Purgatory Creek
Use Attainability Analyses

Prepared for
Riley-Purgatory-Bluff Creek Watershed District

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Plant Community and Bird Habitat Evaluation

In 2003, Barr Engineering Company conducted an inventory of plant communities and a bird habitat evaluation of the Purgatory Creek riparian corridor. The largest contiguous natural area in the Purgatory Creek watershed, the corridor extends more than 16 miles from Shorewood, Chanhassen, and Minnetonka to Eden Prairie, where it meets the Minnesota River. A total of 2,540 acres comprising 604 sites were assessed during 2003.

A riparian corridor is the linear vegetated area along a stream or river, extending from the normal water level up to and including the transition from hydrophytic (wet) to mesic (moist) plant communities. Linked to a larger ecosystem of water, plant, animal, and human components, the corridor serves a number of important purposes. Corridor vegetation traps pollutants that would otherwise enter the creek, provides shade that helps regulate water temperatures and reduce algae growth, and provides a wildlife travel network. The corridor offers a refuge for plants and a greenway for human recreation.

The inventory and analysis sought to: (1) obtain data on the quality of plant communities; and (2) assess the quantity of bird habitat in the corridor. The plant community inventory employed the Minnesota Land Cover Classification System (MLCCS), a nationally recognized, hierarchical method developed by the Minnesota Department of Natural Resources (MDNR). Bird habitat assessment used a series of species-area models and a modified habitat analysis method that takes in account the context, isolation and structural qualities of vegetation plots.

The most prevalent natural community in the corridor is forest, which makes up 28 percent of the area, followed by herbaceous communities (23.3 percent), open water communities (22 percent), shrub communities (8.3 percent) and woodland (1 percent). Planted or cultivated sites make up 1.4 percent of the land area. Due to heavy development in the corridor, areas with partial or complete impervious surface cover were also included in the inventory. These areas comprise 16 percent of the corridor, and include a variety of plant communities along with pavement and buildings.

Bird habitat within the corridor is highly fragmented by development and other degradation of native plant communities. So, while the corridor provides a wealth of suitable habitat types—lowland forests and cattail marshes, for example—it offers few areas of high quality with respect to large-scale, landscape-level factors. These factors include quantity of core habitat area and spatial relationship to other similar patches.

This means that while the corridor may support a large quantity of birds, it offers relatively little area to support more selective interior species, mainly neotropical migrants. The areas most likely to support the greatest number of bird species are, in descending order: lowland forests, shrublands, upland forests, cattail marshes, wet meadows, deep marshes, open water, upland fields, and developed areas.

Recommendations for managing the corridor include:

- Prioritizing sites on the basis of their ecological quality. Rare community types and their importance in providing habitat also could be considered when allocating resources for preservation and restoration. Wetlands are an important component for wildlife in the corridor, and thus may warrant more detailed assessment for value and function.
- Controlling invasive species, particularly reed canary grass in wet meadows and other moist areas; common buckthorn and garlic mustard in forests; and purple loosestrife in wetlands.
- Maintaining restored areas, controlling deer, and controlling erosion.
- Maintaining corridor width, taking special care to maintain forested areas 150 feet or wider. Managing corridor vegetation in zones of permanent forest, shrubs, and herbaceous vegetation may be appropriate in narrower areas.
- Reducing and mitigating the impact of impervious surface areas.
- Educating corridor constituents to help garner support for restoration efforts and encourage stewardship of adjacent lands.

Physical Classification of Purgatory Creek

A physical classification of eight stream reaches on Purgatory Creek was first completed in 1995. That effort was intended to provide a baseline for future comparison of the physical characteristics of the channel. The 2003 classification was the first follow-up visit since the original surveys were made, and allows for evaluation of the rate of change of the stream's physical characteristics.

Although the majority of the surveyed reaches showed relatively little change since the original survey, several showed signs of degradation. In particular, Reaches P-6 and P-7 show signs of significant degradation and should be monitored again in the near future to determine whether they are continuing to deteriorate and whether corrective action should be taken.

For the long term, recommendations are made for watershed and channel improvements that would improve the physical characteristics of Purgatory Creek. Watershed improvements include introduction of extended detention basins where warranted, and introduction of rainwater gardens wherever feasible in order to promote infiltration of rainwater and reduce the volume of stormwater runoff. Channel improvements include the installation of bank protection measures where necessary, providing grade control, and improving the vegetation adjacent to the creek.

The feasibility of improving low quality reaches of the creek should be investigated, especially reaches of formerly E stream types that have been straightened.

Attainable Ecological Use Classification of Purgatory Creek

Purgatory Creek was classified as to attainable ecological use in 1996 and again in 2003 to determine stream management goals and stream management practices. The classification determined the average biological community Purgatory Creek is able to support. Changes occurring during the 1996 through 2003 period were evaluated to determine their causes and management measures to protect the stream from future changes.

Unfavorable climatic conditions during 2003 degraded stream habitat by reducing stream depth and flow in Purgatory Creek. Other types of habitat degradation occurring during the 1995 through 2003 period include stream bank erosion, watershed erosion, reductions in bank vegetative protection, increased bottom scouring and deposition, increases in lower bank deposition, degradation in bottom substrate and available cover, and an unfavorable change in pool/riffle, run/bend ratio. Habitat degradation in Purgatory Creek degraded its attainable ecological use in 2003.

The 2003 attainable ecological use of much of Purgatory Creek was Class D, tolerant forage fishery. One reach, P-3 (located upstream of Staring Lake), had an attainable ecological use of Class C, intolerant forage fishery. The low flow and periodic dry stream bed at the stream's headwaters reach (P-8) resulted in an attainable ecological use of Class E, no aquatic life.

With the exception of a couple of reaches (P-3 and P-8), the average fish community of Purgatory Creek is tolerant to suboptimal habitat, flow, and water quality conditions. Although the average fish community is tolerant, all reaches of the stream except its headwaters (P-7 and P-8) support (1) gamefish and a diverse aquatic life community and (2) some species that require optimal oxygen conditions.

Because a current national focus for stream management is compliance with regulatory criteria, a second classification system was used to evaluate Purgatory Creek. The fish and aquatic life use classification is designed to determine whether or not streams comply with Federal Water Quality Standards Regulations.

Fisheries data collected during 1997 through 2003 from Purgatory Creek indicate most of the stream is classified as DFAL-GF (diverse fish and aquatic life—game fish). The use indicates that most of the stream supports a diverse fish and aquatic life community, including game fish. The stream's game fish (GF) designation indicates more than 2 game fish have generally been collected annually from reaches P-1 through P-6. The classification of all but the stream's headwaters as DFAL-GF (diverse fish and aquatic life—game fish) indicates that the stream, except for its headwaters reaches, complies with Federal criteria.

The stream's headwaters reaches (P-7 and P8, Figure EUC1) are intermittent streams with little or no flow. These reaches generally had a flow insufficient for the life requirements of gamefish and were dry for periods of time during the 1997 through 2003 monitoring period. The presence or absence of aquatic life at these locations was dependent upon flow.

Because habitat appears to be the primary limiting variable for the stream's biological community, stabilization of the stream's habitat is necessary to protect the stream's current biological community. Implementation of the recommended measures in the previous section (Physical Classification of Purgatory Creek) will both stabilize and improve the stream's habitat.

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1.0 Purgatory Creek Riparian Corridor Plant Community Inventory and Bird Habitat Evaluation

This section of the report presents the plant community inventory and a bird habitat evaluation of the Purgatory Creek riparian corridor for 2003. This study is designed to meet objectives outlined in the Metro Region Forest Resource Management Plan (Minnesota Department of Natural Resources, 1995). The strategy of the Forest Resource Management Plan promotes cooperative efforts of local government agencies to implement goals of the plan by conducting natural resource inventories of plant communities. The 2003 vegetation inventory used the Minnesota Department of Natural Resources (MDNR) Minnesota Land Cover Classification System (MLCCS) (Leete, Richardson et al,. 2000). The MLCCS is related to other standardized classification systems at both the state and the national level.

1.1 Introduction

The Purgatory Creek corridor is the largest contiguous area of naturally occurring vegetation and wildlife habitat within the Purgatory Creek Watershed. The corridor extends more than 16 miles from Shorewood, Chanhassen, and Minnetonka to Eden Prairie, where it meets and joins the Minnesota River (Figure RC1).

A riparian corridor is the linear vegetated area along a stream or river. For the 2003 inventory the riparian corridor was defined as the area directly adjacent to Purgatory Creek and within the Riley-Purgatory-Bluff Creek Watershed District's (District) floodplain envelope. To obtain a comprehensive assessment of the Purgatory Creek corridor, all sites within the floodplain, including residential and commercial sites with paved (impervious) surfaces, were included.

The natural communities that encompass the Purgatory Creek corridor are part of a larger ecosystem, whose land, water, plant, animal, and human components are linked. The riparian corridor extends from the normal water level of the stream, up to and including the transition from hydrophytic (wet) to mesic (moist) plant communities. The unique plant and animal communities within the riparian corridor are affected by the level and quality of the stream discharge in Purgatory Creek.

The riparian corridor serves to trap sediments and nutrients from entering the creek, thus improving water quality. The corridor vegetation may shade the creek, preventing algal growth and providing fish habitat. Corridor vegetation also serves to prevent erosion.

The corridor provides a refuge for plant and animal species and offers pathways for wildlife movement across the watershed. It also functions as a greenway for public recreation. The multiple benefits provided by the plant communities along Purgatory Creek underlie the importance of preserving high quality sites and restoring more degraded areas. The Purgatory Creek corridor includes natural communities identified by the Minnesota County Biological Survey (Figure RC2) (Minnesota County Biological Survey 1998).

1.2 Objectives

The objectives of the inventory and analysis were twofold: (1) to obtain data on quality of plant communities; and (2) to assess the quantity of bird habitat within the Purgatory Creek corridor. While additional large forest and prairie tracts contiguous with the corridor were not included in the inventory, they too provide important wildlife habitat, and are briefly discussed later in this report.

1.2.1 Plant Community Inventory

The objective of the plant community inventory is to provide a geographical information system (GIS) map and database of plant community types, location and quality. Data were collected and sites classified using the Minnesota Land Cover Classification System (MLCCS). Another objective was to identify high quality plant communities for preservation. Invasive plant species problem sites were highlighted, and can be the focus of future management plans. Other general information was collected, such as connectivity and erosion, to provide further focus for management at each site.

1.2.2 Bird Habitat Evaluation

Riparian corridors provide essential habitat for many wildlife species, with up to 70 percent of vertebrate species using riparian corridors during their life cycle (Raedeke 1989). Many bird species, both breeding and migrant, depend on plant communities found within riparian corridors (Graber and Graber 1976; Mossman 1988; Kilgo, Sargent et al. 1998; Saab 1999). We evaluated the potential number of bird species that would be expected to use each habitat type as a measure of the habitat suitability of wildlife habitat within the corridor.

The assessment and management of wildlife habitat in recent years has shifted from a focus on individual species to emphasizing community and ecosystem-level habitat relationships. This shift springs from a need to evaluate habitat quality for numerous species during a period of rapid habitat loss and fragmentation. Species richness is defined as the number of species found at a defined site. Bird richness is a community-level rather than an individual species variable.

As with many other types of wildlife, bird richness declines with reductions in habitat size. Many bird species of forests and marshes are area-sensitive and will not use habitat patches unless they exceed a particular minimum size (Best, Freemark et al. 1995). Researchers have found that larger marshes support greater bird species richness (Tyser 1983; Brown and Dinsmore 1986). In forests, generalist species (less selective species that thrive in a wide variety of habitats) dominate smaller sites, while specialists (those requiring very specific types of food and cover to survive) increase in number with area (Blake and Karr 1987). The increase in species richness in larger areas is due to more long-distance migrants (thrushes and warblers, for example) being found in large forests. The species that breed in forest interior habitats and winter in the tropics are most likely to be adversely affected by a reduction in forest habitat (Blake 1991).

Examining bird habitat this way allows us to assess degradation in wildlife habitat due to fragmentation and decreased patch size, using bird richness as a rough correlate for general wildlife habitat quality. The data is organized and presented by means of a GIS database.

1.3 Methods

1.3.1 Minnesota Land Cover Classification System

The MLCCS integrates classification of cultural (human-created) features and non-native, natural and semi-natural vegetation into a comprehensive land cover inventory system. The MLCCS is based on two native vegetation classification standards: the U.S. National Vegetation Classification System (NVCS) and Minnesota's Native Vegetation: A Key to Natural Communities, version 1.5 [Minnesota Department of Natural Resources Natural Heritage Program (NRNHP), 1993 #100]. The MLCCS natural resource inventory system allows researchers to accurately map all land cover types, including developed and cultivated land. MLCCS relies on observed physical cover rather than how the land is being used. This emphasis results in an inventory that is especially useful to resource managers and planners.

The MLCCS is a five-level hierarchical system that gradually produces a refined classification. The highest level is divided into: (1) Natural/Semi-Natural; and (2) Cultural cover types. The Natural/Semi-Natural types are next subdivided into seven categories: Forests, Woodlands, Shrublands, Herbaceous, Nonvascular, Sparse Vegetation, and Water. The Cultural classification is composed of cover types influenced by humans, including artificial surfaces and agriculture. Succeeding levels of classification indicate deciduous vs. evergreen, hydrology, species composition, etc., with the final level of classification corresponding to the NHNRP community type. For example, the code 32113 represents 30000 for Forest, 32000 for Deciduous Forest, 32100 for Upland Deciduous Forest, 32110 for Oak Forest, and, finally, 32113 for Oak Forest, Dry Subtype.

For each site, MLCCS modifiers can be used to describe features in more detail. For the 2003 inventory we included the MLCCS modifiers for Ecological Quality and for Invasive Plant Species. The Ecological Quality rankings were:

- **High** = Sites with little or no human disturbance, important to preserve, with less than 5 percent invasive plant species.
- **Medium** = Sites with some disturbance, but with potential for restoration, and 5 to 60 percent invasive plant species.
- **Low** = Very disturbed sites, most appropriate for development, with 60 percent or more invasive plant species.

Management issues including erosion, overgrown native communities, and browse damage were also recorded. The MLCCS specifies a minimum spatial scale of 1 acre for Natural/Semi-Natural polygons and 2 acres for Cultural polygons. The Purgatory Creek study met or exceeded this level of detail.

1.3.2 Mapping

The extent of the study area was based on the 100-year floodplain of Purgatory Creek. The 100-year floodplain was determined using aerial photography, USGS 7.5 minute topographic maps, and 100-year Federal Emergency Management Agency (FEMA) data. The limits of the floodplain were mapped and then used to define the study area (Figure RC1).

Prior to field investigations, plant communities within the study area were delineated on 2002 color aerial photographs (scale: 1 inch = 200 feet). A preliminary MLCCS code was assigned to each site, interpretation assisted by color infrared photography and the 1998 inventory data.

Researchers then visited each site to confirm airphoto interpretation and to collect the following data: total percent cover of each vegetation strata (canopy, shrub, and herbaceous layers); dominant species (those with >20 percent cover within each stratum); percent cover of any invasive plant species; ecological quality; management issues; and connectivity. A "species of mention" list noted rare and unique species that made up less than 20 percent cover. A total of 2,540 acres comprising 604 sites were assessed in 2003.

1.3.3 Species-Area Models

Bird habitat was assessed using a set of species-area models. For most living organisms, the number of species using a site is known to increase in direct relation to the size of the area sampled. This relationship was explored on islands (MacArthur and Wilson 1967) and later extended to interior habitats including isolated forests (Galli, Leck et al. 1976) and wetlands (Tyser 1983). This species-area relationship has been demonstrated for a number of animals, including birds (Blake and Karr 1987).

The general concept is that the number of species found at a site, also known as species richness, is correlated with the area of the site. This relationship can be described with a "species-area curve," in which the species richness initially increases rapidly as site area increases, but gradually levels off with further increases in site area (Figure RC3). The general equation for the species-area relationship is expressed as $S = c*(A)^Z$, where *S* is the number of species (species richness), *c* is a constant that measures the slope of the line, *A* is the area of the habitat site and *Z* is a constant that measures the curvature of the line relating *S* and *A*. The values of c and Z are dependant on taxon and geographic area, and have been derived from empirical data to formulate species-area models.

For the 2003 evaluation the c and Z constants are taken from literature values that were derived in the statistics program SYSTAT (Schroeder 1996b). All graphic and tabular presentations of the species-area model data use the constants developed in the 2003 SYSTAT models shown in Table RC1.

There are a number of explanations for an increase in species number (richness) with area. Larger areas increase the likelihood of colonization by new species and decrease the chances of extinction of existing species (MacArthur and Wilson 1967). Larger areas are also more likely to contain a higher diversity of habitats than smaller areas (Conner and McCoy 1979). Regardless of the explanation, the species-area relationship has been found to be robust for a variety of taxa in a number of habitats (Schroeder 1996).

Six species-area models are used in the analysis of bird habitat within the Purgatory Creek corridor (Table RC1). These models were derived by individual researchers (Graber and Graber 1976; Samson 1980; Tyser 1983; Brown and Dinsmore 1988), with the c and Z values calculated from raw data sources (Schroeder 1996).

1.3.4 Modified Habitat Analysis

Species-area curves alone may be insufficient to evaluate an area. A forest tract, or any plant community, is linked to the habitats that surround it. Habitat fragmentation, which occurs when natural communities are interrupted by development or degradation, can decrease an area's ability to contribute to species richness. So, for the Purgatory Creek corridor, a modified habitat analysis was used in addition to the species-area models. The modified model takes into account plot isolation, surrounding habitat, and plot vegetation structure. By using the results of the modified model along with the species-area models we arrive at a closer estimate of habitat suitability within the corridor.

The modified model is based on calculating two habitat variables: (1) plot level variables using data collected in the field; and (2) landscape level variables calculated using GIS. The plot level variables are used to calculate a Plot Suitability Index (SI) and the landscape level variables are used to calculate a Tract Suitability Index. These two levels of data are combined into an overall Habitat Suitability Index using:

$$\text{Habitat SI} = \text{Plot SI} * \text{Tract SI}.$$

The Plot SI uses plot level variables (PVs), and is based on the assumption that maximum richness of birds will exist in mature plant communities with well developed herb and shrub layers, high levels of soil moisture, and high levels of microhabitat diversity. Variables were recorded in the field and converted into the PV values. Each of the plot variables (PV) has a range of 0 to 1, with higher values indicating better habitat. The PVs were calculated based on formulas that relate field data to the 0-1 range as shown on Figure RC4.

- **PV1** indicates tree canopy height in shrub or forested areas, or interspersion of vegetation in herbaceous areas.
- **PV2** indicates whether foliage is multi-layered and spread evenly through the layers.
- **PV3** indicates whether the soil is seasonally inundated, saturated, temporarily saturated or dry.
- **PV4** indicates the number of microhabitats available. Key microhabitat features include seeps, springs, shorelines, sandy areas, logs, leaf litter, debris, and tree cavities.

The Tract SI uses landscape level variables, and assumes that maximum richness of birds will exist in areas with large acreage where similar plant communities are adjacent and where there are more similar plant communities within a 2 kilometer (km) buffer. These factors are combined into a Tract Suitability Index using:

$$\text{Tract SI} = [2.227 * (\text{Effective area})^{0.273}] / 19.8.$$

The effective area for the Tract SI equation is calculated in GIS using:

$$\text{Effective area} = \text{Area (hectares)} * \text{Core area factor (TV1)} * \text{Isolation factor (TV2)}.$$

The core area factor (Tract Variable 1 or TV1) assumes that tracts with low amounts of interior, or core, habitat offer less effective area for interior species, which are an important component of native species richness. For the Purgatory Creek study the core area factor was calculated by grouping all sites with the same first-level MLCCS class (for example, all MLCCS codes in the 30000 category). Next, a 100-meter-wide strip is removed from the perimeter of the grouped MLCCS codes. The remaining interior is the core area. Finally each original polygon (before grouping) is examined to determine what percent of the original polygon area is "core area." The decimal result is used in the equation:

$$\text{Core area factor (TV1)} = 0.15 + (0.85 * \%\ \text{core area}).$$

The isolation factor is calculated using:

$$\text{Isolation factor (TV2)} = \text{Permeability factor} * 2\ \text{km factor}$$

The permeability factor considers the potential for a site's adjacent habitat to be used by wildlife species. The perimeter of each target site is divided into sections determined by shared borders with adjacent sites (or "polygons," in GIS terminology). The fraction that each perimeter section contributes to the total perimeter is determined. This fraction is multiplied by a coefficient that ranks movement between the target polygon and adjacent habitat types (Table RC2). The results for each perimeter section are summed for each target polygon to get a weighted average permeability factor for the target polygon.

The 2 km factor determines the proximity of similar plant communities to the target polygon. The assumption is that the effective area of a site should be increased if the polygon is within 2 km of one or more similar plant communities. The calculation involves creating a 2 km buffer for each target polygon. This necessitated assigning MLCCS codes to a 2 km buffer of the corridor. This was done by using National Wetlands Inventory (NWI) data and Metropolitan Council land use data (Table RC3). After buffering each target polygon, researchers calculated the percent of this buffer area occupied by plant communities similar to that of the target polygon. Table RC4 indicates the communities that were considered similar for the 2 km calculation. This decimal percentage is used in the equation:

$$2\ \text{km factor} = 1 + (\%\ \text{similar cover} * 1.55).$$

1.4 Results

This section presents the results of the 2003 inventory and habitat assessment of the Purgatory Creek Riparian corridor. Results include the types, amount, location, and distribution of plant communities and the assessed habitat value of each individual plant community within the corridor. All data recorded in the field is compiled in a GIS database.

1.4.1 Plant Community Inventory

A total of 112 MLCCS communities were identified in the inventory. A summary of MLCCS frequency, area and representation in the corridor is listed in Table RC5 and illustrated on Figures RC5 through RC13. A summary of plant community occurrence is shown on Figures RC14 through RC18. Of the 112 MLCCS codes, 40 codes are subclasses of impervious (paved) surfaces and 8 codes represent planted or cultivated landscapes. These constitute the MLCCS Cultural cover types. The remaining 64 codes fall within the MLCCS Natural/Semi-Natural cover types. These MLCCS codes were grouped into larger classes in the discussion below. The following descriptions are based on the MLCCS manual (Leete, Richardson et al. 2000).

1.4.1.1 Forested Communities

Forested areas are defined by the MLCCS as areas dominated by trees with their crowns overlapping, generally forming 60 to 100 percent cover. Forested communities in the corridor include (listed from most to least prevalent): lowland hardwood forest, floodplain forest, boxelder-green ash disturbed native forest, maple-basswood forest, oak forest, upland deciduous forest, mixed hardwood swamp, aspen forest, black ash swamp, and tamarack swamp. The forest communities comprise 28 percent (714 acres) of the corridor.

***Lowland hardwood forest* (32220)** occupies 8.2 percent (207 acres) of the corridor. These sites are situated just above the active floodplain, in an inactive floodplain, or at the upper edge of a wetland basin. They occur on sites with seasonally high water tables (within the tree-rooting zone) but that do not flood regularly and have mineral rather than peat soils. Species that tolerate periodic soil saturation dominate the tree canopy and include American elm, black ash, slippery elm, basswood, bur oak, hackberry, yellow birch, green ash, black ash quaking aspen, balsam poplar and paper birch. The shrub layer is often dominated by buckthorn, an aggressive invasive species. The lowland hardwood forests are the most obvious forested areas in the corridor, commonly situated at the edge of the floodplain and readily visible from roads, parks, businesses, and homes.

Floodplain forest **(32210)** makes up 5 percent (124 acres) of the corridor. The floodplain forest is a seasonally wet forest community that occurs on the active floodplains of major rivers and their tributary streams. They are inundated in the spring or after heavy precipitation in the summer. Black willow, eastern cottonwood, and silver maple dominate the floodplain forest, with green ash and American elm commonly occurring. Areas beneath tree-canopy openings can be dominated by short-lived herbaceous plants or remain unvegetated.

Boxelder-green ash disturbed native forest **(32170)** occurs in 4.5 percent (113 acres) of the corridor. This is upland deciduous forest with typical canopy dominants being boxelder, green ash, and cottonwood. Other tree species include elms, hackberries, oaks, and basswood. The shrub layer is often dominated by the invasive species buckthorn or Tartarian honeysuckle, but native gooseberries and elderberries can also be common.

Maple-basswood forest **(32150)** occurs in 4.4 percent (112 acres) of the corridor. These are upland forests where sugar maples, basswoods, and elms dominate the canopy, or where they dominate along with oaks (<60 percent oak cover). The canopy is very dense, with an understory of American hornbeam and ironwood, and buckthorn dominating some shrub layers. The herb layer species are often spring ephemerals, which bloom in early-spring before the tree canopy becomes filled.

Oak forest **(32110, 32112, 32113)** constitutes 3.7 percent (95 acres) of the corridor. Oak forests are upland forests with >30 percent oak canopy. They are most common on dry to dry-mesic sites. The composition of the community varies in response to variation in soil moisture, texture, and stand history. Oak forests are dominated by bur, white, and northern red oaks. Other tree species include basswood, green ash, aspen, and black cherry. The shrub layer can be dominated by American hazel, gray dogwood, and blackberries.

Upland deciduous forest **(32100)** occurs in 0.8 percent (20 acres) of the corridor. These forests are dominated by sugar maples, basswoods, and oaks. Spring ephemerals are relatively rare, compared to the herb layer in maple-basswood forests.

Mixed hardwood swamp **(32420)** occurs in 0.8 percent (19 acres) of the corridor. Here, the soil substrate is saturated to the surface for extended periods during the growing season, although surface water is seldom present. The canopy is dominated by black ash, red maple, American elm, slippery elm, and green ash. Hardwood swamp forests differ from floodplain forests and from lowland hardwood forests by having an organic substrate (muck and shallow peat) and continuously or nearly continuously saturated soils during normal years. They also lack upland species in the herb layer.

Aspen forest **(32230, 32330)** occurs in 0.5 percent (13 acres) of the corridor. Dominated by aspen, these forests develop on sites with wet, poorly drained soils and high water tables. Two types of hydrology were recorded under the aspen forests in 2003; temporarily flooded (32230) and saturated (32330).

Black ash swamp **(32410)** occurs in 0.3 percent (8 acres) of the corridor. They share the saturated hydrology of the mixed hardwood swamp, described above. In the tree canopy, >50 percent of the species are black ash.

Tamarack swamp **(31210)**, the rarest forest community surveyed, is found in 0.1 percent (2 acres) of the corridor. Tamarack swamps have the saturated hydrology described for the mixed hardwood swamp, above, and the tree canopy comprises >50 percent tamarack.

1.4.1.2 Woodland Communities

Woodland areas are defined by the MLCCS as open stands of trees with crowns not usually touching, generally forming 25 to 60 percent cover. Canopy tree cover may be less than 25 percent as long as it exceeds shrub, herb and nonvascular cover, respectively. Disturbed deciduous woodland is the only woodland community in the corridor.

Disturbed deciduous woodland **(42130)** occurs in 1 percent (28 acres) of the corridor. This is an upland community with 10 to 70 percent tree cover. Aspens comprise <70 percent of the tree cover, and oaks comprise <30 percent. Boxelder, green ash, and cottonwood are typical canopy dominants, with elms commonly being present. Other tree species can include hackberry, oaks, and basswood. The shrub layer is often dominated by buckthorn and Tartarian honeysuckle, but sumac, gooseberry, and elderberry can also be common.

1.4.1.3 Shrub Communities

Shrubland is defined in the MLCCS as an area with individual or clumps of shrubs overlapping to not touching, generally forming more than 25 percent cover, with trees generally less than 25 percent cover. Shrub cover may be less than 25 percent as long as it exceeds tree, herb and nonvascular cover, respectively. Shrub communities in the corridor include (from most to least prevalent): wet meadow shrub subtype, willow swamp, non-native seasonally flooded shrubland, native dominated temporarily flooded shrubland, non-native dominated temporarily flooded shrubland, non-native dominated saturated shrubland, non-native dominated upland shrubland, saturated deciduous shrubland, seasonally flooded deciduous shrubland, and native dominated upland shrubland. Shrub communities occur in 8.3 percent (210 acres) of the corridor. Glossy buckthorn (a nonnative, invasive species, also called alder buckthorn) is common in many areas, and should be removed to protect native shrub diversity.

***Wet meadow shrub subtype* (52420)** occurs in 3.1 percent (80 acres) of the corridor. These are wetland areas with 50 to 70 percent cover by tall shrubs. Dominant species include red-osier dogwood, Bebb's willow, pussy willow, and sedge species.

***Willow swamp* (52430)** occurs on 2.2 percent (55 acres) of the corridor. Willow swamps occur on seasonally flooded soils. Willow swamps are minerotrophic wetlands with a canopy of medium to tall shrubs dominated by willows, especially pussy willow, slender willow, and Bebb's willow. Other species include red-osier dogwood and bog birch. Few sites with bog birch remain in the corridor.

***Non-native dominated shrubland* (52130, 52220, 52330, 52440)** constitutes 2 percent (50 acres) of the corridor. The four code numbers distinguish sites that are, respectively, upland, temporarily flooded, saturated, and seasonally flooded. Typically reed canary grass dominates the herbaceous layer, with Tartarian honeysuckle and buckthorn growing in the shrub layer.

***Native dominated shrubland* (52120, 52210, 52430)** occurs in 1 percent (24 acres) of the corridor. As with non-native shrubland, these sites include upland, temporarily flooded and seasonally flooded areas. Common species include sandbar willow, red-osier dogwood along with Bebb's willow.

1.4.1.4 Herbaceous Communities

Herbaceous areas are defined in the MLCCS as areas where herbs dominate—graminoids (grasses or grass-like plants), forbs (wildflowers), and ferns. These plants generally form at least 25 percent cover, with trees and shrubs forming less than 25 percent cover. Herb cover may be less than 25 percent as long as it exceeds tree, shrub, and nonvascular cover, respectively. Herbaceous communities in the corridor include (from most to least prevalent): non-native dominated grasslands, cattail marshes, mesic and wet prairie, mixed emergent marshes, wet meadow, water lily marsh, grasslands with sparse deciduous trees, Midwest pondweed submerged aquatic wetlands. Herbaceous communities comprise 23 percent (582 acres) of the corridor.

Non-native graminoid communities **(61120, 61220, 61330, 61480, 61530, 61630, 61730, 61830, 62140)** comprise 10.5 percent (266 acres) of the corridor. Often dominated by invasive brome on uplands or reed canary grass and purple loosestrife on wetlands, these communities include upland tall or medium-tall grasslands; wetlands that are temporarily flooded, saturated, seasonally flooded, semi-permanently flooded, intermittently exposed or permanently flooded, and upland grassland areas with sparse trees.

Cattail marshes **(61430, 61510, 61610, 61710, 61810)** comprise 7.7 percent (194 acres) of the corridor. These communities include saturated, seasonally flooded, semipermanently flooded, intermittently exposed, and permanently flooded areas. The non-native cattail species, including narrow-leaf cattail and the hybrid blue cattail, dominate these areas. Few sites still include the native broad-leaved cattail.

Mesic and wet prairie **(61110, 61310, 61410)** comprise 1.7 percent (43 acres) of the corridor. Distinguished by differences in moisture levels, these communities are dominated by native prairie grasses and wildflowers, with shrub cover <50 percent. The three codes denote, respectively, mesic, or moist upland, prairie (big bluestem and Indian grass dominant); wet prairie (on temporarily flooded soils, prairie cordgrass and bluejoint grass dominant); and saturated wet prairie.

Mixed emergent marshes **(61520, 61720, 61820)** comprise 1.2 percent (30 acres) of the corridor. Occurring on seasonally flooded, intermittently exposed, or permanently flooded soils, these wetlands have <30 percent tree cover and <50 percent shrub cover, and are not dominated by cattail or non-native species. Typical plants include rushes, broad-leaved arrowhead, and boneset.

Wet meadow**s (61320, 61420)** comprise 0.9 percent (22 acres) of the corridor. These are wetlands on temporarily flooded or saturated soils where peat is <0.5 meter deep and the leaves of most grasses and sedges are >3 mm wide. Forbs, such as blue vervain and blue flag iris, may be present but are often inconspicuous. With <50 percent cover by tall shrubs, wet meadows include no sphagnum moss and receive no ground water discharge.

Water lily marshes **(64111)** make up 0.6 percent (16 acres) of the corridor. They include areas of standing water with >25 percent cover by rooted species that either float or are submerged, most of which are water lilies. They occupy shallow water depressions, oxbow ponds, backwater sloughs of river floodplains, slow moving streams, ponds and small lakes.

***Grasslands with sparse deciduous trees* (62100, 62220)** make up 0.2 percent (6.3 acres) of the corridor. These are upland vegetation areas with 10 to 50 percent cover by trees and where >30 percent of non-tree cover is herbaceous. In some of these areas the ground layer is dominated by brome or Kentucky bluegrass. Almost any tree species can be found, but elm, cottonwood, green ash, boxelder, and bur oak are common.

***Midwest pondweed submerged aquatic wetland* (64120)** make up 0.2 percent (5 acres) of the corridor. These are areas of standing water with hydrophytic vegetation. Water lilies do not dominate the vegetation.

1.4.1.5 Open Water Areas

Open water areas are defined in MLCCS as an area where open water covers >96 percent of the area. Emergent vegetation generally contributes less than 5 percent total cover. Open water areas in the corridor include from most to least prevalent: limnetic (central) open water, littoral (shoreline) open water, aquatic beds with floating algae or vascular vegetation, and riverine and palustrine (lake) open water areas. Open water areas comprise 22 percent (561 acres) of the corridor.

***Limnetic open water* (92000, 92100)** comprises 14.7 percent (374 acres) of the corridor. These are non-channeled areas with <25 percent vegetative cover. Water covers >8 hectares (20 acres) OR water depth is >2 meters (6.6 feet) in the deepest part of the basin at times of low water.

***Palustrine open water* (93000, 93300)** comprises 4.8 percent (121 acres) of the corridor. These too are non-channeled area areas with <25 percent vegetative cover, but where water covers <8 hectares (20 acres) AND water depth is <2 meters (6.6 feet) in the deepest part of the basin at times of low water.

***Littoral open water* (92500)** comprises 1.8 percent (45 acres) of the corridor. These are non-channeled open water areas >8 hectares (20 acres) with <25 percent vegetative cover. Water depth is <2 meters (6.6 feet) at times of low water. Cowardin has defined littoral open water areas as extending from the shoreward boundary of the system to a depth of 6.6 feet (2 meters) below low water or to the maximum extent of non-persistent emergents, if these grow at depths greater than 6.6 feet (Cowardin, Carter et al., 1979).

***Aquatic beds with floating algae or vascular vegetation* (92420, 93100, 93110, 93120, 93200, 93220)** comprises 0.5 percent (12 acres) of the corridor. These are permanently flooded open water areas with >25 percent vegetative cover (mostly floating algae) in a basin that is <8 hectares (20 acres) AND water depth of <2 meters (6.6 feet) at times of low water.

***Riverine* areas (91100, 91200)** comprise 0.3 percent (9 acres) of the corridor. 91110 denotes low-gradient, slow-velocity linear open water areas with <25 percent vegetative cover. Dissolved oxygen is low, with deficits sometimes occurring. The fauna is mostly species that reach their maximum abundance in still water, and true planktonic organisms are common. The floodplain is well-developed. Cowardin calls this a lower perennial riverine system. 91200 denotes higher velocity channels with <25 percent vegetative cover, near-saturated oxygen concentration and little floodplain development. Unlike the former, substrate in this habitat is mostly rock, cobble or gravel with occasional patches of sand. Few or no planktonic forms live here. Cowardin (Cowardin, Carter et al., 1979) calls this an upper perennial riverine system.

1.4.1.6 Impervious Surface Areas

Impervious surface areas are defined in MLCCS as areas where total vegetation cover is <96 percent because of direct human alteration, such as roads, buildings, or bulldozing. These codes fall within the 10000 range (all begin with "1") and are grouped by ranges of impervious cover: 4 to 10 percent, 11 to 25 percent, 26 to 50 percent, 51 to 75 percent, 76 to 90 percent, and 91 to 100 percent (Table RC2). Since humans have altered so much of the landscape, the 10000 category encompasses a diverse range of plant communities. Those found in the corridor are described above, in the natural/semi-natural cover type section. Areas characterized by partial or total impervious surface comprise 16 percent (405 acres) of the corridor.

