improvements programming for funding utility services and roads as may be required.



LEGEND

COMPATIBLE ZONING

- CLEARLY ACCEPTABLE
- NORMALLY ACCEPTABLE

INCOMPATIBLE ZONING

- NORMALLY UNACCEPTABLE
- CLEARLY UNACCEPTABLE
- NAS BOUNDARY
- AICUZ BOUNDARY
- NADC BOUNDARY
- NADC AICUZ BOUNDARY

SOURCE: CH2M HILL

0 4000
FEET

AICUZ STUDY
NAVAL AIR STATION
WILLOW GROVE, PA.

VI-3

EXISTING ZONING COMPATIBILITY

APPENDIX K

Community Services

Table K-1. Park and recreational lands in the Horsham, Warminster, and Warrington PA planning area by municipality. Data from municipal officials 1978.

MUNICIPALITY	NAME OF PARK	ACRES
Horsham Township	Deep Meadow Park	51.8
	Hideaway Park	2.0
	Keith Valley Park	32.6
	Maple Park	7.5
	Kohler Park	68.6
		162.5
Warminster Township	Barness Park	13.9
	Centennial Park	10.6
	Kemper Park	30.0
	Log College Park	26.6
	Maple Street Playground	0.6
	Meadow Run Park	1.9
	Munro Park	35.0
	Szymanek Park	10.8
	Werner Park	6.8
		136.2
Warrington Township	Alou Village Park	3.1
	Palomino Park	5.6
	Warrington Tennis & Swim Club	11.3
		20.0
Ivyland Borough	2 small recreational areas	4
Upper Dublin Township	Three Tuns Playground	3.1
Warwick Township	None in planning area	0.0

