ALLEN BROOK-MUDDY BROOK STORMWATER MANAGEMENT EVALUATION

Prepared For:
Lake Champlain Basin Program
54 West Shore Rd
Grand Isle, Vermont 05458

December 1997

Prepared By:
James Pease
Vermont Department of Environmental Conservation
Water Quality Division
10 North Building
103 S. Main Street
Waterbury, VT 05676

PART 2: Individual Watershed Stormwater Management Evaluations

The findings of this project are presented in the following individual watershed evaluations. The intent of reporting results in watershed format is to facilitate the incorporation of these findings into comprehensive watershed management plans for each of the project watersheds. These evaluations are not comprehensive management plans and should not be viewed as such. The intent is for these evaluations to serve to focus planning efforts and to provide a basis for evaluating specific implementation activities that will most likely result in environmental benefits in the form of minimized pollutant loadings to the target watersheds and to Lake Champlain and restoration of impaired riparian and aquatic habitat and the biologic communities that those habitats support. Above all, it is the hope of this project that these findings will stimulate the development of comprehensive multi-jurisdictional watershed planning efforts within the project area, resulting in watershed management conducted across political boundaries with full investment by local and regional authorities.

This project has assembled and/or created a number of Geographical Information System (GIS) data layers relevant to watershed planning in the project area (see Part I). Information from these data layers is presented in a series of figures attached to each watershed evaluation. These data layers with their associated data tables, will be available to local and regional planners. It should be recognized that the pollutant projections presented here are planning estimates and caution should be exercised when interpreting these values.

This project recognizes that local governments in the project area have made tremendous commitments to protecting and preserving the natural resources associated with surface waters. Local and regional planning, zoning, and conservation commissions have established a strong record of environmental concern. In order to fully realize effective watershed management, it is critical that individual missions, goals, objectives, and policies be consolidated under the umbrella of comprehensive watershed planing and management. It is hoped that the findings of this project will assist those responsible for planning and environmental management in the project area in their efforts to restore, protect, and preserve the aquatic resources of these highly vulnerable developing watersheds.

Allen Brook-Muddy Brook Stormwater Management Evaluation

Watershed Description

Allen Brook was originally called Allen's Brook. It was named for Ethan Allen who was active in land speculation in Chittenden County. A mill and millpond were once located just below the Industrial Avenue crossing at the fall line. The watershed was converted from forest to open agricultural lands in the early 19th century. Allen Brook watershed (**Figure Al:1**) is located almost entirely in the town of Williston. The stream has its source in Mud Pond, a protected natural area in the southeast corner of the town. The stream flows north and then west to meet the Winooski River and Muddy Brook at the S.Burlington town line. The watershed area is approximately 30 km2.

Muddy Brook was named by early settlers for its turbid appearance and muddy bottom. It is one of the earliest named streams being mentioned in the 1794 survey that separated Williston from Burlington. A large saw and carding mill, whose foundation still exists today, operated on the brook just north of the Williston Road crossing from 1790-1850. The watershed was largely converted from forest to agriculture. The upper tributary which drains south to Shelburne Pond was originally named Seely Brook. Muddy Brook watershed (**Figure Mu:1**) is located in the towns of Shelburne, St. George, Williston and S.Burlington. The headwaters can be separated into the Shelburne Pond watershed and Sucker Brook. The north and western half of the watershed, including the Shelburne Pond drainage, is experiencing the greatest development pressure. Shelburne Pond is a protected University of Vermont natural area although its watershed is not. The watershed area is approximately 54 km2.

Land Use (see Table 1-1)

In 1995 the Allen Brook watershed was approximately 50% agricultural cropland or pasture (both idle and active), 25% forest and 25% residential/developed. Projected future land use is approximately 50% agricultural/open space, 30% urban mixed use, 10% designated growth centers, and 10% industrial/commercial. Allen Brook watershed is approximately 5% impervious (**Figure Al:2**).

In 1995 the land use of upper Muddy Brook (Sucker Brook and Shelburne Pond) was approximately 50% agricultural (idle and active farmland), 30% forest and 20% residential. The lower watershed was approximately 30% commercial/industrial, 30% residential and 40% agricultural (idle and active farmland). Projected future land use in the upper watershed is 20% urban mixed use, 20% open space, and 60% agricultural. In the lower watershed, projected land use is 30% mixed industrial/commercial, 20% subregional growth center, 10% mixed urban use, and 40% agricultural. Muddy Brook watershed is approximately 4% impervious; the Taft Corners tributary is approximately 14% impervious (**Figure Mu:2**).

Soils

Adams-Windsor sandy loams are predominant in the area bounded by Industrial Ave-Route 2a and could provide excellent opportunities for stormwater infiltration treatment. Soils suitable for stormwater ponds are also abundant throughout the lower developing areas of both drainages. Highly erodible soils exist to a very limited extent. However these soils are predominant near Taft Corners; construction BMP's for erosion control of these soils should be required as this subregional growth center expands. These soils are also predominant in the developing north west corner of the Muddy Brook watershed. Wetpond/wetland soils are also present and could provide sites for stormwater BMP's for the proposed large scale residential developments in this area. (**Figures Al:3-5, Mu:3-5**).

Table 1-1. Allen Brook - Muddy Brook: Current and Projected Land Use as percent watershed area. Projected land use is indicated in terms of zoning or planning categories. Forest and Residential/Developed land-use categories are subsumed into the planning designations.

	Allen Brook		Muddy Brook-Upper		Muddy Brook-Lower	
Land Use	**1995**	**Projected**	**1995**	**Projected**	**1995**	**Projected**
Ag/Open	50	50	50	80	40	40
Forest	25		30			
Res/Dev	25		20		30	
Com/Ind		10			30	30
Urban/Mixed		30		20		10
Regional Growth Center		10				20
Impervious Surface Area	*5.5*		*1.5*		*11.9*	

Riparian Corridor and Biological Evaluations

Evaluation of the Allen Brook riparian habitat in 1995 indicated a relatively healthy riparian ecosystem and corridor with several exceptions: five small tributaries are currently degraded by agriculture, residential development and the municipal golf course **(Figure Al:6)**. These tributaries are experiencing runoff impacts resulting in some loss of aquatic habitat and nutrient enrichment.

Levels of sediment embeddedness in Allen Brook, indicative of aquatic habitat degradation, are most severe at the mouth and in the central area of the watershed between mileposts 0-1 and 2.5-5 **(Figure Al:8)**. The high levels of sediment at the mouth are attributable to erosion from unstable banks where the brook passes through active agricultural lands. The high levels at mile 2.5-5 are directly attributable to erosion from construction in the Taft Corners-Southview area. The fish community reflects this pattern of impairment with increasing biological integrity from the mouth to the headwaters **(Figure Al:7)**. Macroinvertebrate sampling indicates that at all sites sampled the Class B water quality standard is being achieved although at least one tributary, the Williston Golf Course trib, is habitat impaired. Nutrient enrichment and sediment impairment were not evident at the 3 sample sites. The upstream sites are among the least impaired of all sites evaluated during the course of this project and are rated as showing good to excellent biological condition. These sites, as representatives of potential biological condition in urban streams, are worthy of protection given the rarity of such sites in the study area.

In Muddy Brook, only the corridor in the lower watershed was assessed **(Figure Mu:6)**. Although the main stem appears to have a relatively healthy riparian corridor, the tributaries are being paved over, piped, channelized, or otherwise developed relatively quickly. Degradation of these tributaries is reflected in the overall health of the aquatic biota in the main stem.

Sediment levels in Muddy Brook were moderate given the sand plain character of the stream, although silt levels were excessive in the study tributary and the channel below Kimball Drive **(Figure Mu:7)**. Construction in the Taft Corners Commercial Parks and along Kimball Drive are the most likely source for this sediment. A high frequency of occurrence of black spot parasite in nongame fish in the main channel may be indicative of environmental stress (Langdon, personal communication). Macroinvertebrate sampling indicates that enrichment is occurring in the brook. The Muddy Brook tributary watershed (Taft Corners) and the main brook do not currently meet Class B standard for biological condition at the sites sampled **(Figure Mu:8)**.

Watershed Management Goals

The following are watershed management goals suggested by the findings of this evaluation:

1. Have in place the appropriate watershed planning and management infrastructure for the Muddy Brook and Allen Brook watersheds such that comprehensive watershed management issues become an integral part of local planning processes. Watershed management should emphasize stream buffer protection, land acquisition, and watershed restoration.

2. Ensure the maintenance and protection of any existing high quality biological communities and habitats.

3. Restore impaired aquatic and riparian habitat such that biological integrity consistent with Class B water quality standards is attained.

4. Establish consistent inter-jurisdictional (Williston, South Burlington, Shelburne) stormwater management and stream protection policies throughout the Allen and Muddy Brook watersheds.

5. Ensure that watershed residents are aware of watershed management issues and are well educated in the principles of stream and watershed protection.

Existing Zoning

Allen Brook and Muddy Brook are viewed jointly here for watershed management purposes. Allen Brook is located entirely in the town of Williston, Muddy Brook is located in Williston, S.Burlington and Shelburne.

The town of Williston has established a 150' setback (150'/side) conservation buffer zone. This zone does not specifically prohibit development and is termed an "aesthetic" conservation buffer (Jeff Fehrs, personal communication). The Williston Conservation Committee reviews development proposals and verifies its compatibility with the buffer zone; variances are allowed. The committee makes decisions on development based on wildlife, recreation and water quality protection. Agriculture is exempt from the buffer zone. Mud Pond and lands surrounding it in the headwaters of Allen Brook have been designated a biological natural area. The zoning designation of almost the entire lower watershed (I89 to the mouth (2391 acres)) as medium density residential may drastically change water quality in the brook in the foreseeable future.

The east side of Muddy Brook in Williston has the same flood plain buffer zone as Allen Brook. The west side of the brook in S.Burlington is protected by a 100' setback (100'/side) conservation buffer where development is precluded; variances are not allowed although there is a significant amount of development that pre-existed establishment of this zone in 1974. This setback is reduced to 50' (50'/side) on all tributaries of the brook. The S.Burlington Natural Resources

Committee reviews all proposed development adjacent to the buffer. Agriculture is exempt from the buffer zone. The S.Burlington Natural Resources Committee has proposed designating the entire S.Burlington portion of the upper Muddy Brook watershed as a Water Quality District (City of S.Burlington, 1991) in order to protect water quality in Shelburne Pond from nutrient enrichment. In this district impervious surface area would be regulated, permeable pavement would be utilized, and infiltration and wetpond best management practices would be required. S.Burlington has requested that Shelburne also designate its portion of the upper Muddy Brook watershed as a similar Water Quality District. However this designation has not as of yet occurred.

Potential nonpoint sources of pollution in the Allen and Muddy Brook watersheds were inventoried and mapped as described in Part 1 of this report. **Figures Al:9 and Mu:9** show impervious surface; **Figures Al:10 and Mu:10** show outlines of stormwater sewersheds; **Figures Al:11 and Mu:11** show VTDEC stormwater discharge permit locations and nonpoint sources such as eroding stream banks identified during the course of this project. **Figures Al:12 and Mu:12** show various natural features of the watershed, including wetlands and public lands.

Education Strategy

An education strategy for urban nonpoint source pollution should include the following actions: 1) informational mailings and public service announcements to watershed residents on clean stream habits, 2) public involvement in cleanup, erosion and habitat restoration projects, 3) storm drain stenciling, 4) school natural history programs and, 5) citizen monitoring (Drinkwin, 1995; Lake Champlain Committee, 1992).

Implementation Strategy

As described in Part 1 of this report, annual pollutant loadings for total phosphorus, total suspended solids, total metals, and fecal coliform were calculated for each sewershed and the sewersheds ranked; sewersheds exceeding threshold criteria were targeted for further evaluation **(Table 1-2, Figures 1.1-1.4)**.

Allen Brook: There are no targeted storm sewersheds or permitted storm water discharges at the present time in Allen Brook. A large percentage of the existing residential and commercial development is under an active permit with VTDEC. Only one storm sewershed, Williston Elementary School, showed high total PAH loadings and the recommended treatment BMP for this site is a constructed wetland. At the present time the VTDEC is coordinating, with private landowners and USFWS, the voluntary establishment of an agricultural buffer on the lower reaches of Allen and Muddy Brooks.

Muddy Brook: Implementation strategies here refer only to the lower reaches of Muddy Brook (Van Sicklen Rd. to the mouth) and include the Taft Corners tributary. There are 2 targeted storm sheds constructed prior to the VTDEC stormwater permitting program (non-permitted), and 6 targeted storm sewersheds with pending or active VTDEC discharge permits to Muddy Brook. One additional storm sewershed, Digital Equipment Building 2, was targeted but is not included in the following implementation recommendations **(Figure Al:13)**.

- Non-permitted:
    - Griswold Industrial Park
    - Engineers Drive
- VTDEC Permit active or pending:
    - Burlington International Airport
    - Taft Corners Commercial Parks 4 (Walmart) and 5
    - Maple Tree Place

Alling Industrial Park 1
Blair Park

The recommended strategy for these targets is as follows:

- Infiltration BMP's are recommended for the non-permitted storm sewer sites. Recommended structure sites, based on the presence of soil types conducive to infiltration and land ownership, are indicated in map 7 (Part 1). Implementation would result in an estimated Total Suspended Solids (TSS) and Total Phosphorus (TP) annual load reduction to Muddy Brook, as calculated from the mean of a range of export coefficients, of 13,660 kg and 17 kg respectively. Treatment option efficiencies for all targeted pollutants and cost estimates are included in **Table 1-3**. Cost estimates for infiltration basin implementation, based on available BMP construction cost estimates (Griffin, 1993) range from $966 - $5800 for the Engineers Drive site to $4,060 - $24,360 for the Griswold Industrial Park site (see Part 1 of this report for cost estimation methodologies).

- Wetpond BMP's are recommended as modifications to the targeted discharge permits. TSS and TP annual loading reduction at these sites would be 24,205 kg and 28 kg respectively. Individual site treatment efficiencies for all target pollutants are detailed in **Table 1-3**. Cost estimates for wetpond implementation are detailed in **Table 1-3** and range from $1340 - $27,000 at Burlington International Airport to $4,400 - $87,000 at the Taft Corner Commercial Park 4 site.