1.4.1.7 Planted or Cultivated Vegetation

Planted or cultivated vegetation areas are defined in MLCCS as those with >96 percent plant cover, where natural vegetation has been removed or modified and replaced with plants from anthropogenic sources. Vegetation may be planted, cultivated, annually managed, and/or otherwise altered by humans. These communities are listed in order of abundance below. Planted or cultivated areas comprise 1.4 percent (36 acres) of the corridor.

***Planted or maintained grasses with sparse tree cover* (23111, 23112)** comprise <u>1 percent</u> (20 acres) of the corridor.

***Planted or maintained grasses or forbs on upland soils* (23311, 23211, 23312)** occupy 0.3 percent (8 acres) of the corridor area.

Planted, maintained or cultivated deciduous trees on upland soils **(21213)** comprise 0.2 percent (4 acres) of the corridor.

Planted or maintained grass on hydric soils **(23221)** occupies 0.1 percent (3 acres) of the corridor.

Planted, maintained or cultivated coniferous trees **(21113)** occupy 0.1 percent (2 acres) of the corridor.

1.4.2 Bird Habitat Assessment

Bird habitat values are illustrated on Figures RC19 through RC27. The mapped values are expressed in avian species richness, the predicted number of bird species in each area derived from the species-area models. The mapped values are categorized in a distribution from 0-3, 3-6, 6-10, 10-15, and 15-24 species. A summary of average bird species richness for each community type is provided in Table RC6. The MDNR considers Purgatory Creek part of the Big Woods Ecological Classification. A list of bird species that utilize the Big Woods is shown in Table RC7.

The species-area curve model will calculate more species in larger areas and more species in vegetation that provides "better" habitat, such as lowland hardwood forests. This can be illustrated looking at Figure RC12. The large lake area in Figure RC12, shown in yellow to the west, is predicted to provide habitat for 15 to 24 bird species due to its large contiguous area (158 acres). On a per area basis, the communities that support the greatest number of bird species are, in descending order: lowland forests, shrublands, upland forests, cattail marshes, wet meadows, deep marshes, open water, upland fields, and developed areas. This is exemplified on Figures RC11 and RC25, where one of the lowland forest patches along the southern boundary of the lake (labeled 32220 on RC11) is predicted to support 15 to 24 species, even though it is only 5 acres in size.

Predictions for bird species richness were tested by calculating an area-weighted average of bird richness for each plant community type in 2003 (Table RC6). The 2003 bird richness value for each plant community follows the predicted sequence listed above. The one exception is open water, which supports greater bird richness on average than expected. This is because within a riparian, lowland corridor, most open water areas are relatively large. Other important variables affect the actual number of species recorded in the field, including landscape context and quality of the plant community at the site. These factors are considered in the modified habitat analysis described in the next section. The bird richness values generated using the species-area models provide a framework for expected bird richness under ideal circumstances.

1.4.3 Modified Habitat Analysis

The plot and tract variables were calculated with data collected in the field and on GIS analysis. All variables have a potential range of 0 to 1, with higher values indicating better habitat.

The plot variables (PV: data collected in the field) showed both high- and low-quality site factors.

- **Plot variable 1 (PV1)** measures tree canopy height in shrub or forested areas, or interspersion of vegetation in herbaceous areas. Values for PV1 ranged from 0.1 to 1, with 66 percent of the values being greater than 0.5, and 12 percent being greater than 0.7. The higher values reflect areas with taller tree canopy or herbaceous communities with multiple vegetation types.
- **Plot variable 2 (PV2)** measures foliage height diversity (whether foliage is multi-layered and spread evenly through the layers). PV2 values ranged from 0.33 to 1, with 67 percent of the values being greater than 0.5 and 23 percent being greater than 0.7. The higher values reflect greater structural diversity.
- **Plot variable 3 (PV3)** indicates soil moisture regime (seasonally inundated, saturated, temporarily saturated or dry). PV3 values ranged from 0.1 to 1, with 62 percent of the values being greater than 0.5, and 47 percent being greater than 0.7. The abundance of sites with significant soil moisture is expected in a riparian corridor. In general, wetter areas provide important habitat for a wide variety of species.
- **Plot variable 4 (PV4)** indicates the number of microhabitats available. PV4 values ranged from 0 to 1, with 73 percent of the values being greater than 0.5 and 38 percent being greater than 70 percent. A moderate number of microhabitats are available at most corridor sites.

This variety of on-site conditions (PVs) contributed to a range of final Plot Suitability Indices (Figure RC28). The Plot Suitability Indices (PSI), which are calculated from the PVs, ranged from 0.03 to 1, with 63 percent of the areas having a PSI greater than 0.5, and 24 percent having values greater than 0.7. The PSI indicates a range of on-site plot conditions within the corridor, and does not appear to be a limiting factor for habitat. It is important to note that the PSI primarily considers structural qualities at a site and does not take into account invasive species abundance.

The tract variables (TVs), landscape level variables calculated using GIS, indicated that most sites are low quality with respect to landscape level factors.

- **Tract variable 1 (TV1):** core area factor) ranged from 0.15 to 0.63, with only one area having a value greater than 0.5, and no areas with TV1 greater than 0.7. This calculation is based on percent core area of each area. The percent core area is found after grouping similar, adjacent areas and then determining a core. It is assumed species that live in the interior of a community are not present until there is at least a 100-meter border of the entire area. The lack of significant core areas within the sites is shown on Figure RC29.

- **Tract variable 2 (TV2: isolation factor)** consists of two variables. The permeability factor and the 2 km factor.

  - Edge permeability refers to the capacity of a tract's adjacent habitat to support wildlife dispersal and movement. The permeability factor had values over the entire range, from 0 to 2.55, with 71 percent having values greater than 1.5 and 21 percent having values greater than 2 (Figure RC30). Edge permeability does not appear to be a limiting factor for landscape movement in the corridor.
  - The 2 km factor refers to the percent of land cover within a 2 km buffer that is similar to that of the target polygon. The 2 km factor ranged from 0 to 84 percent, with 39 percent of the values greater than 50 percent, and 9 percent of the values greater than 70 percent (Figure RC31). The assumption is that the effective area of a site will be increased if the site is within 2 km of similar habitat types. Calculations used for the 2 km factor assumed that forested areas with 0 to 25 percent impervious surfaces would function much like non-developed forested areas. This increases the 2 km factor for a number of forested areas.

The tract suitability indices (TSI) were calculated using the TVs. With a possible range of 0 to 1, TSIs for the corridor were consistently low; no value was higher than 0.36 (Figure RC32). This is due to low values for TV1 (core area factor) throughout the corridor. Even when TV2 (2 km and permeability factor) was higher, the low core area brought the overall rating down. This is a clear reflection of the fragmentation and isolation of habitat areas within the corridor. As a result there is little effective area for interior species, which are an important component of native bird richness.

The habitat suitability indices (HSI) (Figure RC33) were calculated using the PSI and TSI values. Within the possible range of 0 to 1, HSI for the corridor ranged from 0 to 0.22. These extremely low HSI values reflect the low input values from the TSI. The fragmented landscape along the corridor and within the Purgatory Creek watershed is incorporated into the modified habitat model to result in very low overall HSI values throughout the corridor.

The bird richness values calculated using the species-area models did correlate with the habitat suitability index (Table RC8). The correlation value of 0.74 indicates on a scale of 0 to 1 that values of bird richness corresponded fairly well, but not exactly, to the habitat suitability index. Bird richness correlated less with the PSI and TSI, indicating that the HSI is a more useful measure of potential bird richness. This result is in part due to the importance the area value has in both the bird richness and HSI calculations.

1.4.4 Using Maps and Database for Analysis and Impact Assessment

1.4.4.1 Changes Over Time

The vegetation and bird species richness maps provide a useful tool to follow changes within the Purgatory Creek corridor over time. The 2003 study provides baseline data and a baseline area on which future studies can be based. Future researchers should attempt to use precisely the same corridor boundaries in order to make comparable determinations of landscape and habitat change. This baseline data will also serve to measure improvements in the corridor that result from new management plans. MLCCS provides a consistent method for recording and analyzing plant community integrity in the corridor, and will enable consistent comparison of data between years.

1.4.4.2 Special Management Areas

Some of the plant communities and locations within the Nine Mile Creek corridor warrant special attention because they provide habitat for either threatened or endangered species, or represent unique areas of natural vegetation. Although most of the corridor has been at least incidentally disturbed due to urban development, there are areas that still provide refuge for these significant species and communities.

The Department of Natural Resources Natural Heritage Database identifies two noteworthy sites within the corridor (Table RC9; Figure RC2). Both are small remnants of dry prairie, sand-gravel subtype, located on the upper parts of a southwest slope on the east side of the valley, flanked by dense housing. The MDNR rated the sites C and D in Element Occurrence quality, the two lowest rankings. Both sites are dominated by grasses including native *Bouteloua* sp., *Schizachyrium* sp., and *Stipa* sp. Other native species present are *Koeleria* sp., *Liatris punctata, Petalostemum purpurea, Calamovilfa* sp. and *Penstemon* sp. The sites are low in diversity, however, with heavy infestation of exotic invasive species leafy spurge (*Euphorbia esula),* Kentucky bluegrass (*Poa pratensis*), Canadian bluegrass (*Poa compressa),* and crown vetch (*Coronilla* sp.).

Adjacent to the corridor, a variety of threatened and endangered and "special concern" species are influenced by the quality and extent of the corridor. Listed in Table RC9, those species within 0.5 miles of the corridor include mucket mussel, ebonyshell mussel, pistolgrip mussel, Blanding's turtle and pugnose shiner. Significant communities within 0.5 miles of the corridor include colonial nesting bird sites and additional dry prairie, sand-gravel subtype. Table RC9 also lists other species found within approximately one mile of the corridor.

1.5 Discussion

1.5.1 Alteration of Plant Communities

The extent of the Purgatory Creek corridor has been reduced and its plant communities fragmented and isolated over the past 200 years. Since the time of European settlement, the landscape has been altered by agricultural and urban development. These latter changes have affected the levels of stream discharge and water quality and introduced exotic plant species. Fire, once set by lightning strikes and by Native Americans to create habitat and clear hunting grounds and transportation routes (Williams, 2001), has been suppressed, allowing woody plants to overtake prairies and savannas. Fragmentation of natural areas has interrupted propagule dispersion. These impacts have reduced the amount of wildlife habitat in the corridor and degraded those that remain, particularly wetlands. Recommendations for restoration are made in Section 5.

1.5.2 Habitat Analysis

The modified habitat analysis described above indicated that corridor bird habitat is very fragmented, which is to be expected in a largely developed area. Nonetheless, a review of the factors provides insight and suggests opportunities for improvement.

Plot level factors—qualities of small-scale, individual sites—are important both for bird species that require large areas and for those found on smaller sites or urbanized areas. By managing plots for vertical structure, plant community diversity, and microhabitat (qualities are found in mature forests and communities with few invasive species), species richness can be increased. It is important to ensure that plot quality does not degrade, since this factor is fundamental to habitat quality in the Purgatory Creek corridor.

The landscape level factors—shown in the tract variables, can override plot factors for species that require large tracts of land. Where habitat fragmentation occurs, smaller tracts and those with low connectivity to similar communities lose effective core area. Interior species populations become stressed and are eventually eliminated. For example, if tracts are small, interior species will not be found regardless of tree height (PV1), foliage height diversity (PV2), moisture (PV3), and microhabitat (PV4) values.

In general, the best predictors of bird species richness have been found to be a natural, heterogeneous landscape, large community patches, and close proximity to other like patches, along with microhabitats with open canopies (Saab, 1999).

1.5.3 Invasive Species

In most areas of the Purgatory Creek corridor, invasive plant species cover more than 50 percent of at least one vegetative layer (Figures RC34 – RC42). As in many urbanized areas, invasive species are a serious and widespread problem. The most abundant invasive plant species, in approximate order of decreasing abundance, are reed canary grass (*Phalaris arundinacea*), common buckthorn (*Rhamnus cathartica*), narrow-leaf and hybrid cattail (*Typha angustifolia, Typha* x. *glauca*), smooth brome (*Bromus inermis*), exotic honeysuckle shrubs (*Lonicera tartarica, L. morrowii, L.* x *bella*), leafy spurge (*Euphorbia esula*), garlic mustard (*Alliaria petiolata*), purple loosestrife (*Lythrum salicaria*), Canada thistle (*Cirsium arvense*), glossy buckthorn (*Rhamnus frangula*), and white and yellow sweetclover (*Melilotus alba* and *M. officinalis*).

1.5.4 Wetlands

The wetlands along the Purgatory Creek corridor (Table RC10) perform a variety of important functions: protecting stream water quality and shoreline integrity; maintaining vegetative diversity; providing wildlife and fishery habitat, flood storage and attenuation; and creating recreation and aesthetic values. Cattail marshes, lowland forests, and saturated, non-native dominated meadows are the most abundant wetland types in the corridor. Many of these areas are dominated by invasive plant species, such as reed canary grass and buckthorn (both common, *Rhamnus cathartica,* and glossy, *R. frangula*). Because wetlands play such an important role in the landscape, targeting certain wetlands for restoration would provide multiple benefits along the corridor.

1.6 Applicability of Bird Habitat Evaluation to Other Forms of Wildlife

Planning for or estimating presence of one or multiple species depends on individual site factors as well as spatial interactions on a landscape scale. Most models that predict habitat suitability are species-specific, and not even applicable to other similar organisms. With this in mind, the predictions of bird species richness in each of the plant communities may be a rough indicator of habitat quality for other types of wildlife such as mammals. The figures generated for the modified model (Figures RC28 through RC33) also provide insight into wildlife movement on the landscape. Mammals are affected by many of the same environmental factors (human activity, vertical stratification, plant community diversity) as birds. Some other generalizations that apply to both birds and other wildlife are: natural areas adjacent to other types of natural areas, or exhibiting greater connectivity serve as important corridors for animal movement in the landscape; larger areas tend to support more species than many small areas because both interior and edge species can exist there; abundance of invasive plant species tends to decrease native plant species diversity and, thus, decreases habitat quality.

1.7 Recommendations

A variety of approaches may be used to improve the quality of the plant communities and wildlife habitat along the corridor. The first recommendation, prioritizing sites, will increase cost effectiveness of restoration efforts and help preserve valuable and fragile high-quality areas. Prioritizing should occur early, and the resulting big-picture view should remain at the forefront of ongoing vegetation management efforts.

1.7.1 Prioritize Sites

We strongly recommend that high quality ecological communities (shown on Figures RC6 through RC14) be prioritized for preservation, and that they inform decisions about where other restoration and management efforts take place. Fifty-six sites (367 acres) were classified as having high ecological quality; 315 sites (1,407 acres) medium ecological quality; and 231 sites (763 acres) low ecological quality (Figures RC6 through RC14) .

High-quality sites could be targeted as "special management areas," where invasive plant species would be closely monitored and controlled. High-quality undeveloped sites with less than 30 percent invasive species cover should be first in line for special management. Whatever their plant community type, sites with low invasive cover are rare, and efforts should be made to preserve and restore them. In order to help prevent further encroachment of exotic species in to high-quality areas, management efforts could be extended into adjacent, lower-quality areas in order to create buffer zones.

High quality sites with more than 30 percent invasive cover could be next in line. Within these sites, priority should be given to those that exhibit less common plant communities in order to preserve corridor diversity.

Another approach, which could augment an overarching emphasis on high-quality sites, is to target particular plant communities or habitat types, such as wet and mesic prairie or riparian bird habitat. This is discussed further in the invasive species section below.

Since wetlands are such an important component on the corridor, a more detailed assessment of their quality may be warranted. The Minnesota Routine Assessment Method (MnRAM 3.0) evaluates a set of 12 wetland functions and values, and provides a score for each. Conducting a MnRAM analysis along the corridor would provide a framework for prioritizing wetlands to be preserved or restored. In addition to the function and quality of individual wetlands, however, it is important to consider the importance of relationships between wetlands. A complex of different types of wetlands supports greater species richness than one large, isolated wetland. (Brown and Dinsmore 1986).

Other factors that may influence priority-setting include: available funding opportunities (which may target specific plant or geographic communities), interest level of nearby residents, and site visibility, which could affect the ability of the District to educate constituents, promote restoration efforts, and leverage other resources.

1.7.2 Control Invasive Species

Quickly mobilizing resources and initiating an invasive species control program would greatly aid in conserving and expanding important natural communities within the Purgatory Creek corridor. The 2003 inventory recorded percent cover of the most important invasive plant species along the corridor. In addition to the general areas mapped on Figures 34 through 42, detailed information is available in the GIS database.

Maintaining the overall priority on high-quality communities, as discussed above, will mean battling a wide variety of invasive species on a limited number of sites. However, a wider-scale focus on specific plants is also recommended: (1) purple loosestrife in wet meadow, shallow marsh, and cattail marsh areas; (2) reed canary grass in wet meadow and other moist areas; (3) common buckthorn in forested areas; and (4) garlic mustard in forests.

Compared to buckthorn and reed canary grass in particular, garlic mustard is currently a minor component in the corridor, with the majority of occurrences at 5 percent cover or less and only 3 sites exhibiting more than 20 percent cover. However, this plant deserves to be considered a priority for eradication, since it will be much more effective to control it now, in its early stages of invasion. Its aggressive spread by seed could soon make it a much larger, more daunting issue in the corridor. The same is true for purple loosestrife.

Another approach to invasive species control is to assess impacts on a plant community basis. For example, management to improve riparian bird habitat would target lowland forest and shrub swamp areas. The invasive species of concern would include common buckthorn (*Rhamnus cathartica*) in wooded areas and glossy buckthorn (*Rhamnus frangula*) in shrub swamp areas.

Prior to implementing any invasive species control program, a survey should be conducted to ascertain work scope for particular species control efforts. Determining number of sites, priority for treatment, and areal extent of invasion per site will be important both for tracking progress and budgeting. It is critical that budgeting considerations always take long-term management into account. Funding a 1-year program for buckthorn, for instance, will be of little value if subsequent re-sprouts and seedlings are not attacked in the years following. Careful monitoring will determine the extent of follow-up needed.

Keeping up to date on control methods is important, since new research continually emerges regarding the effectiveness and ramifications of various chemicals and other techniques. For some species, the District may wish to implement and thoroughly document several proven control methods in order to determine the best solution for a given location.

In addition to partnerships with other agencies, some of which are noted in the species-specific information below, the District can benefit from recruiting volunteers in corridor communities or interested nonprofit groups.

1.7.2.1 Purple Loosestrife

The preferred method for large-scale purple loosestrife control in Minnesota has been leaf-eating beetles, which affect growth and seed production by consuming foliage and new shoots of the plants.

The first step is to conduct a detailed wetland survey during August when purple loosestrife is most apparent. Based on this survey, work scope and project cost would be calculated. The District could then partner with the MDNR, which has begun control of purple loosestrife in the vicinity of Purgatory Creek. The MDNR has recruited partners to rear insects statewide, and will assist land managers in collecting insects from established release sites and moving them to new loosestrife infestations. Surveys would be conducted in the years following beetle release to track both beetle population and purple loosestrife demise. Beetles would be reintroduced at sites where further loosestrife control is required.

1.7.2.2 Reed Canary Grass

Wet meadows dominated by reed canary grass characteristically support a low number of bird species, as well as a low numbers of individuals per bird species (Tyser 1982). Reducing reed canary grass is not an easy task, but given its widespread negative impacts on wetlands, it should not be glossed over during management and restoration planning. Best opportunities for success are wetlands where some native species still thrive. Control methods include:

- Frequent cutting or mowing (4 to 6 times per growing season, beginning in mid-June) over a period of at least three years to reduce seed and encourage native species. (Lyons 2000)
- Chemical control. Research indicates that fall chemical application may be most effective, and that at least two years of treatment is necessary to diminish reed canary stands.

Reed canary grass is NOT effectively controlled by burning; late-spring burns can actually accelerate its spread. Preliminary data suggests that a multi-year combination treatment of burning in conjunction with herbicide may be effective. (Reinhardt 2003)

1.7.2.3 Buckthorn

Buckthorn is well-known for its aggressive invasion of forest understories and other areas, where it creates dense shade (which discourages many tree species from regenerating) and exudes allelopathic chemicals that inhibit other plant growth. The berries have a cathartic effect on birds (thus the species name, *cathartica)*, causing them to lose nutritional value from the rest of their diet. Control methods vary depending on the stage of invasion and size of plants and include:

- Hand removal, including roots.
- Repeated cutting and stump spraying.
- Girdling, or cutting away the bark and cambium in a complete ring around the trunk. (The cambium, a thin layer of cells just beneath the bark, transports water and nutrients through the plant).
- .Foliar spraying seedlings when other plants are dormant.

In areas where full-scale buckthorn eradication is not immediately feasible, progress can be made by eliminating fruiting, female specimens.

In the years following successful buckthorn removal, the native seed bank often results in desirable native plants reemerging. In some cases, native shrubs or herbs could be planted to accelerate the restoration process. Follow-up surveys would guide control and restoration efforts over a series of years.

1.7.2.4 Garlic Mustard

Garlic mustard spreads into high quality forests, not just disturbed areas like many of its invasive kin. Within 10 years, invaded sites undergo a significant decline in native herbaceous cover. Garlic mustard is on the prohibited noxious weeds list in Minnesota. Control methods include:

- Pulling in areas of light infestations.
- Cutting flowering stems at ground level.
- Prescribed burning, when there is enough fuel to carry the flames.
- Spot applications of herbicide in early-spring or late-fall when native plants are dormant.

1.7.2.5 Other Invasive Species

A perennial cool season grass, 2 to 3 feet high, **smooth brome** is widely planted as a forage crop and for roadside erosion control. It reproduces vegetatively through rhizomes, which grow horizontally below the soil surface. Control methods include:

- Late-spring prescribed burns.
- Mowing and then, after a flush of growth, spraying repeatedly with chemicals.

Non-native, invasive **honeysuckle** is an upright deciduous shrub, about 5 to 12 feet tall, often found growing with buckthorn. There is a native honeysuckle shrub, but the dominant understory honeysuckle in the corridor is usually the non-native species *Lonicera* x *bella*, *L. tartarica*, or *L. morrowii*. Control methods include:

- Mechanical control.
  - Pulling plants while soil is moist.
  - Prescribed burning, which will set back but not eliminate these species..
- Cutting plants and treating stumps with chemicals.

Leafy spurge is a highly invasive perennial herbaceous plant. It grows to 2 to 3 feet tall with small flowers and showy yellow-green bracts visible from June into fall. Stems, flowers, and leaves emit a characteristic white milky sap when broken. Leafy spurge is a threat to moist and dry prairies and savannas, quickly displacing native plants. Tolerant of a wide range of habitats, from dry to moist, sunny to semi-shade, it rapidly invades non-cropland disturbed environments, such as roadsides. Leafy spurge is on the noxious weed list in Minnesota. Control methods include:

- Mechanical and chemical control.
  - Prescribed burning in conjunction with repeated chemical treatment..
  - Grazing goats.
- Biological control: Release of root-boring beetles, root-mining beetles or shoot-tip gall midge.

Canada thistle is a perennial herbaceous plant, 2 to 5 feet tall with numerous small purple flowers on top of the upper branched stems between June and September. Each plant has a fibrous taproot and each small section of root can form a new plant, enabling it to spread vegetatively as well as by seed. It grows in circular patches spreading vegetatively through horizontal roots, which can spread 10 to 12 feet in one season. Canada thistle invades natural areas such as prairies and savannas if some degree of disturbance already exists. It also invades wet areas with fluctuating water levels such as streambanks, sedge meadows, and wet prairies. Once established it spreads quickly and replaces native plants, diminishing diversity. It has been declared a noxious weed in 43 states, including Minnesota, and is one of the most tenacious agricultural weeds. Control includes:

- Mechanical
  - Repeated pulling and mowing to weaken roots.
  - Mowing when flower buds are just ready to open.
  - Late-spring burns (May/June) are most detrimental to the plant, but also stimulate seed germination; burn consecutively for 3 years for best results.
- Chemical: Spot application with glyphosate or with selective herbicides.
- Biological: Stem weevil, bud weevil, and stem gall fly are commercially available.

White and yellow sweet clovers are biennial herbaceous plants that grow 3 to 5 feet high and bloom during the second year. Both species are very fragrant. Sweet clover invades and degrades native grasslands by shading native sun-loving plants thereby reducing diversity. It grows abundantly on disturbed lands, roadsides and abandoned fields. Sweet clover thrives with prescribed burning, which stimulates seed germination, so appropriate follow-up to burning is critical. First-year plants are hard to detect. Control methods include:

- Mechanical
  - Repeated prescribed burning; a hot, early, complete first-year burn followed by a hot late-spring second-year burn. Repeat after two years.
  - Hand pulling can be effective on small infestations when the soil is moist.
  - Cutting, before flowers emerge.
- Chemical. Spray emergent seedlings after a fall burn, or after a spring burn before native vegetation emerges.

1.7.3 Restoration-Related Management Issues

When removing invasive plants and reintroducing native species, a number of related and follow-up measures must be addressed, either by the District or in collaboration with municipalities and other agencies. These include

- Ongoing maintenance of restored areas (even after invasive species have been eradicated, the threat for new infestations remains)
- Controlling deer, which can decimate a newly planted area and degrade existing diverse areas
- Controlling erosion, which is often related to unmanaged foot paths on steep slopes. Establishing properly sloped, sustainable trails and cutting off certain routes may be necessary.

1.7.4 Increase Effective Area and Mitigate Effects of Development

As noted in the discussion of plant communities and habitat, larger, better connected tracts and a diverse association of adjacent plant community types result in greater species richness. While invasive species control will help improve plant species diversity and thus increase the effective habitat area of a site, additional efforts involving spatial relationships in and around the corridor are recommended. Enlisting the cooperation of adjacent landowners is a particularly important strategy in moving toward some of these goals.

The discussion below suggests some general approaches. The District may wish to perform more detailed analysis using the data and models generated during this report process. For instance, further analysis of plant communities adjacent the corridor (which are contributing the effective size of corridor patches) could focus efforts for preservation and management partnerships. A model could show potential effects of establishing rainwater gardens or native plant buffers on private land adjacent the corridor. GIS analysis (perhaps in conjunction with a MnRAM assessment, mentioned above) could also help assess the most important complexes of distinct wetland types.

1.7.4.1 Corridor Width and Composition

The width of forested wetlands has been shown to affect number of bird species present (Kilgo, Sargent et al., 1998). Wider forest stands are more likely to contain features found in the forest interior that create avian habitat, such as shrub thickets or water channels. Some bird species, which are dependent on edge habitat, will be found more in narrow corridor areas (which are more plentiful in the Purgatory Creek corridor and elsewhere in the region). Overall, research has found that a forested wetland width greater than 150 feet best maintains the complete avian community (Kilgo, Sargent et al., 1998).

The District could map areas where this width does exist, and take pains to protect it.

Development, topographic and other factors make this goal unrealistic in some areas; encouraging buffer zones on adjacent property may help extend the effective area. In areas where a wide forested corridor does not exist, the following management approach may help protect riparian areas from upland impacts. The aim: to create three zones, described here in up-slope order from the stream:

1. A permanent forest about 30 feet wide,
2. Shrubs and trees up to 12 feet wide (managed to maximize biomass production)
3. Herbaceous vegetation up to 20 feet wide.

The first zone influences the stream environment such as temperature, light, habitat diversity, channel morphology, food webs, and in-stream species richness. The second zone controls pollutants in subsurface flow and surface runoff that feed into the stream. Biological and chemical transformations occur in the second zone, as well as storage in woody vegetation, infiltration, and sediments deposition. Both of these first two zones contribute to nitrogen, phosphorus, and sediment pollution removal. The third zone helps to spread overland flow, thus facilitating deposition of coarse sediments (Naiman and Décamps 1997).

In some areas, the third zone might be achieved by providing incentives for or otherwise encouraging private landowners to establish native buffer zones on their properties.

1.7.4.2 Impervious Surface Areas

The increased runoff volume and velocity associated with impervious surfaces degrade riparian plant communities as well as damage in-stream processes. Runoff volume can be mitigated via rainwater gardens or other alternative stormwater management techniques. These methods might be employed across a selected subwatershed, where impact could be measured and cost-effectiveness assessed.

Rainwater gardens, which can incorporate native species, and other areas converted to native plantings, can enhance the habitat quality of developed areas as well. Areas that provide bird habitat, but with some amount of impervious surfaces, are indicated with hatch lines in Figures RC19 through RC27. While efforts in these areas will not increase core area for selective, migrant species, they will provide useful edge habitat and, in some cases, help buffer larger, undeveloped habitat tracts. Developed sites that are adjacent to high quality areas could be the focus of native plantings.

1.7.5 Initiate Education Efforts

Given finite resources, the District may need to recruit volunteers in order to reach some of its goals. Educating constituents to influence their property management and engender their participation in projects is an important component of many of the above strategies.

The most active participants (and accepting observers) are those who understand the importance of healthy native plant communities on water quality and wildlife habitat. To this end, the District may wish to consider brochures explaining invasive species control efforts, workshops on yard design and maintenance, and other events that explain the riches of the District and how a combination of public and private efforts can help retain them.

Potential volunteer, or voluntary, contributions to the corridor include: helping remove and monitor invasive plants, planting restoration sites, and establishing buffer zones on lawns adjacent the corridor.

Just as for restoration and plant community management programs, education efforts should be monitored and assessed for effectiveness.

1.8 Conclusion

The authors hope this 2003 corridor inventory will help the District and its constituents understand, preserve, and restore this valuable urban greenway. The data offers a baseline from which to track corridor changes due to continued development or as a result of restoration efforts. These changes can be mapped and measured in terms of loss or gain in wildlife habitat value and plant community types and quality.

Riparian corridors possess a diversity of hydrologic regimes, nutrient cycles, and geomorphic processes which have resulted in a wide variety of plant and animal adaptations (Naiman et al. 1993); the dynamic environment has created valuable biodiversity. By maintaining and enhancing quality of the Purgatory Creek corridor, the district is making a critical contribution to environmental vitality, both at a local and regional level.

1.9 References

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Table RC1
Species Area Models 2003[1]

Model Description	Constants		Correlation Coeeficient (r^2)	Source
	C	Z		
Lowland forest	12.8	0.275	0.946	Graber and Graber (1976)
Upland forest	6.01	0.417	0.948	Graber and Graber (1976)
Shrub land	9.71	0.326	0.869	Graber and Graber (1976)
Fallow field	1.94	0.282	0.927	Samson (1980)
Cattail marsh	5.27	0.323	0.921	Tyser (1983)
Seasonal and semi-permanent marsh (includes wet meadow and open water)	6	0.23	0.68	Brown and Dinsmore (1988)

[1] R. L. Schroeder, "Wildlife community habitat evaluation using a modified species-area relationship:Technical Report WRP-DE-12" (U.S. Army Engineer Waterways Experiment Station, 1996).

Table RC2

Modified Model: Permeability Look Up Table[1]

MLCCS	10000s	1121x	1122x	1123x	1124x	20000s	30000s	40000s	50000s	60000s	80000s	90000s
10000s	1	1	1	1	1	1	1	1	1	1	1	1
1121x		1.2	1.2	1.2	1	1.2	1.89	1.2	1.2	1.2	1.2	1.2
1122x			1.2	1.2	1	1.2	1.89	1.2	1.2	1.2	1.2	1.2
1123x				1.2	1	1.2	1.89	1.2	1.2	1.2	1.2	1.2
1124x					1	1	1	1	1	1	1	1
20000s						1.53	1.53	1.53	1.53	1.53	1.53	1.53
30000s							2.55	2.55	1.97	1.6	1.53	1.53
40000s								2.55	1.89	1.6	1.53	1.53
50000s									2.55	1.89	1.53	1.53
60000s										2.55	1.53	1.53
80000s											2.55	1.53
90000s												1.53

[1] Derived from Shroeder, R.L. 1996 Wildlife Community Habitat Evaluation: A Model for Deciduous Palustrine Forested Wetlands in Maryland

Table RC3
Modified Model: MLCCS Codes Assigned to Met Council and National Wetland Inventory (NWI) Data

MLCCS Code Assigned	NWI-Cowardin	Barr Land Use Code
10000		Airport, Commercial, Highway, Industrial/Office
11220		Low density residential
11230		Institutional, Medium density residential
11240		High density residential
20000		Agricultural, Golf course
30000		Natural/Park/Open space
32200	PFO1C	
52400	PSS1C	
60000	Some 'U'	
61400	PEMA, PEMB	
61500	PEMC	
61600	PEMF	
61700	PUB/EMF	
61800	PUBG	
90000	PUBG, LUBH, R2UBH	Open water

Table RC4
Modified Model: 2 Km Factor Look Up

	100000	1121x	1122x	1123x	1124x	20000s	30000s	40000s	50000s	61100s	61200s	61300s	61400s	61500s	61600s	61700s	61800s	62000s	64000s	90000s
10000	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1121x		1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1122x			1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1123x				1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1124x					1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20000s						1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30000s							1	1	0	0	0	0	0	0	0	0	0	0	0	0
40000s								1	0	0	0	0	0	0	0	0	0	0	0	0
50000s									1	0	0	0	0	0	0	0	0	0	0	0
61100s										1	1	1	1	1	1	0	0	1	0	0
61200s											1	1	1	1	1	0	0	1	0	0
61300s												1	1	1	1	0	0	1	0	0
61400s													1	1	1	0	0	1	0	0
61500s														1	1	0	0	1	0	0
61600s															1	1	1	1	1	
61700s																1	1	0	1	1
61800s																	1	0	1	1
62000s																		1	0	0
64000s																			1	1
90000s																				1

Table RC5
2003 MLCCS Plant Community Summary

MLCCS Code	Description	Count	Total Acres	% Total Area
11210	4% to 10% impervious cover with deciduous trees	1	2.9	0.1
11214	Boxelder-green ash (forest) with 4-10% impervious cover	11	43.4	1.7
11219	Other deciduous trees with 4-10% impervious cover	1	1.2	0.0
11220	11% to 25% impervious cover with deciduous trees	1	10.5	0.4
11221	Oak (forest or woodland) with 11- 25% impervious cover	2	6.5	0.3
11223	Maple-basswood (forest) with 11- 25% impervious cover	2	4.0	0.2
11224	Boxelder-green ash (forest) with 11- 25% impervious cover	3	12.4	0.5
11229	Other deciduous trees with 11- 25% impervious cover	2	3.2	0.1
11230	26% to 50% impervious cover with deciduous trees	1	3.7	0.1
11231	Oak (forest or woodland) with 26-50% impervious cover	1	0.8	0.0
11234	Boxelder-green ash (forest) with 26-50% impervious cover	6	32.1	1.3
11239	Other deciduous trees with 26-50% impervious cover	1	0.4	0.0
11240	51% to 75% impervious cover with deciduous trees	3	5.8	0.2
11244	Boxelder-green ash (forest) with 51-75% impervious cover	2	3.6	0.1
11324	Planted mixed coniferous/deciduous trees with 11-25% impervious cover	1	4.6	0.2
11334	Planted mixed coniferous/deciduous trees with 26-50% impervious cover	1	10.9	0.4
12133	Other coniferous and/or deciduous shrubs, 26-50% impervious cover	1	0.6	0.0
13110	4% to 10% impervious cover with perennial grasses and sparse trees	1	4.1	0.2
13114	Short grasses and mixed trees with 4-10% impervious cover	4	36.3	1.4
13124	Short grasses and mixed trees with 11-25% impervious cover	5	15.7	0.6
13125	Long grasses and mixed trees with 11-25% impervious cover	1	5.7	0.2
13134	Short grasses and mixed trees with 26-50% impervious cover	7	26.5	1.0
13135	Long grasses and mixed trees with 26-50% impervious cover	1	1.4	0.1
13144	Short grasses and mixed trees with 51-75% impervious cover	5	30.0	1.2
13145	Long grasses and mixed trees with 51-75% impervious cover	1	3.6	0.1
13211	Short grasses with 4-10% impervious cover	2	5.2	0.2
13212	Non-native dominated long grasses with 4-10% impervious cover	4	9.6	0.4
13213	Mesic prairie with 4-10% impervious cover	1	1.2	0.0
13221	Short grasses with 11-25% impervious cover	3	13.5	0.5
13222	Non-native dominated long grasses with 11-25% impervious cover	2	5.2	0.2
13231	Short grasses with 26-50% impervious cover	3	23.0	0.9
13232	Non-native dominated long grasses with 26-50% impervious cover	4	4.9	0.2
13241	Short grasses with 51-75% impervious cover	1	0.5	0.0
13242	Non-native dominated long grasses with 51-75% impervious cover	1	3.0	0.1
14111	Buildings with 76-90% impervious cover	1	0.5	0.0
14112	Pavement with 76-90% impervious cover	6	45.8	1.8
14113	Buildings and pavement with 76-90% impervious cover	1	3.2	0.1
14122	Pavement with 91-100% impervious cover	7	7.0	0.3
14123	Buildings and pavement with 91-100% impervious cover	1	2.5	0.1
14214	Other exposed/transitional land with 0-10% impervious cover	4	10.4	0.4
21113	Red pine trees on upland soils	1	2.3	0.1
21213	Deciduous trees on upland soils	1	4.1	0.2
23111	Short grasses with sparse tree cover on upland soils	5	17.0	0.7
23112	Long grasses with sparse tree cover on upland soils	1	2.9	0.1
23211	Short grasses on upland soils	2	3.0	0.1
23221	Short grasses on hydric soils	2	2.7	0.1
23311	Short grasses and forbs on upland soils	1	0.5	0.0
23312	Long grasses and forbs on upland soils	2	4.0	0.2
31210	Tamarack swamp	1	1.9	0.1
32100	Upland deciduous forest	4	20.0	0.8
32110	Oak forest	3	18.9	0.7
32112	Oak forest mesic subtype	8	43.6	1.7
32113	Oak forest dry subtype	5	32.3	1.3
32150	Maple-basswood forest	15	112.3	4.4
32170	Boxelder - green ash disturbed native forest	26	113.0	4.5
32210	Floodplain forest	41	110.2	4.3
32212	Floodplain forest swamp white oak subtype	1	13.7	0.5