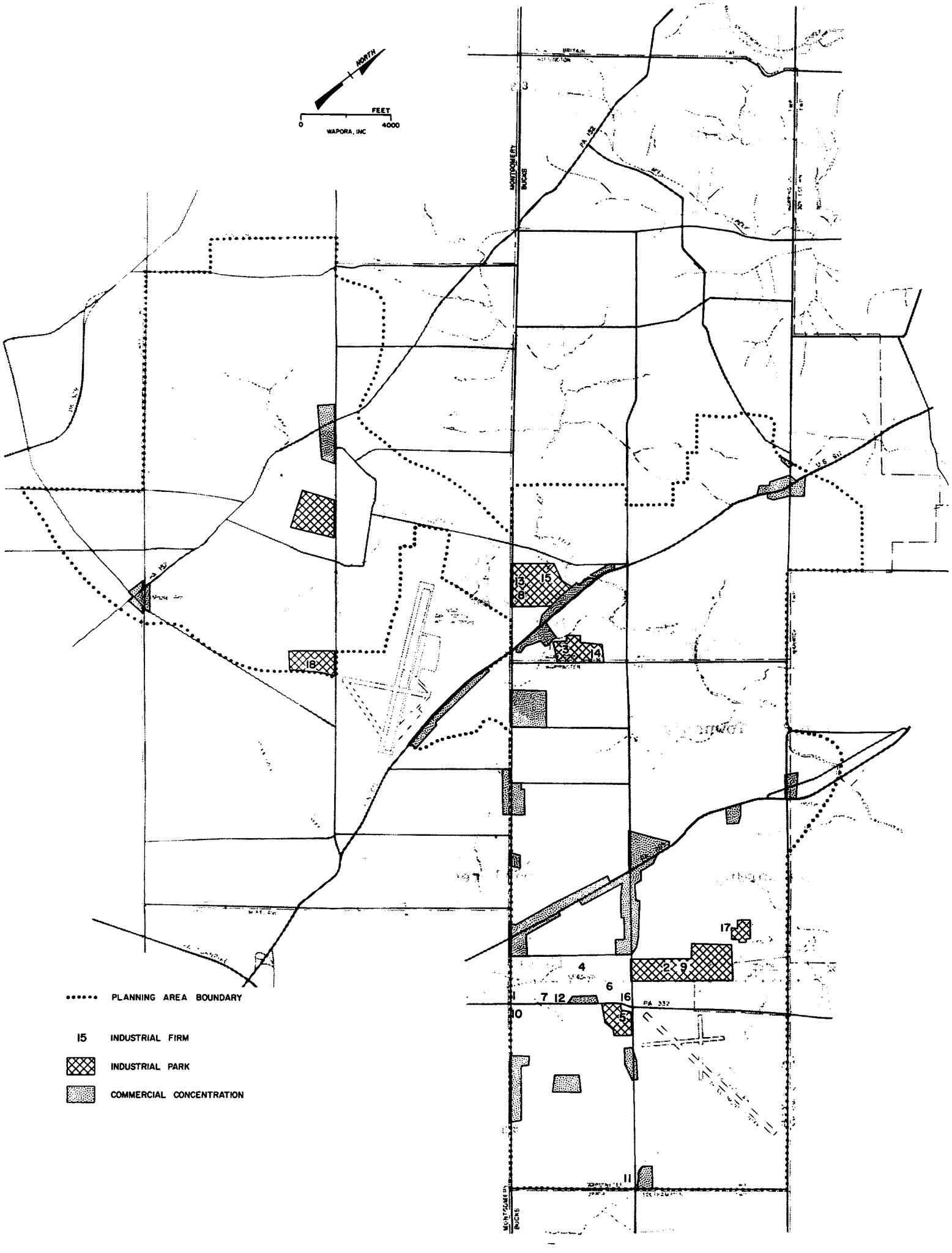


FIGURE K-1

MAJOR INDUSTRIAL AND COMMERCIAL CONCENTRATIONS

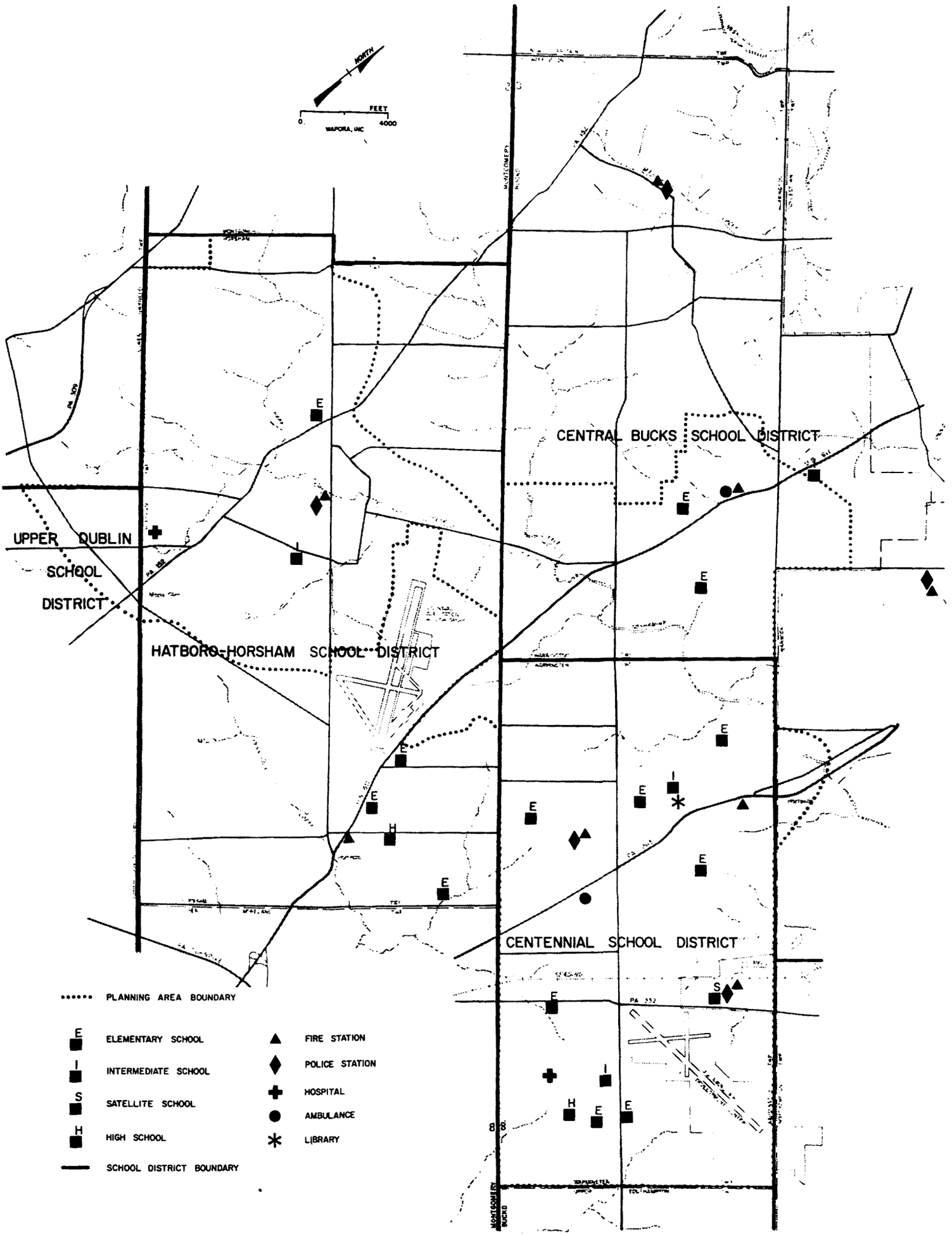


FIGURE K-2

PUBLIC SCHOOL AND COMMUNITY SERVICES

APPENDIX L

Historic Cultural Resource Inventory

Historic Cultural Resource Inventory

Horsham Township (Figure 2-7)

LOCATION NO.	STATUS	DESCRIPTION
1	(ENR)	Buttonwood Farm: restored farmhouse constructed c. 1720.
2	(MCI)	Phillip J. Baur House: original section constructed in 1730. There are several additions to house, a barn (c. 1850), and a springhouse on the site.
3	(MCI)	Sidney N. Repplier House: constructed during the 1700's on a William Penn land grant.
4		Hip-roofed house owned by M. Robinson during 1877.
5	(MCI)	EE Novotny House: pre-Revolutionary War house which retains many original features.

LOCATION NO.	STATUS	DESCRIPTION
6	ENR	A. J. White House: five bay colonial fieldstone house, constructed in two stone sections with a frame Victorian addition and window trim.

7	(MCI)	Mrs. Herbert W. Anderson House: fieldstone house constructed c. 1797 with frame addition c. 1850.
8		Brogden House: stone house owned by J. Shutt in 1877.
9		Stone house constructed c. 1810, with additions to west end owned by C. F. Burkley in 1877.
10		J. Clayton House: stone house owned by J. Clayton in 1877.
11-20		Historic District of Prospectville: the village of Prospectville was established during the 1700's. Several eighteenth century structures are still standing. The building which contained a store and post-office, established in 1854 and operated by C. B. Reading between 1867 and 1903, has been replaced by a gas station. Two mid to late eighteenth century residences and a toll house are included in this historic cross roads village, the integrity of which has been altered by a modicum of twentieth century intrusions.

LOCATION NO.	STATUS	DESCRIPTION
11	ENR	Part-log, part-stone house constructed in 1758. One of few examples of this early type of construction remaining in Township.
12		House owned by W. Monteith in 1893. Part of cross-roads village of Prospectville established in the 1700's.
13	MCI	Whitemarsh Cemetery Chapel. This building was constructed for use as a schoolhouse in 1860. May be second oldest chapel in Horsham Township.