- The Engineer Drive site has destroyed much of the existing riparian habitat (see Muddy Brook RCE map). Riparian zone restoration activities are recommended for this area.

The sum total for all implementations would reduce existing sediment and phosphorus loading from these targeted sewersheds by averages of 63% and 48% respectively. Estimated total capital costs for BMP implementation in this watershed ranges from $21,916-$367,962 based on available BMP construction cost estimates (Griffin, 1993). Annualized capital costs for whole watershed implementation based on loans of 30 year term and 5% interest range from $1426 - $23,936. Annual operations and maintenance costs, nor included here, can be estimated at about 5% of the capital cost (Holmes and Artuso, 1995). Since storm water control structures already exist for several of the targeted permits, only modification to these structures would be necessary, substantially reducing potential costs. Maple Tree Place and Walmart (Taft Corners Commercial Park 4) will have wetponds which may remove them from targeting depending on final site plan review (Sternbach, personal communication). Implementation recommendations, estimated treatment efficiencies and loading reductions, and estimated capital and annualized capital costs are summarized in **Table 1-3.** Annualized capital costs for phosphorus and suspended solids loading reduction at individual sites range from $15 - $1,567 per kg/yr for TP and $0.02 - $1.88 per kg/yr for TSS.

Recommendations: The following recommendations, deriving from the findings of this evaluation, are made as technical suggestions that, if implemented, have a high likelihood of positively influencing water quality goals for the watershed. They are not intended to replace the development of a fully comprehensive watershed management plan.

1. The most significant recommendation that can be made here is for the establishment of a watershed

planning process that will be able to incorporate the findings of this evaluation into a comprehensive watershed management plan. Such a plan would institutionalize stormwater and watershed management policies across political boundaries. Such a plan would also necessarily address the implementation issues such as prioritization and financing (Schueler, 1996).

2. Watershed Restoration - The Lower Muddy Brook watershed, with nearly 12 percent impervious surface, is the most sensitive area of the Allen-Muddy watershed. Aquatic biota and habitat are impaired. It is likely that measures to minimize the release of sediments and suspended solids in this portion of the watershed will result in improved habitat and biological integrity. Therefore:

- Additional feasibility studies for BMP implementation recommendations for targeted sewersheds, **(Table 1-3)** prioritized by estimated Total Suspended Solids loading **(Table 1-2)**, should be initiated (see implementation plan).

- Efforts to reduce discharges from significant sources of nonpoint sediment, such as eroding or unstable banks identified by this or other evaluations, should be pursued. Opportunities to implement stream and riparian habitat restoration and improvement activities should be fully explored. Programs such as the Youth Conservation Corps and the USFWS Partnership program are likely resources for implementing watershed restoration activities. Cooperative efforts between landowners and various State, private, and Federal Agencies should be encouraged and coordinated. Riparian habitat associated with the Engineer Drive stormwater discharge site should be targeted for restoration.

3. Coordination - Resources should be allocated to provide for coordination of activities, including the acquisition of implementation resources, related to urban watershed management. VTDEC and USEPA are currently funding a limited service position to provide this function. If multi-jurisdictional urban watershed management is to be effective in the future, this function must be maintained, ideally through institutionalized regional planning.

4. Monitoring - Continued monitoring of watershed condition should be conducted. BMP implementation effectiveness should be monitored. While VTDEC plans to maintain a minimal level of biological monitoring at many of the sites previously monitored, its resources are limited. Monitoring issues should be developed through the watershed planning process that should evolve at the regional or local level (Brown, 1996).

5. Education - A watershed management educational strategy should be developed and implemented for the Allen-Muddy Brook watershed. Generalized materials related to watershed protection are available from various private and governmental organizations. The educational strategy should, among other things, address the means by which residents of the watershed will be exposed to the appropriate materials (Lake Champlain Committee, 1992; Drinkwin, 1995).

Allen - Muddy Brook Resources

Fish Community Sampling In District 4. 1990. Memorandum from Biomonitoring and Aquatic Studies Section to Department of Fish and Wildlife, Agency of Natural Resources, State of Vermont.

Contamination From Airport Tributary. 1996. Memorandum from Biomonitoring and Aquatic Studies Section to Burlington International Airport. Agency of Natural Resources, State of Vermont.

Muddy Brook, Boyer Quarry and Potash Source: A Miniplan for the Southeast Quadrant of South Burlington. 1972. South Burlington Natural Resources Committee, City of South Burlington, South Burlington, VT.

Table 1-2. Significant Stormwater Discharges in the Allen Brook-Muddy Brook Watershed: Discharges are targeted based on estimated exceedance of annual loading thresholds for: suspended solids (4,536 kg/year); total phosphorus (6.8 kg/year); total metals (5.4 kg/year); total PAH's (36 kg/year); fecal coliform (500,000 colonies/yr). Existing treatment structures are indicated. *Italics indicate stormwater discharges with VTDEC permits.* EIA% is the percent surface area as Effective Impervious Surface Area. Loadings are calculated from the means of ranges in export coefficients taken from the literature. See Part 1 of this report for loading calculation methods.

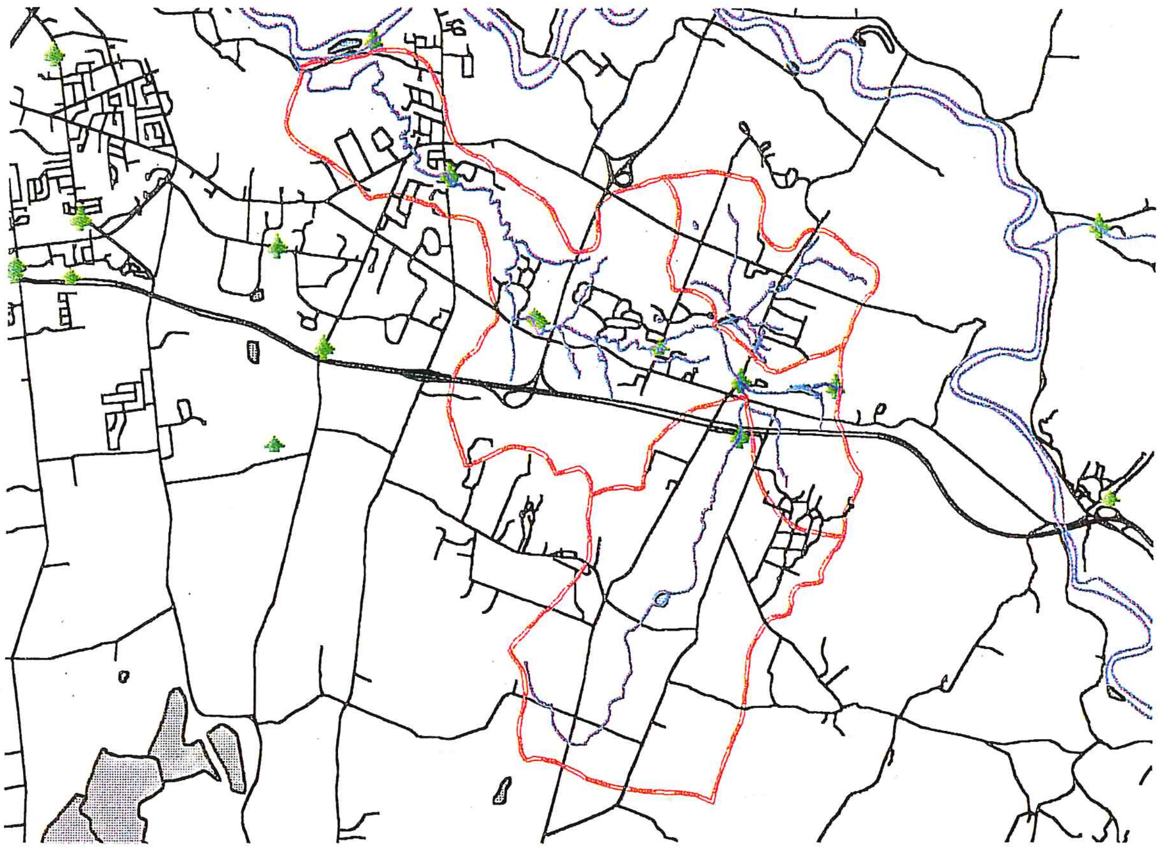
Recwater	Storm sewershed	Treatment (Appendix 4)	EIA%	Loading kg/yr
	Highest Total Suspended Solids (**Figure 1.2**)			
Muddy	Griswold Industrial Park	CB	89.5	15478
Muddy	*Taft Corners Commer. Park 5*	*WL/GS/CB*	37.0	11899
Muddy	*Burlington Interntl. Airport*	*CB*	73.7	8501
Muddy	Digital Equipment Building 2	DP/CB	63.2	7311
Muddy	*Taft Corners Commer. Park 4*	*GS/SB/CB*	10.6	5607
Muddy	*Alling Industrial Park 1*	*CB/IG/SB*	31.7	5570
	Highest Total Phosphorus (**Figure 1.3**)			
Muddy	Griswold Industrial Park			24
Muddy	*Taft Corners Commer. Park 5*			19
Muddy	*Burlington Interntl. Airport*			16
Muddy	Digital Equipment Building 2			56
Muddy	*Taft Corners Commer. Park 4*			9
Muddy	*Alling Industrial Park 1*			9
Muddy	*Maple Tree Place 1*	DP/GS	18.6	7
	Highest Total PAH (Commercial Landuses Only)			
Allen	*Williston Elementary School*	*CB/SB/WL*	70.5	44
Muddy	Griswold Industrial Park			166
Muddy	*Taft Corners Commer. Park 5*			127
Muddy	*Burlington Interntl. Airport*			91
Muddy	Digital Equipment Building 2			78
Muddy	*Taft Corners Commer. Park 4*			60
Muddy	*Alling Industrial Park 1*			60
Muddy	*Maple Tree Place 1*			47
Muddy	*Blair Park*	SB/RR/GS/DP	8.8	45
Muddy	Engineers Dr	CB/CP	99.0	43
Muddy	Taft Corners Shopping Center	SB/CB	55.8	40
	Highest Total Metals (**Figure 1.4**)			
Muddy	Griswold Industrial Park			19
Muddy	*Taft Corners Commer. Park 5*			14
Muddy	*Burlington Interntl. Airport*			10
Muddy	Digital Equipment Building 2			9
Muddy	*Taft Corners Commer. Park 4*			7
Muddy	*Alling Industrial Park 1*			7

Table 1-3. Muddy and Allen Brook Watersheds: Stormwater BMP implementation treatment and capital costs estimates for targeted sewersheds. All estimates are based on a mean of a range of export coefficients for TP and TSS

Rec. Wat.	Sewershed	BMP	TP Pre BMP Kgs/year	TP Post BMP Kgs/year	TP Reduction Kgs/year	TSS Pre-BMP Kgs/year	TSS Post-BMP Kgs/year	TSS Reduction Kgs/year	Capital Cost-Low dollars	Capital Cost-High dollars
Muddy Brk.	Engineers Dr.	Infiltration	6	3	3	4049	1215	2834	$966	$5,796
Muddy Brk.	Griswold Park	Infiltration	24	10	14	15478	4644	10834	$4,060	$24,361
Muddy Brk.	Blair Park	Wet Pond	7	4	3	4172	1669	2503	$3,614	$72,276
Muddy Brk.	Tafts Park 4	Wet Pond	9	5	4	5607	2243	3364	$4,339	$86,788
Muddy Brk.	Tafts Park 5	Wet Pond	19	10	9	11899	4759	7140	$3,485	$69,708
Muddy Brk.	Maple Tree	Wet Pond	7	4	3	4366	1746	2620	$2,249	$44,980
Muddy Brk.	Alling Park	Wet Pond	9	5	4	5570	2228	3342	$1,865	$37,302
Muddy Brk.	BI Airport	Wet Pond	13	7	6	8501	3400	5101	$1,338	$26,751
		Totals	**94**	**48**	**46**	**59642**	**21904**	**37738**	**$21,916**	**$367,962**
		% reduction			49%			63%		

	Capital Costs/kg				*Annualized Capital Costs*					
Sewershed	TP Cost Low Dollars/kg	TP Cost High Dollars/kg	TSS Cost Low Dollars/kg	TSS Cost High Dollars/kg	Annual TP Costs $/kg 30 yrs @ 5% Low	Annual TP Costs $/kg 30 yrs @ 5% High	Annual TSS costs $/kg 30 yrs @ 5% Low	Annual TSS costs $/kg 30 yrs @ 5% High	Total Annualized Costs 30 Years @ 5% Low	Total Annualized Costs 30 Years @ 5% High
Engineers Dr.	$322	$1,932	$0.34	$2	$21	$126	$0.02	$0.13	$63	$377
Griswold Park	$290	$1,740	$0.37	$2	$19	$113	$0.02	$0.15	$264	$1,585
Blair Park	$1,205	$24,092	$1.44	$29	$78	$1,567	$0.09	$1.88	$235	$4,702
Tafts Park 4	$1,085	$21,697	$1.29	$26	$71	$1,411	$0.08	$1.68	$282	$5,646
Tafts Park 5	$387	$7,745	$0.49	$10	$25	$504	$0.03	$0.64	$227	$4,535
Maple Tree	$750	$14,993	$0.86	$17	$49	$975	$0.06	$1.12	$146	$2,926
Alling Park	$466	$9,326	$0.56	$11	$30	$607	$0.04	$0.73	$121	$2,427
BI Airport	$223	$4,459	$0.26	$20	$15	$290	$0.02	$1.30	$87	$1,740
AVERAGE	**$476**	**$7,999**	**$0.58**	**$10**	**$31**	**$520**	**$0.04**	**$0.63**	**$1,426**	**$23,936**

Allen Brook



Watershed Boundary
Allen Brook
Lakes
Winooski River
Fish Monitoring Station
Macroinvertebrate Monitoring Station
Macroinvertebrate Monitoring Station
Roads

Figure AI-1: Allen Brook watershed showing roads, surface waters, and biological monitoring sites.