(continued)

MLCCS Code	Description	Count	Total Acres	% Total Area
32220	Lowland hardwood forest	54	207.4	8.2
32230	Aspen forest temporaily flooded	1	1.3	0.1
32330	Aspen forest saturated	4	12.2	0.5
32410	Black Ash swamp - seasonally flooded	2	8.5	0.3
32420	Mixed hardwood swamp - seasonally flooded	5	19.1	0.8
42130	Disturbed deciduous woodland	10	28.4	1.1
52120	Native dominated upland shrubland	3	2.4	0.1
52130	Non-native dominated upland shrubland	5	8.0	0.3
52210	Native dominated temporarily flooded shrubland	3	11.4	0.4
52220	Non-native dominated temporarily flooded shrubland	2	8.3	0.3
52300	Saturated deciduous shrubland	1	7.4	0.3
52330	Non-native dominated saturated shrubland	2	8.3	0.3
52400	Seasonally flooded deciduous shrubland	4	3.3	0.1
52420	Wet meadow shrub subtype	14	79.9	3.1
52430	Willow swamp	22	55.2	2.2
52440	Non-native dominated seasonally flooded shrubland	8	25.9	1.0
61110	Mesic prairie	5	23.0	0.9
61120	Tall grass non-native dominated grassland	2	3.5	0.1
61220	Medium-tall grass non-native dominated grassland	11	32.0	1.3
61310	Wet prairie	1	19.1	0.8
61320	Wet meadow - temporarily flooded soils	6	8.6	0.3
61330	Temporarily flooded non-native dominated grassland	11	23.5	0.9
61410	Wet prairie - saturated soils	1	0.7	0.0
61420	Wet meadow	7	13.2	0.5
61430	Cattail marsh - saturated soils	1	3.0	0.1
61480	Saturated non-native dominated graminoid vegetation	36	119.1	4.7
61510	Cattail marsh - seasonally flooded	26	87.7	3.5
61520	Mixed emergent marsh - seasonally flooded	4	22.7	0.9
61530	Seasonally flooded non-native dominated emergent vegetation	17	53.6	2.1
61610	Cattail marsh	18	98.9	3.9
61630	Semipermanently flooded non-native dominated vegetation	4	2.4	0.1
61710	Cattail marsh - intermittently exposed	5	3.9	0.2
61720	Mixed emergent marsh - intermittently exposed	2	4.7	0.2
61730	Intermittently exposed non-native dominated vegetation	2	3.8	0.2
61810	Cattail marsh - permanently flooded	2	1.1	0.0
61820	Mixed emergent marsh - permanently flooded	2	2.9	0.1
61830	Permanently flooded non-native dominated vegetation	2	0.9	0.0
62100	Grassland with sparse deciduous trees	1	1.6	0.1
62140	Grassland with sparse deciduous trees - non-native dominated vegetation	10	27.2	1.1
62220	Grassland with sparse conifer or mixed deciduous/coniferous trees - non-native dominated vegetation	1	4.8	0.2
64111	Water Lily Open Marsh	5	15.9	0.6
64120	Midwest Pondweed Submerged Aquatic Wetland	6	4.8	0.2
91100	Slow moving linear open water habitat	3	6.7	0.3
91200	Fast moving linear open water habitat	1	1.9	0.1
92000	Lake (lacustrine)	1	158.0	6.2
92100	Limnetic Open Water	1	215.9	8.5
92420	Floating vascular vegetation - Permanently flooded littoral aquatic bed	1	1.1	0.0
92500	Littoral Open water	1	44.9	1.8
93000	Wetland-Open Water (palustrine)	1	1.7	0.1
93100	Intermittently exposed aquatic bed	1	0.5	0.0
93110	Floating algae - Intermittently exposed aquatic bed	2	3.3	0.1
93120	Floating vascular vegetation - Intermittently exposed aquatic bed	1	0.4	0.0
93200	Permanently flooded aquatic bed	5	4.8	0.2
93220	Floating vascular vegetation	2	2.5	0.1
93300	Open water	29	119.7	4.7

Table RC6
Summary of Bird Species Richness: Species Area Models

Community Type	Number of Sites	Average Area Acres	Total Area Acres	Area Weighted Average Bird Richness
Lowland Forest	117	3.4	393.5	16
Open Water	43	12.9	556.5	15
Lowland Forest - Developed	3	3.4	10.2	14
Shrubland	70	3.0	212.4	13
Upland Forest	74	5.3	390.4	11
Upland Forest - Developed	22	4.8	105.3	9
Cattail Marsh	57	3.8	214.9	7
Wet Meadow	80	3.1	244.3	7
Deep Marsh	17	1.8	31.3	6
Wet Meadow - Developed	1	0.4	0.4	4
Open Water - Developed	6	0.4	2.5	4
Fallow Field	40	2.8	113.7	2
Fallow Field - Developed	22	2.2	47.5	2
Developed	52	4.2	216.8	0

Table RC7

Draft Bird Species List for Big Woods Ecological Classification Subsection[1]

Common Name	Resident Status[2]	State Status[3]	Federal Status[4]	Big Wood ECS Subsection[5]
Common Loon	R	PB	P	B
Pacific Loon	R	PB	P	M
Pied-billed Grebe	R	PB	P	B
Horned Grebe	R	T, PB	P	M
Red-necked Grebe	R	PB	P	B
Eared Grebe	R	PB	P	B
Western Grebe	R	PB	P	B
American White Pelican	R	PB	P	B
Double-crested Cormorant	R	PB, SC	P	M/SV
American Bittern	R	UB	P	B
Least Bittern	R	PB	P	B
Great Blue Heron	R	PB	P	B
Great Egret	R	PB	P	B
Snowy Egret	R	PB	P	M/SV
Little Blue Heron	R	PB	P	M/SV
Cattle Egret	R	PB	P	M/SV
Green Heron	R	PB	P	B
Black-crowned Night Heron	R	PB	P	B
Yellow-crowned Night Heron	R	PB	P	M
Tundra Swan	R	PB, MW	P	M
Mute Swan	R	UB		M
Trumpeter Swan	R	PB, MW, T	P	M
Greater White-fronted Goose	R	PB, MW	P	M
Snow Goose	R	PB, MW	P	M
Ross's Goose	R	PB, MW	P	M
Canada Goose	R	PB, MW	P	B
Wood Duck	R	PB, MW	P	B
Green-winged Teal	R	PB, MW	P	B
Black Duck	R	PB, MW	P	M
Mallard	R	PB, MW	P	B
Pintail	R	PB, MW	P	B
Blue-winged Teal	R	PB, MW	P	B
Cinnamon Teal	R	PB, MW	P	M
Northern Shoveler	R	PB, MW	P	B
Gadwall	R	PB, MW	P	B
American Wigeon	R	PB, MW	P	M
Canvasback	R	PB, MW	P	B
Redhead	R	PB, MW	P	B
Ring-necked Duck	R	PB, MW	P	M
Lesser Scaup	R	PB, MW	P	M
Common Goldeneye	R	PB, MW	P	M
Bufflehead	R	PB, MW	P	M
Hooded Merganser	R	PB, MW	P	B
Common Merganser	R	PB, MW	P	M
Red-breasted Merganser	R	PB, MW	P	M
Ruddy Duck	R	PB, MW	P	B
Turkey Vulture	R	PB	P	B
Osprey	R	PB	P	B
Bald Eagle	R	PB, SC	T, P	B
Northern Harrier	R	PB	P	B
Sharp-shinned Hawk	R	PB	P	M
Cooper's Hawk	R	PB	P	B
Northern Goshawk	R	PB	P	WV
Red-shouldered Hawk	R	PB, SC	P	B
Broad-winged Hawk	R	PB	P	M
Red-tailed Hawk	R	PB	P	B
Rough-legged Hawy	R	PB	P	M
Killdeer	R	PB	P	M
American Kestrel	R	PB	P	B
Merlin	R	PB	P	M
Peregrine Falcon	R	PB, T	P	M
Gray Partridge	PR	PB, SG		P

(continued)

Common Name	Resident Status[2]	State Status[3]	Federal Status[4]	Big Wood ECS Subsection[5]
Ring-necked Pheasant	PR	PB, SG		P
Wild Turkey	PR	SB, SG		P
Yellow Rail	R	PB, SC	P	M
Virginia Rail	R	PB, SG	P	B
Sora	R	PB, SG	P	B
Common Moorhen	R	PB, SG, SC	P	B
American Coot	R	PB, SG	P	B
Sandhill Crane	R	PB	P	B
Black-bellied Plover	R	PB	P	M
American-Golden Plover	R	PB	P	M
Semipalmated Plover	R	PB	P	M
Piping Plover	R	PB, E	P, E&T	M
Killdeer	R	PB	P	B
American Avocet	R	PB	P	M
Greater Yellowlegs	R	PB	P	M
Lesser Yellowlegs	R	PB	P	M
Solitary Sandpiper	R	PB	P	M
Willet	R	PB	P	M
Spotted Sandpiper	R	PB	P	B
Upland Sandpiper	R	PB	P	B
Whimbrel	R	PB	P	M
Hudsonian Godwit	R	PB	P	M
Marbled Godwit	R	PB, SC	P	M
Ruddy Turnstone	R	PB	P	M
Red Knot	R	PB	P	M
Sanderling	R	PB	P	M
Semipalmated Sandpiper	R	PB	P	M
Least Sandpiper	R	PB	P	M
White-rumped Sandpiper	R	PB	P	M
Baird's Sandpiper	R	PB	P	M
Perctoral Sandpiper	R	PB	P	M
Dunlin	R	PB	P	M
Stilt Sandpiper	R	PB	P	M
Buff-breasted Sandpiper	R	PB	P	M
Short-billed Dowitcher	R	PB	P	M
Long-billed Dowitcher	R	PB	P	M
Common Snipe	R	PB,SG	P	B
American Woodcock	R	PB,SG	P	B
Wilson's Phalarope	R	PB, T	P	M
Red-necked Phalarope	R	PB	P	M
Franklin's Gull	R	PB, SC	P	M
Bonaparte's Gull	R	PB	P	M
Ring-billed Gull	R	PB	P	B
Herring Gull	R	PB	P	M
Thayer's Gull	R	PB	P	M
Lesser Black-backed Gull	R	PB	P	M
Glaucous Gull	R	PB	P	M
Caspian Tern	R	PB	P	M
Common Tern	R	PB, T	P	M
Forster's Tern	R	PB, SC	P	B
Black Tern	R	PB	P	B
Rock Dove	R	PB	P	P
Mourning Dove	R	PB	P	B
Black-billed Cuckoo	R	PB	P	B
Yellow-billed Cuckoo	R	PB	P	B
Eastern Screech-Owl	PR	PB	P	P
Great Horned Owl	PR	UB	P	P
Snowy Owl	R	PB	P	WV
Barred Owl	PR	PB	P	P
Long-eared Owl	PR	PB	P	M
Short-eared Owl	R	PB,SC	P	M
Northern Saw-whet Owl	R	PB	P	M
Common Nighthawk	R	PB	P	B
Whip-poor-will	R	PB	P	M
Chimney Swift	R	PB	P	B
Ruby-throated Hummingbird	R	PB	P	B
Belted Kingfisher	R	PB	P	B

(continued)

Common Name	Resident Status[2]	State Status[3]	Federal Status[4]	Big Wood ECS Subsection[5]
Red-headed Woodpecker	R	PB	P	B
Red-bellied Woodpecker	PR	PB	P	P
Yellow-bellied Sapsucker	R	PB	P	B
Downy Woodpecker	PR	PB	P	P
Hairy Woodpecker	PR	PB	P	P
Northern Flicker	R	PB	P	P
Pileated Woodpecker	PR	PB	P	P
Olive-sided Flycatcher	R	PB	P	M
Eastern Wood-Pewee	R	PB	P	B
Yellow-bellied Flycatcher	R	PB	P	M
Acadian Flycatcher	R	PB, SC	P	B
Alder Flycatcher	R	PB	P	M
Willow Flycatcher	R	PB	P	B
Least Flycatcher	R	PB	P	B
Eastern Phoebe	R	PB	P	B
Great Crested Flycatcher	R	PB	P	B
Western Kingbird	R	PB	P	M
Eastern Kingbird	R	PB	P	B
Horned Lark	R	PB	P	B
Purple Martin	R	PB	P	B
Tree Swallow	R	PB	P	B
Northern Rough-winged	R	PB	P	B
Bank Swallow	R	PB	P	B
Cliff Swallow	R	PB	P	B
Barn Swallow	R	PB	P	B
Blue Jay	PR	PB	P	P
American Crow	PR	PB	P	P
Black-capped Chickadee	PR	PB	P	P
Red-breated Nuthatch	PR	PB	P	M
White-breasted Nuthatch	PR	PB	P	P
Brown Creeper	R	PB	P	M
Carolina Wren	R	PB	P	WV
House Wren	R	PB	P	B
Winter Wren	R	PB	P	M
Sedge Wren	R	PB	P	B
Marsh Wren	R	PB	P	B
Golden-crowned Kinglet	R	PB	P	M
Ruby-crowned Kinglet	R	PB	P	M
Blue-gray Gnatcatcher	R	PB	P	B
Eastern Bluebird	R	PB	P	B
Townsend's Solitaire	R	PB	P	WV
Veery	R	PB	P	B
Gray-cheeked Thrush	R	PB	P	M
Swainson's Thrush	R	PB	P	M
Hermit Thrush	R	PB	P	M
Wood Thrush	R	PB	P	B
American Robin	R	PB	P	B
Varied Thrush	R	PB	P	WV
Gray Catbird	R	PB	P	B
Northern Mockingbird	R	PB	P	M/SV
Brown Thrasher	R	PB	P	B
European Starling	PR	UB		P
American Pipit	R	PB	P	M
Cedar Waxwing	R	PB	P	B
Northern Shrike	R	PB	P	WV
Loggerhead Shrike	R	PB, T	P	B
Bell's Vireo	R	PB	P	B
Blue-headed Vireo	R	PB	P	M
Yellow-throated Vieo	R	PB	P	B
Warbling Vireo	R	PB	P	B
Philadelphia Vireo	R	PB	P	M
Red-eyed Vireo	R	PB	P	B
Blue-winged Warbler	R	PB	P	M
Golden-winged Warbler	R	PB	P	M
Tennessee Warbler	R	PB	P	M
Orange-crowned Warbler	R	PB	P	M
Nashville Warbler	R	PB	P	M

(continued)

Common Name	Resident Status[2]	State Status[3]	Federal Status[4]	Big Wood ECS Subsection[5]
Northern Parula	R	PB	P	M
Yellow Warbler	R	PB	P	B
Chestnut-sided Warbler	R	PB	P	B
Magnolia Warbler	R	PB	P	M
Cape May Warbler	R	PB	P	M
Yellow-rumped Warbler	R	PB	P	M
Black-throated Green Warbler	R	PB	P	M
Backburnian Warbler	R	PB	P	M
Pine Warbler	R	PB	P	M
Palm Warbler	R	PB	P	M
Bay-breasted Warbler	R	PB	P	M
Blackpoll Warbler	R	PB	P	M
Cerulean Warbler	R	PB, SC	P	B
Black-and-white Warbler	R	PB	P	M
American Redstart	R	PB	P	B
Prothonotary Warbler	R	PB	P	M
Worm-eating Warbler	R	PB	P	M
Ovenbird	R	PB	P	B
Northern Waterthrush	R	PB	P	M
Louisiana Waterthrush	R	PB, SC	P	M
Kentucky Warbler	R	PB	P	M
Connecticut Warbler	R	PB	P	M
Mourning Warbler	R	PB	P	M
Common Yellowthroat	R	PB	P	B
Hooded Warbler	R	PB, SC	P	B
Wilson's Warbler	R	PB	P	M
Canada Warbler	R	PB	P	M
Yellow-breasted Chat	R	PB	P	M/SV
Summer Tanager	R	PB	P	M/SV
Scarlet Tanager	R	PB	P	B
Western Tanager	R	PB	P	M
Northern Cardinal	PR	PB	P	P
Rose-breasted Grosbeak	R	PB	P	B
Indigo Bunting	R	PB	P	B
Dickissel	R	PB	P	B
Eastern Towhee	R	PB	P	B
American Tree Sparrow	R	PB	P	WV
Chipping Sparrow	R	PB	P	B
Clay-colored Sparrow	R	PB	P	B
Field Sparrow	R	PB	P	B
Vesper Sparrow	R	PB	P	B
Lark Sparrow	R	PB	P	B
Savannah Sparrow	R	PB	P	B
Grasshopper Sparrow	R	PB	P	B
Henslow's Sparrow	R	PB, E	P	M
Le Conte's Sparrow	R	PB	P	M
Nelson's Sharp-tailed Sparrow	R	PB, SC	P	M
Fox Sparrow	R	PB	P	M
Song Sparrow	R	PB	P	B
Lincoln's Sparrow	R	PB	P	M
Swamp Sparrow	R	PB	P	B
White-throated Sparrow	R	PB	P	M
White-crowned Sparrow	R	PB	P	M
Harris's Sparrow	R	PB	P	M
Dark-eyed Junco	R	PB	P	M
Lapland Longspur	R	PB	P	WV
Snow Bunting	R	PB	P	WV
Boblink	R	PB	P	B
Red-winged Blackbird	R	UB	P	B
Eastern Meadowlark	R	PB	P	B
Western Meadowlark	R	PB	P	B
Yellow-headed Blackbird	R	UB	P	B
Rusty Blackbird	R	UB	P	M
Brewer's Blackbird	R	UB	P	B
Common Grackle	R	UB	P	B
Brown-headed Cowbird	R	PB	P	B
Orchard Oriole	R	PB	P	B

(continued)

Common Name	Resident Status[2]	State Status[3]	Federal Status[4]	Big Wood ECS Subsection[5]
Baltimore Oriole	R	PB	P	B
Purple Finch	R	PB	P	M
House Finch	PR	PB	P	B
Pine Siskin	R	PB	P	WV
American Goldfinch	R	PB	P	B
Evening Grosbeak	R	PB	P	M
House Sparrow	PR	UB		P

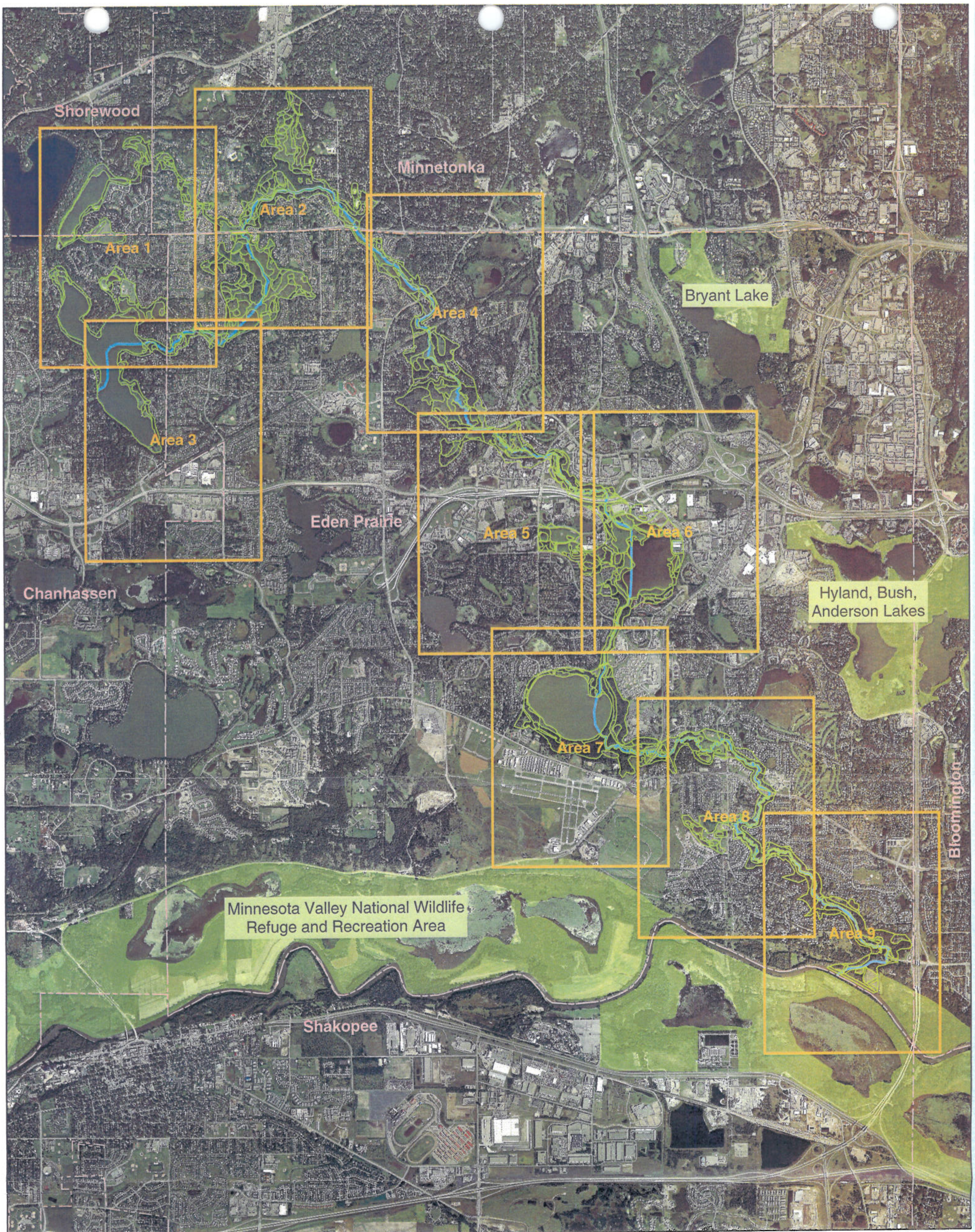
[1] Minnesota Departement of Natural Resouces, Wildlife Resource Assessment Team (9-24-03)

[2] R = Resident Status: R=Regular resident as Breeding, Nesting, or Migratory (acceptable record exists in at least eight of the past ten years); PR=Permanent Resident (exists year-round); A=Accidental (acceptable record exists in zero to three of the past ten years); C=Casual (acceptable record exists in three to eight of the past ten years).

[3] State Legal Status: E=State Endangered; T=State Threatened; SC=State Speces of Special Concern; MW=Migratory Waterfowl; UB=Unprotected Bird; PB=Protected Bird.

[4] Federal Legal Status: T=Federal Threatened; E=Federal Endangered; P=Federal Protection by Migratory Bird Treaty Act and/or Bald Eagle Protection Act and/or CITES

[5] ECS Subsection Resident Status: B=Minnesota breeding record exists for the species; M=Spring or fall migrant, non-breeder; SV=Summer visitor, non-breeder; WV=Winter visitor, non-breeder.



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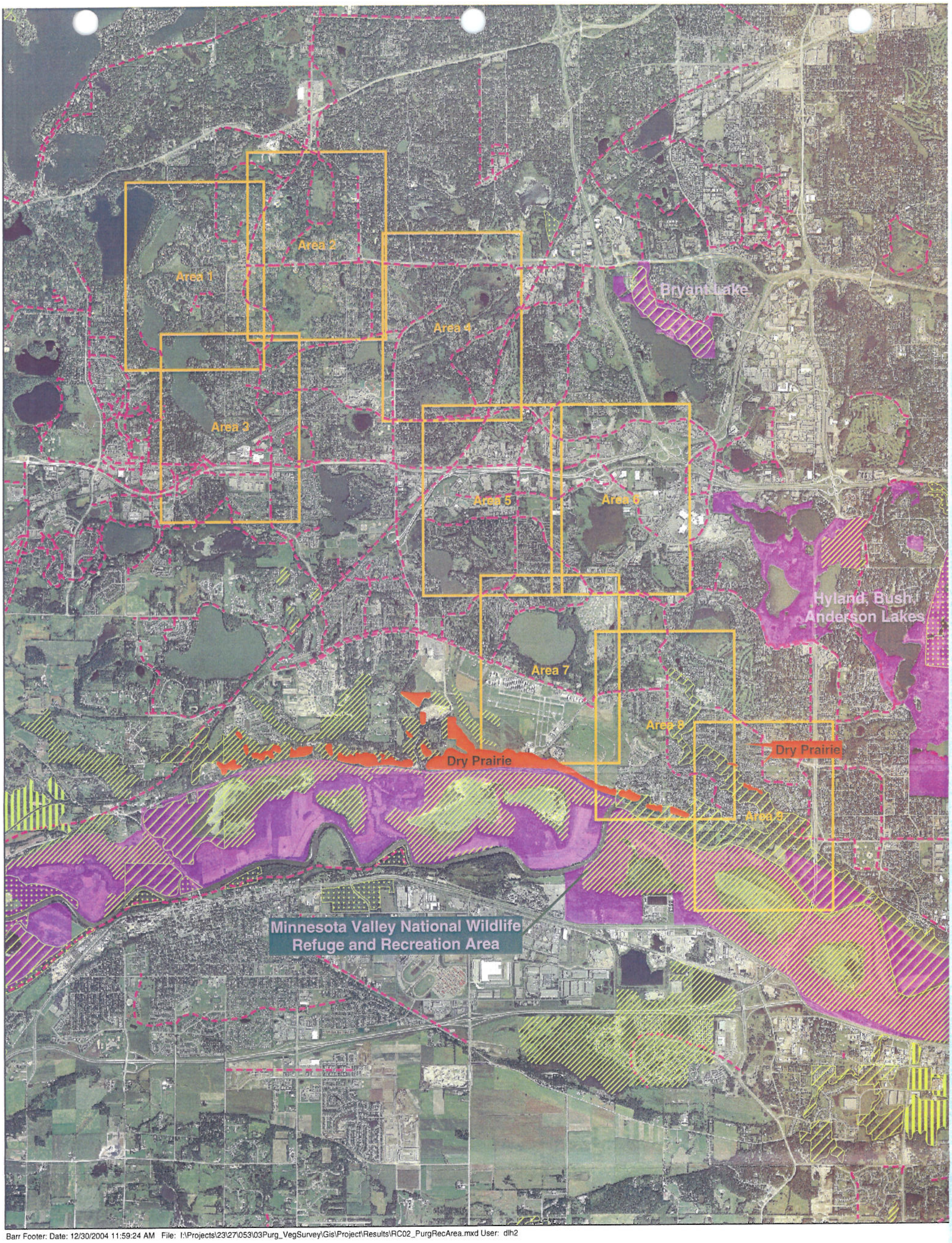
Study Area
Vegetation Corridor
Purgatory Creek
Regional Parks

Figure RC1
PURGATORY CREEK CORRIDOR

Vegetation Corridor Study Areas and
Municipal Boundaries

N W E S

0 4,000 8,000 Feet



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- Existing Trails
- Regional Parks
- Dry Prairie, Sand-Gravel Subtype
- Outstanding Biodiversity Significance
- High Biodiversity Significance
- Moderate Biodiversity Significance
- Below Minimum Biodiversity Significance Threshhold

Figure RC2
PURGATORY CREEK CORRIDOR

Recreation Areas & Significant Biological Communities (from Minnesota County Biological Survey)

N
W E
S

0 5,000 10,000 Feet

Figure RC3
Species Area Curve

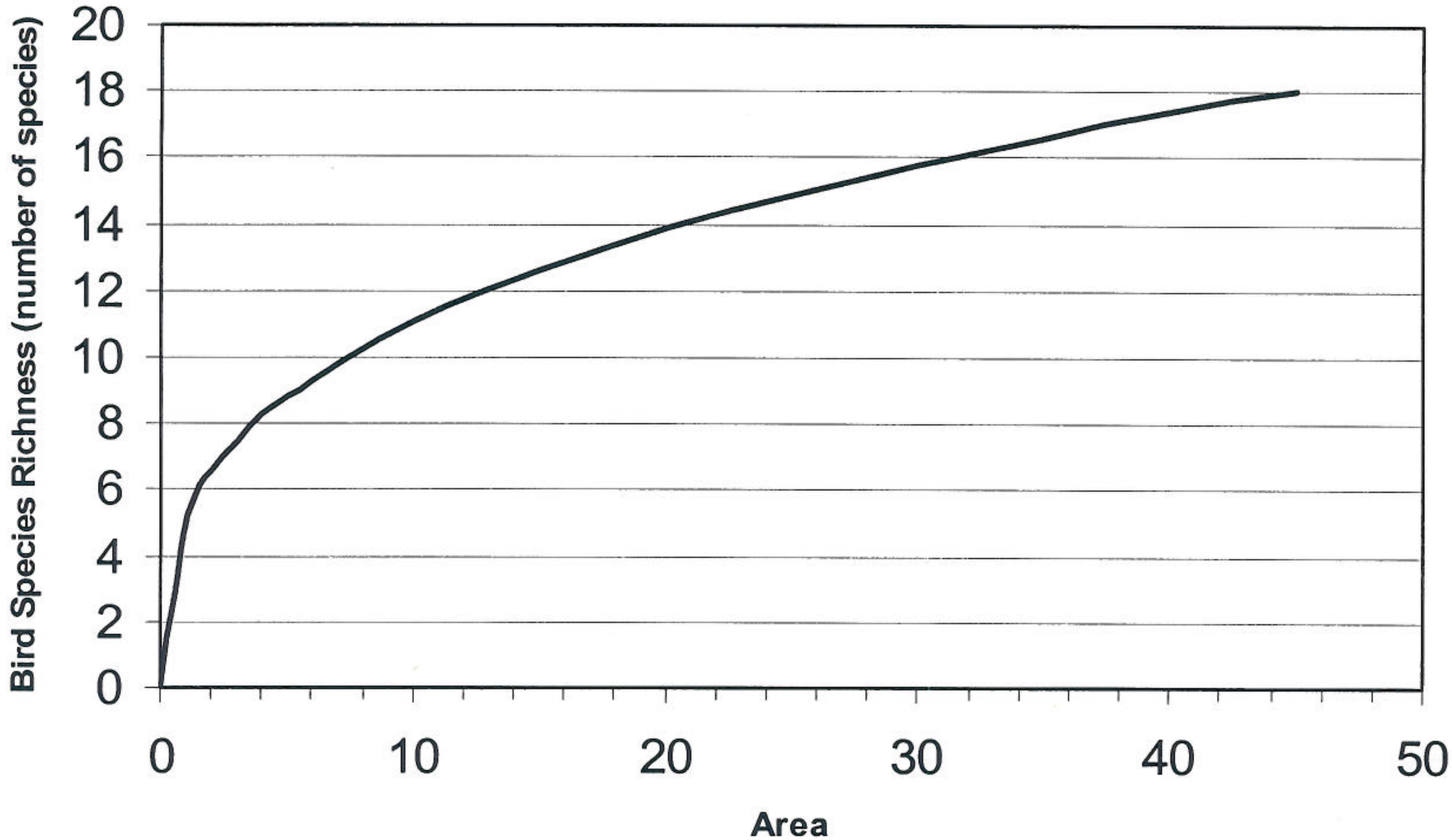
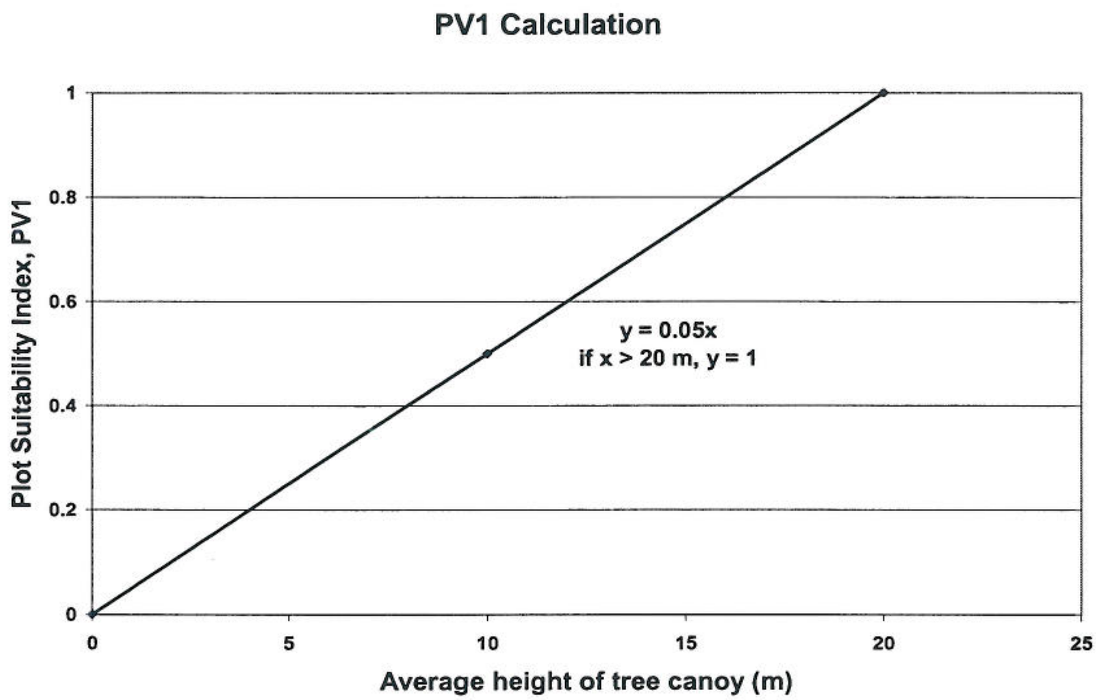


Figure RC4
Modified Species Area Model: Calculations for the Plot Suitability Index Variables