LOCATION NO.	STATUS	DESCRIPTION
14		Late eighteenth and early nineteenth century structures of the crossroads village of Prospectville. Number 14 is on Limekiln Pike. Numbers 15 and 16 are on Horsham Road southeast of the intersection of Limekiln Pike and Horsham Road.

15	MCI	Campbell Toll House

16

LOCATION NO.	STATUS	DESCRIPTION
		Late nineteenth century house with decorative stickwork typical of Gothic stylistic influence.
18		Colonial farmhouse owned by T. Shay during 1877. Original section has 3 bays and is two and one half stories high with dormers.
19		Stone structure, property of J. White in 1877.
20		Stone residence probably constructed as a tenant house. Owned by A. Becker in 1877.
21	MCI	
		William Donnelly house: fieldstone house constructed c. 1810. A large barn and springhouse also stand on the site.

LOCATION NO.	STATUS	DESCRIPTION
22		
		Stone farmhouse with mansard roof and former window additions, owned by C. Houpt in 1877. The stone springhouse stands across Limekiln Pike opposite the house.
23	MCI	Orville W. Marlin House: constructed in 1875 to be used as the Whitemarsh Creamery, this building has been extensively altered for conversion to a residence.
24	(MCI)	Paul A. Urfer House: original section constructed 1717. An addition doubled the size of the house in 1797. There is a stone barn on the site. (ENR)
25		
		McCallison House: This five-bay house with eye-brow windows appears to have been constructed c. 1820-1840. A Victorian peak addition to the gable roof interrupts the essentially Georgian architectural style of the house.

LOCATION NO.	STATUS	DESCRIPTION
26	ENR	

Grist Mill constructed in 1830 by John E. Kenderdine. This mill was known as the Ox Mill because it was designed to be powered by oxen walking a wooden belt. The oxen did not survive. Millworks are at Stever's Mill and the building is used as a residence. (Smith, 1979)

27	MCI	Miss Maria Snyder's Toll House: This private residence built in 1850 was used as a toll house on the Limekiln Pike.
28		Stone house constructed in Georgian style, owned by M. Jones in 1877.
29	MCI	

Richard P. Hart House: the original stone section of the house was constructed c. 1770. Frame wings were added about 1920.

LOCATION NO.	STATUS	DESCRIPTION
30	MCI	Burgdorf House: the house was constructed c. 1730 by Archibald McClean, justice of the peace in Horsham Township and an Assemblyman in 1772.
31	MCI ENR	George Felbin House: The original section of this residence was constructed in 1730. A barn stands on the site adjacent to the Limekiln Pike.

LOCATION NO.	STATUS	DESCRIPTION
32-38	ENR	Davis Grove Historic District: the structures which are located on Davis Grove Road in the vicinity of Park Creek were constructed during the mid-eighteenth and early nineteenth centuries. During 1978, they remained situated in a tranquil rural setting which retained its nineteenth century historic integrity and ambience. About 1734 Joseph Kenderdine constructed a mill on Park Creek at the present intersection of Davis Grove Road and Keith Valley Road. A raceway 0.75 mile long was hand excavated from this mill to another mill built by Joseph Kenderdine on Limekiln Pike. During 1734, Davis Grove Road was opened as a private lane to provide access to Joseph's mill. Joseph Kenderdine apparently lived in a residence, constructed about 1738, which formerly stood on the present Keller property southeast of the mill. The mill, which was sold to John Shay in 1810, operated until just prior to World War I. John Shay also constructed a house on the southeast corner of Davis Grove Road and Keith Valley Road which replaced Joseph Kenderdine's earlier residence. The house standing presently adjacent to the Kenderdine mill on the northeast corner of Davis Grove Road and Keith Valley Road had been constructed by 1819. The area in the vicinity of the mill remains virtually unaltered since the mid-nineteenth century.
32	MCI	The Richard Harvey House: a colonial fieldstone house constructed during 1778 with a spring in the basement.
33	MCI	James L. Milford House: a fieldstone farmhouse and barn constructed in 1811 stand on this site which has attracted artists for many years.

LOCATION NO.	STATUS	DESCRIPTION
34	MCI	

Raymond Onyx House: the farmhouse constructed during 1740, has been remodeled and enlarged. A spring-house and large original barn remain on the site.

35 MCI
ENR

Mrs. Charles Harper Smith House: the stucco over stone house built in 1813 by miller, John Shay contains a large walk-in fireplace. The original wooden pump is in the kitchen.

36 MCI
ENR

Kenderdine Mill: the mill was constructed in 1734 and is the only grist mill remaining as a mill in Horsham Township. The original metalwork in the barn was sold to provide metal for the war effort during World War I. During the early nineteenth century a hand-excavated raceway extended from this mill to the "ox mill" on Limekilm Pike. Traces of this raceway remain south and west of the Kenderdine Mill (Smith [1919]).