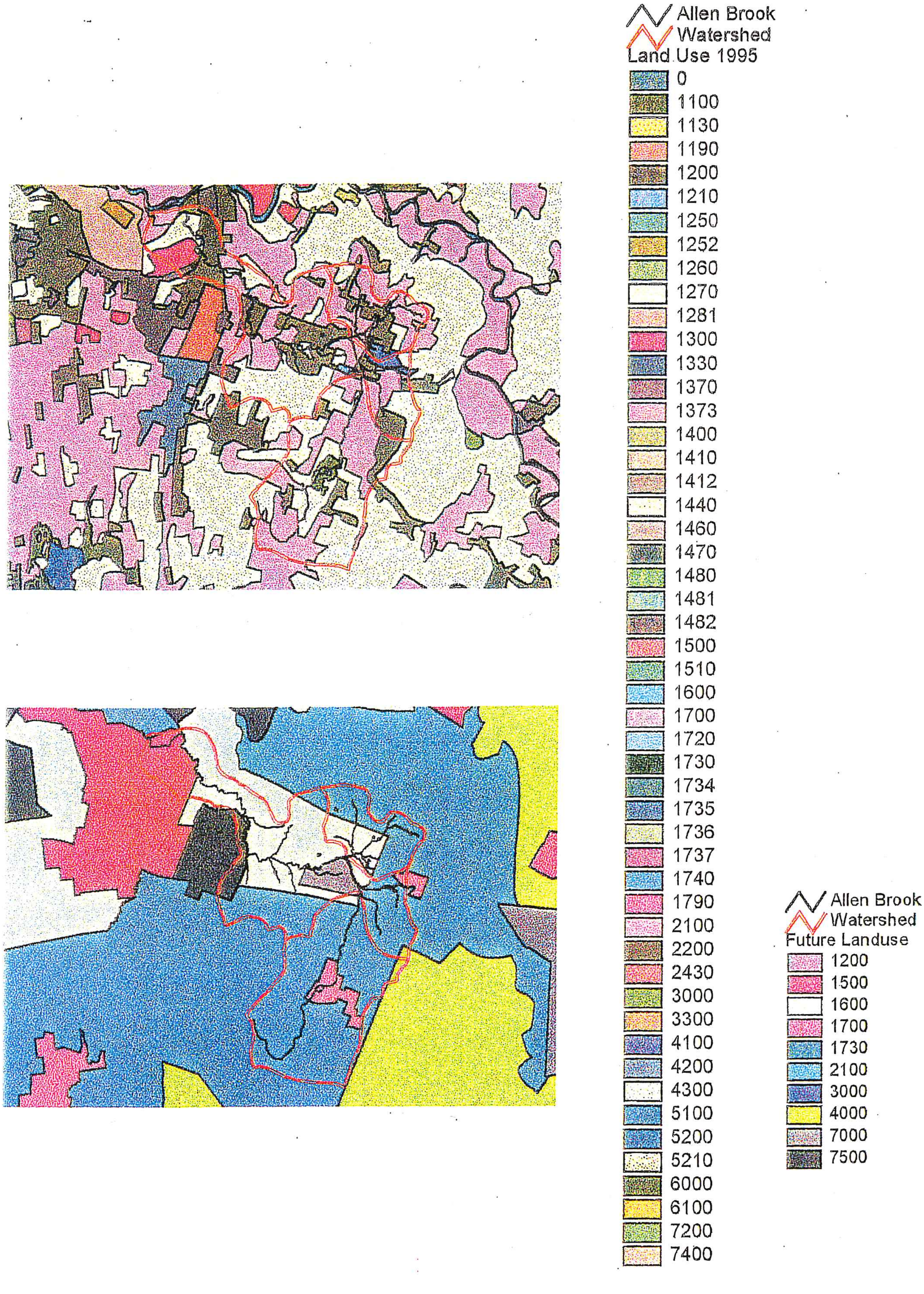


Figure Al-2: Allen Brook watershed 1995 actual land use; and future landuse as defined by zoning designation.

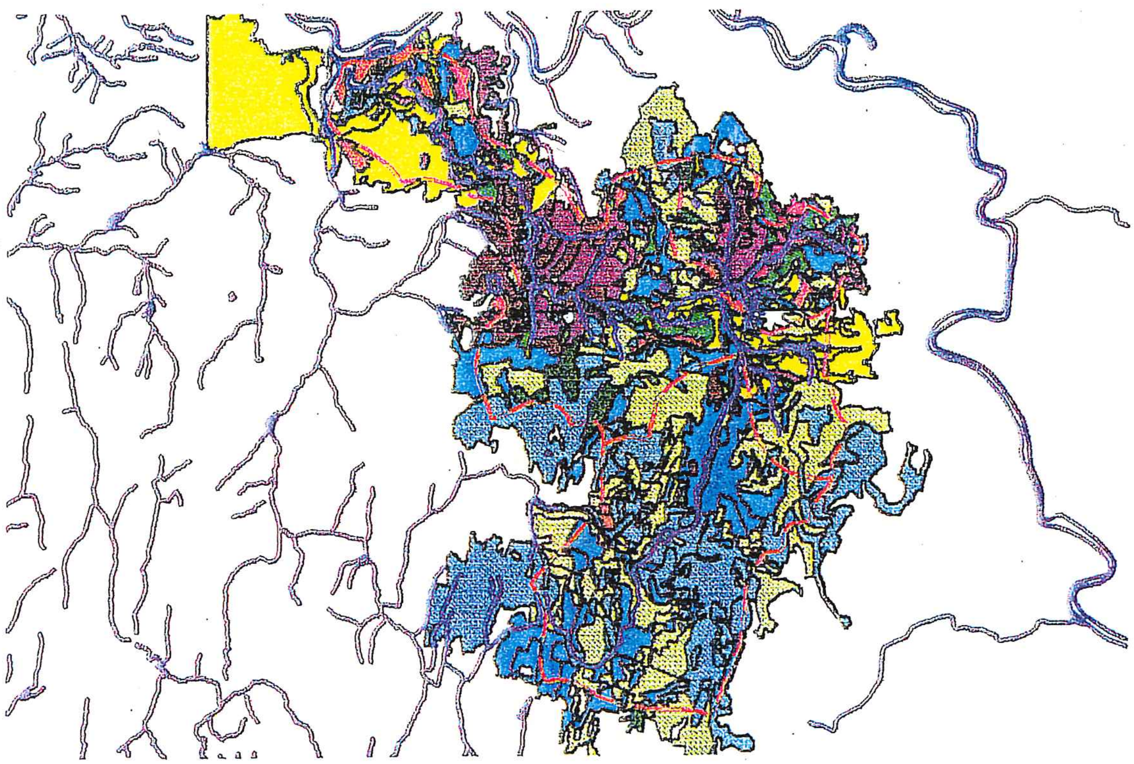


Figure AI-3: Allen Brook generalized soils map.

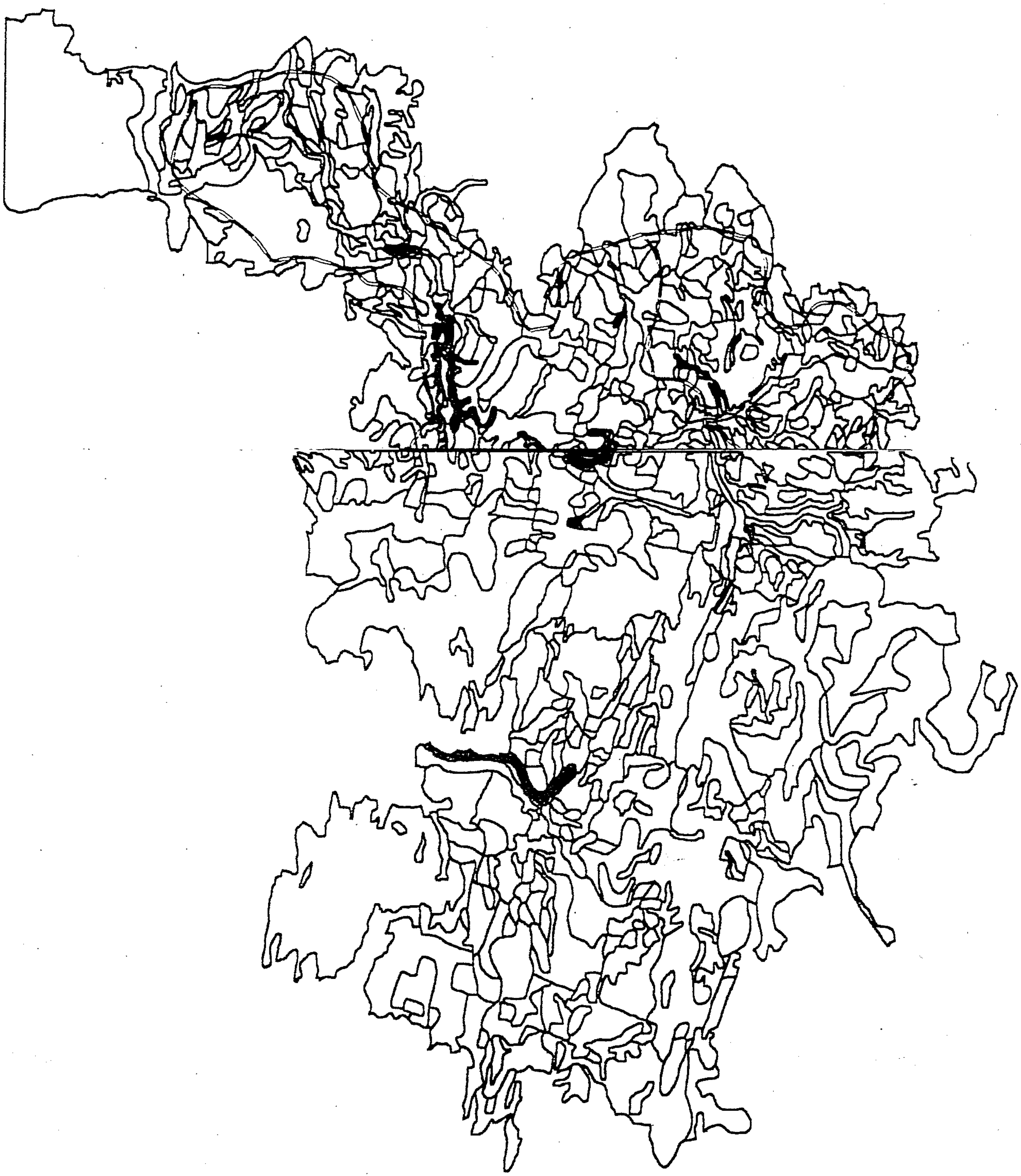


Figure AI-4: Allen Brook watershed - areas of highly erodible soils. These soils are easily displaced.

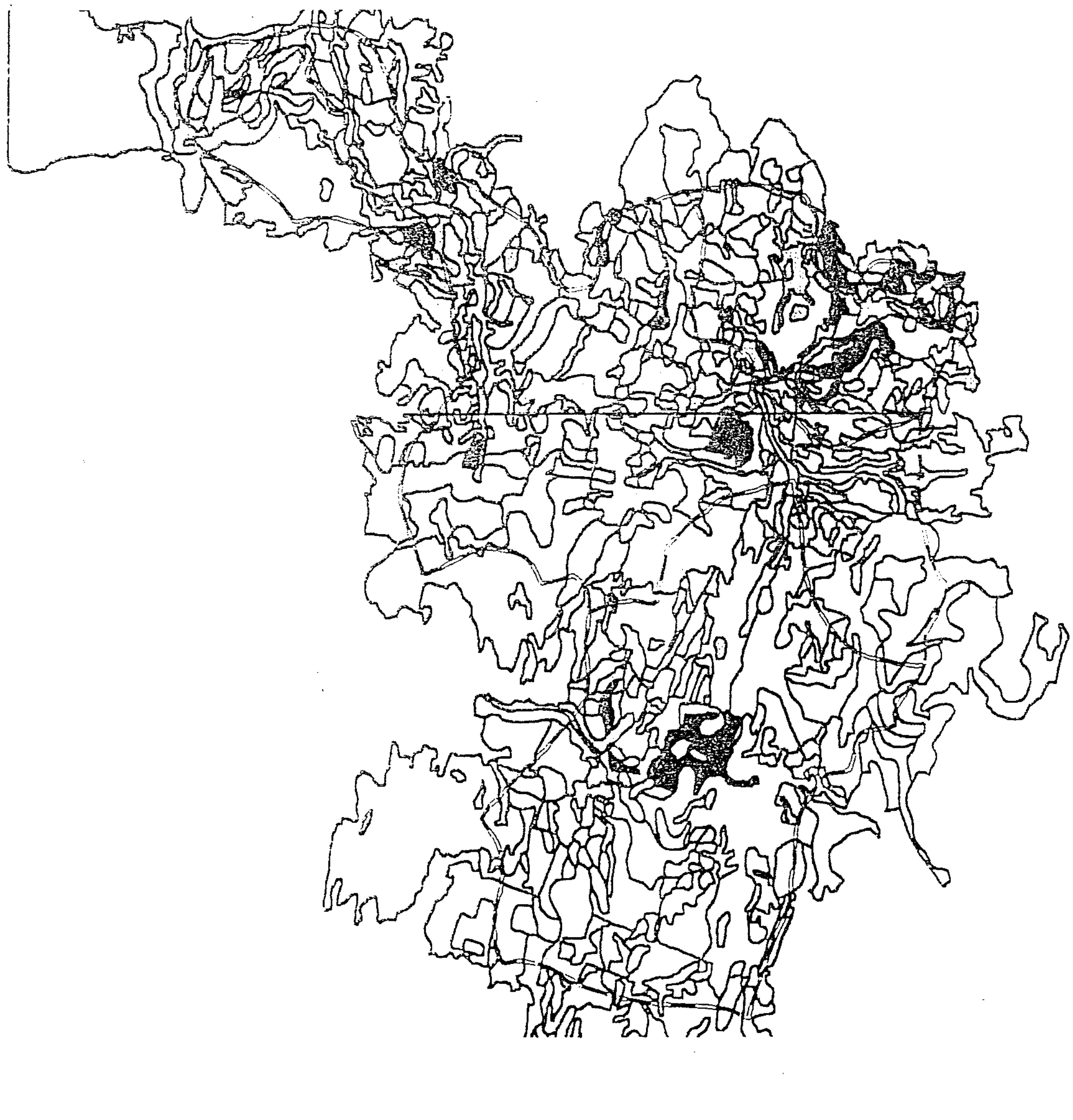
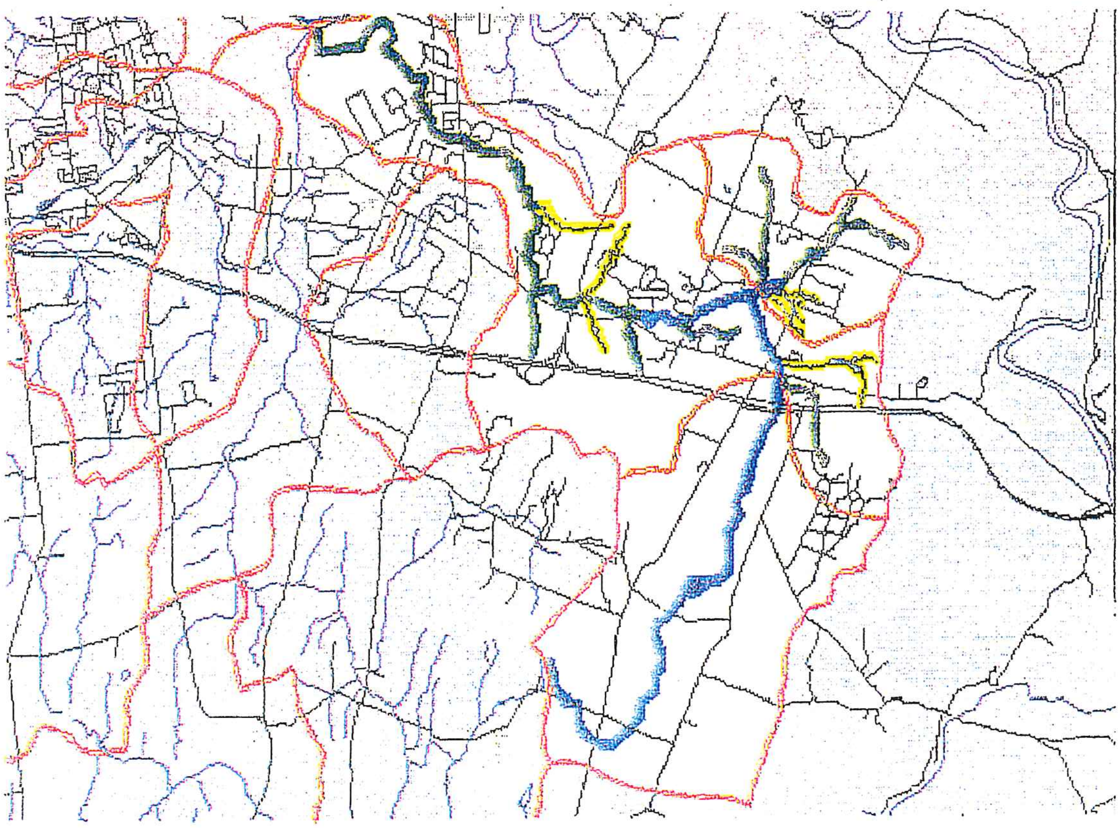