Plot Suitability Index = $(2(PV1 * PV2)^{0.5} + PV3 + PV4)/4$



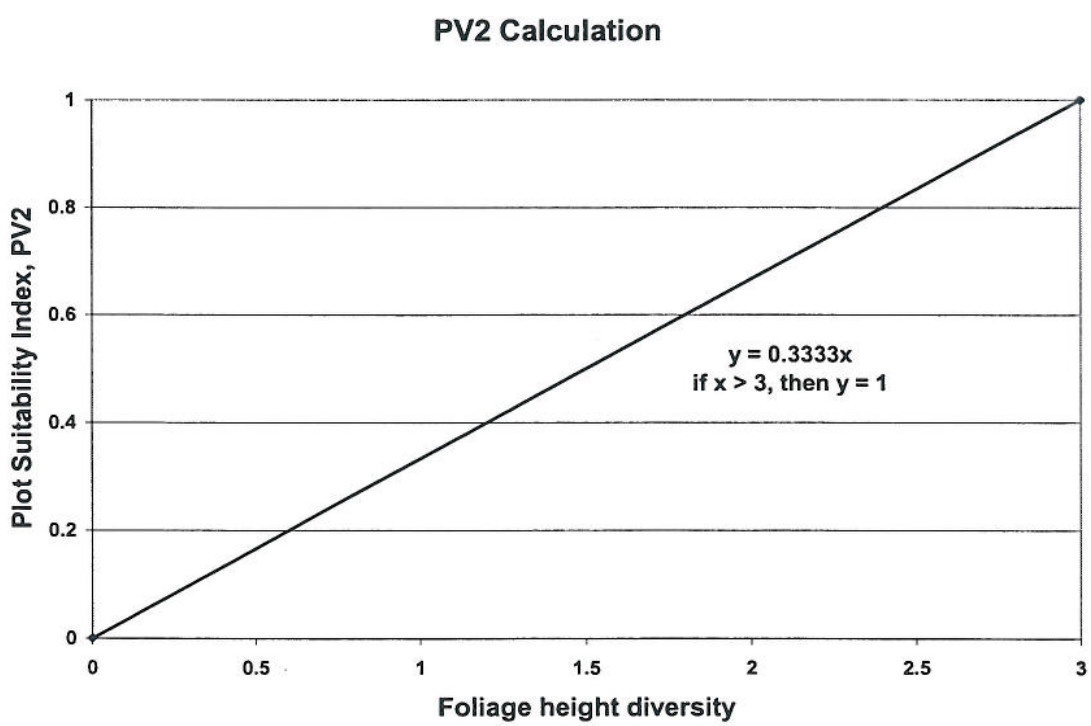
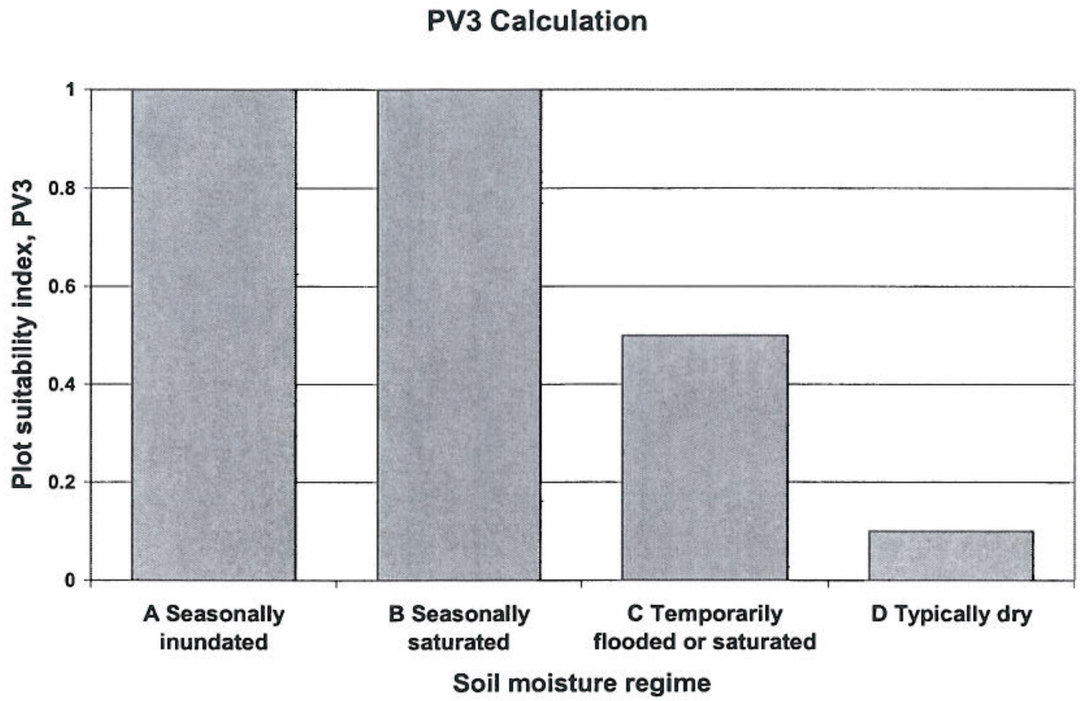
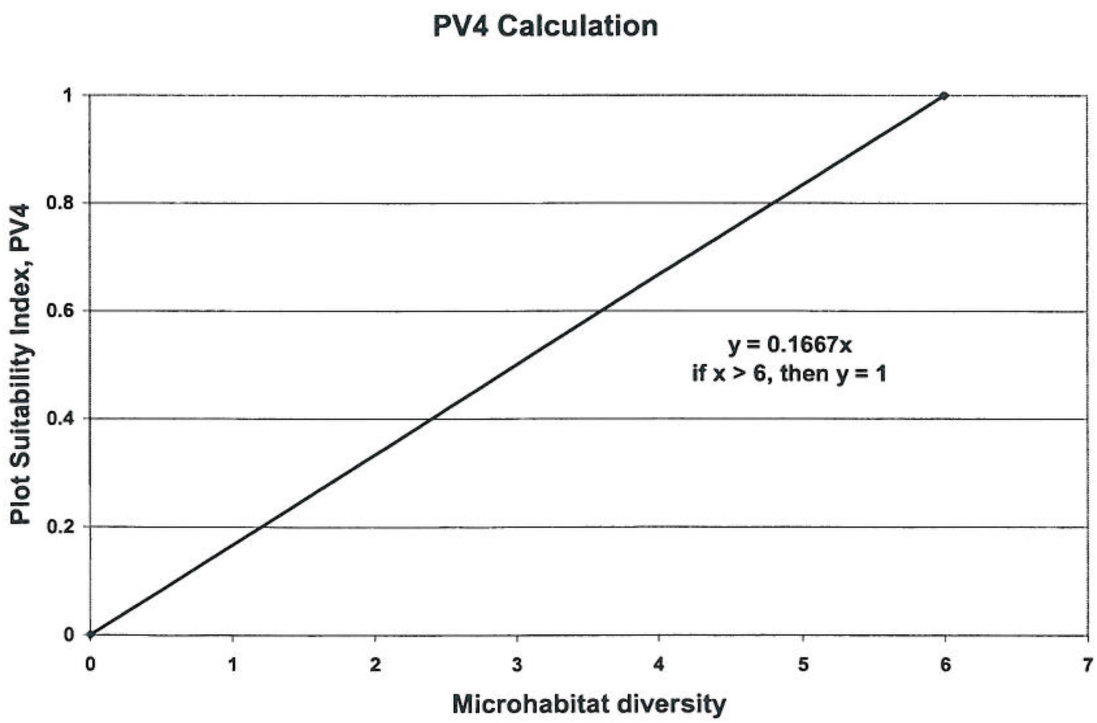
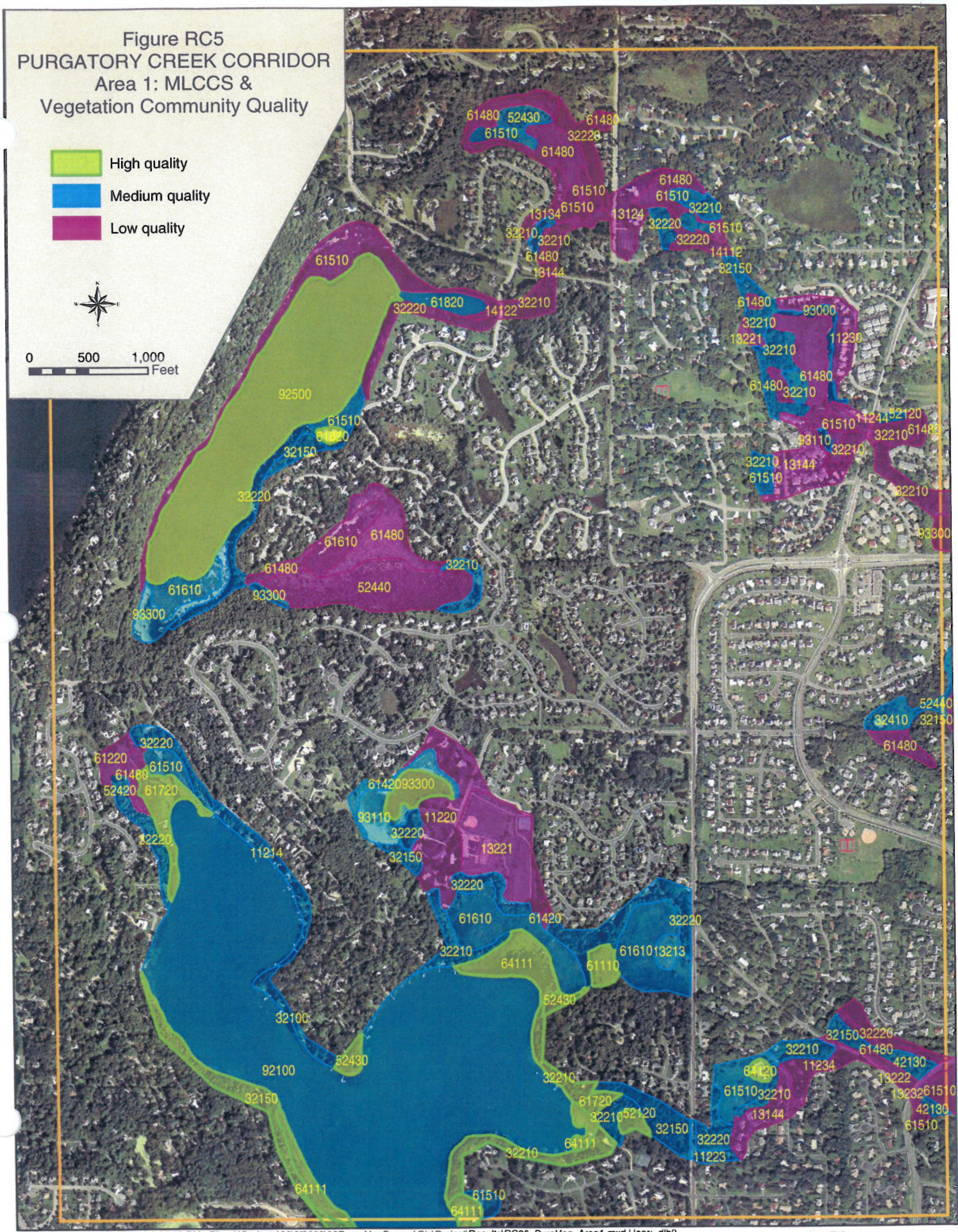


Figure RC4 (continued)







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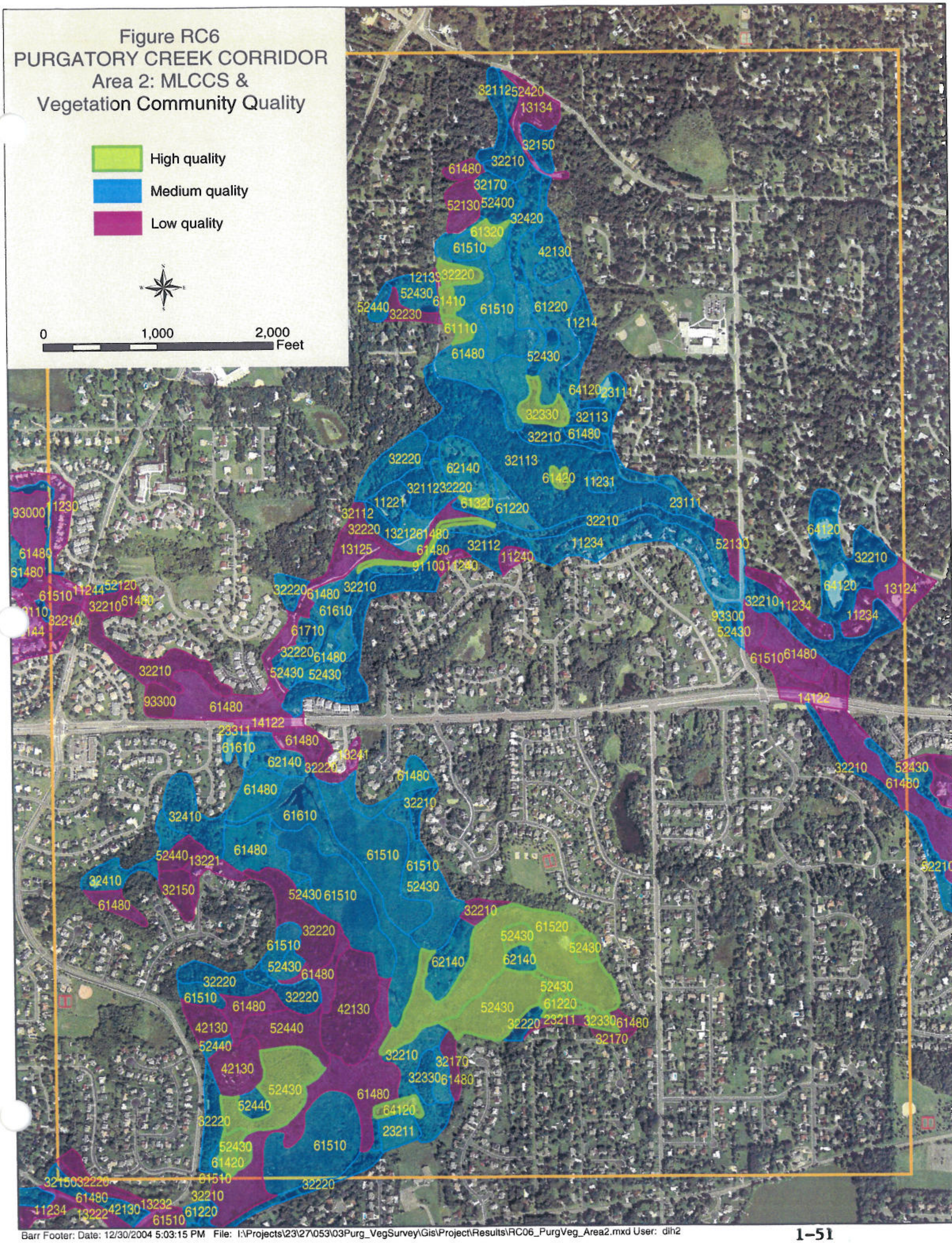
Figure RC6
PURGATORY CREEK CORRIDOR
Area 2: MLCCS &
Vegetation Community Quality
High quality
Medium quality
Low quality
0
1,000
2,000
Feet

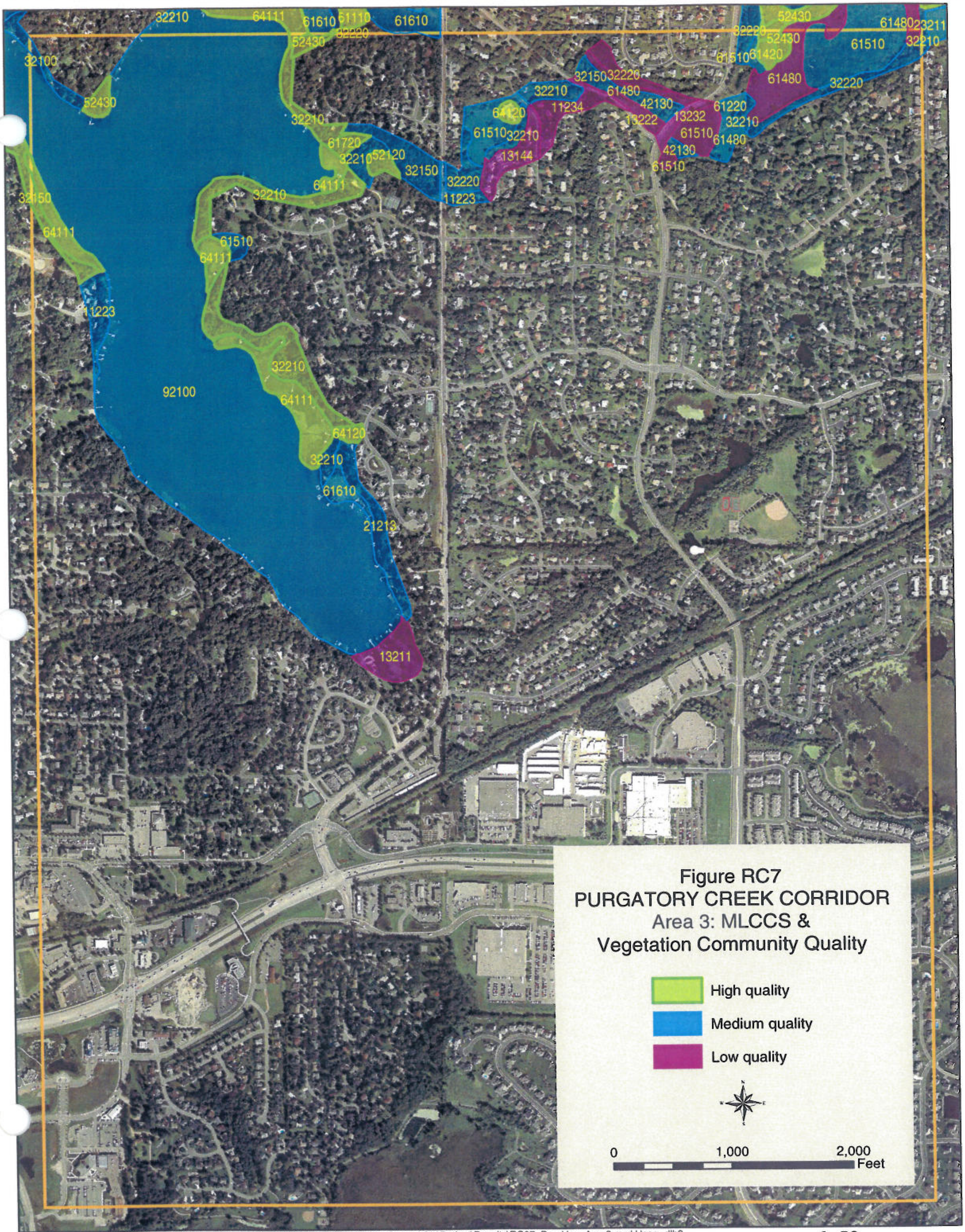
Figure RC7
PURGATORY CREEK CORRIDOR
Area 3: MLCCS &
Vegetation Community Quality
High quality
Medium quality
Low quality
0
1,000
2,000
Feet
92100
32210
64111
61610
61110
32220
52430
32100
32150
11223
61510
61720
52120
64120
21213
13211
13144
11234
32150
61480
42130
13222
13232
61220
61420
61510
23211

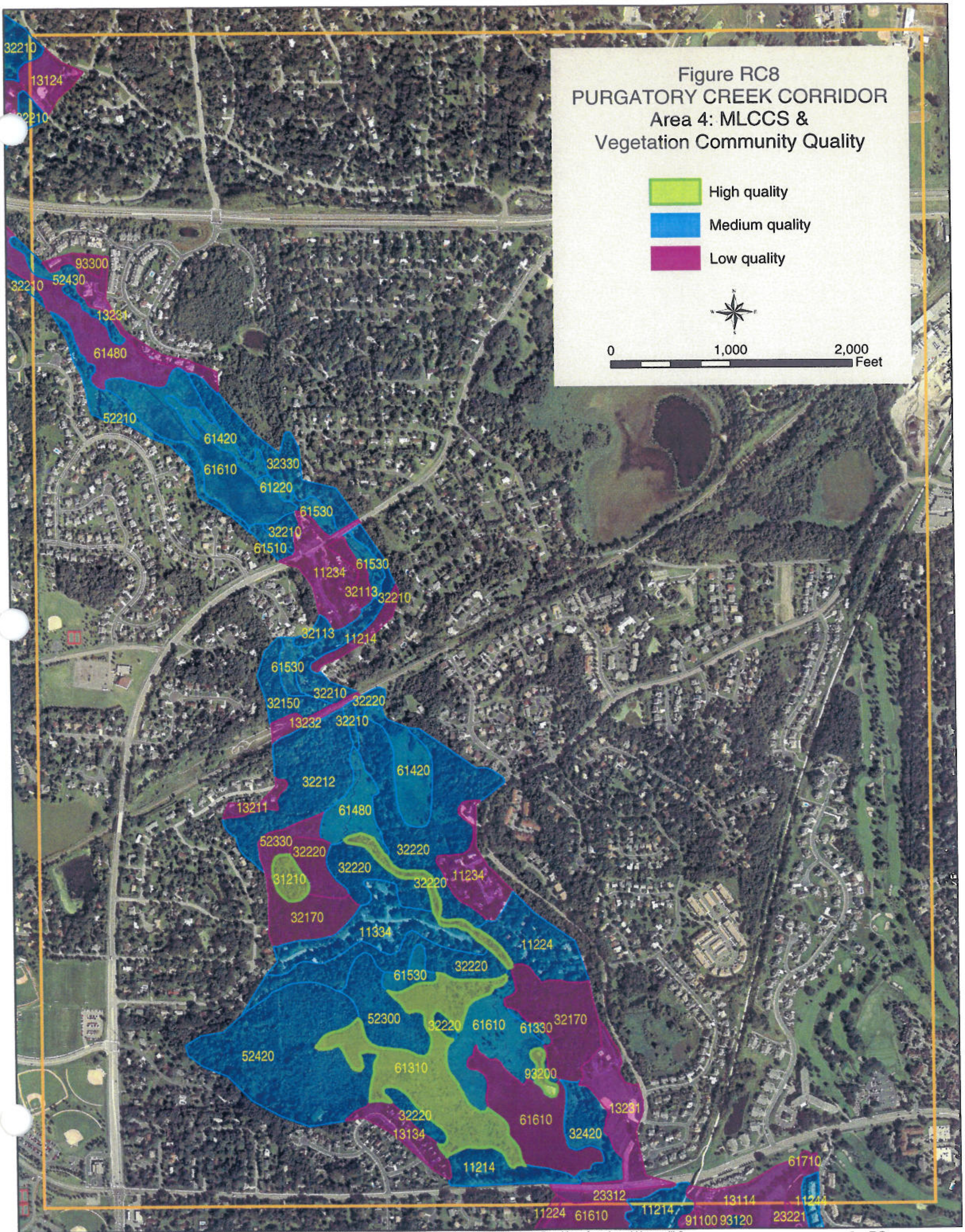
Figure RC8
PURGATORY CREEK CORRIDOR
Area 4: MLCCS &
Vegetation Community Quality
High quality
Medium quality
Low quality
0
1,000
2,000
Feet
32210
13124
32210
93300
52430
32210
13231
61480
52210
61420
61610
32330
61220
61530
32210
61510
11234
61530
32113
32210
32113
11214
61530
32210
32220
32150
13232
32210
61420
32212
13211
61480
52330
32220
31210
32220
32220
32220
11234
32170
11334
11224
61530
32220
52300
32220
61610
61330
32170
52420
61310
93200
32220
13134
61610
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32420
11214
61710
23312
13114
11244
11224
61610
11214
91100
93120
23221

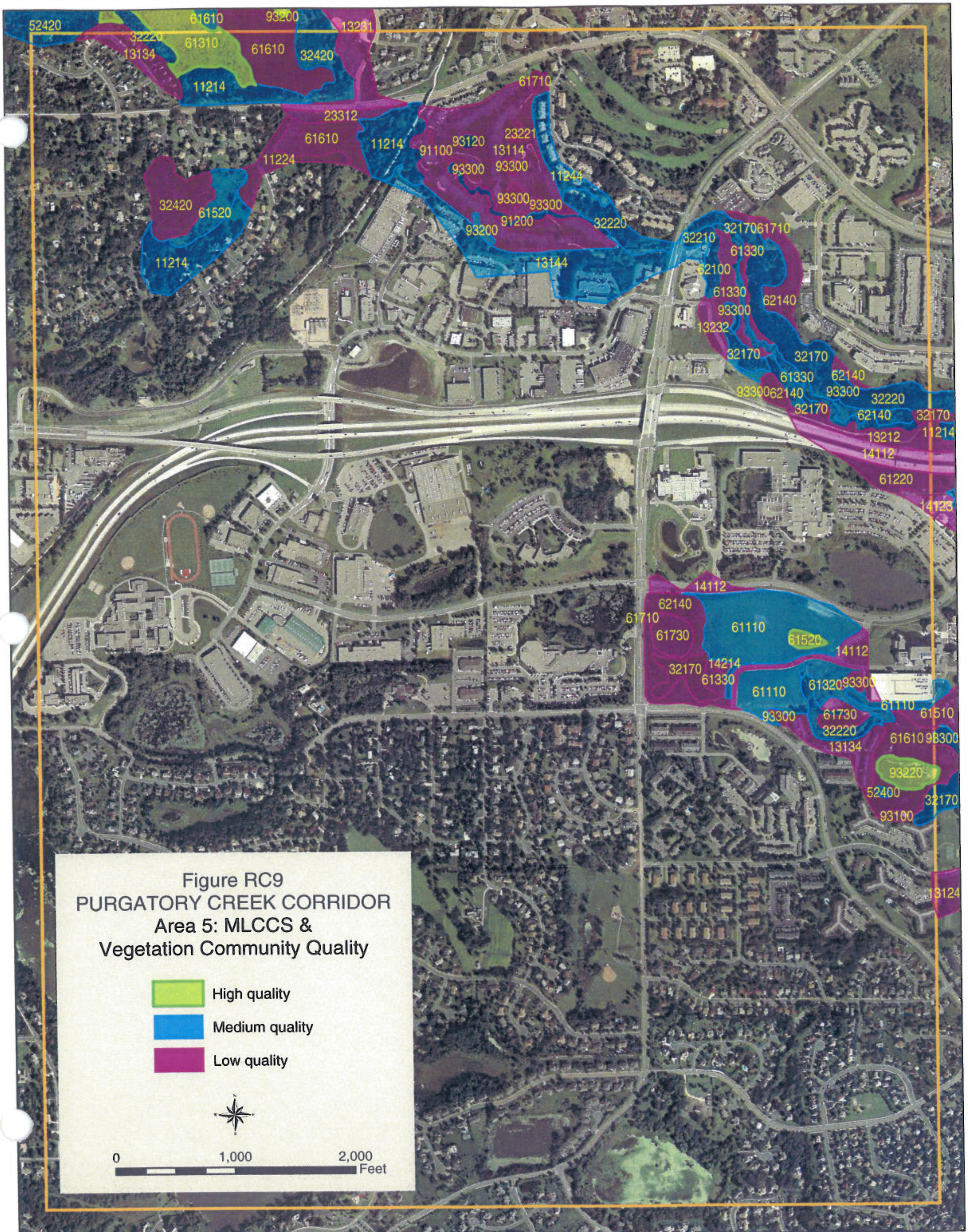
Figure RC9
PURGATORY CREEK CORRIDOR
Area 5: MLCCS &
Vegetation Community Quality
High quality
Medium quality
Low quality
0
1,000
2,000
Feet
52420
61610
93200
13231
32220
13134
61310
61610
32420
11214
61710
23312
61610
11214
91100
93120
23221
13114
93300
93300
11244
11224
32420
61520
93300
93300
93200
91200
32220
11214
13144
32210
3217061710
61330
62100
61330
62140
93300
13232
32170
32170
61330
62140
9330062140
93300
32220
32170
62140
32170
11214
13212
14112
61220
14123
14112
62140
61710
61110
61730
61520
14112
32170
14214
61330
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52400
32170
93100
13124

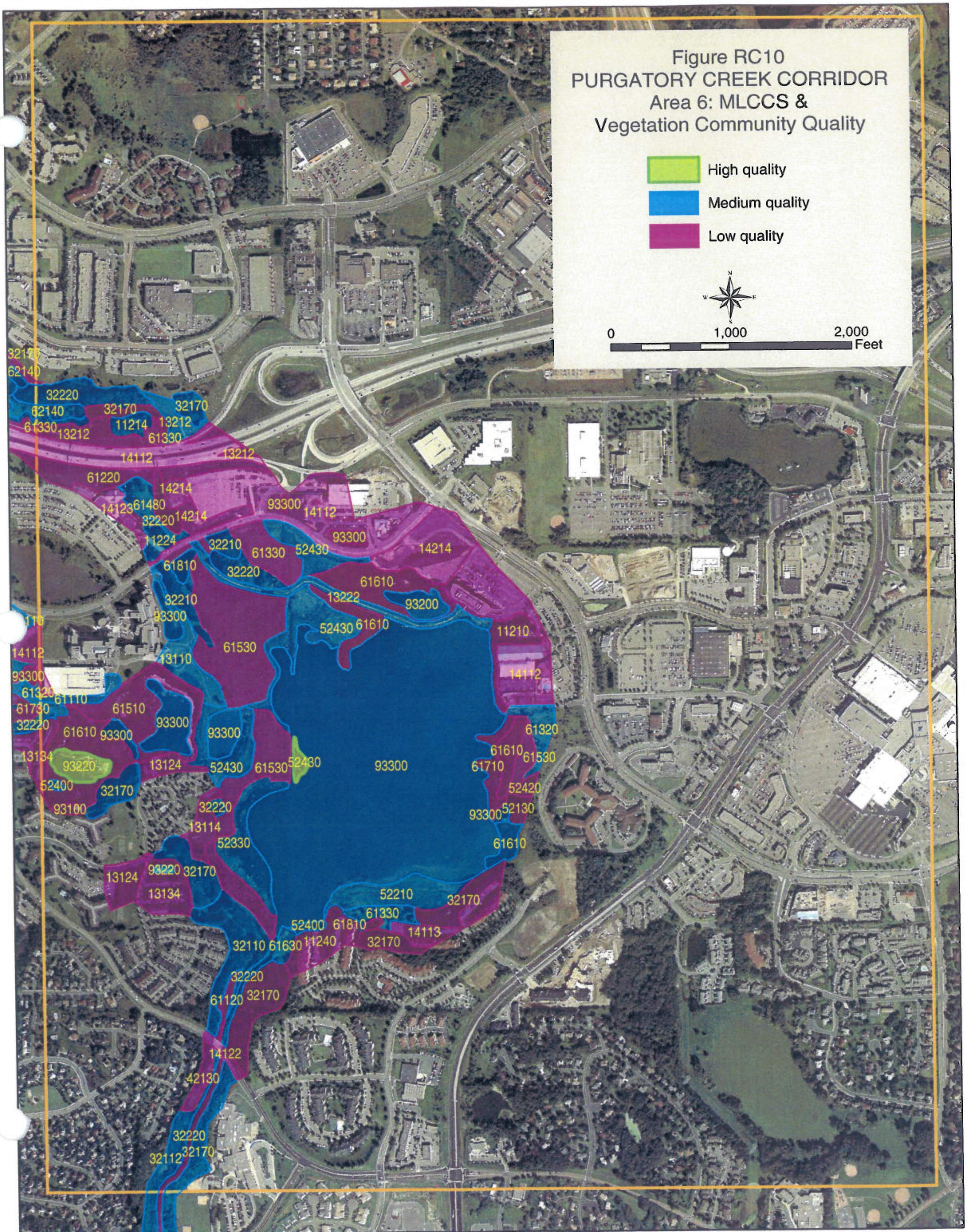


Figure RC10
PURGATORY CREEK CORRIDOR
Area 6: MLCCS &
Vegetation Community Quality

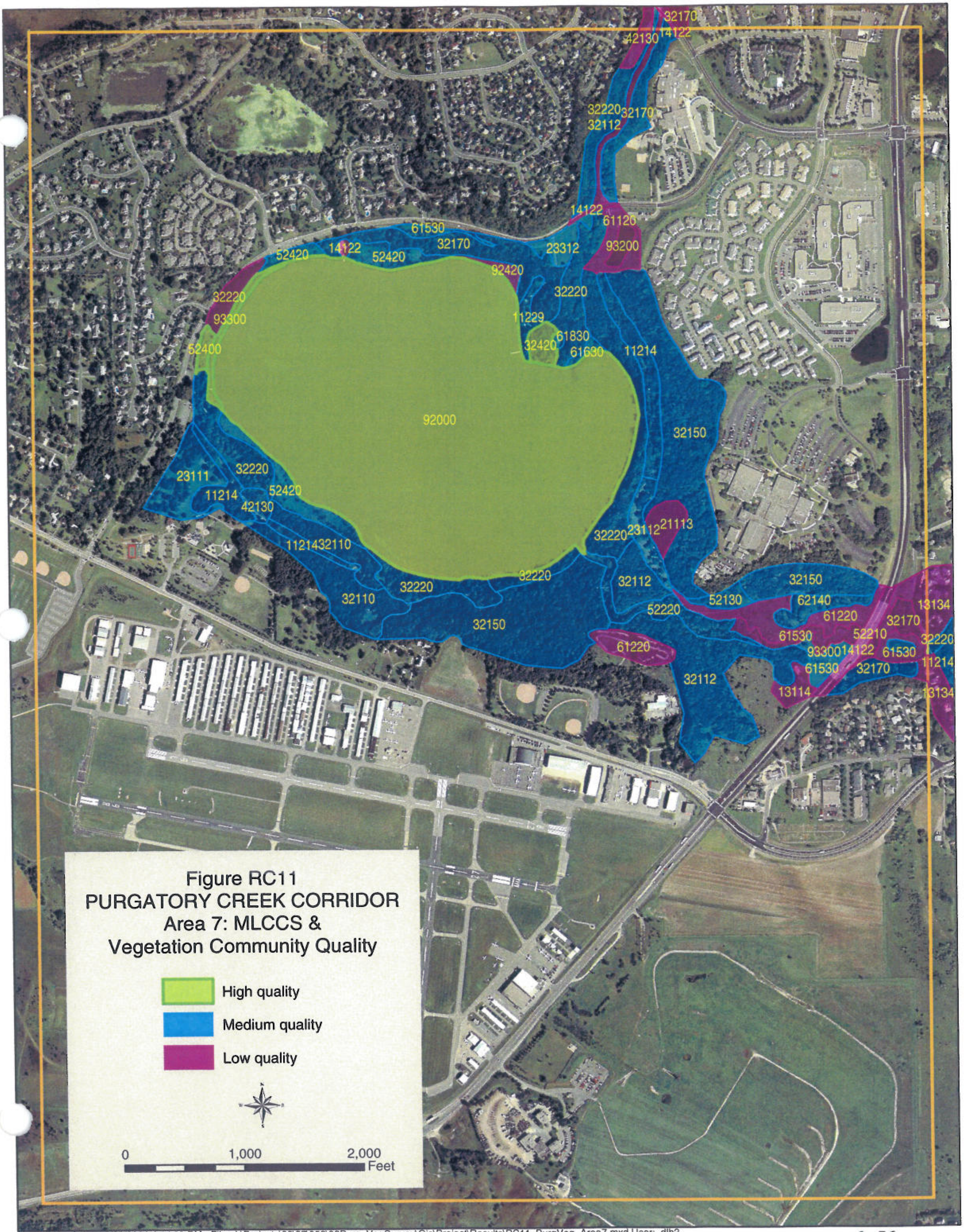
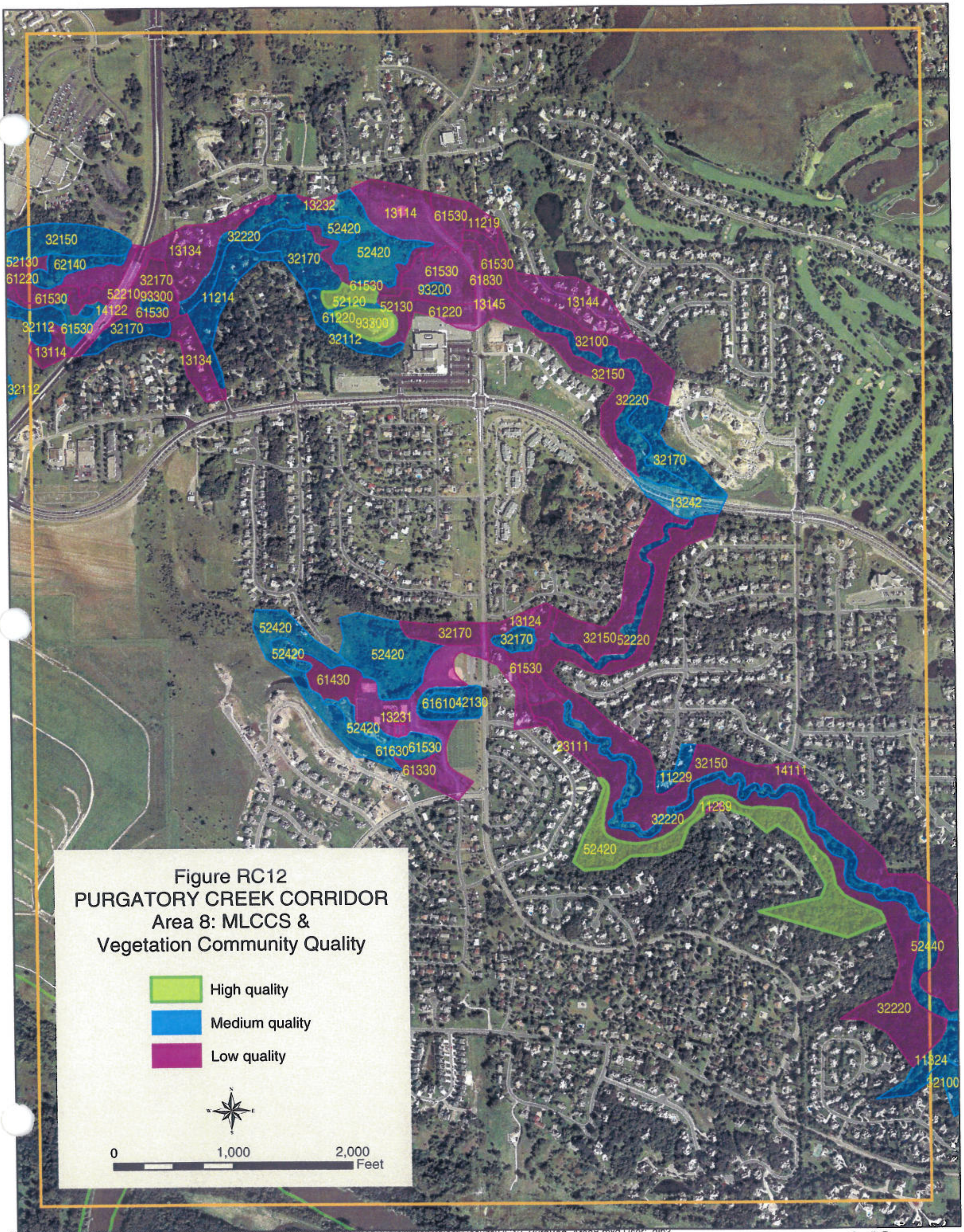