LOCATION NO.	STATUS	DESCRIPTION
37		

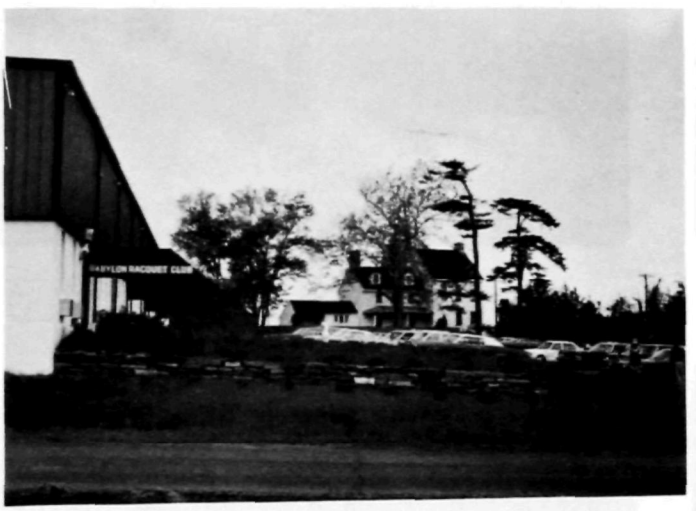
Keller House: a five-bay stucco over stone house built c. 1810 by John Shay. Shay's house replaced an earlier house built by Joseph Kenderdine c. 1738. Foundations of the earlier structure have been located on the site (Smith 1975:55).

38 ENR

Original 1738 barn of the first house on the Keller property stands in very poor condition on the west side of Davis Grove Road.

39 MCI ENR

Gerald Hamburg House: This house constructed in 1856 of native field-stone is a fine example of Georgian architectural style.

LOCATION NO.	STATUS	DESCRIPTION
40		E. Morgan House: the present house constructed on the site c. 1775-1800 replaced an earlier house built by Jabez White sometime prior to 1735.
41		A mid-nineteenth century residence. constructed as a tenant house, and a barn stand in good condition at the corner of Horsham Road and Babylon Road.
42		Colonial house presently surrounded by an industrial complex on Horsham Road. The house was owned by J. Shoemaker in 1887.

LOCATION NO.	STATUS	DESCRIPTION
43		Babylon Schoolhouse: the schoolhouse, extant in 1877, has been restored and converted to a residence.
44	NR, PI, MCI National Historic Landmark	The Keith House at Graeme Park. The land on which the Keith House is situated was purchased in 1717 by Sir William Keith, first Lieutenant Governor of the Province of Pennsylvania under William Penn. The original structure was built by Keith c. 1721 as a malt house. In the 1730's Thomas Graeme converted the structure and added its fine Georgian interior finishes. The Keith House is five bays across and two bays deep with a gambrel roof and attic dormers. During 1730, a barn stood in the location of the present barn.

LOCATION NO.	STATUS	DESCRIPTION

45

Colonial house with two additions, presently used to house a fence company in an industrialized section if County Line Road.

Warrington Township (Figure 2-7)

46

Old Warrington Schoolhouse: This building constructed in 1808 replaced the original schoolhouse built in 1765.

LOCATION NO.	STATUS	DESCRIPTION
47		

Hatboro Federal Savings Building: the original eighteenth century building, owned by J. Grom in 1876, has been converted to use as a bank. Additions conform to the architectural style of the building.

48

Vincent's Warrington Inn: this Inn, which bears a date of 1792, was operated as a hotel in 1876. Several additions have been made to the structure.

LOCATION NO.	STATUS	DESCRIPTION
49		

Four-bay stone house owned by A. Cooper in 1876. Similar in construction style and material to Site No. 48.

50 — Fine stone residence with ashlar patterns, owned by S. Hough in 1876.

51 — Stone farmhouse owned by R. J. Dobbins in 1876.

52

Five-bay stucco over stone farmhouse constructed c. 1840 and owned by E. French in 1876.

LOCATION NO.	STATUS	DESCRIPTION
53		

White stucco over stone farmhouse, owned by J. Selser in 1878.

54

H. W. Davis House: stucco over stone and frame farmhouse owned by J. Philips in 1878.

55 BCR

Arthur Harris House: the living room, library, and master bedroom of the house comprise the original section, constructed in 1760. The second addition in 1800 contained a large walk-in fireplace. A recent addition also has been made to the house.

LOCATION NO.	STATUS	DESCRIPTION
56	BCR	

Paul Valley Farm: two large colonial houses, one constructed in 1727, and owned by Joseph Penrose, and one constructed in 1846 remain on half of a 500-acre tract purchased from William Penn by John Paul in 1727.

Warminster And Warwick Townships (Figure 2-7)

57

The Manse: the stucco over stone house at 1760 Bristol Road was owned by the Petersons in 1876. Its architectural style suggests a construction date of c. 1810 for the original section. A later addition doubles the size of the house.

58 BCR

Neshaminy Cemetery: the cemetery contains an Indian grave.

LOCATION NO.	STATUS	DESCRIPTION
59	BCR	

Neshaminy of Warwick Presbyterian Church: the original church on this tranquil site was constructed in 1727. In 1743 there was a schism in the church and the original section of the present building was built to replace the 1727 structure which was abandoned and razed. The church, founded by William Tennant as the church of the Log College, was enlarged in 1775 and remodeled to its present appearance in 1842.

60	WTI	Darrah Farmstead: the farm may have been the residence of Reverend Beatty while he was pastor of the Warwick Neshaminy Church c. 1750.
61-73	ENR	Hartsville Historic District: The structures which originally were constructed at the cross-roads village of Hartsille stand today in a setting virtually unchanged since the end of the nineteenth century. Traffic on Bristol Road and a modern gas station on the southeast corner of Bristol Road and Old York Road are the only significant intrusions on the peaceful settlement. The structures exhibit a range of architectural styles in a vogue between the mid-eighteenth and late nineteenth centuries. The 1770 Dare Estate, the 1778 Polly Hart House, and the Isaac Lewis House are included in the Hartsville Historic District. The Bucks County Conservancy has indicated that Hartsville constitutes an historic district (Orally, Ms. Kathy Auerback, 26 May 1978).