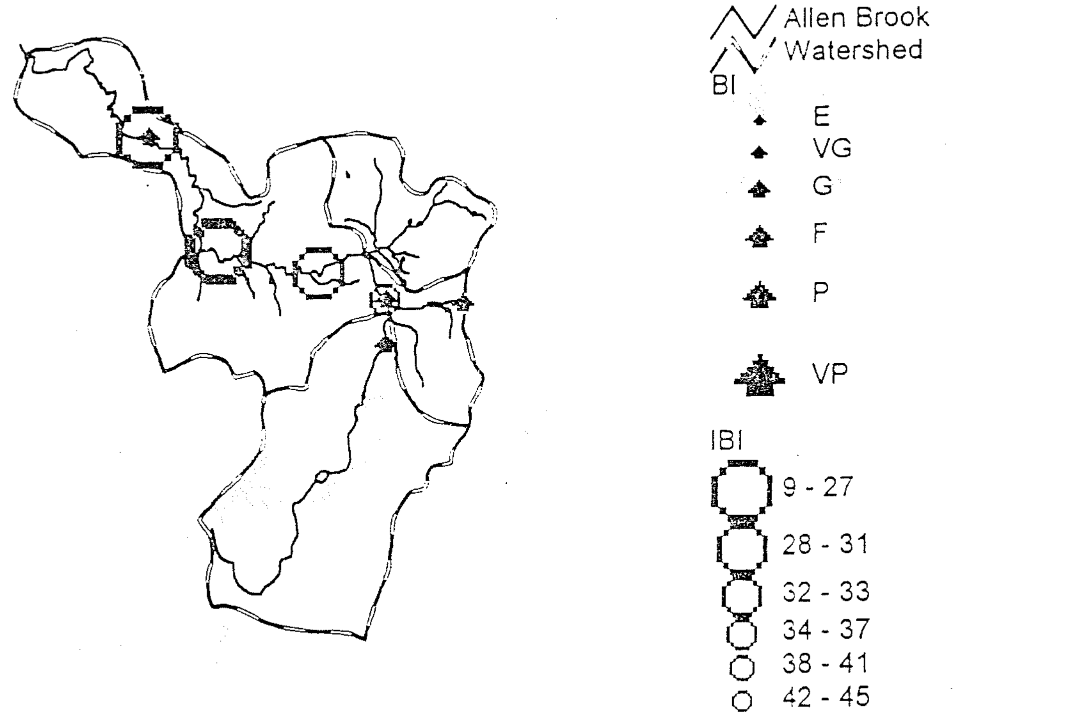
Figure Al-5: Allen Brook watershed - wetpond/wetland soils.



Riparian Corridor Evaluation (RCE)
Red=Poor, habitat structure gone
Brown=Fair, major habitat alteration
Yellow=Good, minor habitat alteration
Green=Very Good, monitor for changes
Blue=Excellent, protect existing status

Figure AI-6: Allen Brook Riparian Corridor Corridor Evaluation. Evaluation was conducted using the Riparian Corridor Evaluation methodology (Petersen, 1992). A series of measurements and observations are recording while walking the stream channel.

Figure AI-7: Allen Brook watershed - biological condition. Fish and macroinvertebrate community measures of integrity. A macroinvertebrate biotic index (BI) rating of less than good is indicative of sub-Class B condition. A fish Index of Biotic Integrity (IBI) rating of less than 31 is indicative of sub-Class B condition.



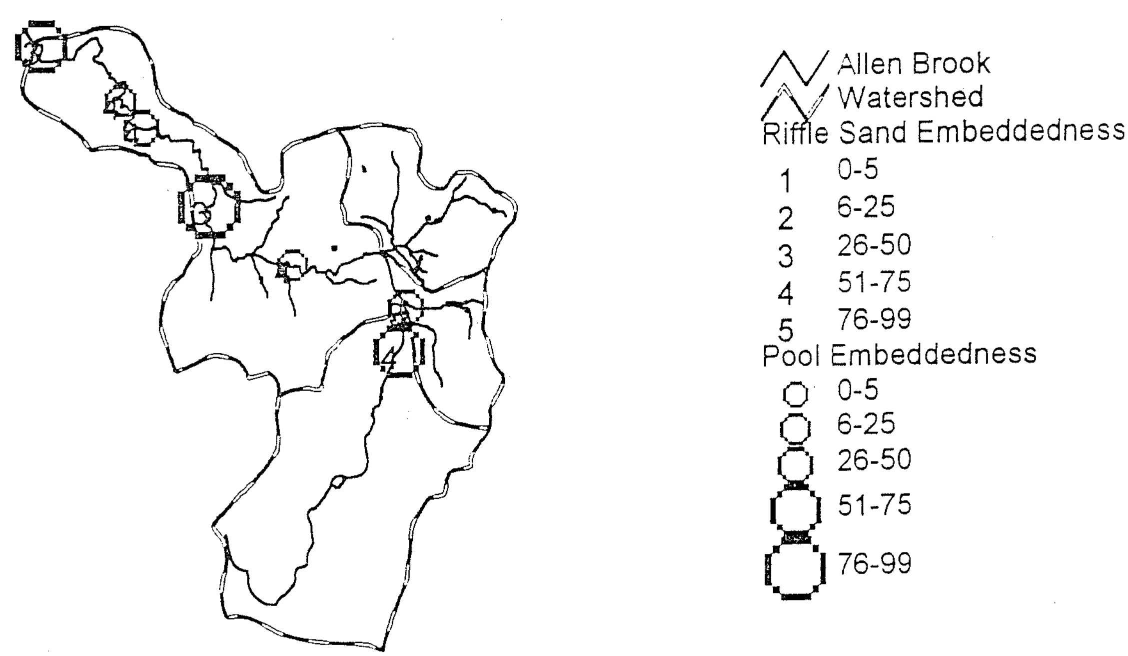
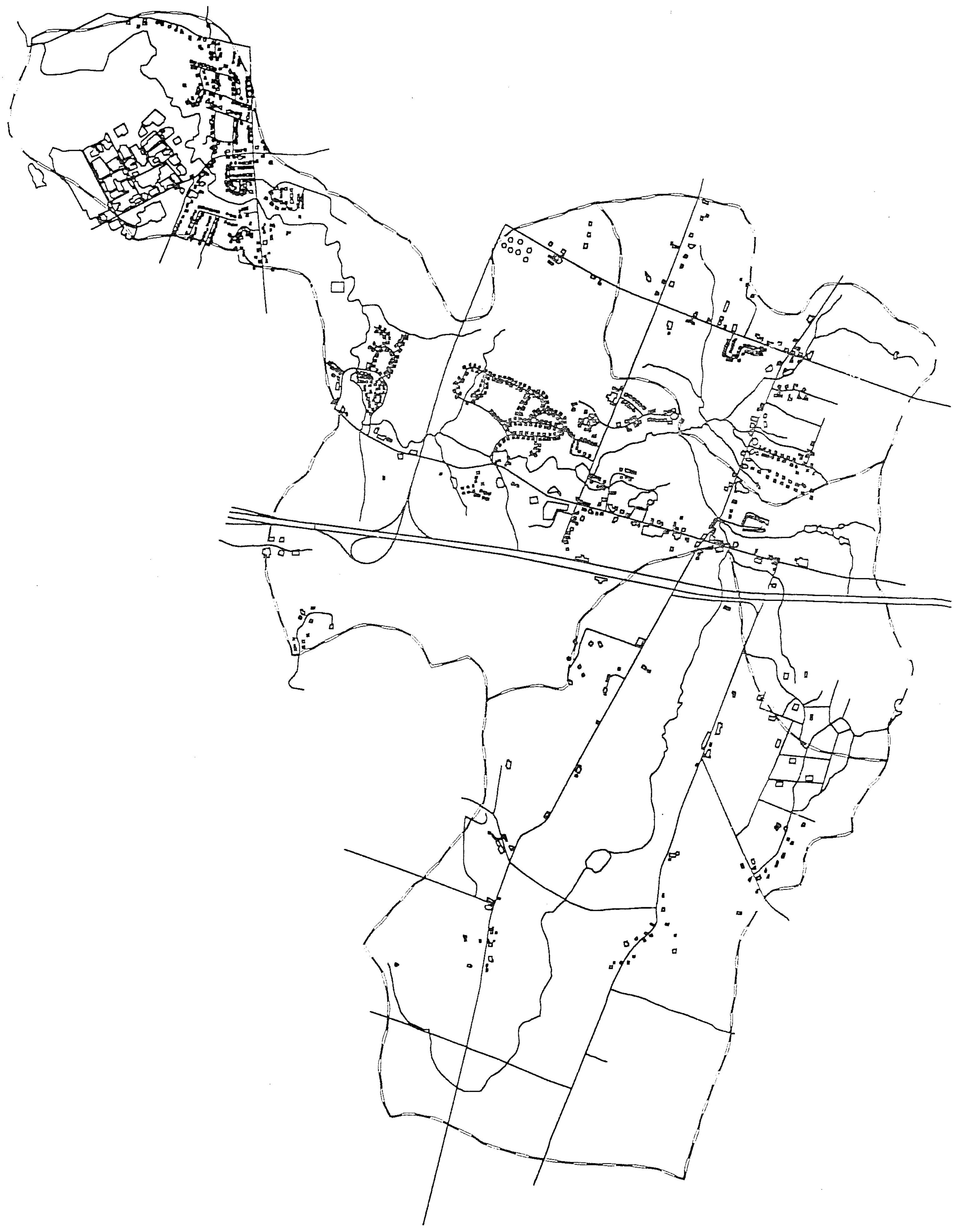


Figure AI-8: Allen Brook watershed measure of pool and riffle sedimentation. A high degree of sand embeddedness indicates excessive erosion and impairs aquatic habitat and the biological communities that are supported by that habitat.

Figure AI-9: Allen Brook watershed mapped impervious surface - 1996.