Figure RC11
PURGATORY CREEK CORRIDOR
Area 7: MLCCS &
Vegetation Community Quality



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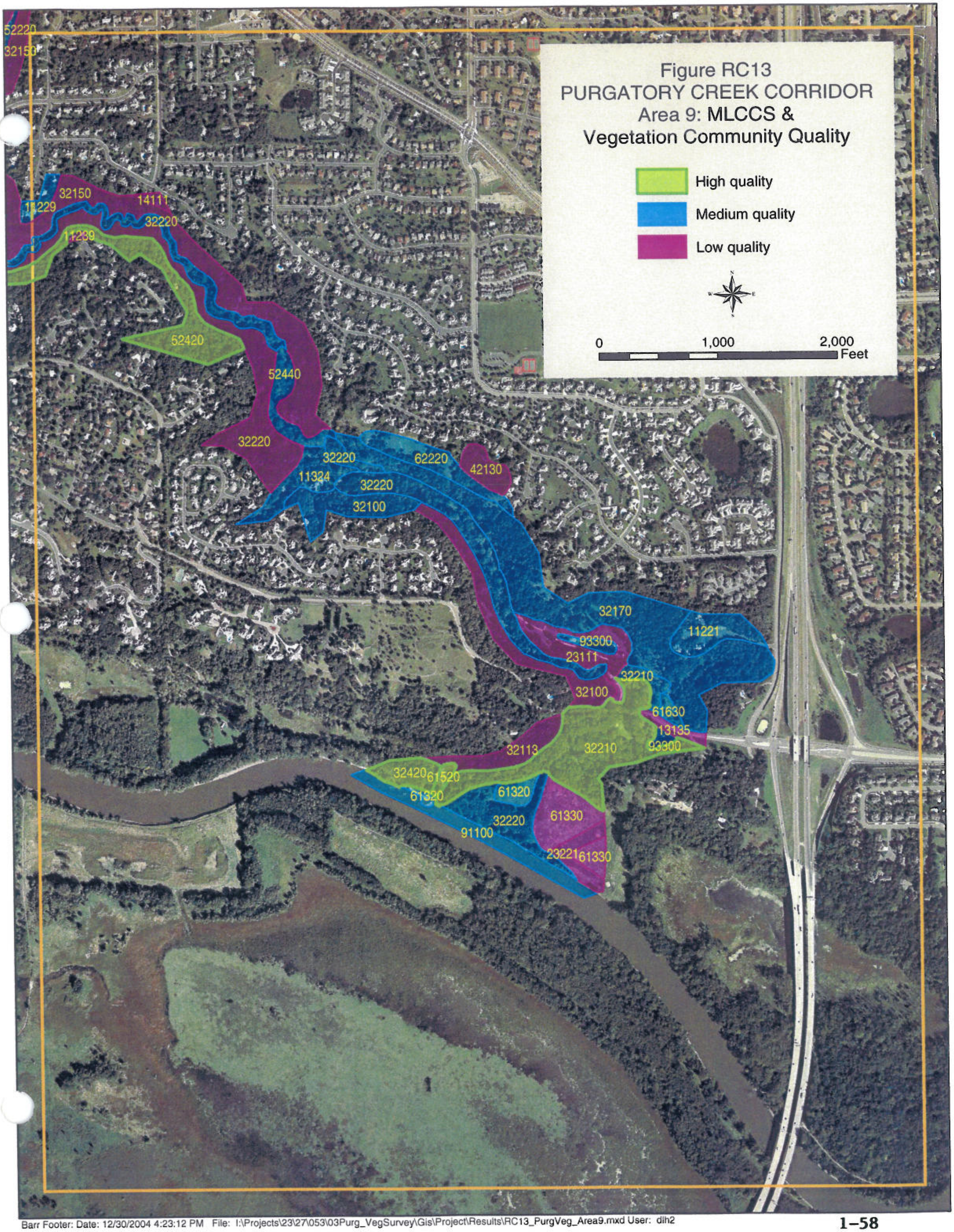
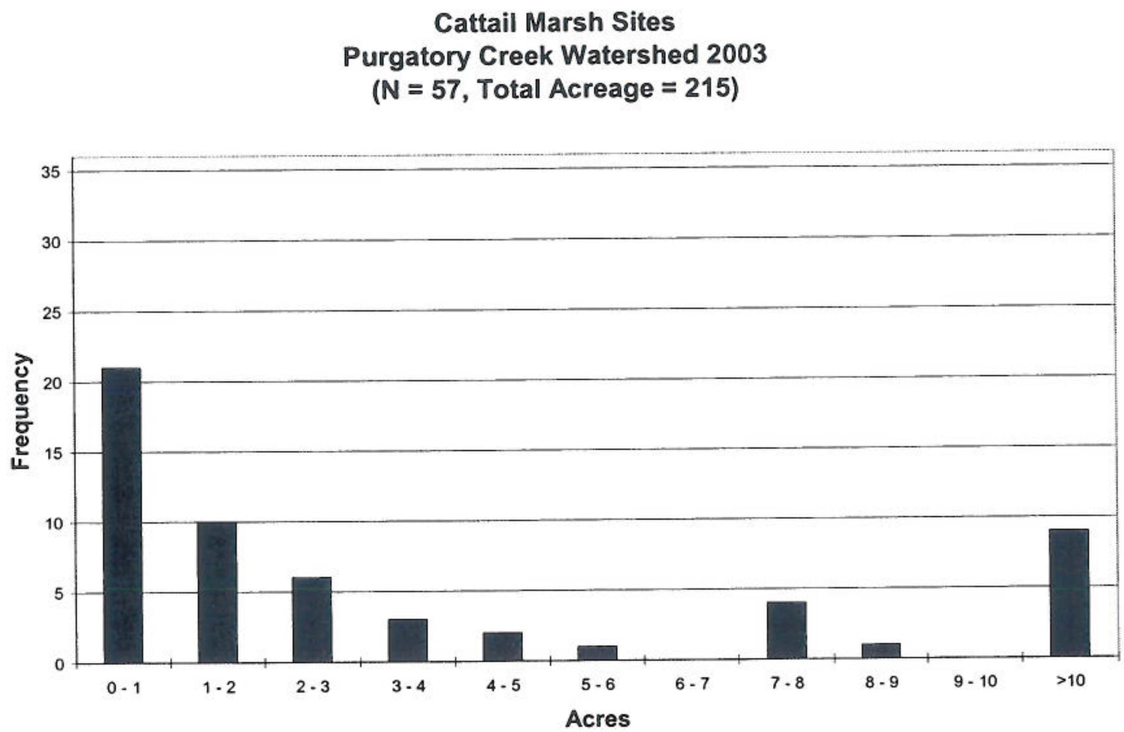


Figure RC13
PURGATORY CREEK CORRIDOR
Area 9: MLCCS &
Vegetation Community Quality
High quality
Medium quality
Low quality
0
1,000
2,000
Feet
52220
32150
11229
32150
14111
32220
11239
52420
52440
32220
32220
62220
42130
11324
32220
32100
32170
11221
93300
23111
32210
32100
61630
13135
32113
32210
93300
32420
61520
61320
61320
32220
61330
91100
23221
61330

Figure RC14 Plant Community Occurrence



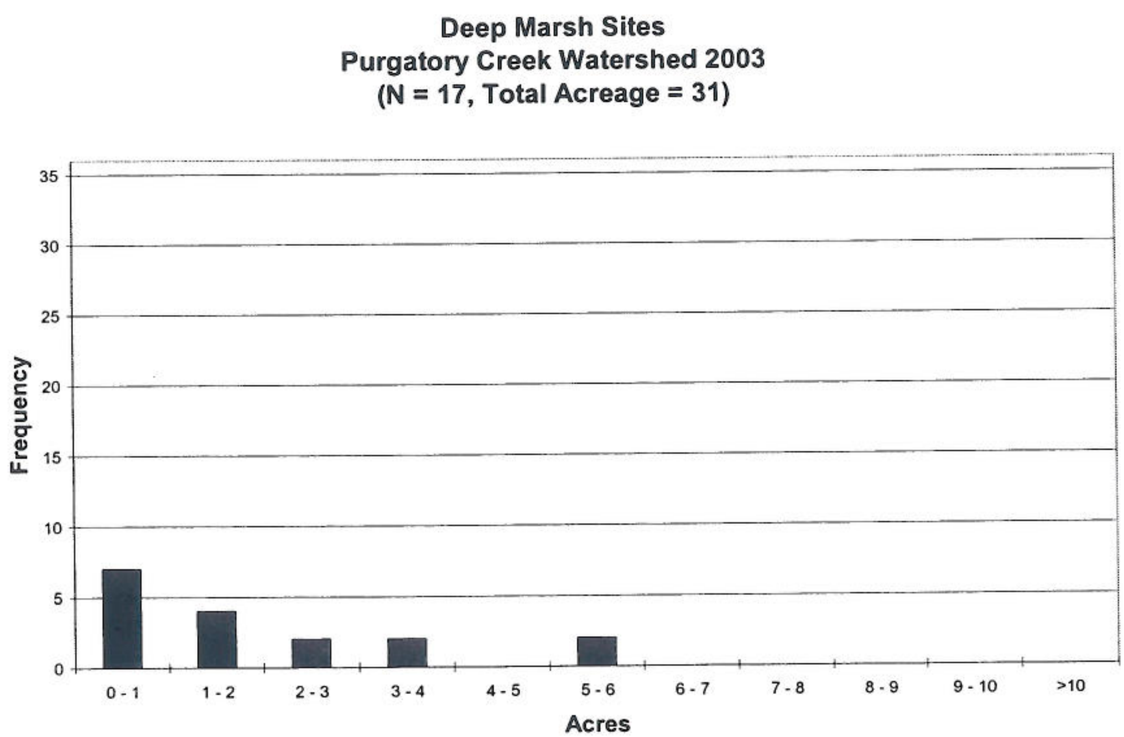
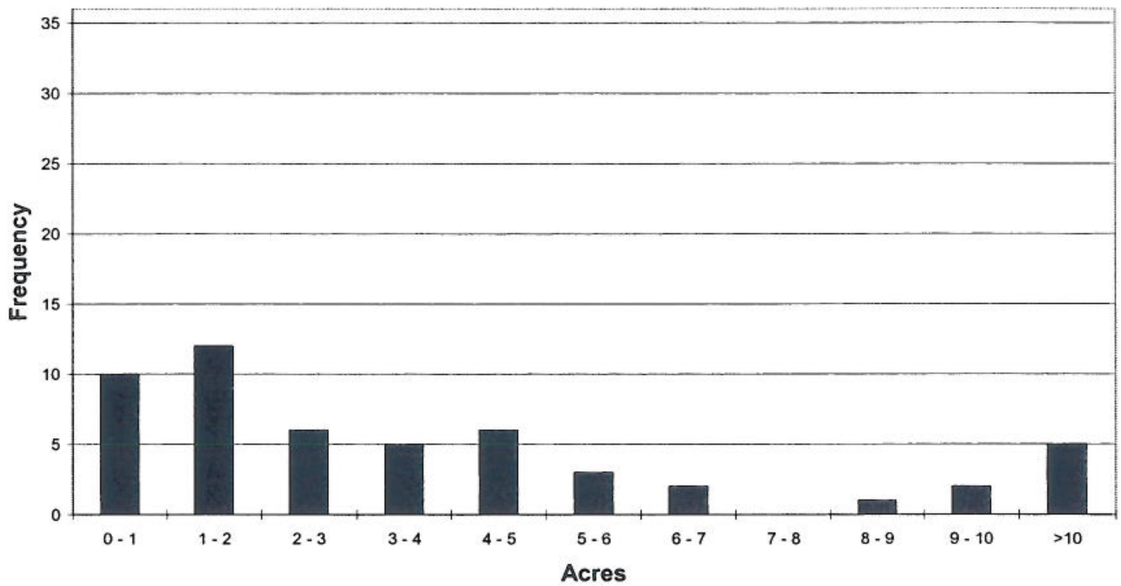


Figure RC15 Plant Community Occurrence

Developed Sites
Purgatory Creek Watershed 2003
(N = 52, Total Acreage = 217)



Lowland Forest Sites
Purgatory Creek Watershed 2003
(N = 120, Total Acreage = 404)

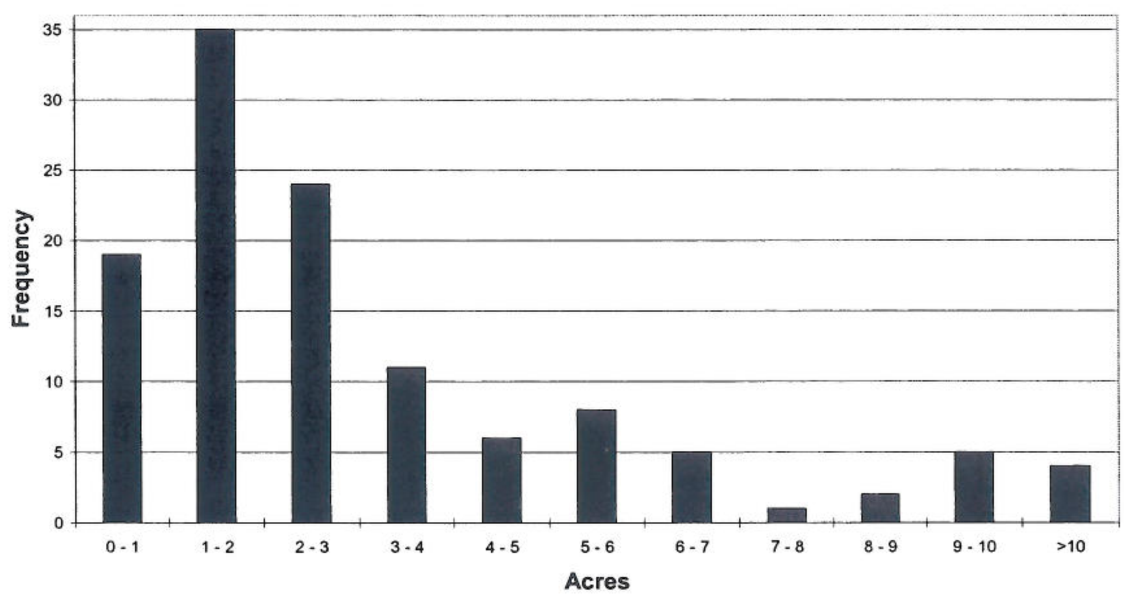
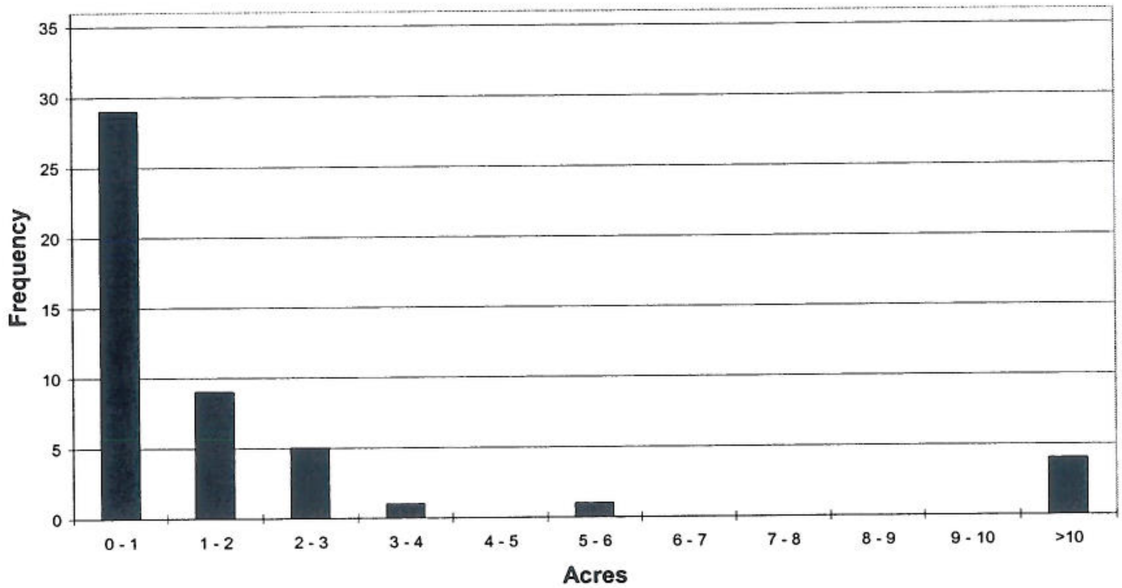


Figure RC16 Plant Community Occurrence

Open Water Sites
Purgatory Creek Watershed 2003
(N = 49, Total Acreage = 559)



Shrubland Sites
Purgatory Creek Watershed 2003
(N = 69, Total Acreage = 212)

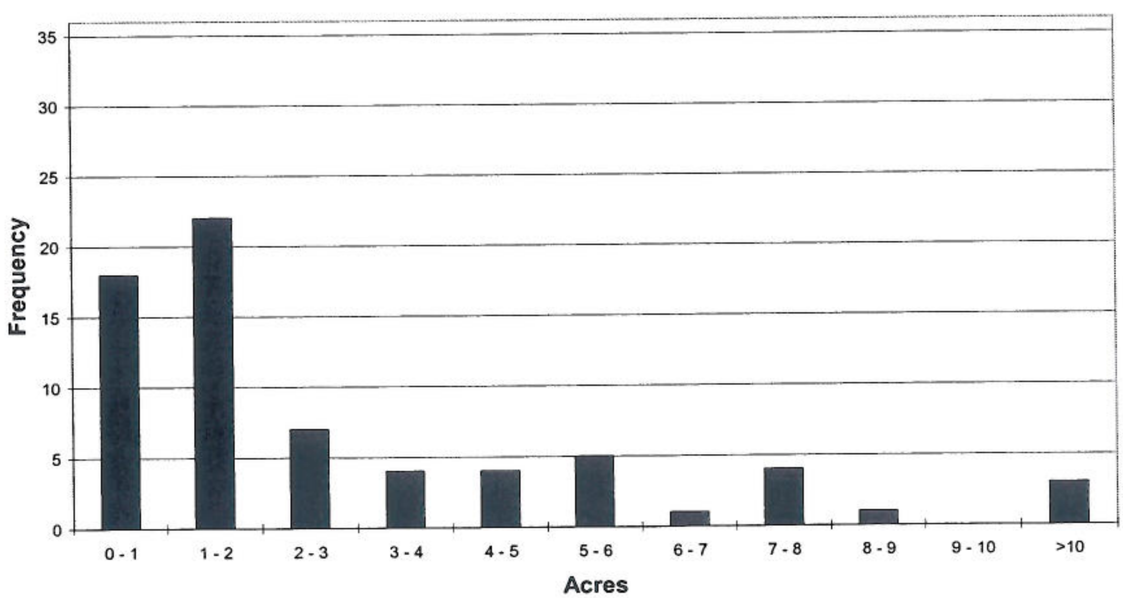
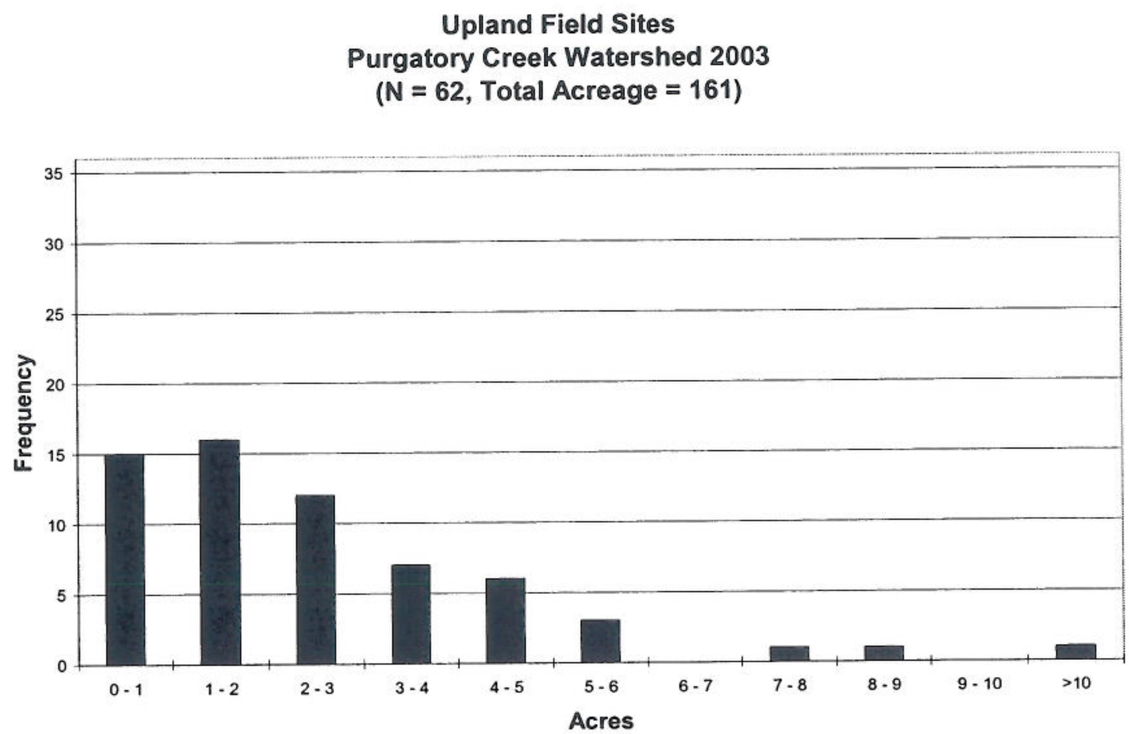


Figure RC17 Plant Community Occurrence



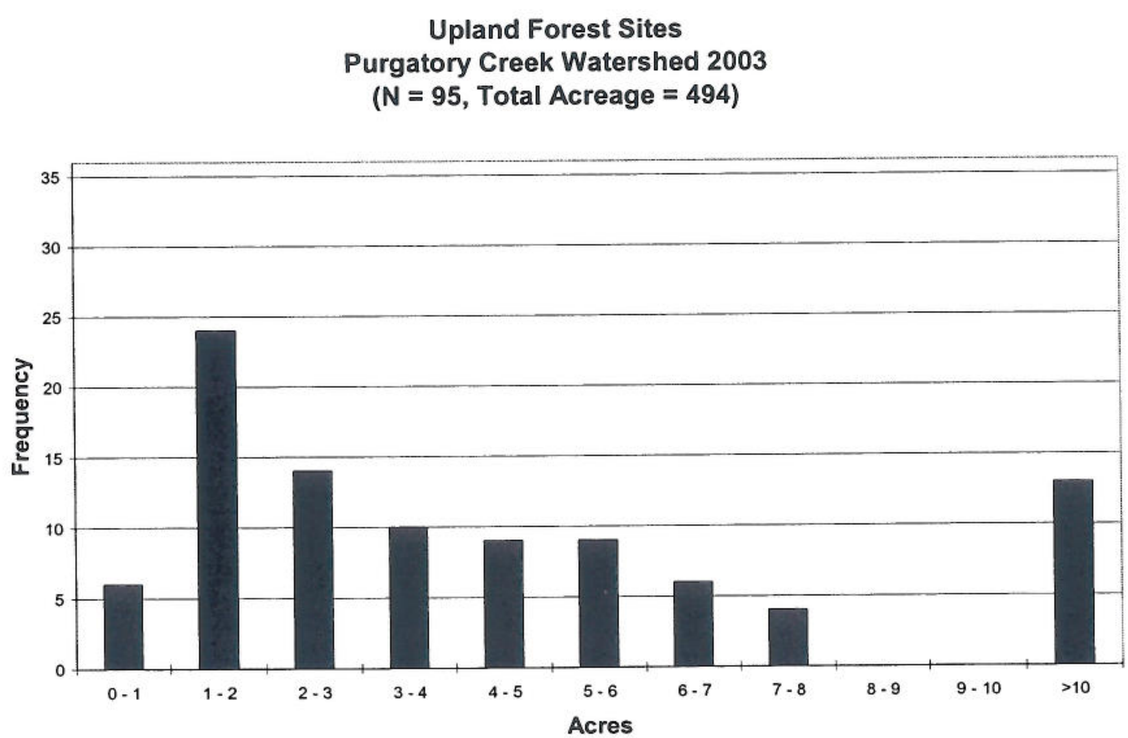
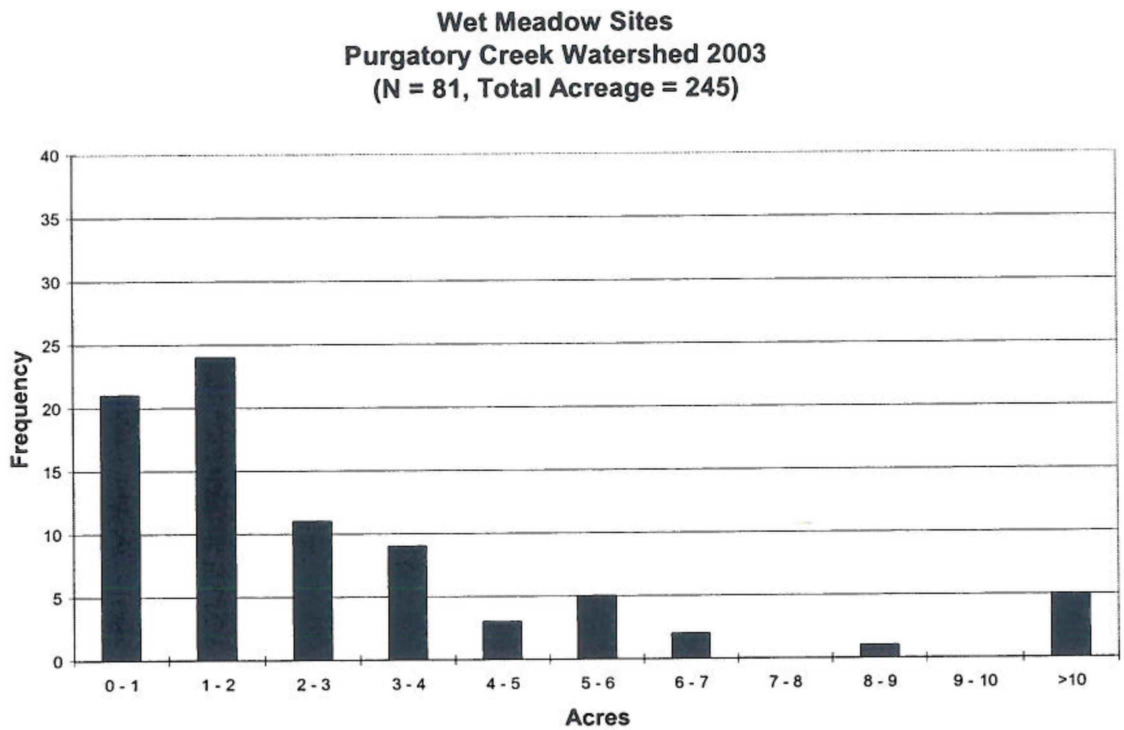


Figure RC18 Plant Community Occurrence



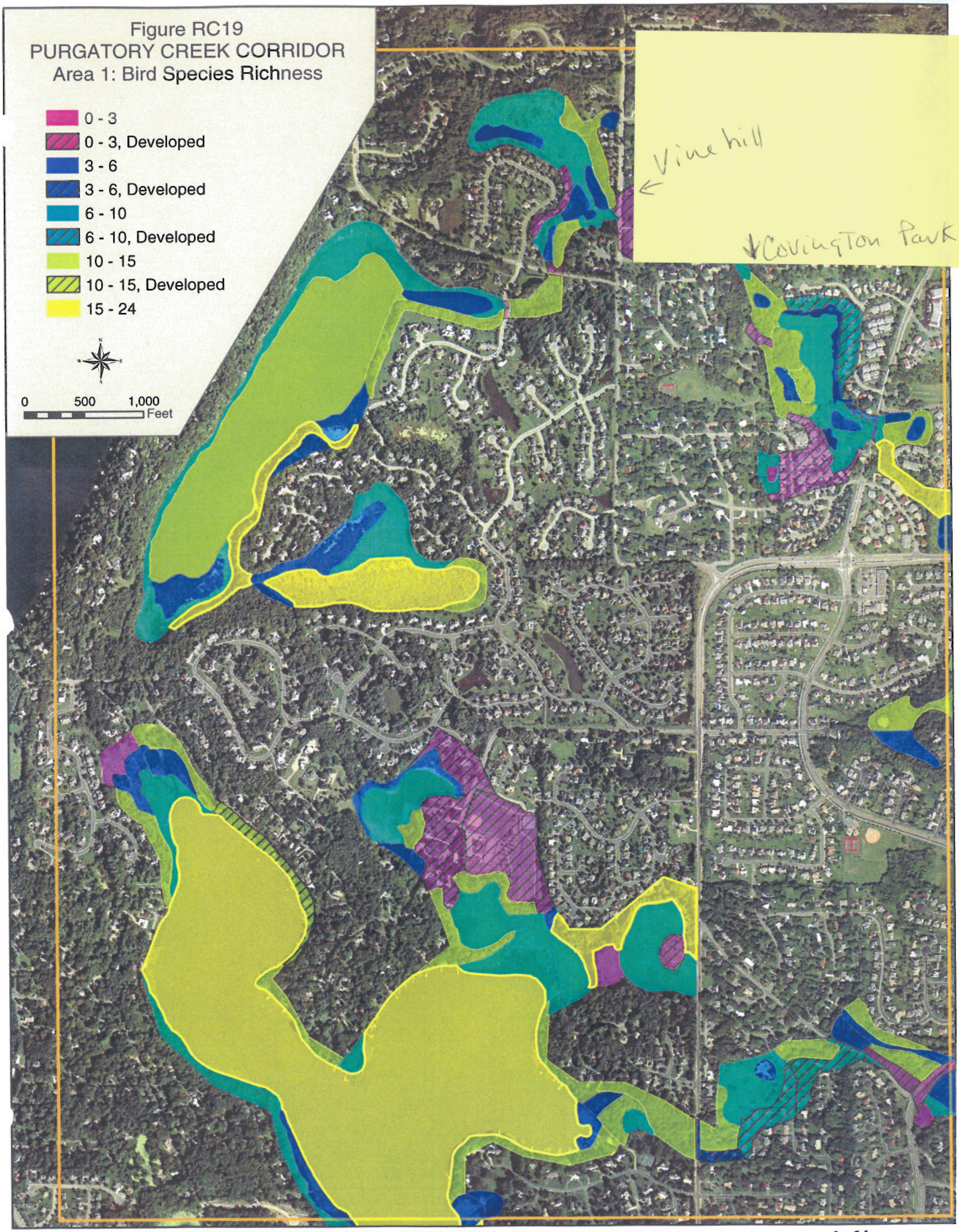


Figure RC19
PURGATORY CREEK CORRIDOR
Area 1: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet
Vine hill
Covington Park

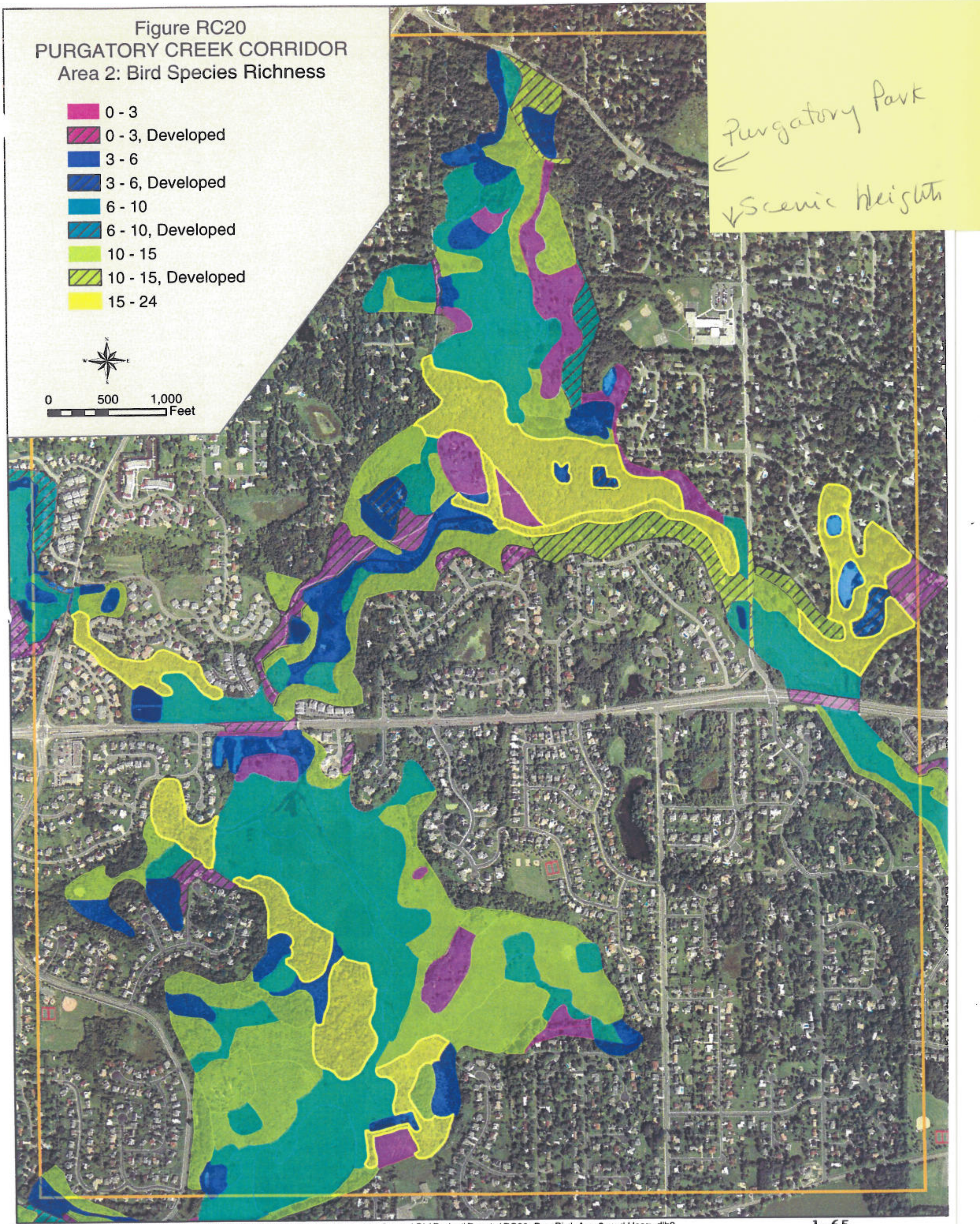


Figure RC20
PURGATORY CREEK CORRIDOR
Area 2: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet
Purgatory Park
Scenic Heights