LOCATION NO.	STATUS	DESCRIPTION
61		
		1180 Bristol Road: stucco over stone house with eyebrow windows, constructed c. 1830.
62		
		1140 Bristol Road: five-bay frame structure with dormers and elaborate decorative stickwork on first story porch.
63		
		1120 Bristol Road: frame building with mansard roof and exterior chimney. Victorian style structure appears to have been constructed c. 1870.

LOCATION NO.	STATUS	DESCRIPTION
64	BCR WTI	

Dare Estate: the original section of this house, which was constructed by Reverend Charles Beatty, second minister of the Neshaminy of Warwick Church, may be 200 years old. The interior has yellow pine random width floors.

65	BCR	The Polly Hart House: deeds to this house have been traced to 1838. Reverend Turner was a former owner, and the house may be 200 years old. Victorian additions have been removed and the original house has been altered.
66		

Colonial stone house constructed in two sections at corner of Bristol Road and Old York Road.

LOCATION NO.	STATUS	DESCRIPTION
67		Outbuilding of Number 66, converted for use as a commercial establishment.

68	WTI	Hartsville Hotel: a famous stage stop on the route from New York to Philadelphia. The original proprietor in 1744 was John Baldwin. Colonel William Hart kept the hotel between 1780 and 1817.

69		Three bay frame structure with bracketed roof and bracketed shed roofed porch with decorative stickwork. Constructed c. 1870.

LOCATION NO.	STATUS	DESCRIPTION
70	PI	Isaac Lewis House: 1040 Bristol Road. This two and one-yalf story, stone, gable roofed house, constructed during the mid eighteenth century is listed on the Pennsylvania Register of Historic Places.
71	WTI	Hartsville Fire House #1: the building bears a sign "Built 1843 by the Ladies Association of Neshaminy Church." The building was used for church and community purposes.

72		Elegent three bay structure with mansard roof, dormer windows and decorative stickwork in Gothic architectural style.

LOCATION NO.	STATUS	DESCRIPTION
73	WTI	

Duffy's Tavern: about 1832, Reverend James P. Wilson started a "classical school for boys" in the building which became the Roseland School for Girls, and is presently used as a tavern.

74

Three bay two and one-half story stucco over stone house at the intersection of Creek Road and Old York Road.

LOCATION NO.	STATUS	DESCRIPTION

75

Residence at corner of Creek Road and Old York Road was formerly a grist mill. The intersection is potentially an historic district.

76

Substantial stucco over stone structure constructed c. 1850. Porch and roof brackets are later additions. This is one of three nineteenth century historic structures at the intersection of Creek Road and Old York Road.

LOCATION NO.	STATUS	DESCRIPTION
77	PI, ENR, BCR, WTI	

Headquarter's Farm or the Moland House: about 1750, John Moland built the original two and one-half story, stone, gable-roofed structure which was used as George Washington's headquarters in August of 1777.

78	WTI	Pennebacher Farm: here Lafayette first received his commission from Washington. The house which was constructed in 1713, was leased by Washington during his stay in August 1777 (Bailey et al.1961).
79	WTI	Warminster Manor Inn: In 1730 Thomas Linter petitioned the court for a license "to keep a house of entertainment for man and horse". In 1791 the property belonged to Isaac Beans. During the War of 1812, the drafters assembled at Bean's Tavern on 18 September 1814 for a march to Philadelphia.
80	WTI	John Craven Beans House: the original section of this house may have been built during the late 1700's. A datestone on the later section bears the inscription "J.C. and ?? Beans 1847".

LOCATION NO.	STATUS	DESCRIPTION
81	BCR	Lukens-Jarrett House: Deeds to the Lukens-Jarrett House, similar in style to the pre-Revolutionary War McNab House in Tyler Park have been traced to 1775.
82	WTI	Philip Reeves House: Believed to be the ancestral home of the Nobel family the original kitchen with one room upstairs was constructed prior to 1734. An addition was made in 1826.
83	WTI	Fireside Inn: The Inn was originally the home of Job Nobel, in the 1700's. The house was later owned by Andrew Yerkes, and is presently used as an inn.
84	BCR	Vicinity of the Battle of Crooked Billet and cemetery which contains bodies of soldiers killed during the Revolutionary War. At this site, General John Lacey and 400 men fought a British detachment of 800 men under Lieutenant Colonel Abercrombe.
85	WTI	Duval Farm: The original section of this farm was constructed in 1762 by Harman Yerkes, the first member of the Yerkes family to settle in Warminster. The eastern addition was made in 1810, and the property remained in the Yerkes family until 1951.
86	WTI	John Hart J. House: Typical of Colonial Pennsylvania Manor Houses, this home was built in 1750 by John Hart, son of John Hart who received a grant of 1,000 acres from William Penn in 1681.

LOCATION NO.	STATUS	DESCRIPTION
87	BCR ENR	

Craven Hall: There is a walk-in fireplace in this structure which reflects the Greek Revival influence of the 1823-1850 addition and interior renovations. The original section was built c. 1780-1820 a second addition was made c. 1823-1850, and there is a third twentieth century addition.

88

View southeast on one of Ivyland's shaded streets.

Ivyland Historic District: Ivyland was founded in 1873 by Edwin Lacey on a section of a tract of land which Thomas Hart received in 1719. Lacey's plan was to provide facilities for the 1876 Centennial Exposition in Philadelphia. The Temperance House, a large four-story building with a mansard roof and porches surrounding the building on the first and second stories was designed to receive thousands of extra visitors to the Philadelphia area. The hotel, however, was not completed in time for the Centennial. Ivyland Borough was incorporated in 1905. It's shaded streets retain a quiet late eighteenth-early twentieth century dignity. The structures form a homogeneous group typical of the architectural styles of that period.

APPENDIX M

Cost of Alternative Systems

Table M-1. Summary of costs for Alternative 1 by municipality (in thousands of dollars).