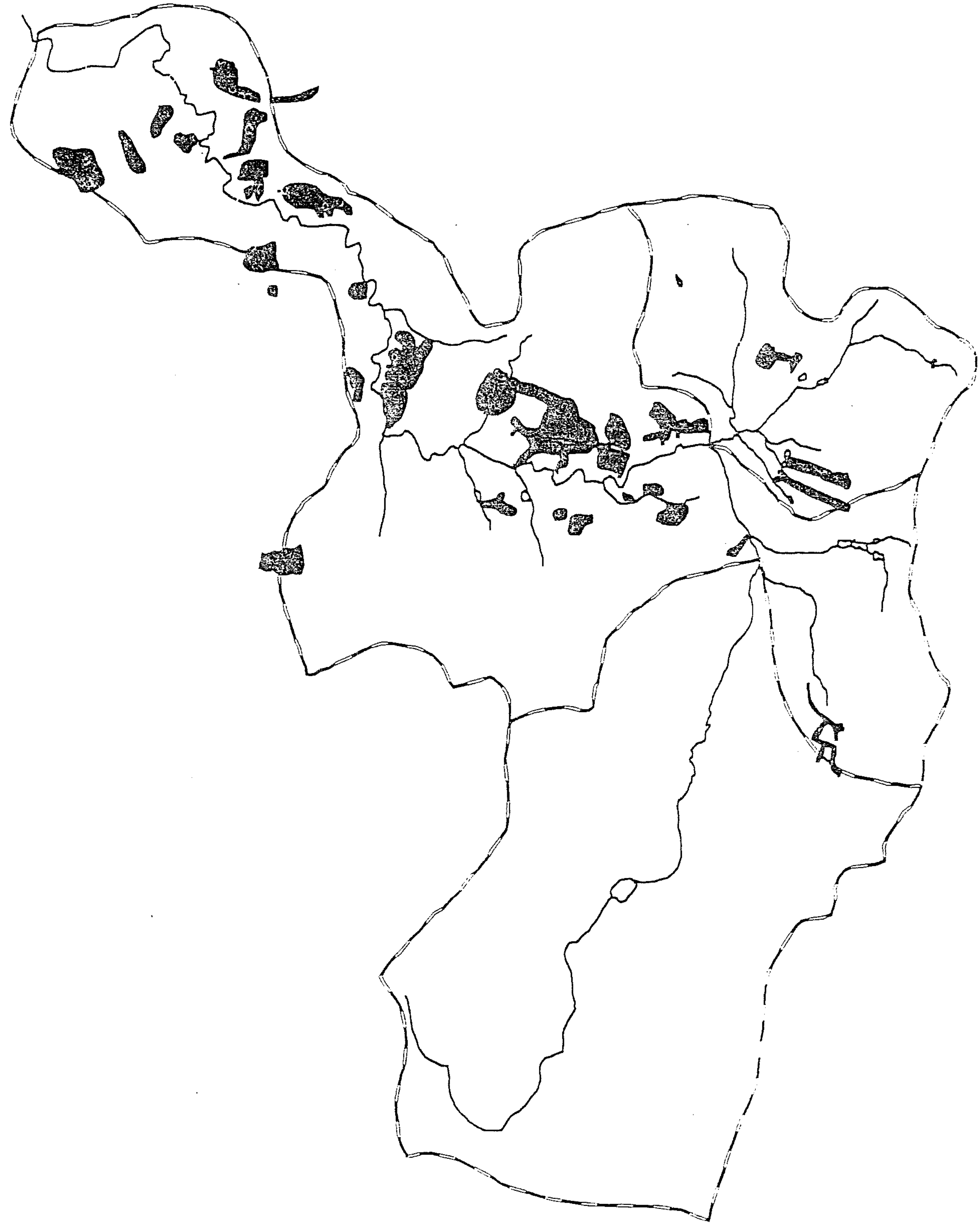


Figure AI-10: Allen Brook watershed mapped sewersheds - 1996.

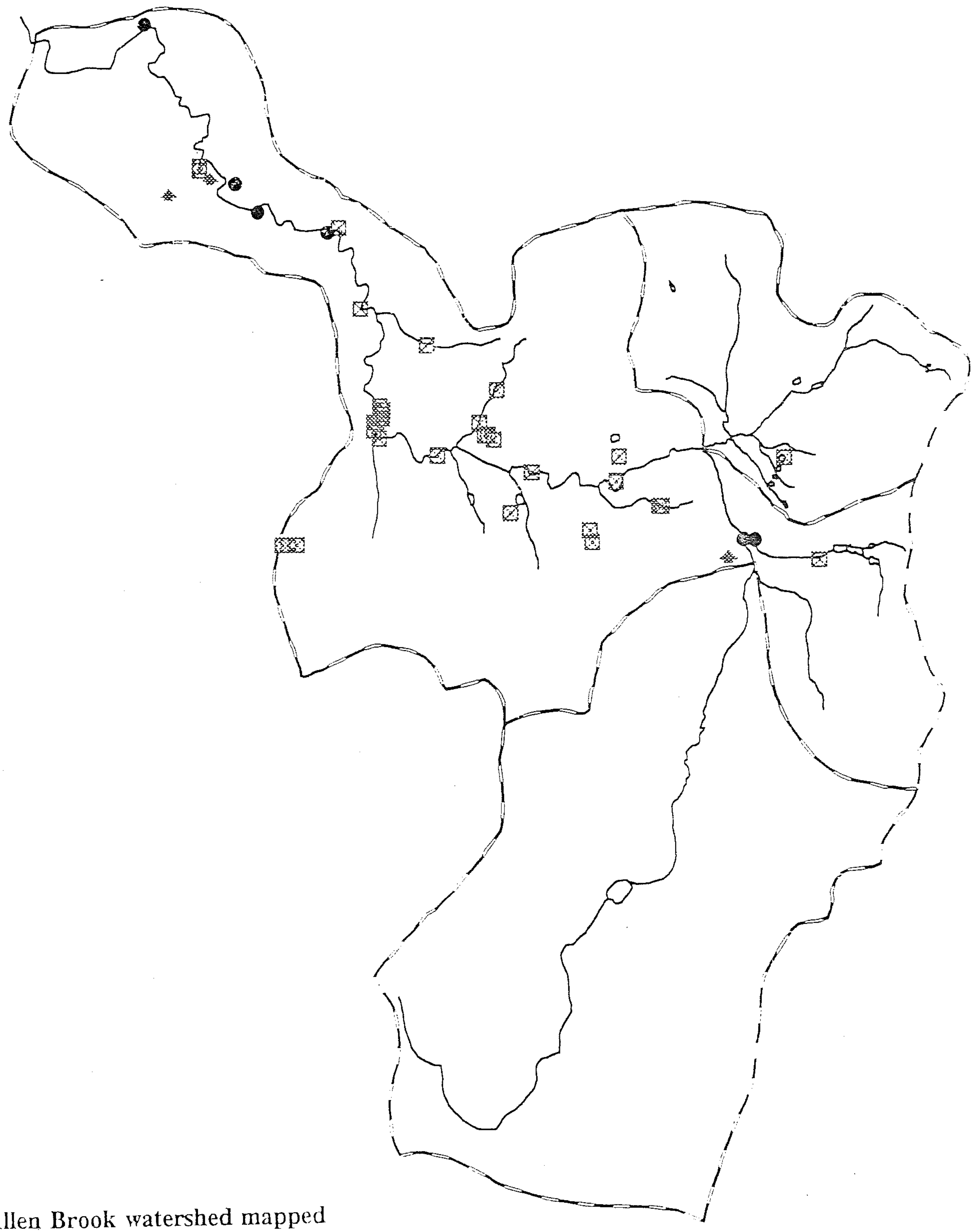


Figure Al-11: Allen Brook watershed mapped non-point sources. Mapped sources include: nonpoint sources such as eroding banks identified during RCE; stormwater permitted discharges; EPA hot landuses (quik-stops with gas pumps, gas stations).

Figure Al-12: Allen Brook watershed - mapped wetlands, 100 yr. floodplain, public land, and Natural Heritage sites.

Muddy Brook

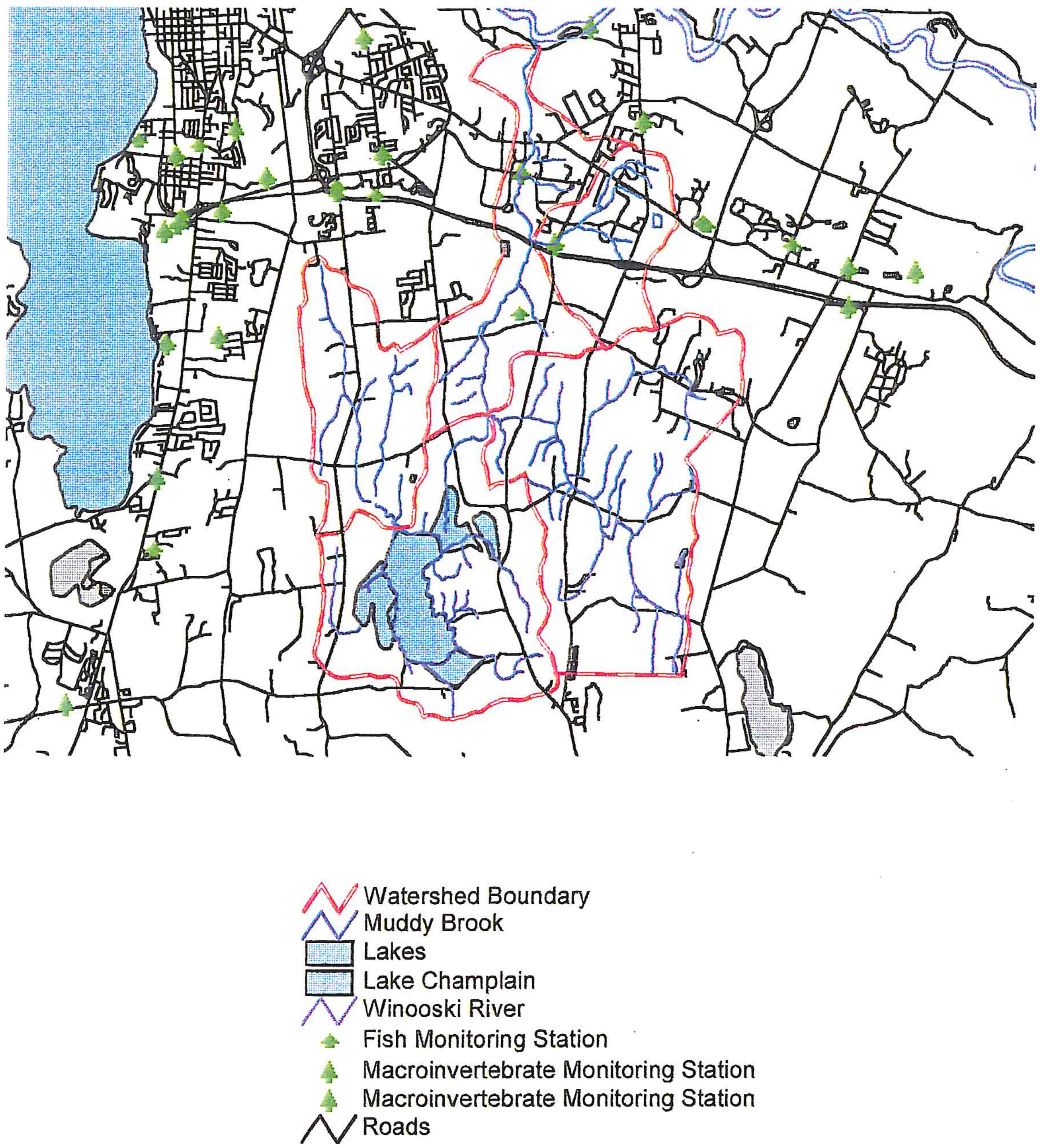


Figure Mu-1: Muddy Brook watershed showing roads, surface waters, and biological monitoring sites.

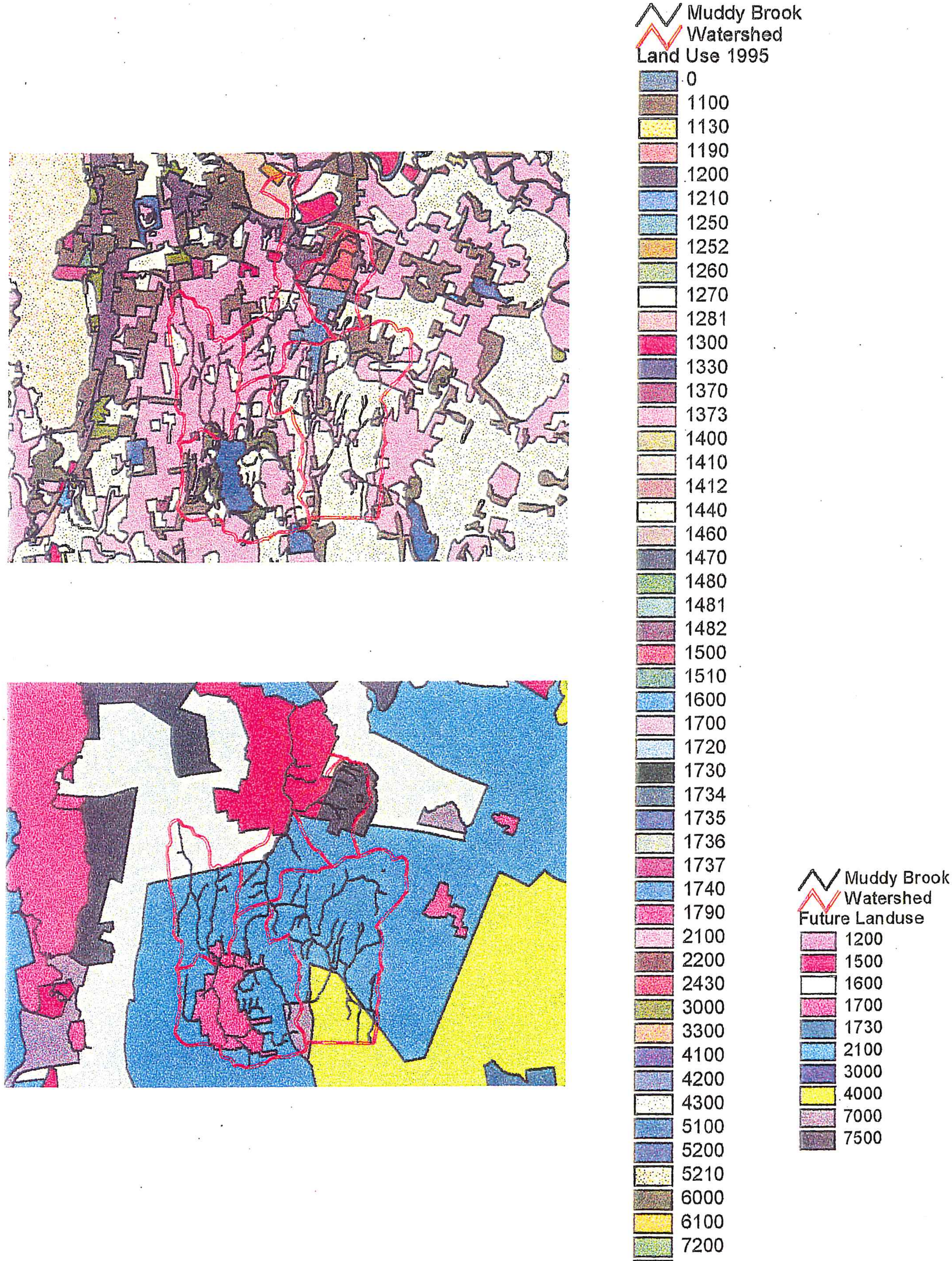


Figure Mu-2: Muddy Brook watershed 1995 actual land use; and future landuse as defined by zoning designation.