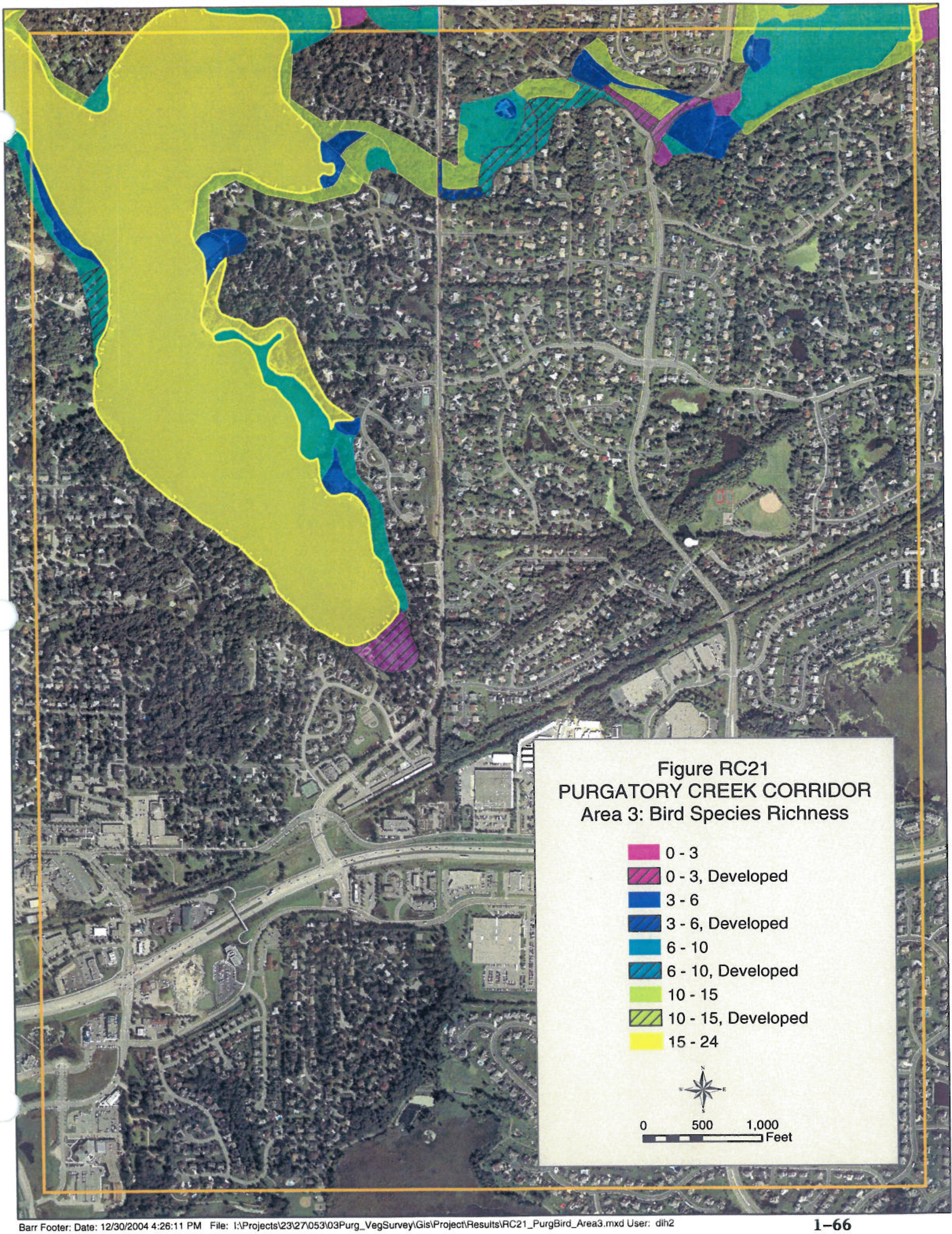


Figure RC21
PURGATORY CREEK CORRIDOR
Area 3: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet

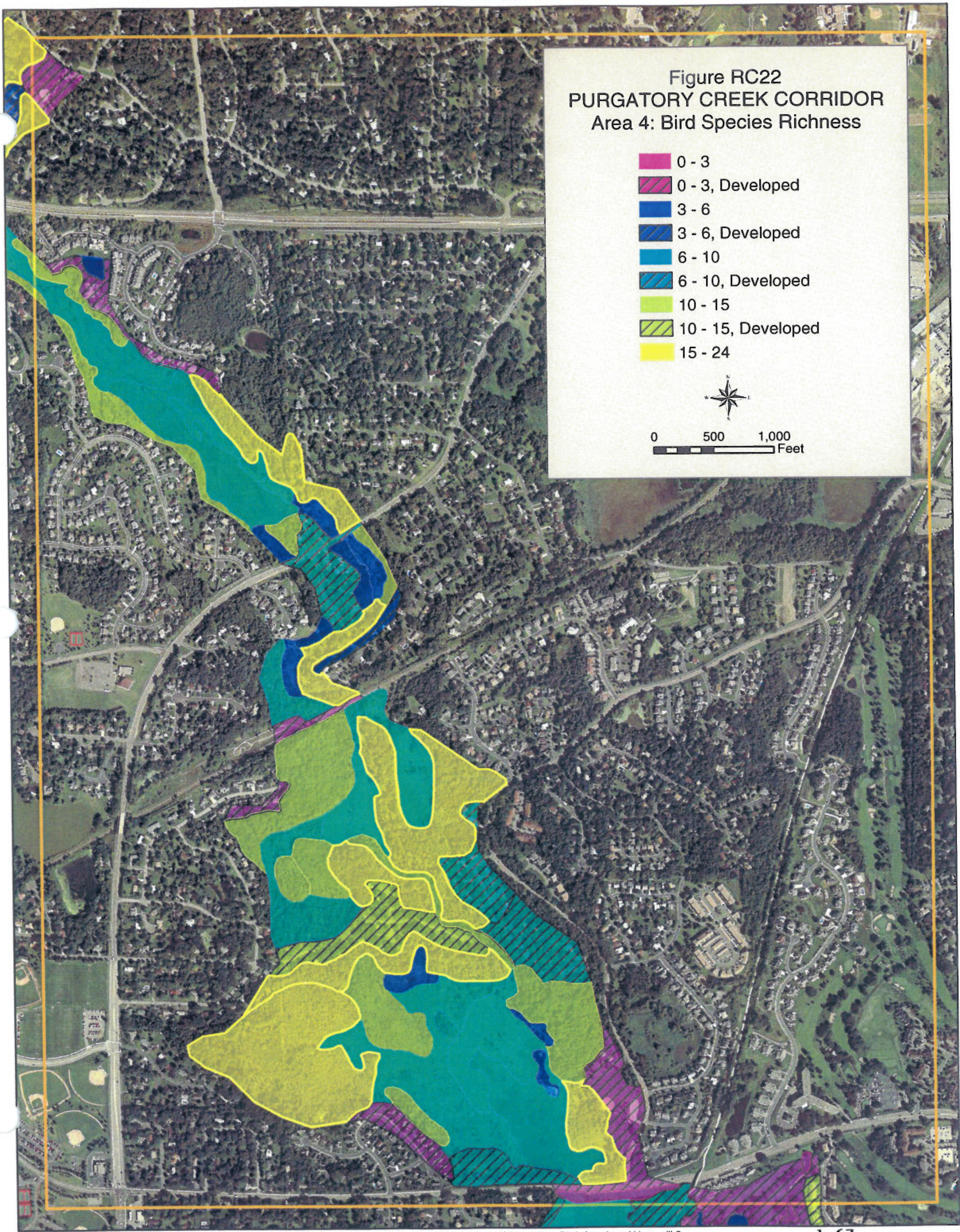


Figure RC22
PURGATORY CREEK CORRIDOR
Area 4: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet

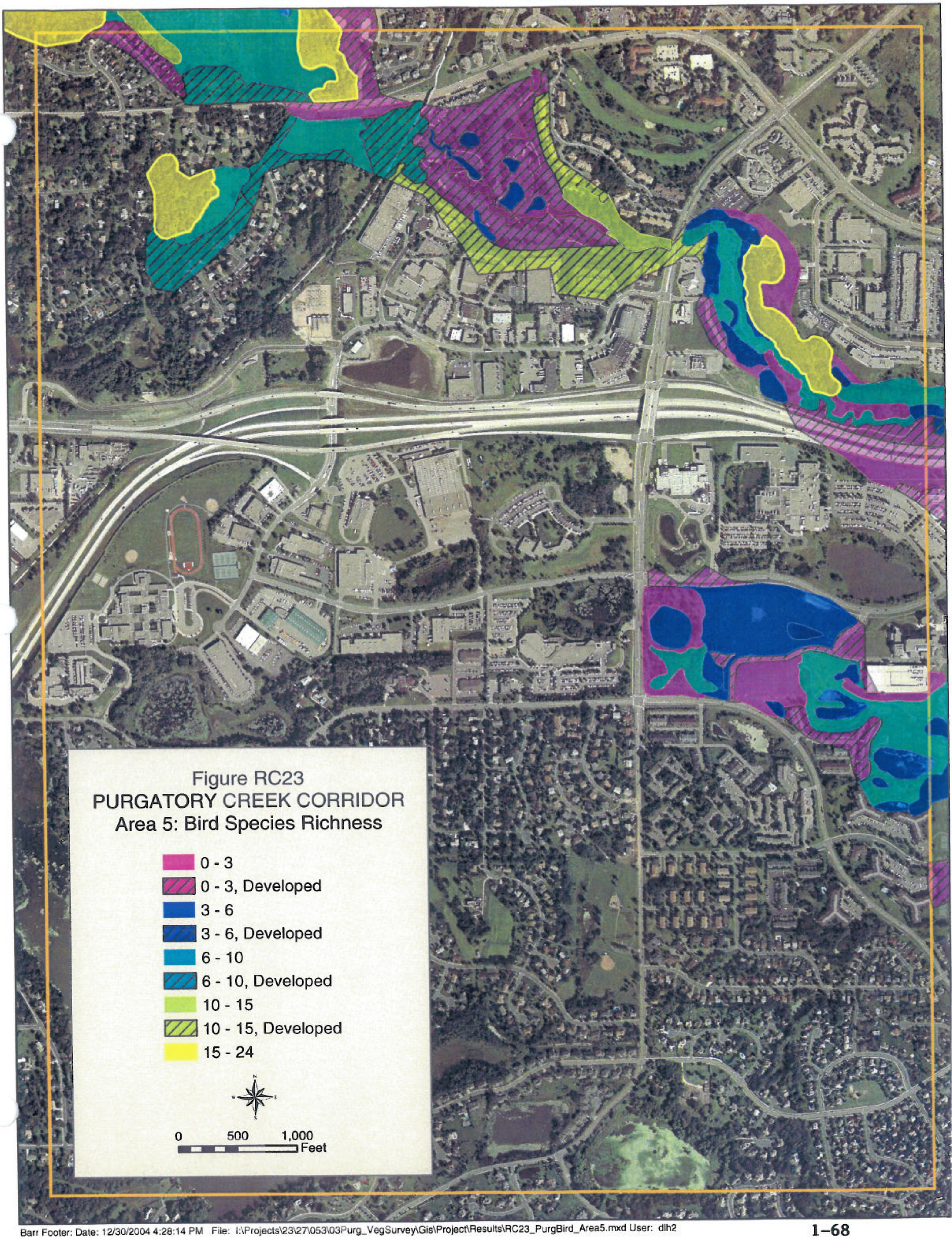


Figure RC23
PURGATORY CREEK CORRIDOR
Area 5: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet

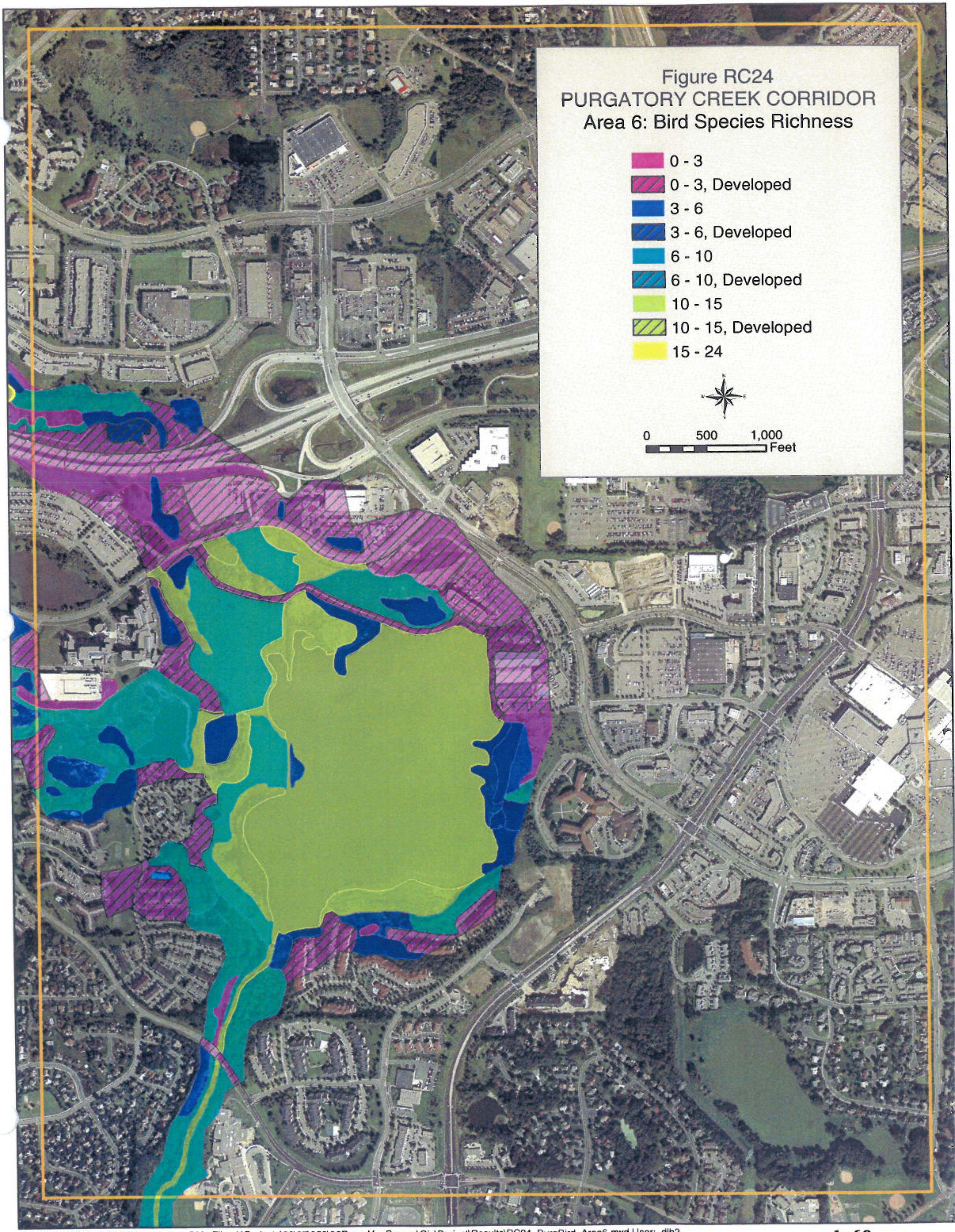


Figure RC24
PURGATORY CREEK CORRIDOR
Area 6: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet

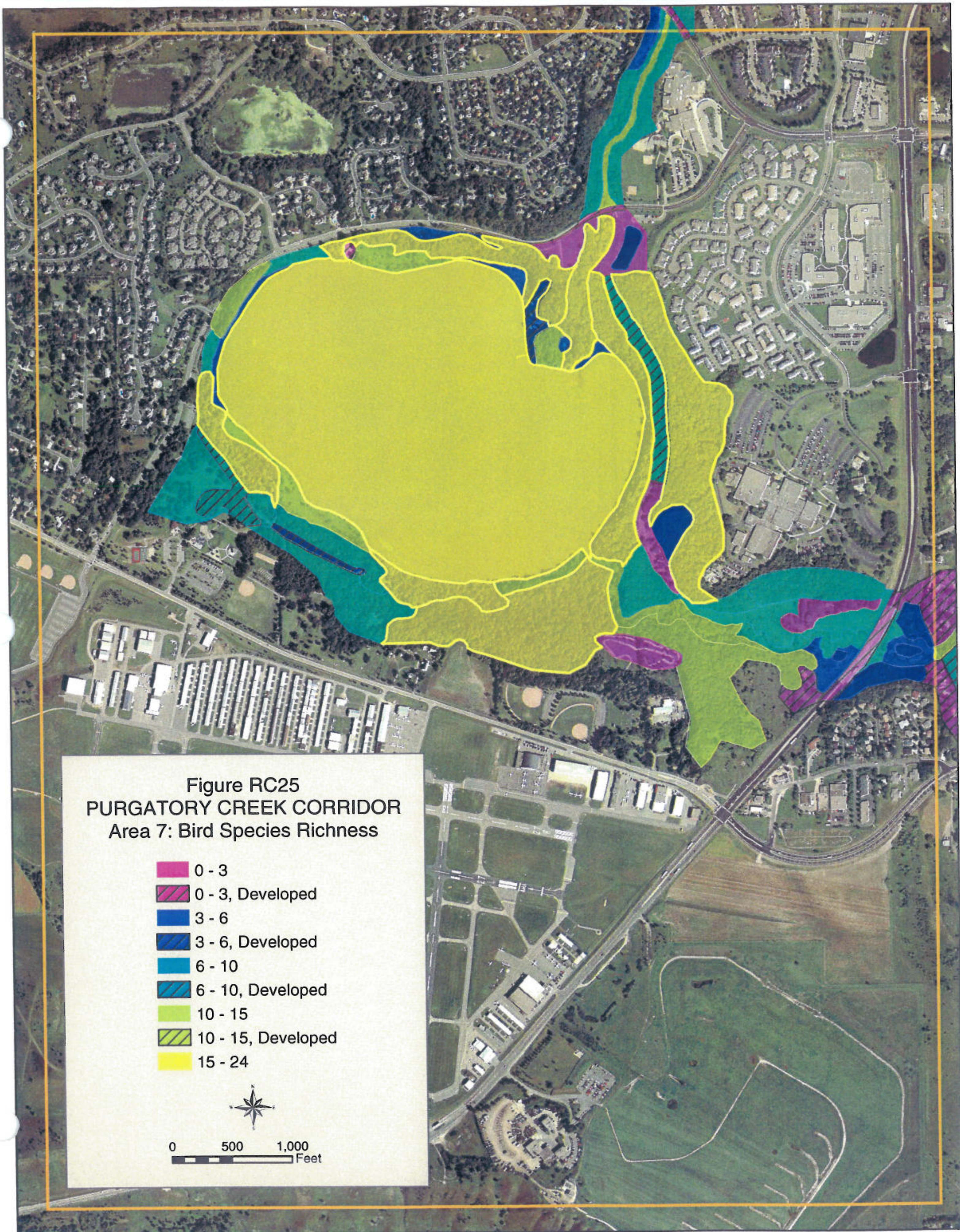
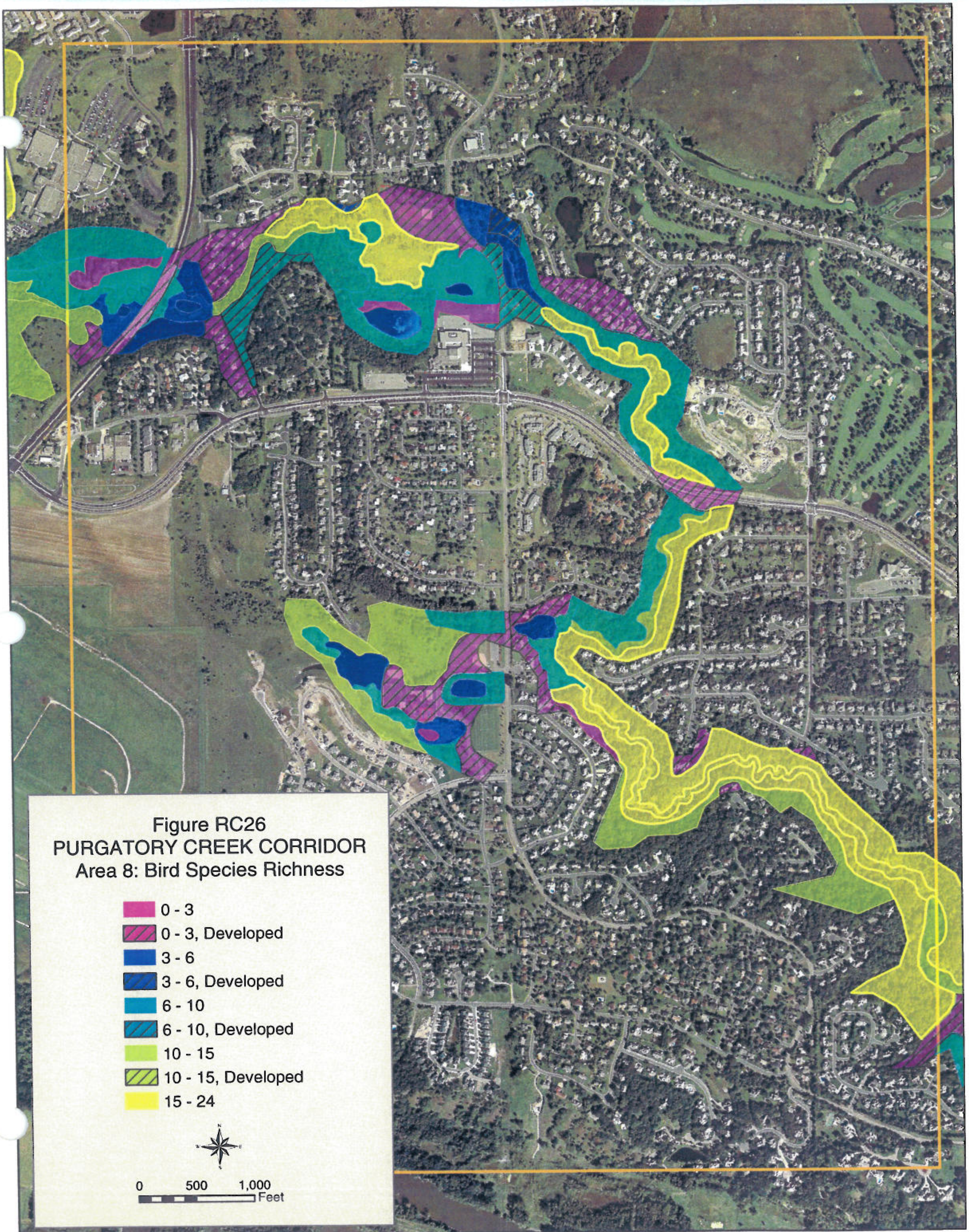


Figure RC25
PURGATORY CREEK CORRIDOR
Area 7: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet



Barr Footer: Date: 12/30/2004 4:31:47 PM File: I:\Projects\23\27\053\03Purg_VegSurvey\Gis\Project\Results\RC26_PurgBird_Area8.mxd User: dlh2

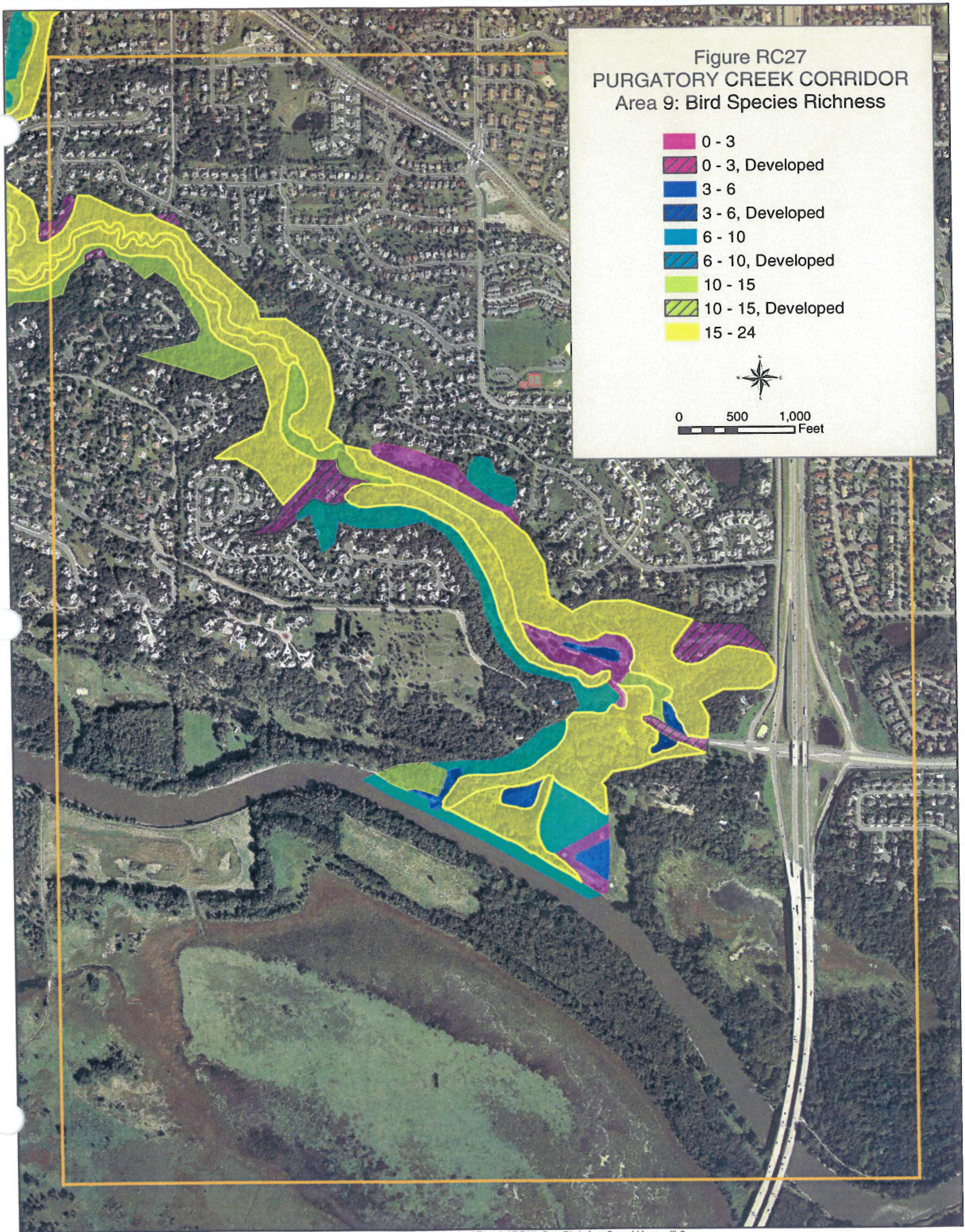


Figure RC27
PURGATORY CREEK CORRIDOR
Area 9: Bird Species Richness
0 - 3
0 - 3, Developed
3 - 6
3 - 6, Developed
6 - 10
6 - 10, Developed
10 - 15
10 - 15, Developed
15 - 24
0
500
1,000
Feet

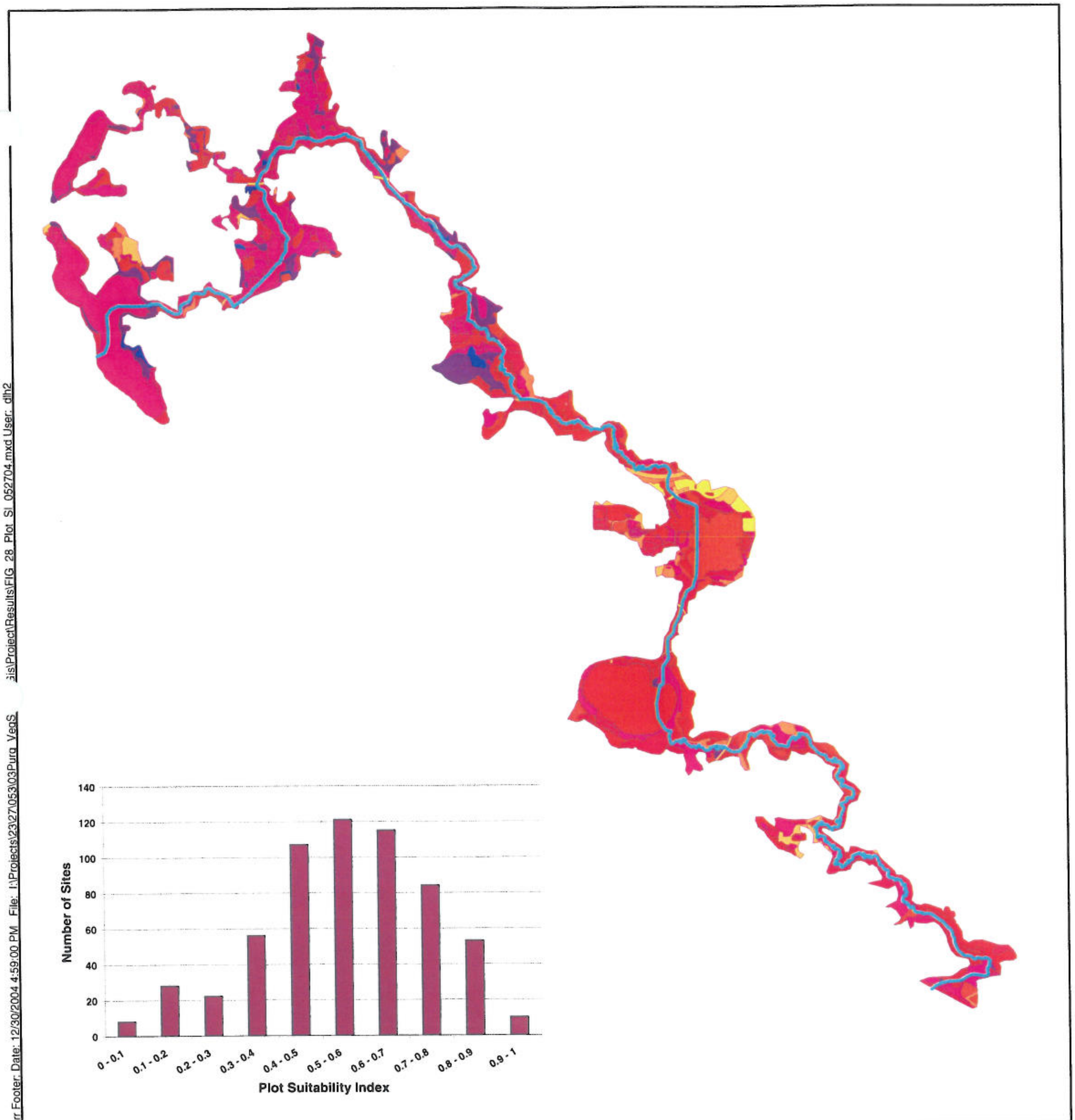
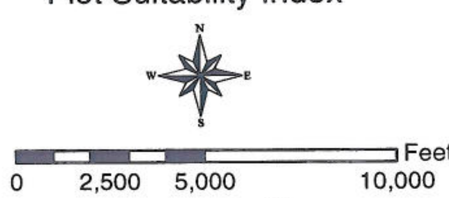
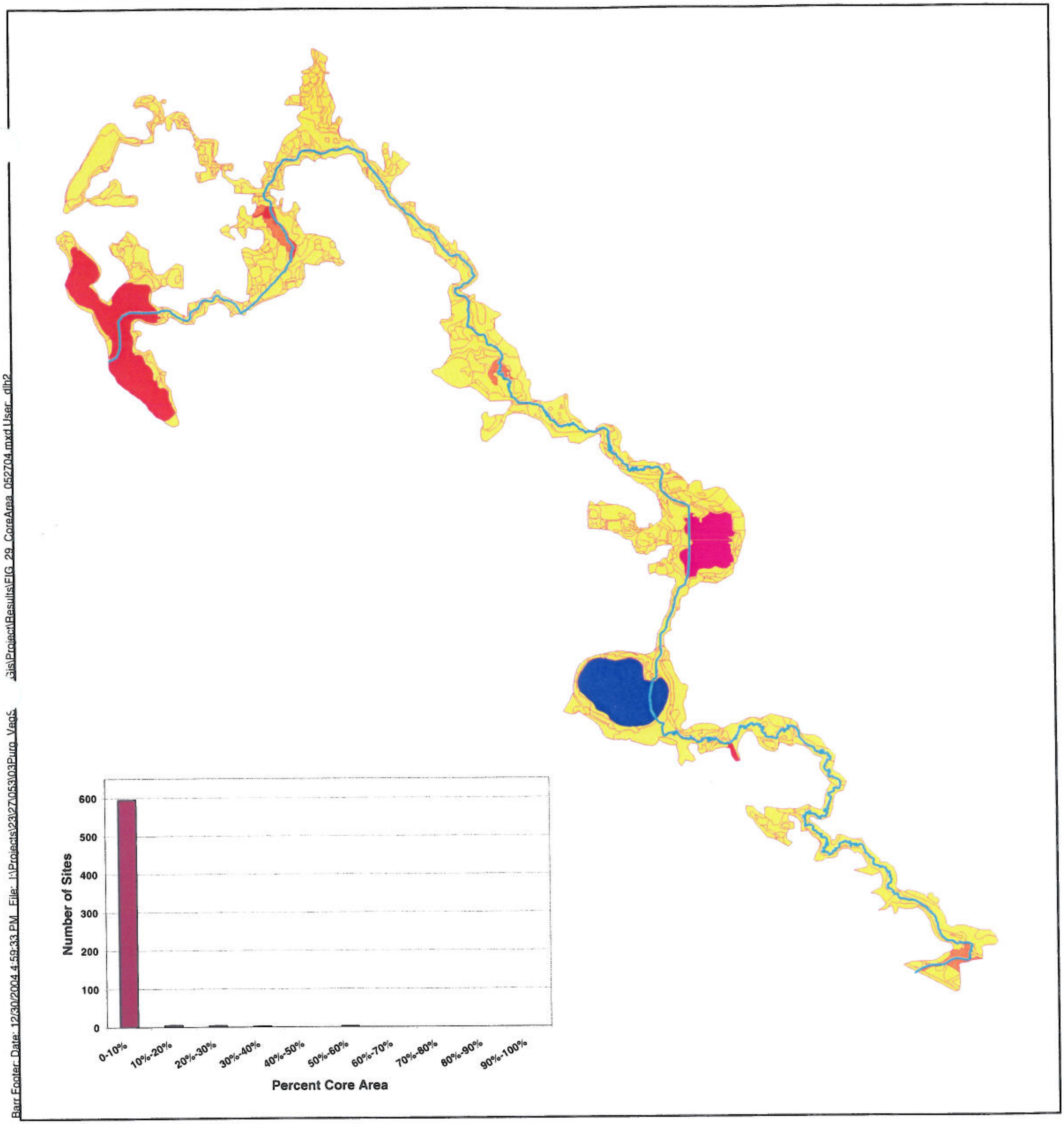