COST	Upper Dublin	Horsham	Warrington	Warminster	Warwick	Ivyland	All Municipalities
Construction Cost	454.1	3,509.3	2,836.0	7,049.6	192.2	115.2	14,156.3
Salvage	187.5	1,536.0	910.4	1,073.0	29.3	17.5	3,753.7
Annual Operation & Maintenance	15.0	61.5	155.3	783.3	21.4	12.8	1,049.3
Total Present Worth	555.7	3,754.5	4,277.9	15,298.0	417.6	249.8	24,563.7
Average Annual Equivalent Cost	51.9	344.3	392.3	1,402.8	38.3	22.9	2,252.5
Distribution of Costs							
Federal EPA	340.6	2,507.9	2,048.9	5,287.1	144.1	86.4	10,415.0
Local Share	113.5	1,001.4	787.1	1,762.5	48.1	28.7	3,741.3
Annual Costs							
Operation and Maintenance (Industrial and Commercial)	0	8.5	16.9	31.2	1.3	0.6	58.5
Operation and Maintenance (Residential)	15.0	53.0	138.4	752.1	20.1	12.2	990.8
Debt Service (Industrial & Commercial)	0	12.7	7.9	6.4	0.3	0.1	27.4
Debt Service (Residential)	10.4	79.1	64.9	155.2	4.1	2.5	315.6
Typical User Charges							
Monthly O&M (Residential)	1.21	2.85	4.30	1.61	4.80	1.66	1.82
Monthly Debt Service	0.84	4.26	2.00	0.33	0.98	0.34	0.58
Total Monthly Charges	2.05	7.11	6.30	1.94	5.78	2.00	2.40

Table M-2. Summary of costs for Alternative 2 for Horsham Township and all municipalities (in thousands of dollars). Costs for all other municipalities in the planning area are same as indicated in Table M-1.

COST	Horsham Township	All Municipalities
Construction Cost	2,802.9	12,992.5
Salvage	1,248.2	3,296.0
Annual Operation & Maintenance	141.2	1,107.1
Total Present Worth	3,997.4	24,157.3
Average Annual Equivalent Cost	366.6	2,215.2
Distribution of Costs		
Federal EPA	1,980.7	9,545.4
Local Share	822.2	3,447.1
Annual Costs		
Operation and Maintenance (Industrial and Commercial)	19.5	67.6
Operation and Maintenance (Residential)	121.7	1,039.5
Debt Service (Industrial and Commercial)	10.4	25.2
Debt Service (Residential)	65.0	291.0
Typical User Charges		
Monthly O&M (Residential)	3.49	1.80
Monthly Debt Service	3.50	0.54
Total Monthly Charges	6.99	2.34

Table M-3. Summary of costs for Alternative 3 for Horsham Township and all municipalities (in thousands of dollars). Costs for all other municipalities in the planning area are same as indicated in Table M-1.

COST	Horsham Township	All Municipalities
Construction Cost	3,953.4	14,143.9
Salvage	1,405.9	3,453.7
Annual Operation & Maintenance	98.4	1,064.3
Total Present Worth	4,637.2	24,798.0
Average Annual Equivalent Cost	425.2	2,274.0
Distribution of Costs		
Federal EPA	3,160.9	10,725.6
Local Share	792.5	3,418.3
Annual Costs		
Operation and Maintenance (Industrial and Commercial)	13.6	61.7
Operation and Maintenance (Residential)	84.8	1,002.6
Debt Service (Industrial and Commercial)	10.1	24.9
Debt Service (Residential)	62.6	288.6
Typical User Charges		
Monthly O&M (Residential)	2.97	1.78
Monthly Debt Service	3.37	0.53
Total Monthly Charges	6.34	2.31

Table M-4. Summary of costs for Alternative 4 by municipality (in thousands of dollars).

COST		MUNICIPALITIES						
		Upper Dublin	Horsham	Warrington	Warminster	Warwick	Ivyland	All Municipalities
Construction Cost	Initial	0	1,444.9	2,933.5	6,952.5	183.1	113.4	11,635.4
	Phased		42.4					58.4
Salvage	Initial	0	638.6	960.7	1,041.8	28.3	17.0	2,681.4
	Phased		9.3					9.3
Annual Operation and Maintenance	Initial	28.8	81.3	149.8	754.5	20.5	12.3	1,047.2
	Phased		11.7					11.7
Total Present Worth		314.2	9,764.6	4,303.5	14,895.3	405.0	242.9	23,925.5
Average Annual Equivalent Cost		28.8	345.2	394.6	1,365.9	37.1	22.3	2,194.0
Distribution of Costs								
Federal EPA		0	1,027.2	2,123.3	5,214.4	141.9	85.1	8,591.9
Local Share		0	1,119.2	812.2	1,738.1	47.2	28.3	3,745.0
Annual Costs								
Operation and Maintenance (Industrial and Commercial)		0	43.6	16.3	30.0	1.3	0.5	91.7
Operation and Maintenance (Residential)		28.8	271.7	133.5	724.5	19.2	11.8	1,189.5
Debt Service (Industrial and Commercial)		0	14.2	8.1	6.3	0.3	0.1	29.0
Debt Service (Residential)		0	88.4	66.4	153.1	4.0	2.5	314.4
Typical User Charges								
Monthly O&M (Residential)		1.77	1.19	4.15	1.55	4.58	1.61	1.70
Monthly Debt Service		0	2.60	2.04	0.33	0.96	0.34	0.55
Total Monthly Charges		1.77	3.79	6.21	1.88	5.44	1.95	2.25

Table M-5. Summary of costs for Alternative 5 for Horsham and Upper Dublin Townships and all municipalities (in thousands of dollars). Costs for all municipalities in the planning area are same as indicated in Table M-1.