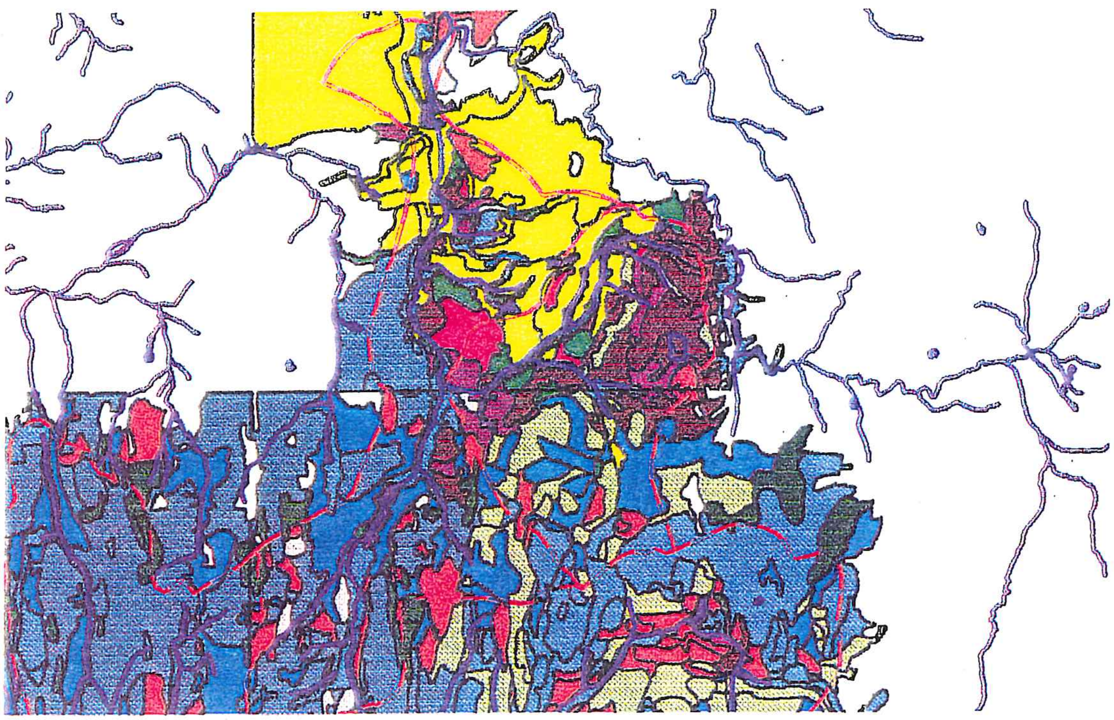


Figure Mu-3: Muddy Brook generalized soils map.

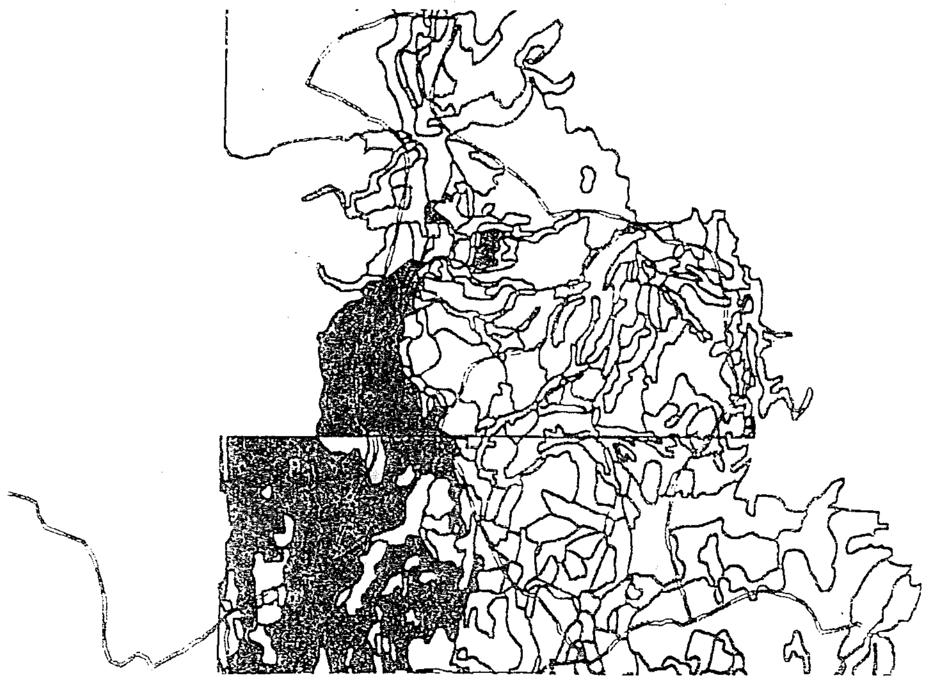


Figure Mu-4: Muddy Brook watershed - areas of highly erodible soils. These soils are easily displaced.

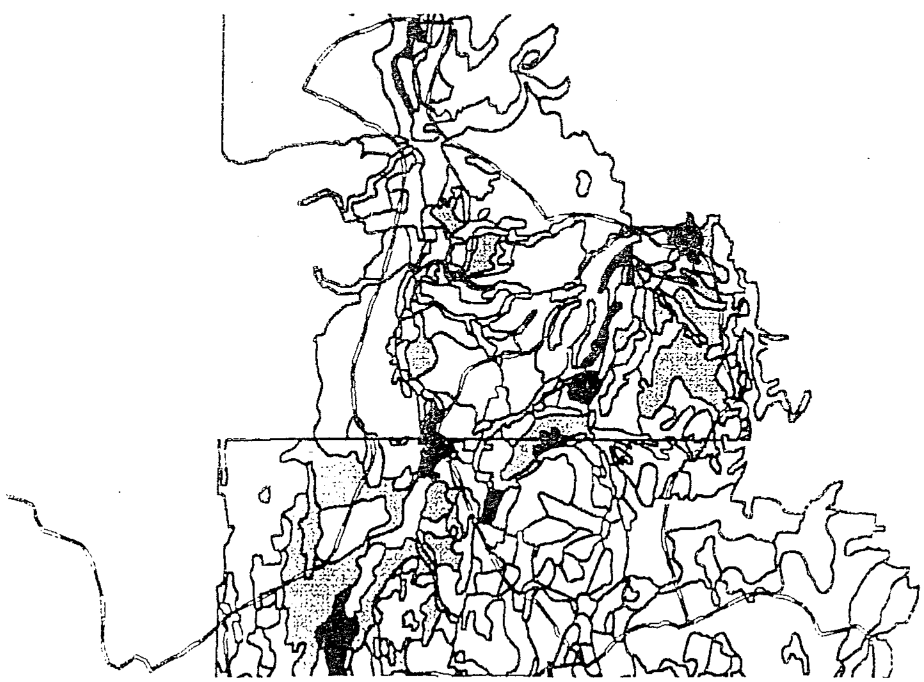
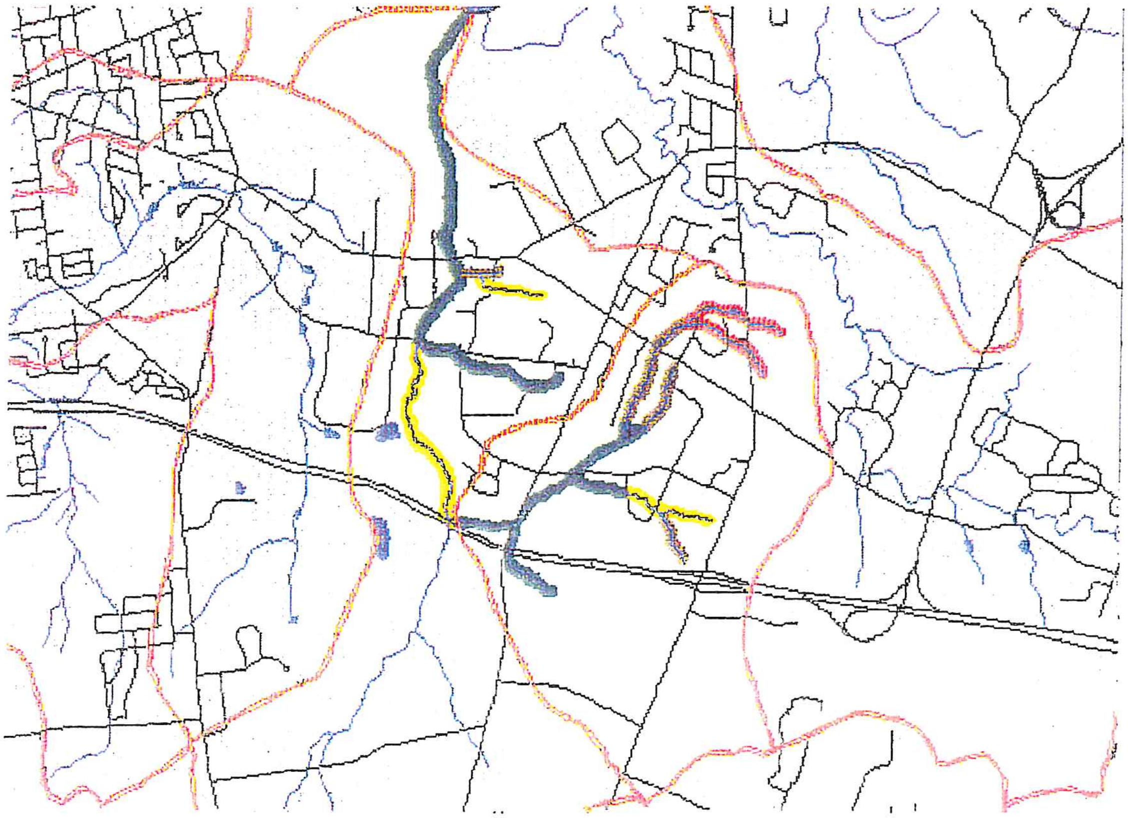


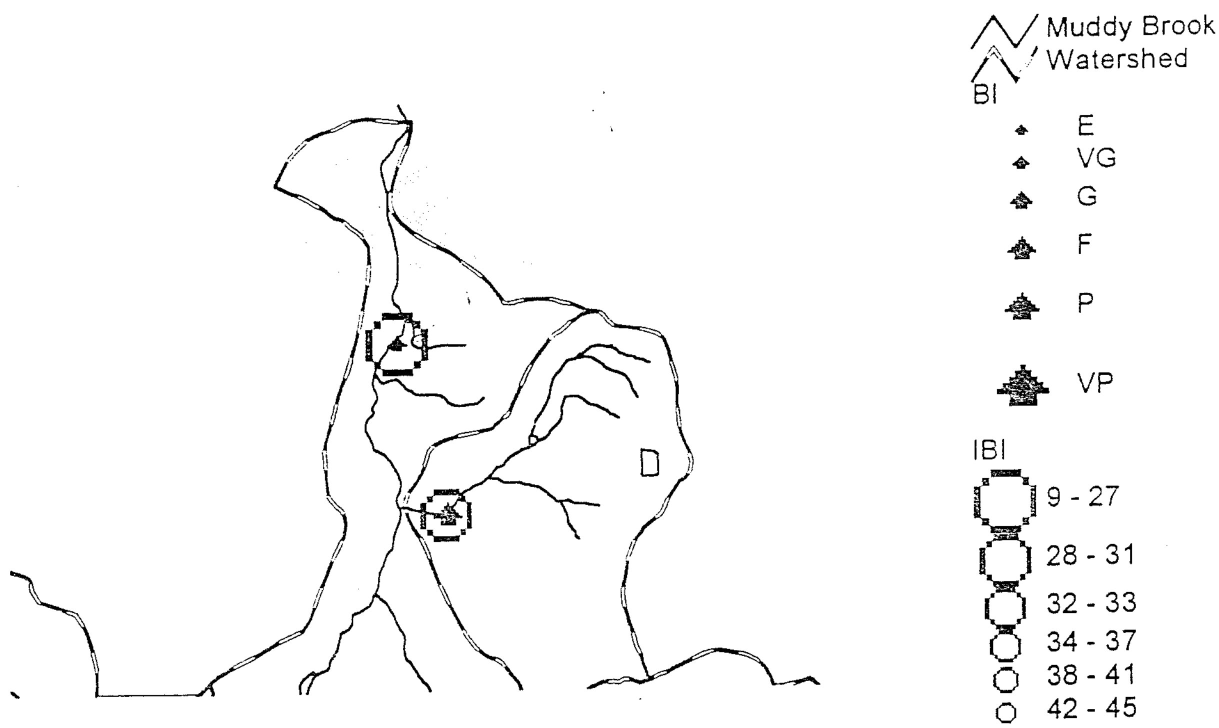
Figure Mu-5: Muddy Brook watershed - wetpond/wetland soils.



Riparian Corridor Evaluation (RCE)
Red=Poor, habitat structure gone
Brown=Fair, major habitat alteration
Yellow=Good, minor habitat alteration
Green=Very Good, monitor for changes
Blue=Excellent, protect existing status

Figure Mu-6: Muddy Brook Riparian Corridor Corridor Evaluation. Evaluation was conducted using the Riparian Corridor Evaluation methodology (Petersen, 1992). A series of measurements and observations are recording while walking the stream channel.

Figure Mu-7: Lower Muddy Brook watershed - biological condition. Fish and macroinvertebrate community measures of integrity. A macroinvertebrate biotic index (BI) rating of less than good is indicative of sub-Class B condition. A fish Index of Biotic Integrity (IBI) rating of less than 31 is indicative of sub-Class B condition.