Figure RC28
PURGATORY CREEK CORRIDOR
Plot Suitability Index





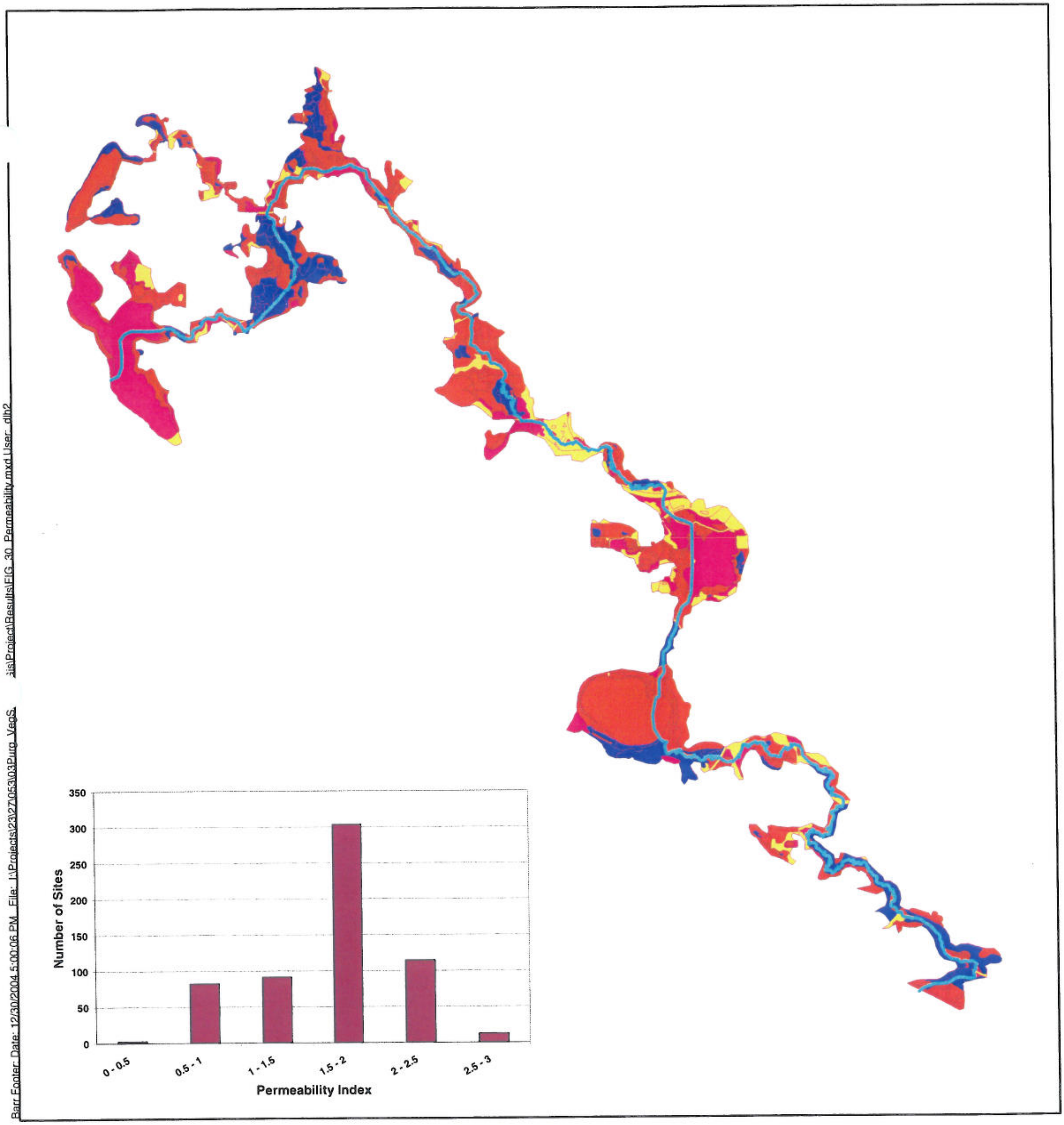
Percent Core Area

- 50% - 60%
- 30% - 40%
- 20% - 30%
- 10% - 20%
- 0 - 10%

Figure RC29
PURGATORY CREEK CORRIDOR
Percent Core Area

N
W E
S

Feet
0 2,500 5,000 10,000



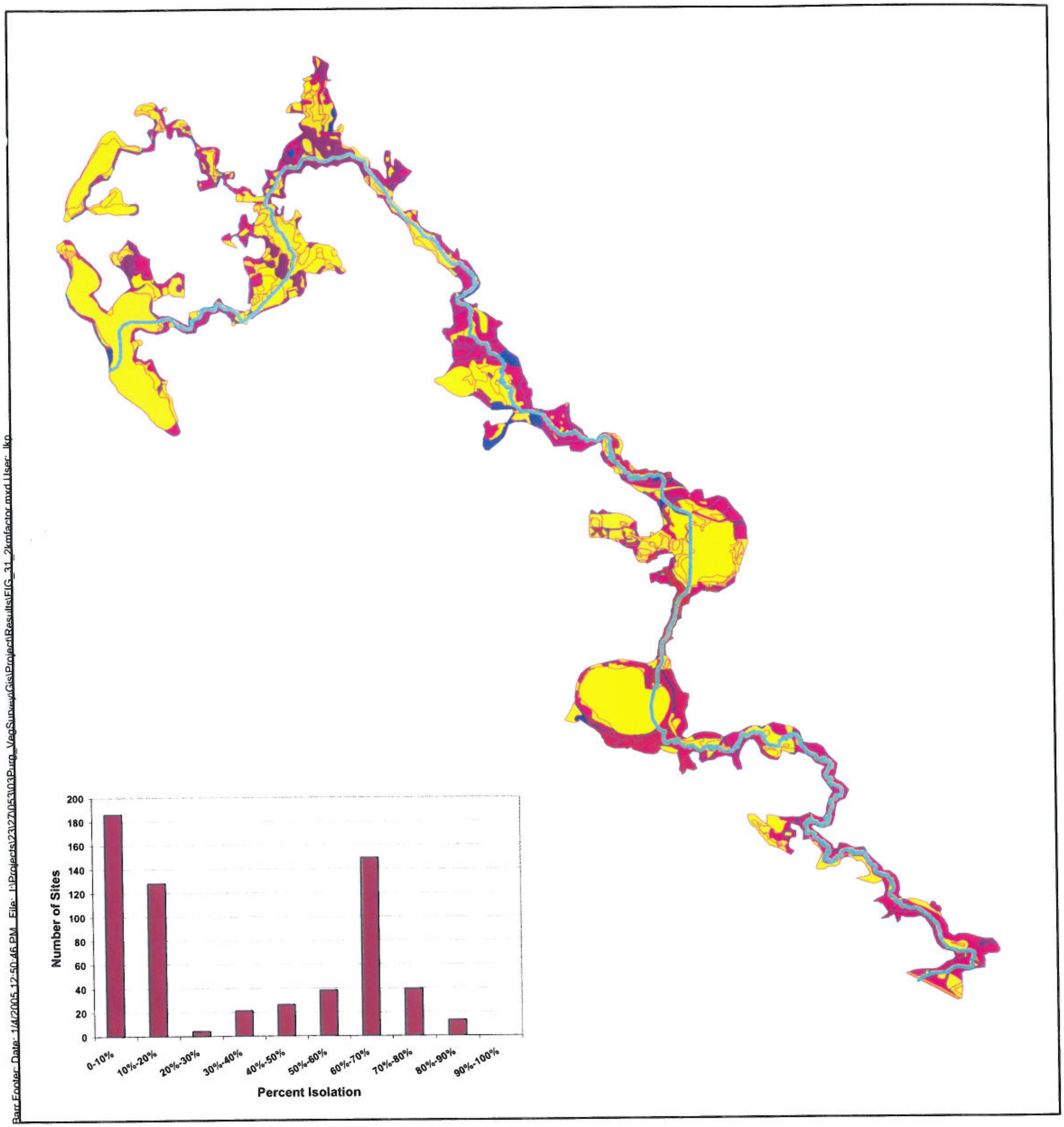
Permeability Factor

- 0 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.55

Figure RC30
PURGATORY CREEK CORRIDOR
Permeability Factor

N W E S

Feet
0 2,875 5,750 11,500



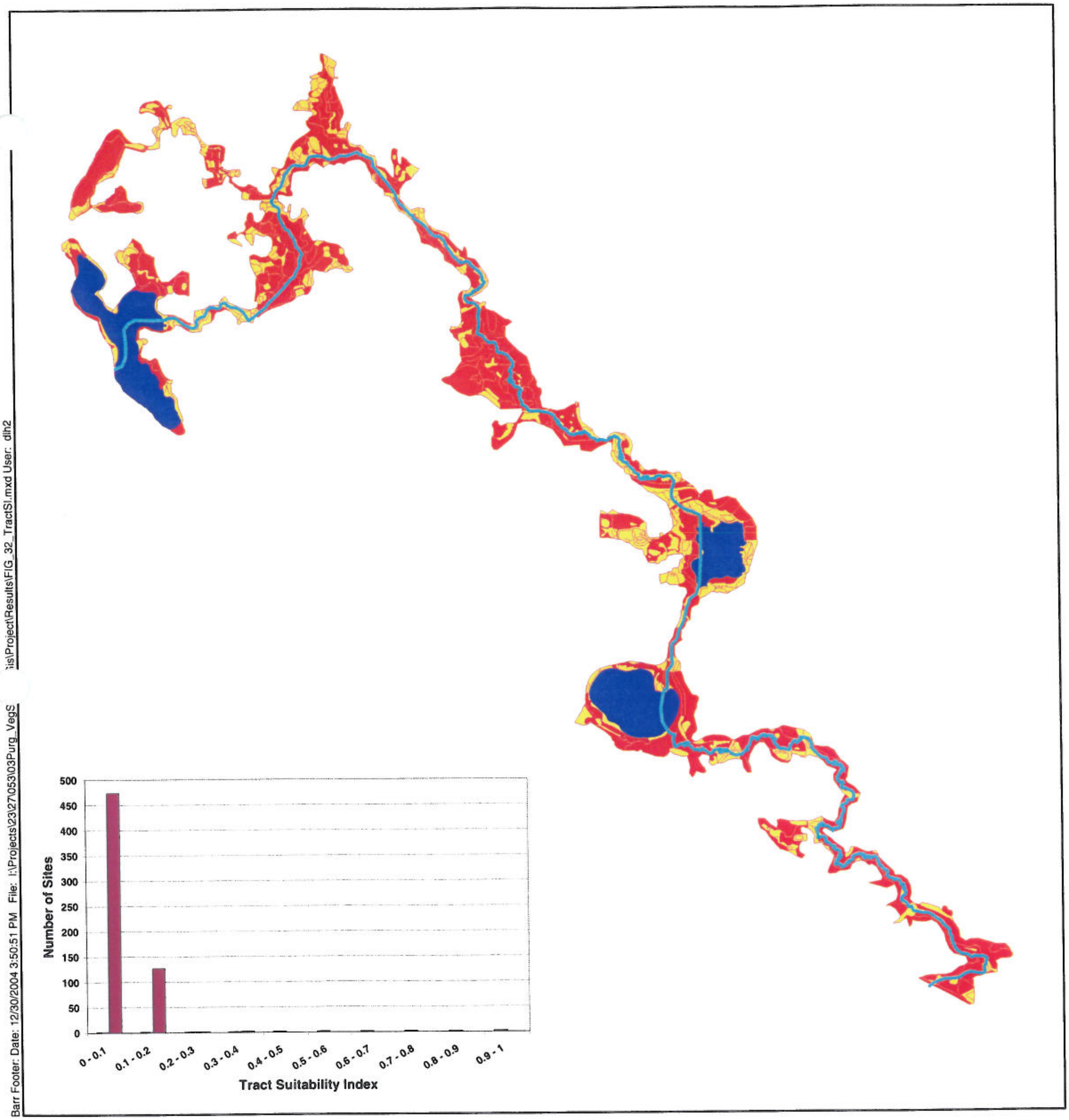
Percent Similar Land Cover Within 2 km

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 60%
- 60 - 70%
- 70 - 80%
- 80 - 90%

Figure RC31
PURGATORY CREEK CORRIDOR
Two Kilometer Factor

N W E S

0 2,500 5,000 10,000 Feet



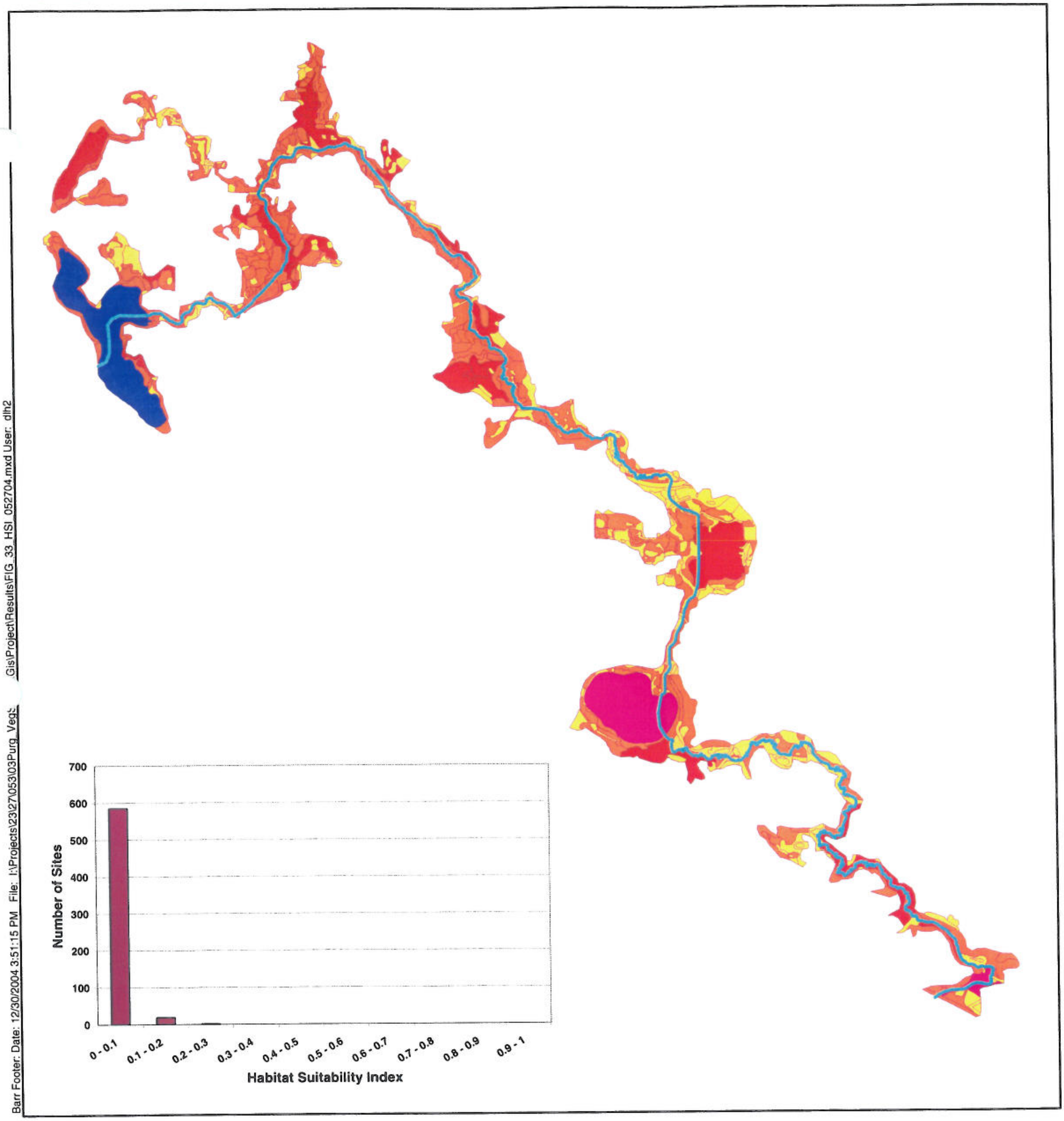
Tract Suitability Index

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3

Figure RC32
PURGATORY CREEK CORRIDOR
Tract Suitability Index (TSI)

N W E S

0 2,500 5,000 10,000 Feet



HSI

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25

Figure RC33
PURGATORY CREEK CORRIDOR
Habitat Suitability Index (HSI)
(Landscape + Plot)

N
W E
S

0 2,500 5,000 10,000 Feet

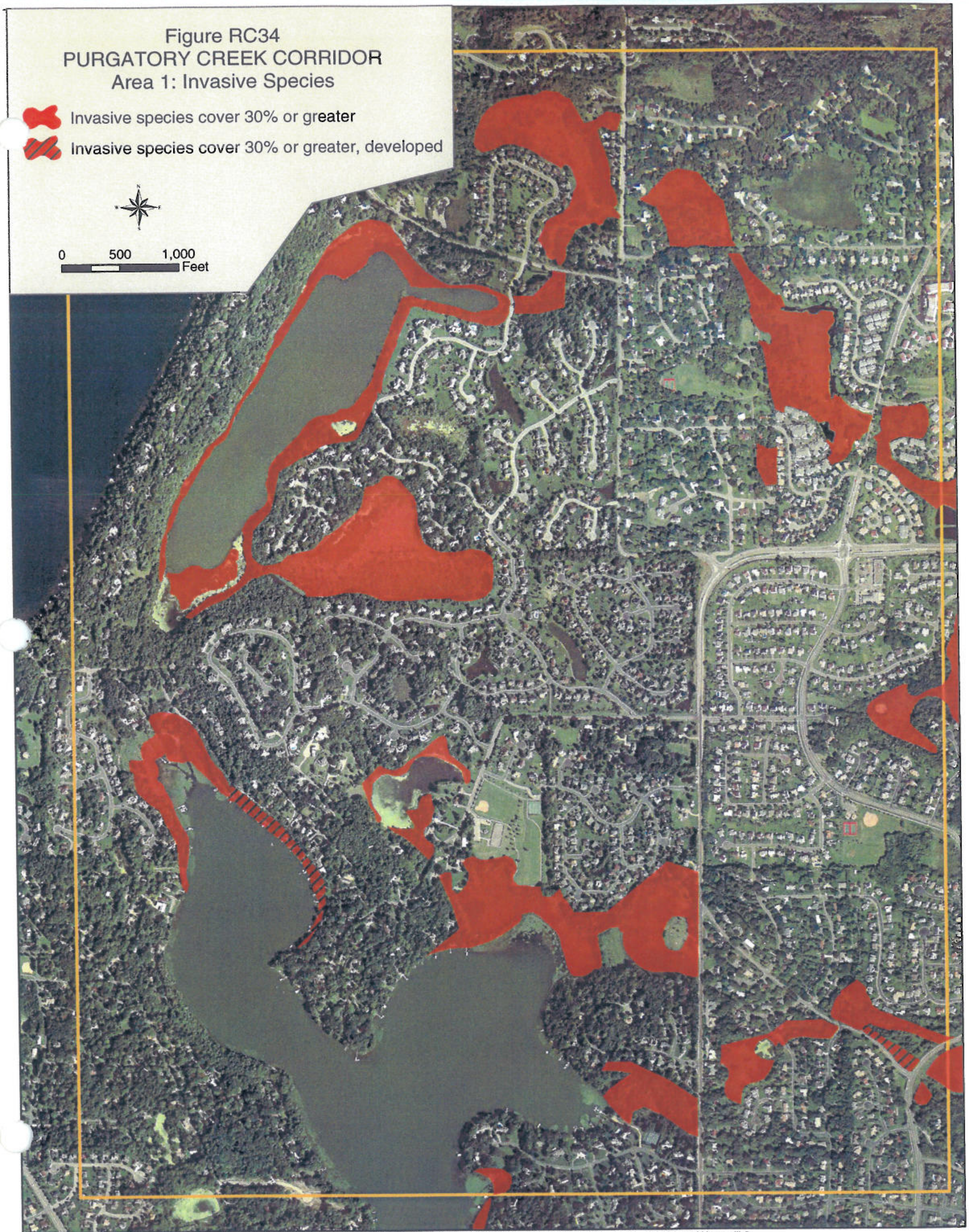


Figure RC34
PURGATORY CREEK CORRIDOR
Area 1: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

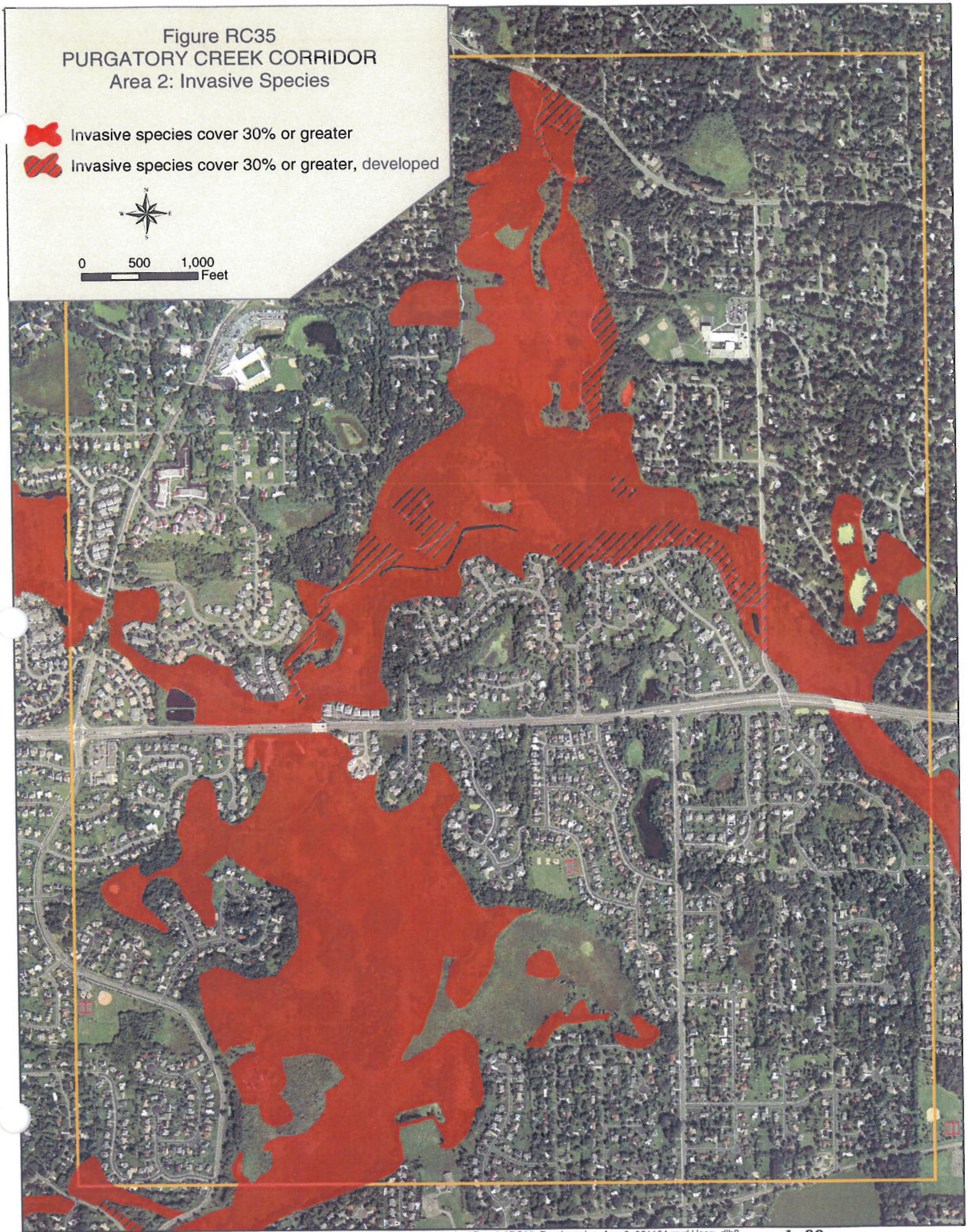


Figure RC35
PURGATORY CREEK CORRIDOR
Area 2: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
N
S
E
W
0 500 1,000
Feet

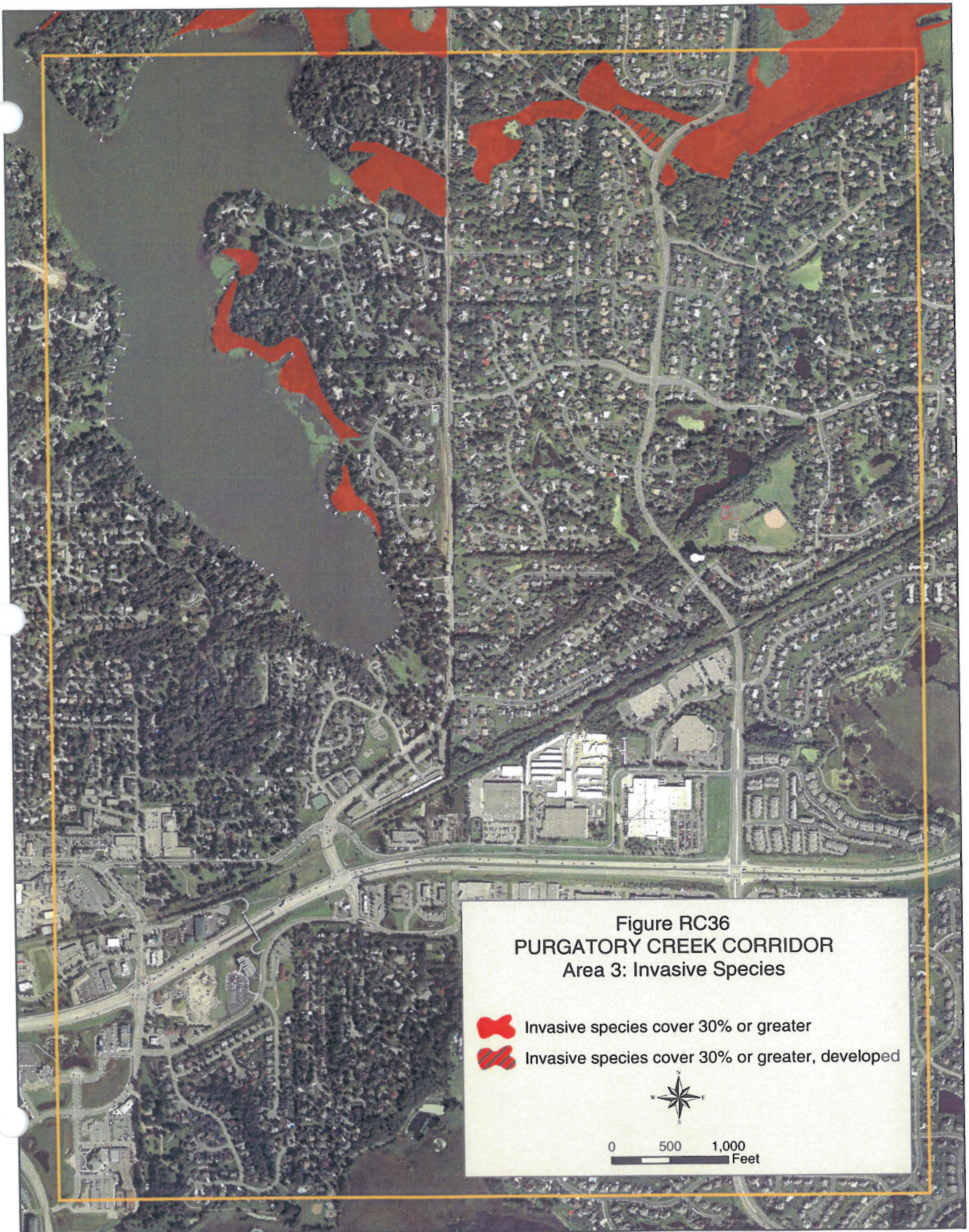


Figure RC36
PURGATORY CREEK CORRIDOR
Area 3: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
N
S
E
W
0
500
1,000
Feet

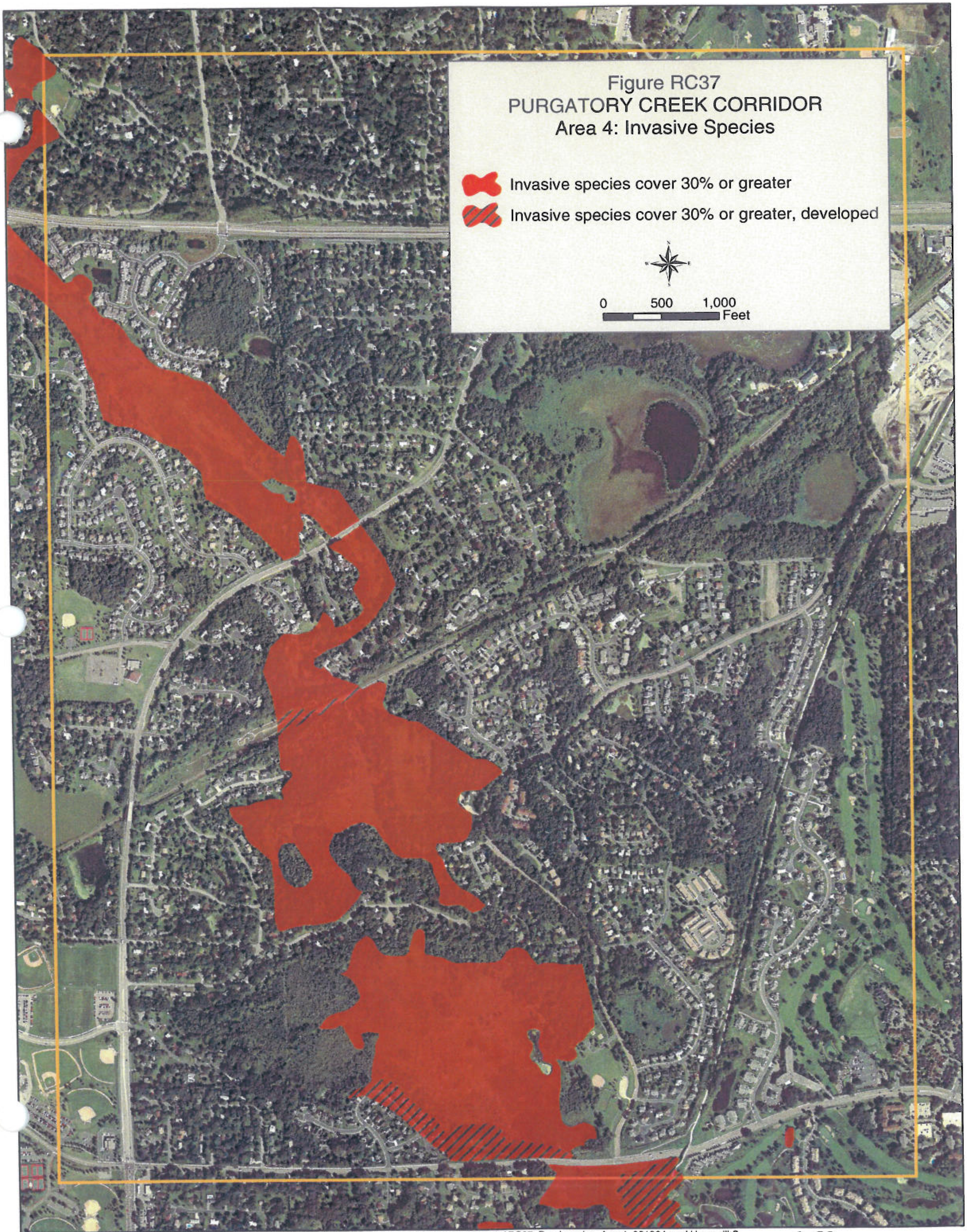


Figure RC37
PURGATORY CREEK CORRIDOR
Area 4: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

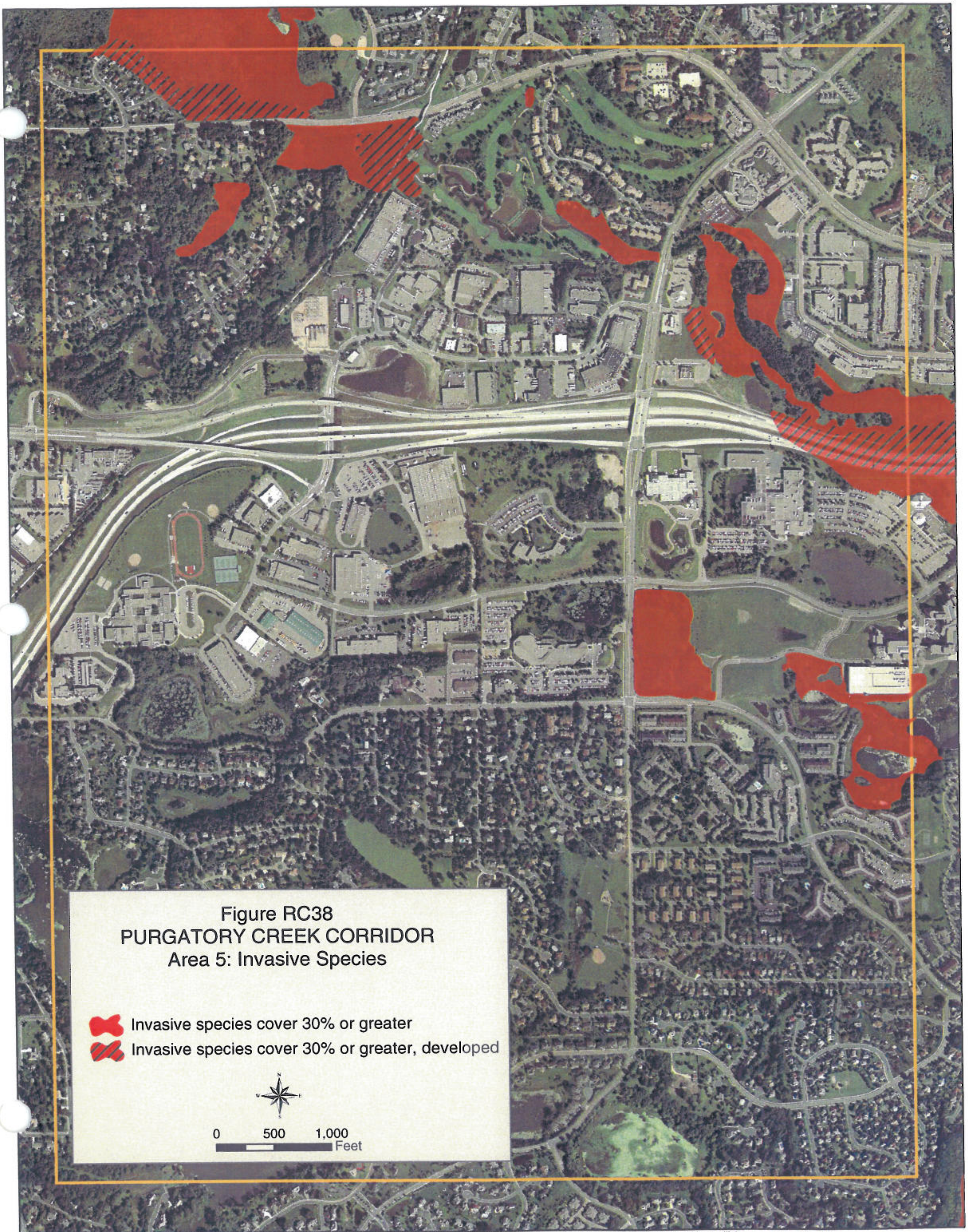


Figure RC38
PURGATORY CREEK CORRIDOR
Area 5: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
N
0
500
1,000
Feet

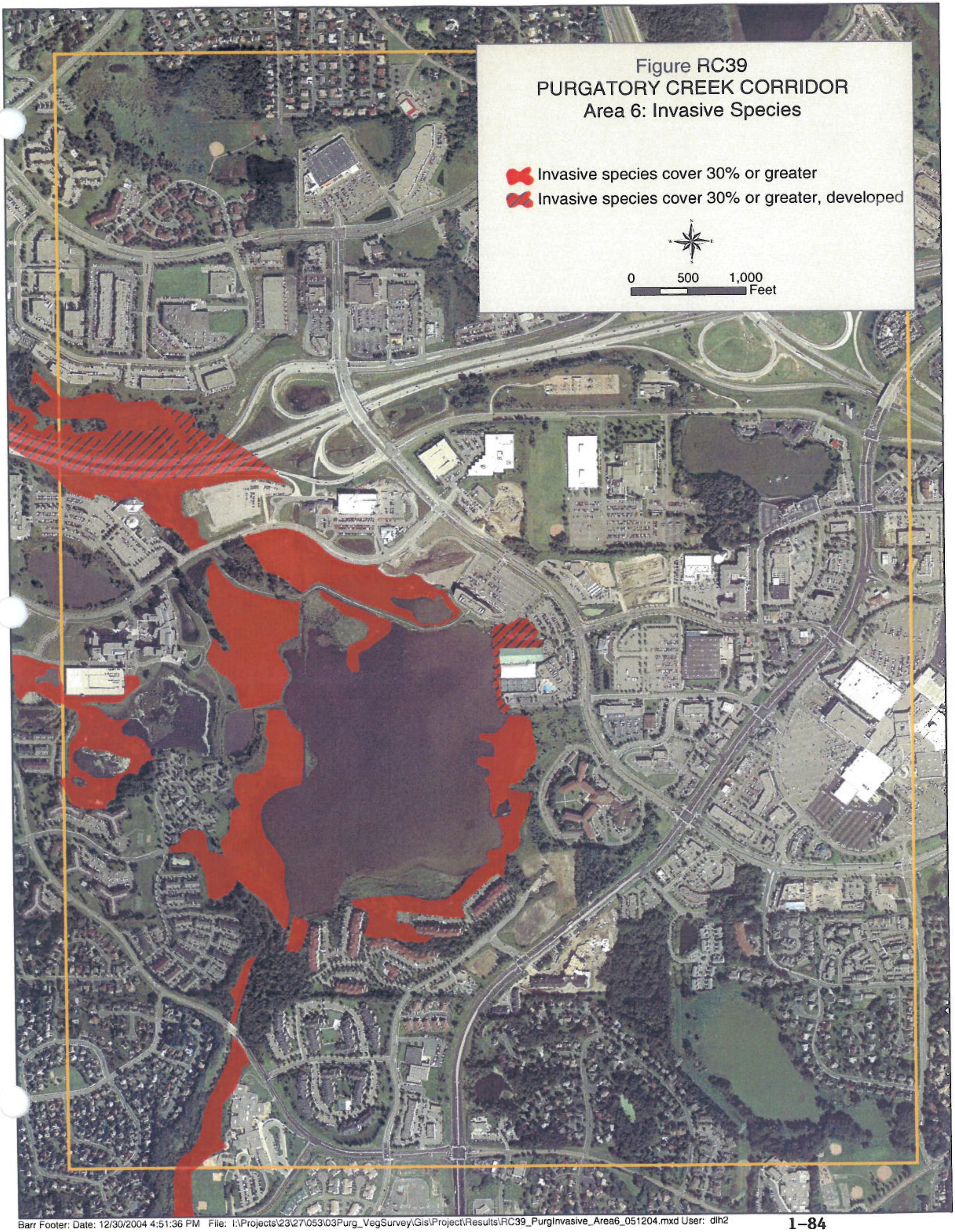


Figure RC39
PURGATORY CREEK CORRIDOR
Area 6: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