COST	Upper Dublin Township	Horsham Township	All Municipalities
Construction Cost	715.5	4,712.6	15,618.6
Salvage	201.7	1,688.0	3,937.5
Annual Operation and Maintenance	35.6	140.3	1,113.0
Total Present Worth	1,048.0	5,775.4	26,699.9
Average Annual Equivalent Cost	96.1	529.6	2,445.6
Distribution of Costs			
Federal EPA	542.0	3,405.1	11,551.8
Local Share	173.5	1,307.5	4,106.8
Annual Costs			
Operation and Maintenance (Industrial and Commercial)	0	19.4	67.5
Operation and Maintenance (Residential)	35.6	120.9	1,045.5
Debt Service (Industrial and Commercial)	0	16.6	31.4
Debt Service (Residential)	15.9	103.3	345.2
Typical User Charges			
Monthly O&M (Residential)	2.86	6.51	1.92
Monthly Debt Service	1.28	5.56	0.64
Total Monthly Charges	4.14	12.07	2.56

APPENDIX N

Overview of Waste Management Systems

Overview of Waste Management Systems

The range of alternative waste management systems to be initially addressed in facilities planning is defined by US-EPA Cost Effectiveness Analysis Guidelines [40 CFR part 35, Subpart E, Appendix A (5)]. These alternatives should include:

-Systems discharging to receiving waters
-Land application systems
-On-site and other non-centralized systems
-Systems employing the reuse of wastewater and recycling of pollutants

Systems discharging to receiving waters

Systems which discharge wastewater directly to receiving waters (streams, rivers, lakes, and oceans) require wastewater treatment works. These facilities remove objectionable constituents from the wastewater and discharge an effluent which is expected to meet State and Federal requirements for protection of surface water quality. The alternatives for municipal wastewater treatment comprise 3 major categories:

-Primary treatment
-Secondary treatment
-Advanced or Tertiary treatment

The treatment processes described here are for conventional regional treatment plants and as such may differ from treatment processes employed in small community treatment systems which utilize surface water discharge.

Primary treatment removes from the wastewater those pollutants which either will settle out or float. Wastewater which enters a plant for primary treatment first flows through a screen. The screen removes large floating objects, such as rags and sticks, that may clog pumps and small pipes. The screens typically are made of parallel steel or iron bars with openings of about 0.5 inches.

The screened wastewater then passes into a grit chamber, where sand, grit, cinders, and small stones are allowed to settle to the bottom. The grit or gravel removed by the grit chamber usually is taken from the tank, washed so that it is clean, and disposed of by landfilling near the treatment plant.

After screening and grit removal, the wastewater still contains suspended solids, some of which can be removed from the sewage by treatment in a sedimentation tank. These tanks are round or rectangular, usually 10 to 12 feet deep, and designed to hold the wastewater for periods of 2 to 3

hours. The rate of flow of wastewater must be very slow to allow sufficient time for the suspended solids to sink to the bottom. This mass of settled solids is called raw primary sludge. The sludge is removed from the sedimentation tank by mechanical scrapers and pumps.

The major purpose of secondary treatment is to remove the soluble biochemical oxygen demand (BOD) and suspended solids that are not removed by primary treatment. BOD is the amount of oxygen required to sustain microorganisms which consume the organic matter present in sewage. Secondary treatment is the minimum level of treatment which municipalities currently must provide. In most cases, secondary treatment systems employ biological processes and are designed to provide the proper environment for the microorganisms which break down the soluble organic materials.

The basic requirements for secondary treatment by biologic processes are: a large supply of microorganisms, good contact between these microorganisms and the organic material in the wastewater, adequate supplies of oxygen, and the presence of environmental conditions which enhance the growth and activity of these microorganisms (for example, proper temperature and sufficient time). A variety of approaches have been used in the past to meet these basic needs. The most common approaches are:

-Trickling filters
-Activated sludge
-Oxidation ponds (or lagoons)

Secondary treatment also can be achieved by non-biological processes which employ physical-chemical treatment or application to land.

Although secondary treatment processes, when coupled with disinfection, may remove over 85 percent of the BOD and suspended solids and nearly all pathogens, only minor amounts of some pollutants, such as nitrogen, phosphorus, soluble COD, and heavy metals, are removed. In certain situations, such as when the need to protect local water supplies is great, pollutants contained in a secondary effluent are of major concern. In these cases, processes capable of removing pollutants not adequately removed by secondary treatment are used in what is called tertiary or advanced wastewater treatment. These processes improve the effluent quality to the point that it is adequate for many reuse purposes and may convert what was originally a wastewater into a valuable resource.

Advanced wastewater treatment processes may include phosphorus removal, filtration (to remove suspended or colloidal matter), carbon adsorption (for removal of soluble organic materials which are resistant to biological breakdown), and nitrogen control.

Land application

The land application of wastewater or treated effluent entails the use of plants, the soil surface, and the soil matrix to remove certain wastewater constituents. In addition to treatment, land application systems may

be used for a combination of water reuse and disposal. The renovated water is either discharged to the groundwater or collected for discharge to surface waters.

Four processes which have been used successfully for land-based treatment of wastewater effluents are: overland flow, irrigation, high-rate irrigation, and infiltration-percolation. Except for overland flow, all processes have been used successfully in the US for the treatment of municipal wastewater. In other countries, the overland flow process has been used effectively for domestic wastewater treatment. All four processes have been applied to industrial wastewater, both in this country and elsewhere. Table N-1 is a list of the characteristics and requirements of the four land application processes.