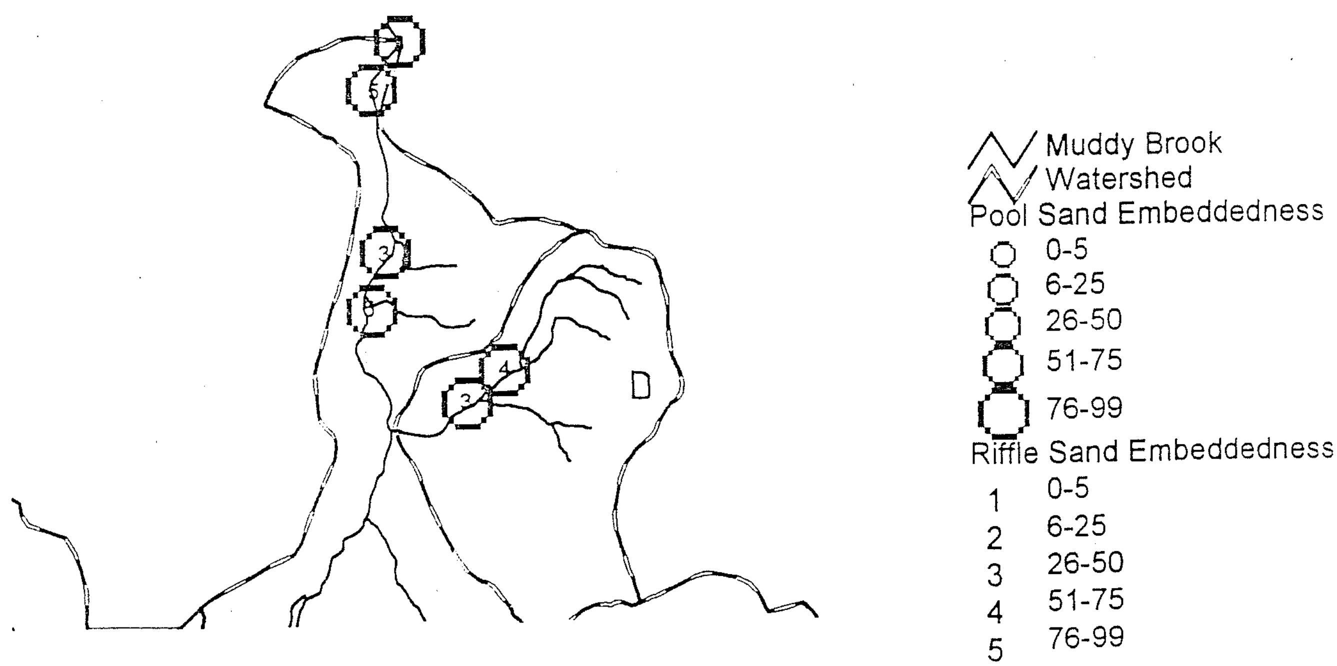


Figure Mu-8: Lower Muddy Brook watershed measure of pool and riffle sedimentation. A high degree of sand embeddedness indicates excessive erosion and impairs aquatic habitat and the biological communities that are supported by that habitat.

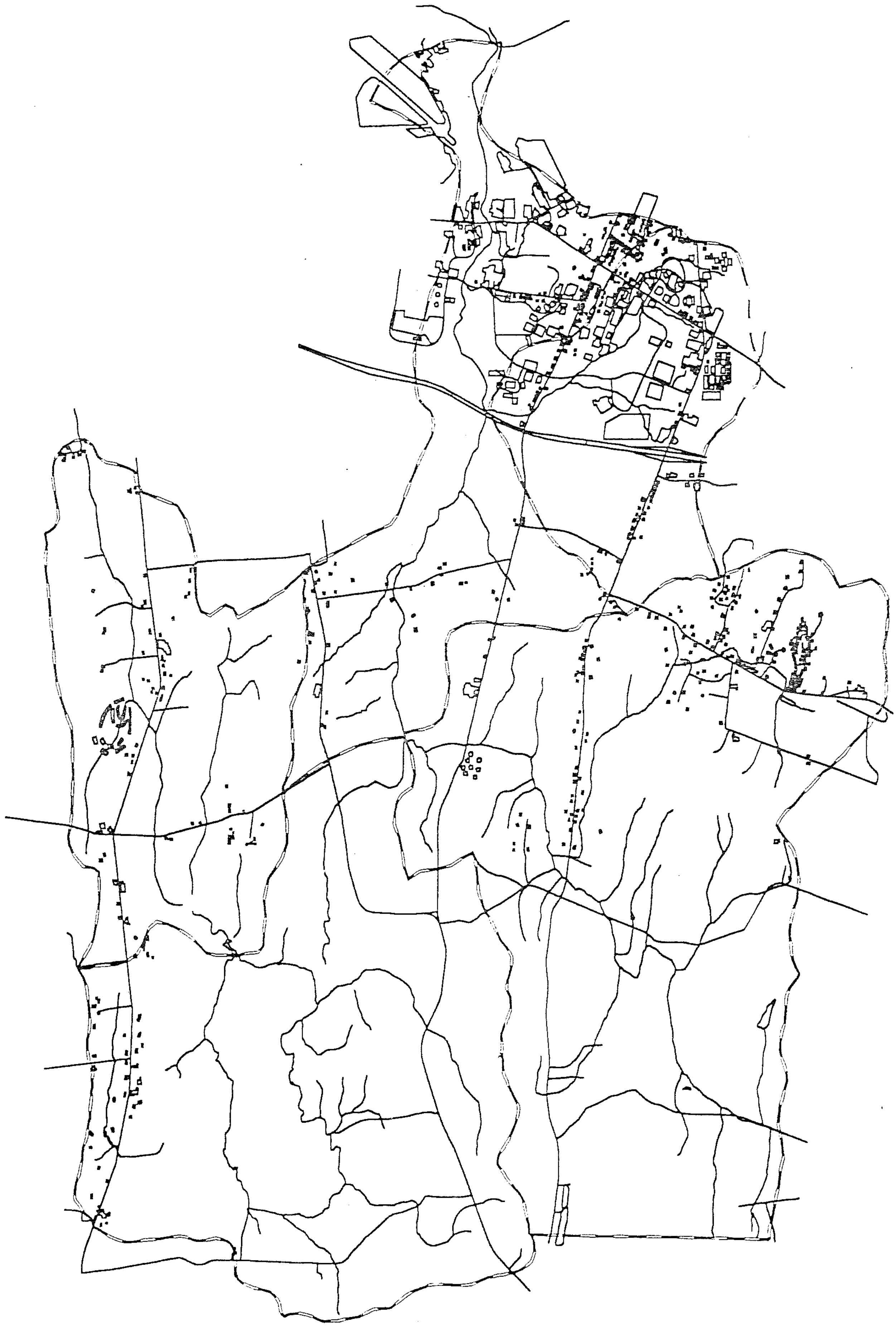
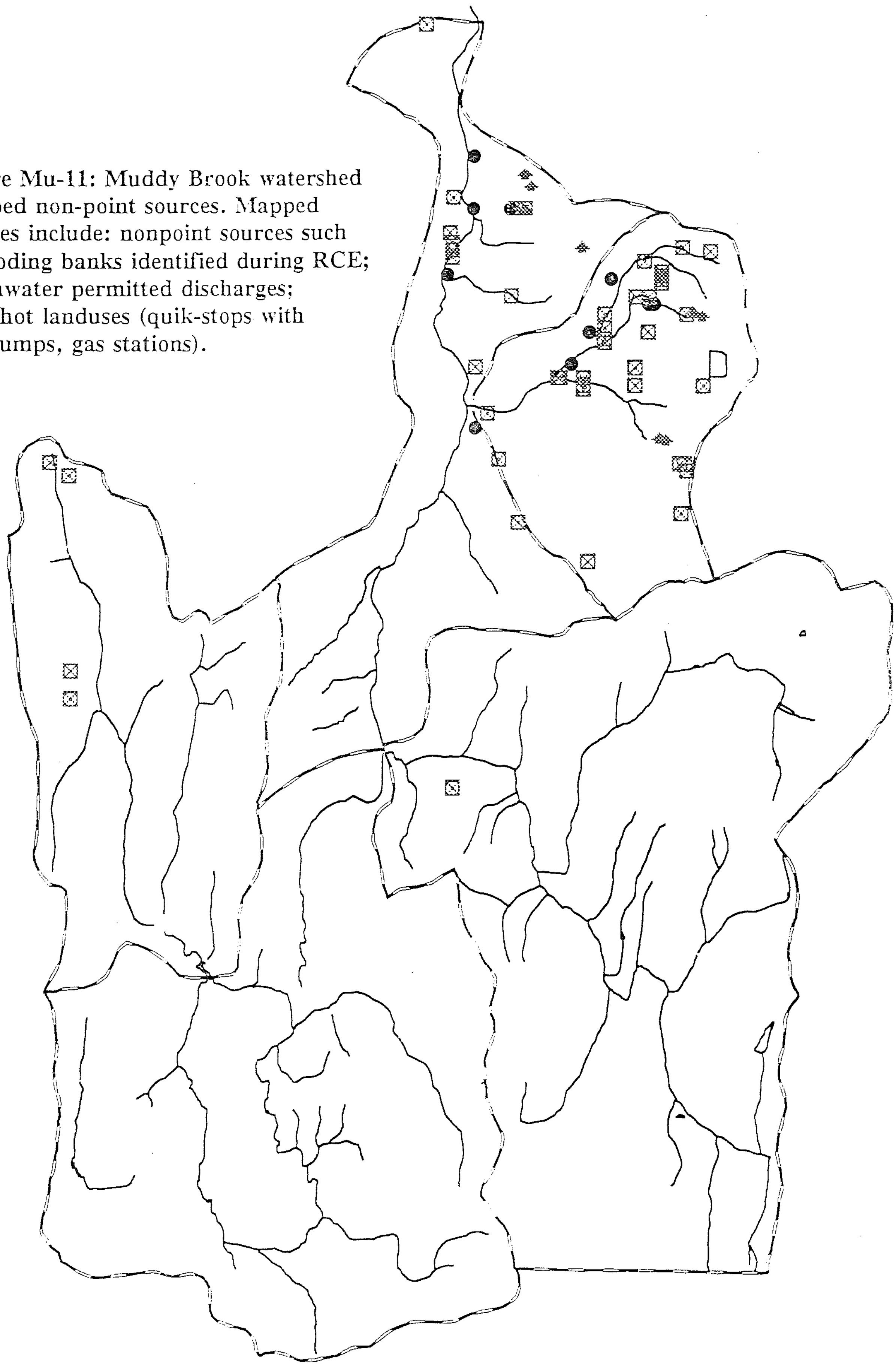


Figure Mu-9: Muddy Brook watershed mapped impervious surface - 1996.

Figure Mu-10: Muddy Brook watershed mapped sewersheds - 1996.

Figure Mu-11: Muddy Brook watershed mapped non-point sources. Mapped sources include: nonpoint sources such as eroding banks identified during RCE; stormwater permitted discharges; EPA hot landuses (quik-stops with gas pumps, gas stations).



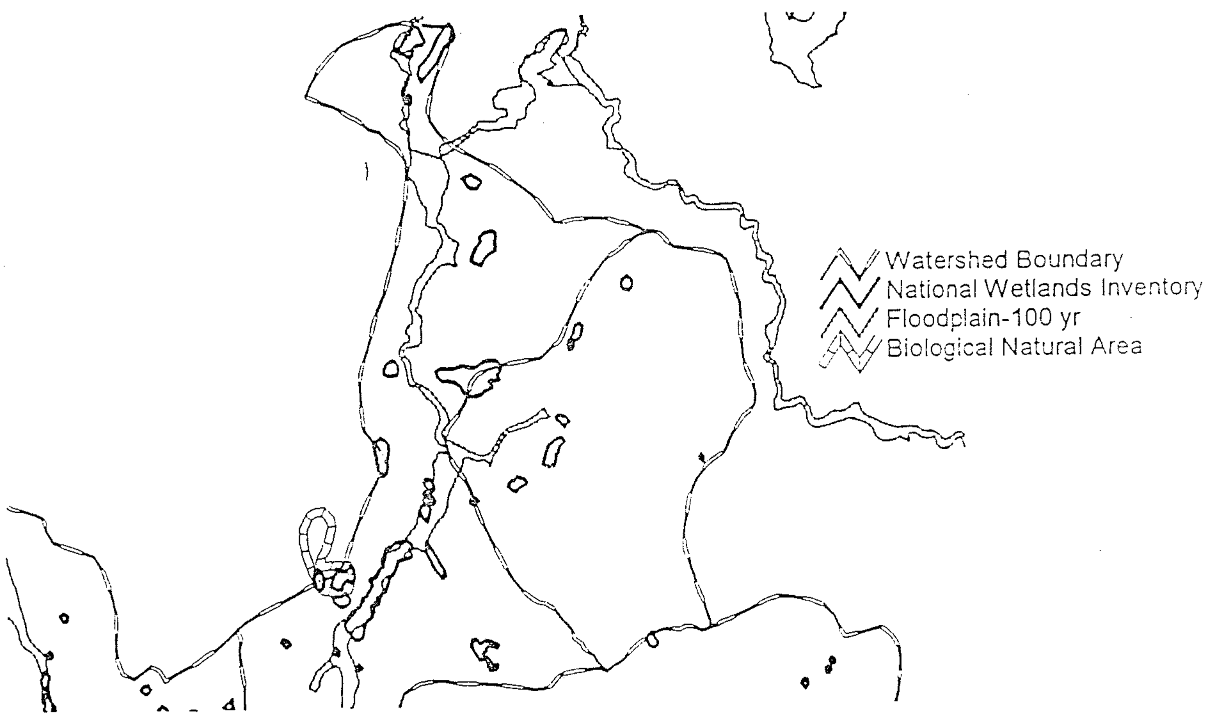


Figure Mu-12: LowerMuddy Brook watershed - mapped wetlands, 100 yr. floodplain, public land, natural areas, and Natural Heritage sites.

Targeted Stormwater Sewersheds
Muddy Brook Watershed

Figure 1.1: Targeted Stormwater Sewersheds in Muddy Brook Watershed - Sewersheds were targeted based on exceedences of loading thresholds as described in Table 1.2. BMP recommendations are made for each targeted sewershed. Eight sewersheds i the Muddy Brook watershed have been targeted.