The process characteristics, quality of the treated water, and how the applied water is dispersed differ greatly among the four processes. The quality of the water after treatment is a function of soil characteristics, crop type, system management, and especially loading rate. Loading rate and land area requirements overlap for the different processes. The wastewater quality, climate, soil, geology, topography, land availability, and quality requirements for return flow generally determine which of the four land treatment processes is most suitable for a particular region.

On-site and other non-centralized systems

Non-centralized collection, treatment, and disposal systems may be used to serve individual residences (on-site systems) or clusters of residences or commercial units (community systems) which neither are connected into nor a part of conventional treatment work. In nonurban settings, such arrangements may offer a less costly alternative to a conventional central or regional facility which serves a much more expansive area.

On-site systems may be publicly or privately owned. On-site technology may include treatment with surface or subsurface discharge, recycle and reuse, or evaporation. On-site systems characteristically provide treatment and disposal of wastewaters in the immediate locality of their generation.

Numerous strategies, including soil-dependent and non-soil dependent systems, must be considered for on-site and community treatment and disposal of wastewater. Land application systems and surface water discharge systems, as previously discussed for centralized facilities, also may be suitable and adaptable to non-centralized situations. Commonly used on-site technology includes the following:

- Septic Tank - Soil Absorption Systems
- Aerobic Treatment - Soil Absorption Systems
- Sand Filtration, Polishing and Disinfection

Table N-1. Four land application processes for treatment of municipal wastewater. (US-EPA 1976).

	Annual loading acre ft/ac/yr	Net irrigated land area requirement for 1-mgd flow	Objective	Soils and geologic materials	Dispersal of applied water	Impact on quality of applied water
Overland flow	5 to 25	45 to 225 ac plus buffer areas, etc.	Maximizes water treatment Crop harvest is incidental. May be used as secondary treatment of raw wastewater or advanced treatment of secondary treated wastewater.	Suitable for slow or very slow permeable soils and/or high water table conditions. Generally requires natural or constructed slopes of 2 to 8 percent.	Most water to surface runoff. Some water to evapotranspiration and very little water to percolation.	BOD and suspended solids greatly reduced. High nitrogen removal. Some phosphorous removal. Reduction of some heavy metals. Little change in total dissolved ionic solids (TDIS).
Irrigation	1 to 5	225 to 1,100 ac plus buffer areas, etc.	Maximizes agricultural production by supplying irrigation needs. May be considered a reuse option as well as advanced treatment of partially treated wastewater.	Suitable for most irrigable agricultural soils. Irrigation method will depend on soil, topography and crop.	Most water to evapotranspiration. Some water to percolation and leaching of salts. Tailwater runoff from surface irrigation can be controlled.	BOD and suspended solids almost completely eliminated. Nutrients removed by crop and soil. Heavy metals adsorbed or precipitated. TDIS concentration greatly increased by evapotranspiration. Little change in total salts (applied ≃ leached). Increase in hardness of percolate.

Table N-1. Four land application processes for treatment of municipal wastewater. (concluded)

	Annual loading acre ft/ac/yr	Net irrigated land area requirement for 1-mgd flow	Objective	Soils and geologic materials	Dispersal of applied water	Impact on quality of applied water
High-rate irrigation	1 to 10	110 to 1,100 ac plus buffer areas, etc.	Maximizes wastewater treatment by supplying nutrients and water as needed by crop. Agricultural crops are a side benefit. In case of conflict, wastewater treatment is higher priority than crop production.	Suitable for more permeable irrigable agricultural soils. Irrigation method will depend on soil, topography, and crop. Requires good natural or constructed drainage.	Most water to percolation and evapotranspiration. Tailwater runoff from surface irrigation can be controlled. May result in buildup of groundwater mound.	BOD and suspended solids almost completely eliminated. Nutrients removed by crop and/or soil. TDIS concentration increased by evapotranspiration. Additional salts leached out of soil by excess applied water (salt loading).
Infiltration-percolation	11 to 500	2 to 100 ac plus buffer areas, etc.	Maximizes water filtration and percolation to groundwater. Crop production is not a benefit. There may not be a crop.	Suitable for highly permeable soils. Requires very good natural or constructed drainage.	Most water percolates to groundwater. Some water to evapotranspiration. No runoff. May result in buildup of large groundwater mound.	BOD and suspended solids reduced. Some nutrient removal by soil and crop. Additional salts leached out of soil by excess applied water (salt loading). Increase in hardness of percolate.

- Mound Systems
- Evapotranspiration Systems
- Evaporation Systems
- Waterless Toilets/Greywater Systems
- On-Site Recycle Systems
- Combination systems

In choosing on-site systems, first it is necessary to evaluate design constraints, such as soil types, site topography, geological characteristics, climate, and water quality objectives. Then the construction, operation, and maintenance requirements must be identified for each system. Although many choices are available for on-site and community systems, only a few offer economical and environmentally acceptable solutions.

Reuse of wastewater

Reuse and by-product recovery is one of the major techniques for handling wastewater. Effluent quality required for reuse varies greatly by the situation, however the ultimate pollutional effect must not exceed that which would occur if treatment and discharge or land application were employed. Wastewater effluent, after varying levels of treatment, may be reused for:

- Irrigation to recover nutrient or water value
- Industrial recycling to recover nutrient, water, or heat value
- Commercial recycling to recover nutrient, water, or heat value
- Aquaculture uses, including all farming and production operations
- Groundwater injection to supplement water supplies or prevent subsidence
- Development of arid lands

In addition to effluent, other treatment plant wastes such as sludges, methane gas, and waste-activated carbon also may be reused. Sludge may be applied to land or used to provide raw materials for industrial or commercial manufacture of saleable products. The sale of dried sludge as a soil builder or conditioner may provide additional revenue. Similarly, methane gas can be put to beneficial use for municipal or industrial purposes.