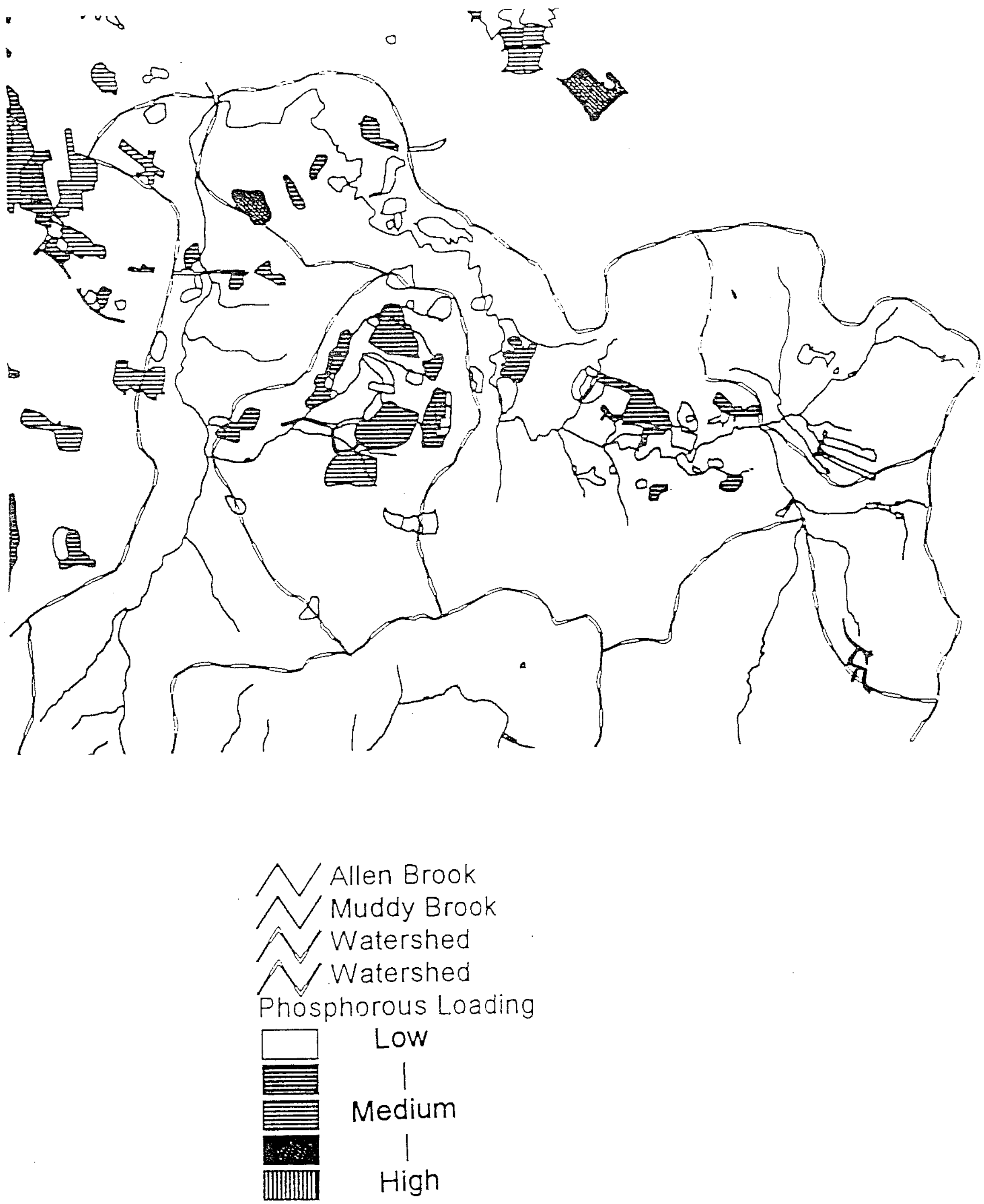


Figure 1.2: Estimated total phosphorus loading from sewersheds in the Allen and Lower Muddy Brooks watersheds.

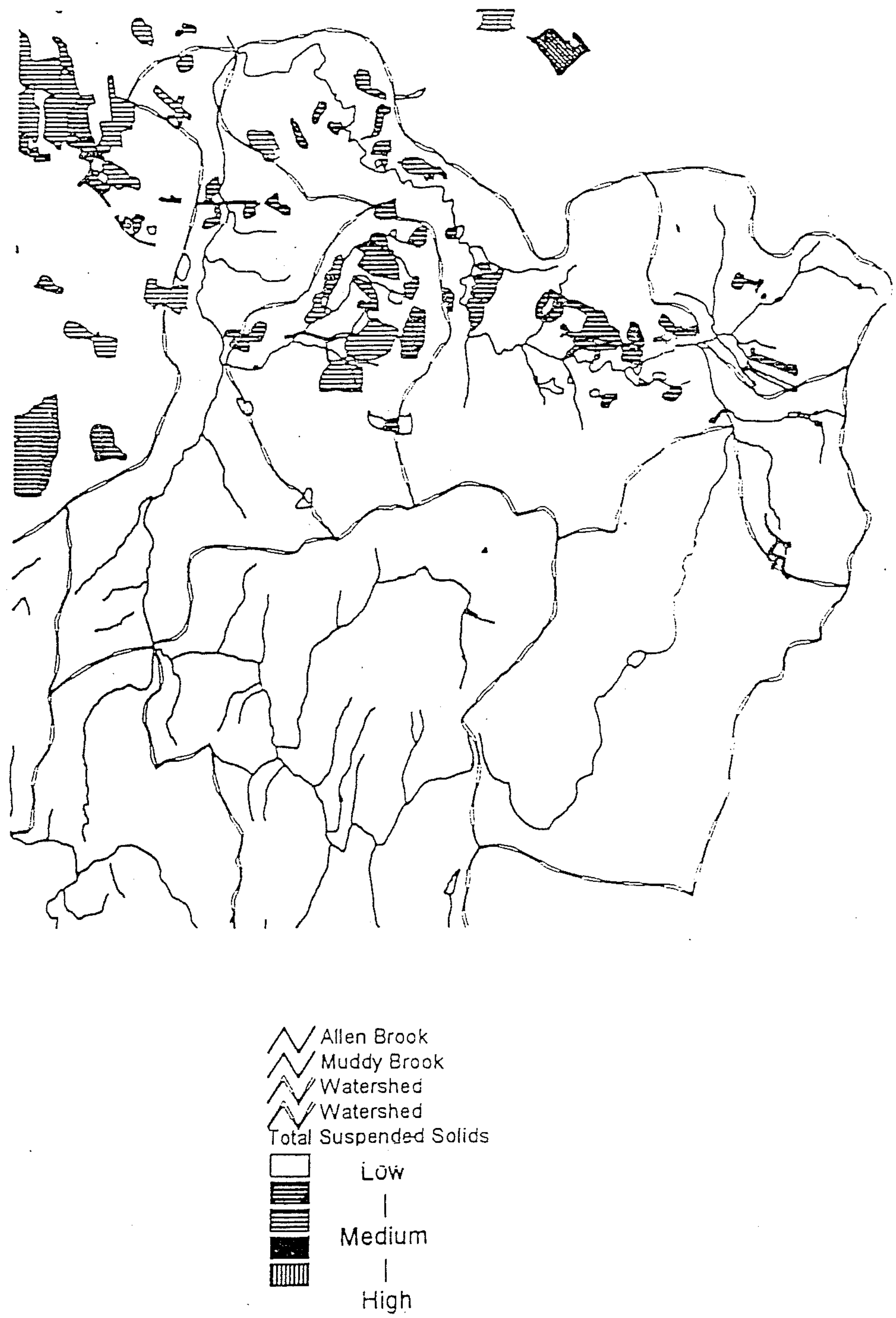
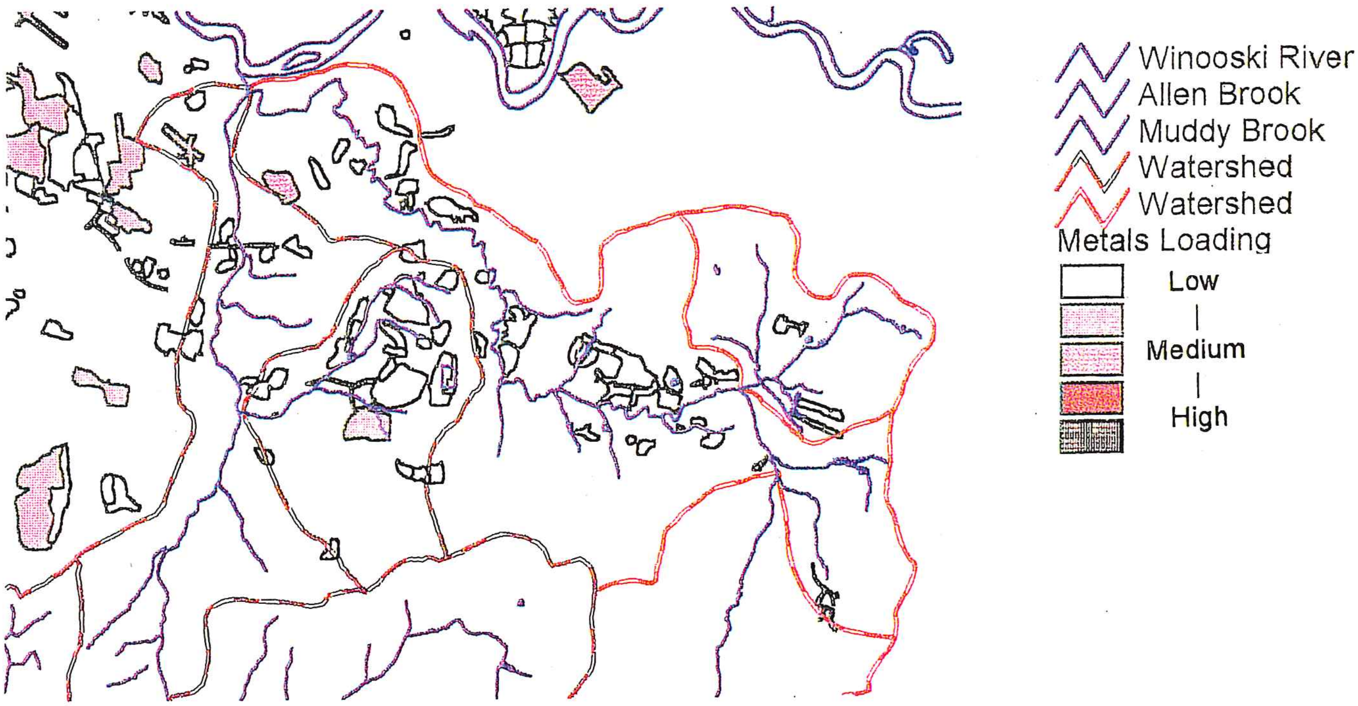


Figure 1.3: Estimated total suspended solids loading from sewersheds in the Allen and Lower Muddy Brooks watersheds.



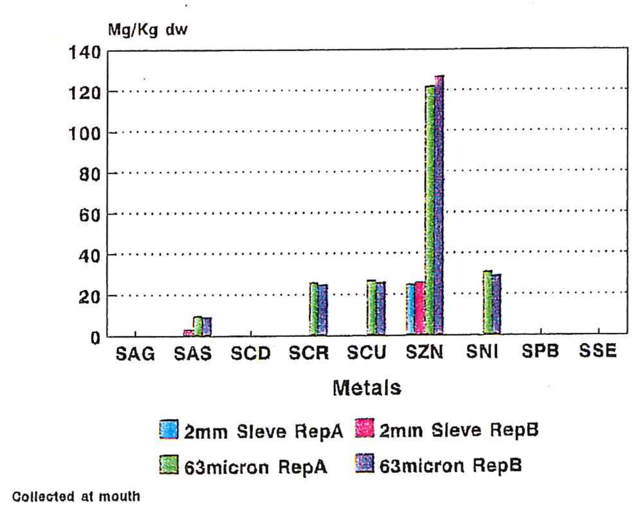


Figure 1.4: Estimated total metals loading from sewersheds in the Allen and Lower Muddy Brooks watersheds. Graph at bottom shows concentrations of metals in whole (2mm) and fine fraction (63u) sediments at the mouth of the Muddy-Allen watershed. Samples collected in 1995.

Soils

- AdA
- AdA
- AdA - AdB
- AdB - AdD
- AdD - AdE
- AdE - Au
- Au - BlA
- BlA - Br
- Br - Cv
- Cv - DdA
- DdA - EwA
- EwA - FaC
- FaC - FaE
- FaE - FsB
- FsB - Fu
- Fu - HlB
- HlB - HlE
- HlE - HnB
- HnB - Le
- Le - Lf
- Lf - MuD
- MuD - MyB
- MyB - MyC
- MyC - Rk
- Rk - ScB
- ScB - TeE
- TeE - W
- W - Wo

Land Use 1995

- 0
- 1100-Residential
- 1130-Residential-Single Family
- 1190-Residential-Other
- 1200-Commercial
- 1230-Commercial Services
- 1250-Government
- 1252-Military
- 1260-Institutional
- 1270-Educational
- 1281-Museum
- 1300-Industrial
- 1330-Industrial-Stone
- 1370-Industrial-Mining
- 1373-Sand/Gravel
- 1400-Transportation
- 1410-Transportation-Air
- 1412-Transportation-Air
- 1440-Transportaiton-Road
- 1460-Utilities
- 1470-Utilities
- 1480-Utilities
- 1481-Utilities
- 1482-Utilities
- 1500-Industrial
- 1510-Industrial Park
- 1600-Mixed Use
- 1700-Outdoor Built
- 1720-Outdoor Built
- 1730-Outdoor Recreation
- 1734-Ski Area
- 1735-Golf Course
- 1736-Campground
- 1737-Parks
- 1740-Cemetaries
- 1790-Other outdoor built
- 2100-Cropland
- 2200-Orchards
- 2430-Other Agriculture
- 3000-Brush
- 3300-Mixed Brush-grass
- 4100-Broadleaf Forest
- 4200-Coniferous Forest
- 4300-Mixed Forest
- 5100-Rivers
- 5200-Lakes/Ponds
- 5210-Lakes/Ponds
- 6000-Wetlands
- 6100-Forested Wetland
- 7200-Beaches/River banks
- 7400-Exposed Rock

Future Landuse

- 1200-Commercial
- 1500-Industrial
- 1600-Mixed Use
- 1700-Outdoor Built
- 1730-Outdoor Recreation
- 2100-Cropland
- 3000-Brush
- 4000-Forest
- 7000-Growth Center
- 7500-Subregional Growth Center