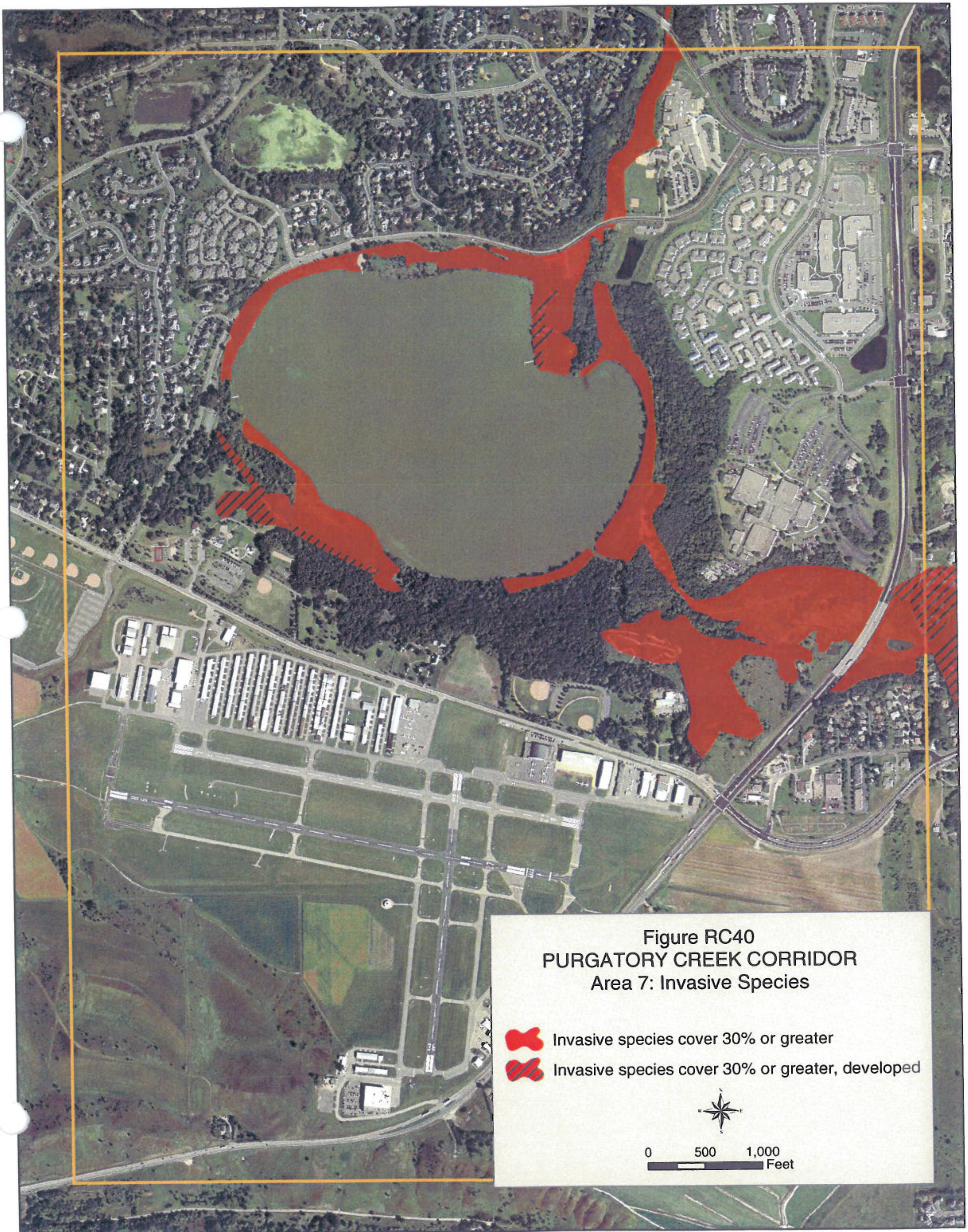


Figure RC40
PURGATORY CREEK CORRIDOR
Area 7: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

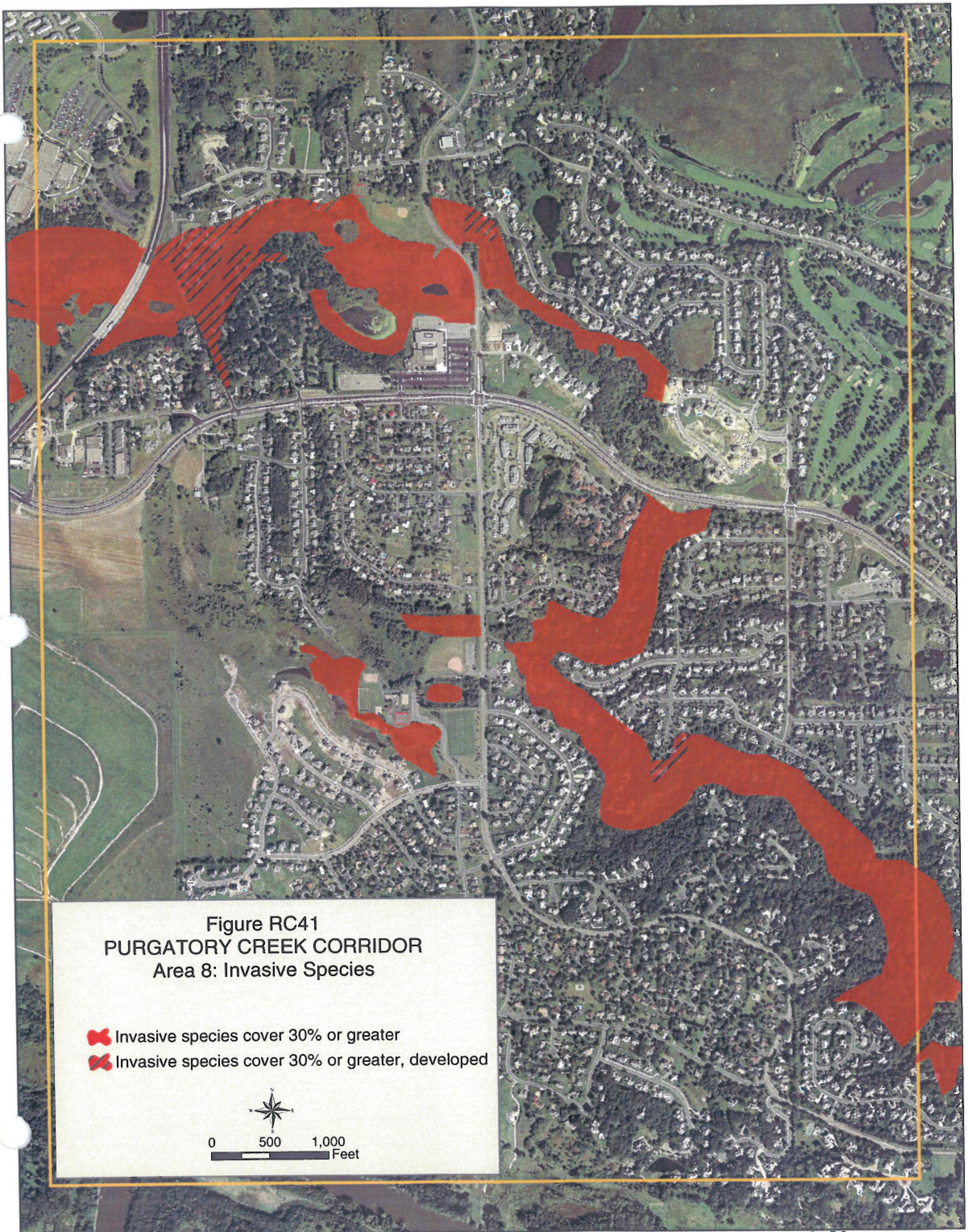


Figure RC41
PURGATORY CREEK CORRIDOR
Area 8: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

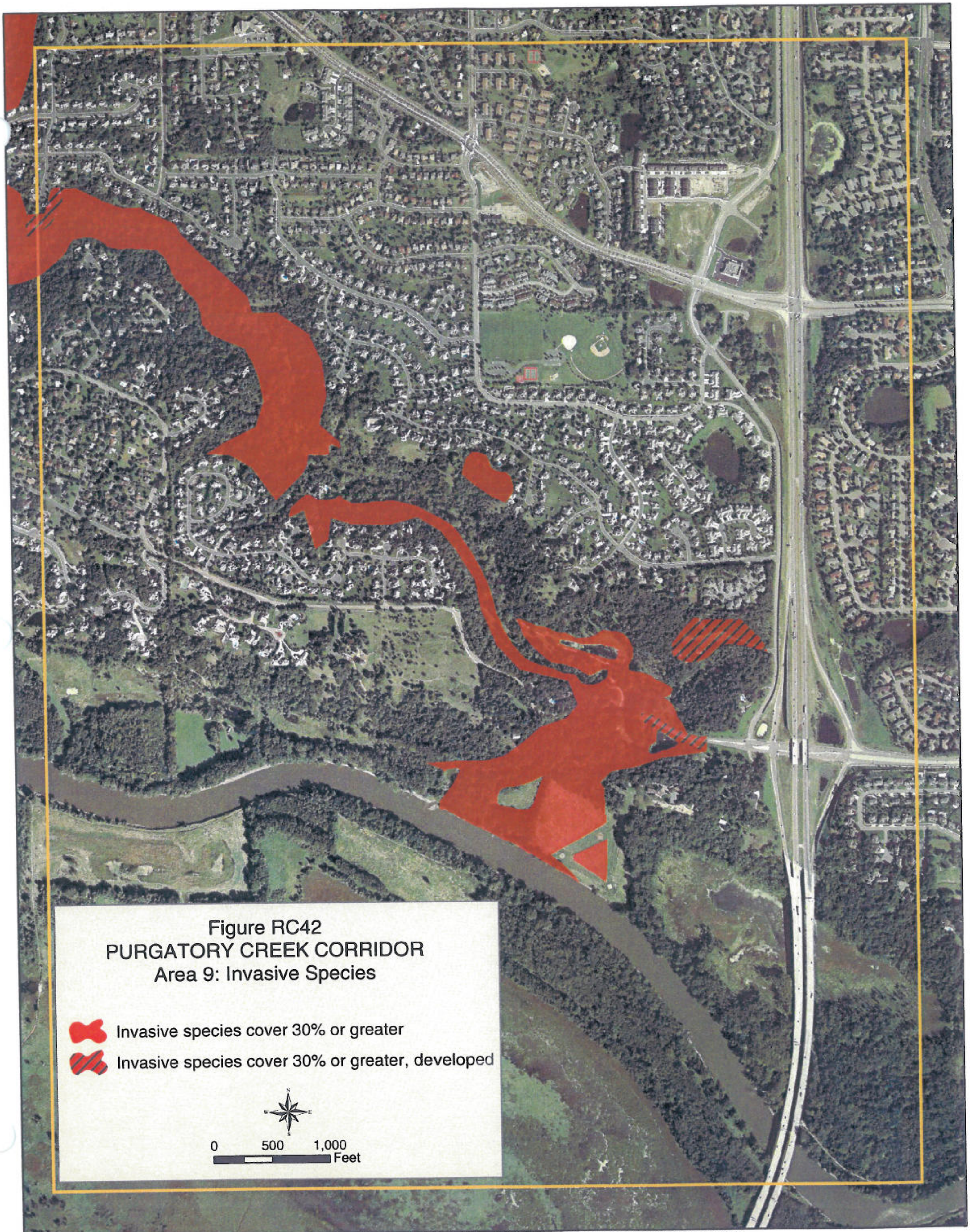


Figure RC42
PURGATORY CREEK CORRIDOR
Area 9: Invasive Species
Invasive species cover 30% or greater
Invasive species cover 30% or greater, developed
0
500
1,000
Feet

2.0 Physical Classification of Purgatory Creek

2.1 Introduction

A physical classification of a stream classifies a stream into various types based on the relationship of its physical geometry and hydraulic characteristics. The purpose of a physical classification is to provide evidence of how the stream has been affected by changing land use, how the stream will behave under existing conditions, and to indicate how restoration may be approached if a portion of the stream becomes unstable. The physical classification is used in conjunction with the ecological classification to aid in the management of Purgatory Creek.

Eight reaches of Purgatory Creek (Figure PC1) were surveyed and classified in 1995 as part of the District's Water Management Plan (published in 1996). The results of that study indicated that the creek is comprised of stream types that are sensitive to disturbance. Disturbance can be watershed-wide, such as urban development, or channel specific, such as introducing a road crossing. The Purgatory Creek watershed is nearly fully developed; the creek is likely still adjusting to the changes in watershed characteristics. Because the 1996 classification was the first time the creek had been classified, conclusions about the rate of change of the creek were not made.

2.2 Background

2.2.1 Description of Purgatory Creek

Purgatory Creek has a direct tributary drainage area of approximately 28 square miles. An additional 3.6 square miles from the Eden Prairie chain-of-lakes watershed also drains to Purgatory Creek. The watershed ranges from marshy and poorly drained north of Highway 7, to a mix of marsh and forested upland in the middle portion of the watershed, and finally the steep valley walls as the creek flows to the Minnesota River.

The history of Purgatory Creek, its watershed and land use can be understood through the examination of aerial photos taken in 1945, 1962, and 1971. The land use of the Purgatory Creek watershed was primarily agricultural until the 1970's. Several portions of Purgatory Creek had been ditched and straightened prior to 1945, with a portion of the creek classified as county ditch. Much of the creek area appears to have been grazed. The lower valley, in particular appeared to have been devoid of undergrowth vegetation. Severe gully formations were evident in the lower valley even in the 1940's.

2.2.2 Urbanization Influence on Purgatory Creek

Because of its proximity to the metro area, the Purgatory watershed saw increased urbanization relatively early, and is now almost fully developed. With urbanization, grazing gradually ended and the floodplain has re-vegetated with grass, willow, dogwood, and other shrub vegetation. Many of the severely eroded gullies bordering the lower valley have also re-vegetated, either naturally or artificially with development. Re-vegetation of the floodplain areas appears to have improved the physical condition of Purgatory Creek.

2.2.2.1 Flood Frequency and Magnitude

Prior to the introduction of agriculture and grazing practices, Purgatory Creek was likely in general equilibrium with the landscape and was able to convey storm runoff without significant change in its shape, pattern, or profile. When agricultural practices began to dominate the land use of the watershed, the natural balance between watershed runoff and the stream shape, pattern, and profile was altered, and the stream began to show signs of degradation. When the watershed began to urbanize, more changes were introduced to the relationship, and the stream shape, pattern and profile has been in a process of adjusting to these changes.

The most significant change associated with urbanization, as far as the stream is concerned, is an increase in runoff from the watershed. With urbanization, the rate and volume of runoff increases, as shown in Figure PC2.

The shape, pattern, and profile of the stream channel are intimately related to the bankfull discharge. When the stream is in equilibrium with its environment, the shape, pattern, and profile are such that the stream can convey the bankfull discharge without significant change in those parameters. With urbanization, the frequency of bankfull discharge increases depending on the amount of impervious area in the watershed. This concept is illustrated in Figure PC3.

Because the bankfull flood is the dominant, channel forming flow, and because under natural conditions this flow only occurs on average once every 1.5 to 2 years, the stream must adjust to what is effectively a larger channel-forming discharge. The channel tends to widen and deepen its cross-section. As it does this, the sinuosity of the stream tends to decrease, with a resulting increase in the slope of the channel.

Detention ponds are often constructed to slow the rate of storm water flow to the stream, and thus attempt to maintain a more natural rate of flow to the stream. Figure PC4 shows that with increasing storm water detention volume available it is possible to approach the pre-urbanized condition of runoff to the stream. Infiltration practices such as rainwater gardens are even more beneficial, because they reduce not only the rate of runoff but also the volume.

Because it is usually impractical to store enough runoff to eliminate increases in the amount of runoff to the channel, the stream must respond to the flow increases. The natural stream channel tends to widen and deepen to convey the greater frequency and volume of discharge.

2.2.2.2 Sediment Transport

Sediment transport is an important function of the stream. It forms the shape of the channel, including the pools and riffles which are so important to aquatic life. Sediment transport consists of suspended sediment, which is distributed throughout the water column, and bed load sediment, which moves along the stream bed. Suspended sediment generally consists of finer particles, while bed load sediment consists of larger, heavier particles. With larger flows, bed load sediment particles may become suspended as the power of the stream increases. Bed load sediment occupies from 5 to 50 percent of the total sediment load of a stream; suspended sediment occupies the remaining larger fraction.

The progression of suspended sediment transport with a single storm is demonstrated in Figure PC5. At low stream flows, the suspended sediment load is also low. As flow increases, the sediment load also increases, until the flow reaches a maximum. As the flood recedes, the sediment load is lower than for similar discharges on the rising limb of the hydrograph. The reason for this is that as the flood is building, all of the previously deposited sediment in the stream is being removed. The sediment deposits may be due to bank slumps, deposits from storm water inflow, or upland erosion. The stream is unable to move the deposited sediment until the flow is large enough to transport the sediment particles. When the flood recedes, there is less sediment available to move.

Although the sediment supply to a stream increases with urbanization, the increase in flood peak overcompensates for the increase in sediment yield (Leopold, 1978). That is, the sediment supply does not always keep up with the increase in flood flow in a mature urban watershed. This is another reason why detention storage is important, because it reduces the magnitude of large flows which have the capacity to remove sediment from the bed and banks of the channel.

2.2.2.3 Channel Disturbance

Activities such as road crossing of the creek, channel straightening and concentration of flow at culvert crossings also have a negative impact on the stream. These activities alter the stable pattern runoff to the stream. Infiltration practices such as rainwater gardens are even more beneficial, because they reduce not only the rate of runoff but also the volume.

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2.2.2.3 Channel Disturbance

Activities such as road crossing of the creek, channel straightening and concentration of flow at culvert crossings also have a negative impact on the stream. These activities alter the stable pattern and profile of the channel. Areas of disturbed natural vegetation along the stream banks and floodplain also results in greater erosion potential.

2.3 Methods

2.3.1 Description of Physical Classification System

The classification system used to classify Purgatory Creek was developed by D.L. Rosgen ("A Classification of Natural Rivers", Catena, 1994). Rosgen's classification system describes a stream on a reach by reach basis. A single stream can have several different stream types over its length. The system defines a stream type according to the shape, pattern, and profile of the reach. In particular, the following parameters are used to classify a stream type: the degree of entrenchment of the channel, the ratio of width to depth, degree of channel meandering or sinuosity, channel material, and the channel surface slope. Some of these parameters are illustrated on Figure PC6.

The Rosgen classification system specifies seven basic stream types, ranging from A to G as shown on Figure PC7. Each type has six subclasses corresponding to the predominant bed material present in the reach. These subclasses are numbered from 1 to 6: 1 is bedrock, 2 is boulder, 3 is cobble, 4 is gravel, 5 is sand, and 6 is silt. This allows for 42 combinations of stream type. A maximum of 15 of these types would likely be found on Purgatory Creek. A description of the stream types is given in Table PC1. This table gives a range of values of the criteria used for stream classification. These ranges are those most commonly observed; the actual observed values can lie outside of these ranges to a certain extent, recognizing that as the stream type changes, the criteria will adjust accordingly.

The ***entrenchment ratio*** is defined as the ratio of the width of the flood-prone area to the bankfull surface width of the channel. The ***flood-prone area*** is defined by Rosgen as the width measured at an elevation which is determined at twice the maximum bankfull depth. Field observation shows this elevation to be a frequent flood (50 year) or less, rather than a rare flood elevation. The entrenchment ratio describes the interrelationship of the river to its valley and landform features. This interrelationship determines whether the river (stream) is deeply incised or entrenched in the valley floor or deposit feature. The entrenchment ratio indicates whether the flat area adjacent to the channel is a frequent floodplain, a terrace (abandoned floodplain), or is outside the flood-prone area.

The ***width/depth ratio*** is the ratio of bankfull channel width to bankfull mean depth; it is used to describe the dimension and shape of the channel. ***Bankfull discharge*** occurs at approximately the 1 to 2 year recurrence interval and is referenced to as the dominant discharge for the stream. Hydraulic geometry and sediment transport relations rely heavily on the frequency and magnitude of bankfull discharge.

Sinuosity is the ratio of stream length to valley length. It can also be described as the ratio of valley slope to channel slope. This value typically varies from 1.0 to 2.5, where a value of 1.0 corresponds to a straight channel. Sinuosity can often be determined from aerial photographs, and interpretations can then be made of slope, channel materials, and entrenchment. Values of sinuosity appear to be modified by bedrock control, roads, channel confinement, and vegetation types, among other factors. Generally, as gradient and particle size decrease, there is a corresponding increase in sinuosity. Meander geometry characteristics are directly related to sinuosity following minimum expenditure of energy concepts. Based on these relations and ease of determination, sinuosity is one of the delineative criteria for stream classification.

Channel materials refer to the bed and bank materials of the stream. Channel material is critical for sediment transport and hydraulic influences, and also modifies the form, plan, and profile of the stream. Interpretations of biological function and stability also require this information. The channel materials can often be predicted from soils maps and geologic information. They can also be determined in the field, and at the detailed level the materials are measured and the size plotted on percent distribution paper.

The ***water surface slope*** is of major importance to the morphological character of the channel and its sediment, hydraulic, and biological function. It is determined by measuring the difference in water surface elevation per unit stream length. It is typically measured through at least 20 channel widths or two meander wavelengths (Rosgen). In broad level delineations, slope can be estimated by measuring sinuosity from aerial photos and measuring valley slope from topographic maps.

2.3.2 Sensitivity to Disturbance by Stream Type

Different types of streams have differing sensitivities to disturbance and varying recovery potential. Sensitivity and recovery potential are interrelated to sediment supply in the stream, bank erosion potential, and the influence of vegetation on controlling bank erosion. These differences are itemized by stream type in Table PC2.

The information in Table PC2 is best applied when a stream's behavior can be predicted by appearance and by extrapolating information from similar stream types. Knowing the sensitivity of each stream type allows for better management of the stream systems, potential impact assessment, and risk analysis.

2.3.3 Data Collection

Eight reference reaches of Purgatory Creek were physically classified as shown on Figure PC3 and summarized in Table PC3. At each reach, the profile and cross section of the channel were surveyed. Water surface elevations and bankfull elevation indicators were surveyed. At each cross section, permanent control monuments were installed to enable future monitoring of the sites. The sediment was characterized for each reach and the grain size distribution plotted.

2.3.4 Mapping

During the field survey, GPS coordinates were surveyed for each site to enable incorporation of the data into ArcMap mapping of the Purgatory Creek system. GPS coordinates were also read for each photograph, and the ground photographs were incorporated into the ArcMap mapping.

2.4 Results of Physical Classification of Purgatory Creek

2.4.1 Physical Classification—Reference Reaches

Eight reference reaches were surveyed and classified using the Rosgen method. The physical classification parameters are listed in Table PC4. A description of each reach follows:

2.4.1.1 P-1

Reach P-1 is located in the lower valley between Antlers Ridge and Holland Circle (south of Pioneer Trail), in the City of Eden Prairie. A map of this reach is shown in Figure PC8. Photographs are shown in Figures PC9 and PC10.

The riparian land is largely forested and relatively undisturbed, with residential development abutting the valley walls on either side. Reed canary grass, dogwood, and other shrubs exist immediately adjacent to the channel. The stream is Type C-5 through this reach, with a meandering channel that is relatively wide compared to its average depth. The predominant channel material is sand. The floodplain is somewhat confined by the valley walls.

A meander bend in this reach has naturally straightened via a cut-off channel since the 1995 survey. This does not seem to have had a detrimental impact on the remaining reach, as there is no significant erosion evident, and the reach has neither aggraded (raised due to sediment deposition) or degraded significantly. The channel parameters have not changed significantly since the 1995 survey, with the exception of the sinuosity. The sinuosity has decreased from 2.7 to 1.7 due to the channel straightening.

2.4.1.2 P-2

Reach P-2 is located immediately upstream of Homeward Hills Road in the City of Eden Prairie. A map of this reach is shown in Figure PC11. Photographs are shown in Figures PC12 and PC13.

This reach is located in a meadow with reed canary grass as the predominant vegetation. Dogwood, willow and other shrubs are scattered along the channel banks. The stream is Type E-5 through this reach, with a meandering channel that is relatively narrow compared to its average depth. The predominant channel material is sand. The floodplain is wide and unconfined. According to the cross-section survey, the channel appears to have aggraded about one foot since the 1995 survey. However, flow rates were much higher during the 1995 survey and the bed material may have been suspended by the higher flows, and re-deposited with the lower flows. The other channel parameters have changed little since the 1995 survey.

2.4.1.3 P-3

Reach P-3 is located upstream of Staring Lake, just downstream of Anderson Lakes Parkway in the City of Eden Prairie. A map of this reach is shown in Figure PC14. Photographs are shown in Figures PC15 and PC16.

This reach lies in a wooded, confined shallow valley. The stream is Type B-5 through this reach, with a relatively straight channel and narrow floodplain. The predominant channel material is sand.

2.4.1.4 P-4

Reach P-4 is located a short distance downstream of Mitchell Road, north of Highway 5 in the City of Eden Prairie. A map of this reach is shown in Figure PC17. Photographs are shown in Figures PC18 and PC19.

This reach is located in a broad meadow with reed canary grass as the predominant vegetation. Dogwood, willow and other trees and shrubs are scattered along the channel banks. The stream is Type E-5 through this reach, with a meandering channel that is relatively narrow compared to its average depth. The predominant channel material is sand. The floodplain is fairly wide compared to the channel width. The channel dimensions have not changed significantly since the 1995 survey, although the bankfull elevation is interpreted to be lower than in the earlier survey. This means that the channel is slightly more incised than previously believed, though not enough to change its classification.

2.4.1.5 P-5

Reach P-5 is located upstream of the Edenvale Park and Conservation Area, between Hillcrest Court and Edgewood Court in the City of Eden Prairie. A map of this reach is shown in Figure PC20. Photographs are shown in Figures PC21 and PC22.

This reach is located in a wooded, gently sloping valley with reed canary grass on the stream banks. A weir has been constructed across the channel at a pedestrian bridge, which is backing up water in the channel. While this isn't presently creating significant problems, it could raise upstream flood levels. Also, if the weir remains in place for a long period of time and is then removed, a large amount of accumulated sediment would be washed downstream. If the weir is illegal or if there is no agreement for its long-term maintenance, it should be removed.

The stream is Type E-5 through this reach, with a meandering channel that is relatively narrow compared to its average depth. The predominant channel material is sand. The floodplain is fairly wide compared to the width of the channel. The channel parameters have not changed significantly since the 1995 survey.

2.4.1.6 P-6

Reach P-6 is located immediately upstream of Scenic Heights Drive in the city of Minnetonka. A map of this reach is shown in Figure PC23. Photographs are shown in Figures PC24 and PC25.

This reach is located in a wooded valley in a residential area. Portions of the creek have reed canary grass on the banks, while other areas are wooded. A large mowed yard abuts a portion of this reach, with erosion evident. The homeowner has lined the channel toe with riprap and gravel.

The old Creek Ridge Trail bridge was removed since the 1995 survey, with large stones placed in the channel bottom for grade control.

The stream appears to have degraded in this reach. Of the two cross-sections surveyed, one has widened and the other has deepened. The profile survey indicates that much of the reach has downcut since the 1995 survey. This reach was classified as Type F-4, which is a meandering channel that is incised, or eroded downward, to the extent that it has abandoned its original floodplain and is thus more constrained. This channel type is indicative of an unstable channel. The predominant channel material was gravel, where in 1995 it was sand. This is further evidence that the channel is actively eroding in this reach.

This reach should be monitored again in one year so that appropriate action can be taken if the situation worsens.

2.4.1.7 P-7

Reach P-7 is located downstream of Covington Road in a small city park in the City of Minnetonka. A map of this reach is shown in Figure PC26. Photographs are shown in Figures PC27 and PC28.

The park land adjacent to this reach is partially wooded, with the remainder in turf grass. The channel was dry at the time of the survey. Significant bank erosion is evident, and is exacerbated by the presence of woody debris in the channel.

The stream is Type C-4 through this reach, with a meandering channel that is relatively wide compared to its average depth. The predominant channel material is gravel, a change from the sand that was observed in 1995. According to the cross-section survey, the channel appears to have downcut up to one foot since the 1995 survey. The channel is lowering relative to its floodplain. If the erosion continues it will become a Type F channel, which is an unstable channel type. This reach should also be monitored in one year to determine if corrective action should be taken.

2.4.1.8 P-8

Reach P-8 is located upstream of Dell Road in the City of Eden Prairie, not far downstream from Lotus Lake. A map of this reach is shown in Figure PC29. Photographs are shown in Figures PC30 and PC31.

This reach is located in a meadow with reed canary grass as the predominant vegetation. The stream is Type E-5 through this reach, with a meandering channel that is relatively narrow compared to its average depth. The predominant channel material is sand. The floodplain is fairly wide relative to the channel. The channel parameters have changed little since the 1995 survey.

2.4.2 Extrapolation of Physical Classification to Entire Stream

With the aid of aerial photos and topographic maps, the reference reach classifications were used to classify the remaining stream length. Figure PC32 illustrates the stream types for the entire length of the stream. Overall, the stream types have not changed significantly from the 1995 survey.

Type E stream occurs in much of the middle and upper portion of the watershed, where the channel slope is mild and the valleys are broad and shallow. This stream type is defined by a deep, narrow channel with a low, wide floodplain. It is a very desirable stream type because channels of this type are very efficient at conveying water, and they represent a stable channel condition. It is typical of marsh and meadow areas. Reach P-2, P-4, P-5, and P-8 are all Type E; they have well vegetated banks and floodplains and are highly meandering. Several portions of the stream that were straightened or converted to golf course ponds and artificial lakes are identified as straightened/altered reaches, and were likely Type E before they were altered.

Type C stream is predominant in the lower valley and a few other wooded areas where the floodplain is more confined by the valley walls and the slope tends to be steeper. This is also a desirable channel type and indicates a stable channel.

Type B channel is located between Staring Lake Parkway and the Purgatory Creek Recreation Area. This type is unique in that it is relatively straight and is confined by valley walls. It is, however, a stable channel type.

Type F channel is located in the vicinity of reach P-6. This channel type usually develops from a degraded type C channel, and must be monitored closely or significant erosion can occur.

2.5 Attainable Stream Conditions

Purgatory Creek has retained much of its natural character with regard to aesthetics, ecological value, and flood control. Most of the reaches that are monitored have desirable physical classifications that are appropriate to their location, topography, vegetation and flow conditions. However, since physical monitoring began in 1995, several of the reaches show signs of deterioration. Reach P-6 and P-7 show significant deterioration. The deterioration is testimony to the stress associated with the urban nature of the watershed.

The most commonly observed stream types on Purgatory Creek were C and E. Type C is typical of the creek in the lower valley, and is characterized by a wider channel, is highly meandering, and has a narrower floodplain. Type E is commonly observed in the middle and upper reaches of the stream, and is typified by a narrow, deep, highly meandering channel with a well developed floodplain. These stream types are highly sensitive to disturbance; they have moderate (E) to very high (C) sediment supply, high (E) to very high (C) stream bank erosion potential, and very high vegetation controlling influence. Their natural recovery potential is fair (C) to good (E).

The lower valley, with primarily C stream type, is vulnerable to bank erosion problems. This is especially true where the stream abuts the valley walls. The excellent vegetation in the lower valley contributes greatly to the stability of the channel.

Type E channel is the predominant type in the middle and upper watershed. As with the lower valley, if the vegetation is disturbed along the stream banks severe erosion can occur with this stream type. This is evident in places where the stream abuts manicured yards. The lack of protective vegetation leads to greater bank erosion than in areas with unmowed grass and brush.

The physical classification was performed on reaches that are in relatively good condition, as they serve as good indicators of the stream health. Numerous portions of Purgatory Creek have been impacted by straightening. These areas offer good potential for improvement to a system that has higher quality from a physical and ecological perspective.

2.6 Recommendations

The high sensitivity of Purgatory Creek to impacts warrants careful management of this resource. The physical characteristics of Purgatory Creek are typical of an urbanized watershed. The study reaches should be monitored on a regular basis to detect degradation. In particular, Reaches P-6 and P-7 should be monitored within one year to verify the measurements that were taken and to determine if their condition is rapidly worsening.

To improve the overall quality of Purgatory Creek, improvements should be implemented on a watershed basis to reduce the frequency and rate of runoff to Purgatory Creek, and on a localized basis to restore the physical stability of the stream channel.

Activities associated with reducing the frequency and rate of runoff generally include storm water detention ponds or basins to reduce discharge rates and volumes from the urbanized area. Introduction of rainwater gardens can be used to infiltrate runoff, thereby reducing the volume and rate of runoff to the creek. Implementing these activities can reduce the frequency of bankfull flooding, and help maintain the stability of the stream.

Activities associated with improving the channel stability include channel and floodplain restoration techniques, such as improving stream bank protection, management of riparian vegetation, and restoring a stable channel shape, slope, and sinuosity. Vegetation can also be reestablished at areas that lack sufficient vegetation to prevent erosion. Selective tree removal may be necessary in order to provide more sunlight to areas that have a lack of ground vegetation.

Improving the physical characteristics of Purgatory Creek will improve: (1) the ability of the stream to continue to naturally meander without excessive bank erosion, (2) the ecological characteristics and aesthetics of the stream, and (3) the ability of the stream to convey flood flows efficiently without degradation. Improving stream bank and riparian vegetation throughout the stream system will improve the resistance of the stream to erosion.

Finally, restoration of selected portions of Purgatory Creek that have been previously straightened or dredged should be explored. Several of these areas appear to have significant potential for improvement and could prove to be significant resources for the community.

2.7 References

Barr Engineering Company. (1996). *Water Management Plan*. Prepared for the Riley-Purgatory-Bluff Creek Watershed District. May 1996.

Rosgen, D.L. (1994). "A Classification of Natural Rivers." Catena **22**: 169-199.

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Table PC1 Summary of Criteria for General Classification (from Rosgen)

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/Soils/Features
A	Steep, entrenched, debris transport streams.	< 1.4	<12	1.0 to 1.2	0.04 to 0.10	High relief, mountainous environments; entrenched and confined streams with cascading reaches; frequent deep pools
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequent pools. Very stable.	1.4 to 2.2	>12	>12	0.02 to 0.039	Moderate relief, colluvial deposition and/or residual soils. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids with occasional pools.
C	Low gradient, meandering alluvial channels with broad, well defined floodplain.	>2.2	>12	>1.4	<0.02	Broad valleys with terraces, associated with floodplain, alluvial soils. Slightly entrenched with well-defined meandering channel. Riffle-pool bed morphology.
D	Braided channel; very wide channel with eroding banks.	n/a	>40	n/a	<0.04	Broad valleys with alluvial and colluvial fans. Abundant sediment supply.
E	Low gradient, meandering stream with low width/depth ratio and little deposition. Very efficient and stable.	>2.2	<12	>1.5	<0.02	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well vegetated banks. Riffle-pool morphology with very low width/depth ratio.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio	<1.4	>12	>1.4	<0.02	Entrenched in highly weathered material. Gentle gradients with high W/D ratio. Meandering, laterally unstable with high bank-erosion rates. Riffle-pool morphology.
G	Entrenched Gully step/pool with low width/depth ration on moderate gradients	<1.4	<12	>1.2	0.02 to 0.039	Gully, step-pool morphology with moderate slopes and low W/D ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials. Unstable, with grade control problems and high bank erosion rates.

Table PC2 Sensitivity of Stream Types (from Rosgen)

Stream Type[1]	Sensitivity to Disturbance[2]	Recovery Potential[3]	Sediment Supply[4]	Streambank Erosion Potential	Vegetation Controlling Influence[5]
B-4 (gravel)	moderate	excellent	moderate	low	moderate
B-5 (sand)	moderate	excellent	moderate	moderate	moderate
B-6 (silt)	moderate	excellent	moderate	low	moderate
C-4 (gravel)	**very high**	**good**	**high**	**very high**	**very high**
C-5 (sand)	**very high**	**fair**	**very high**	**very high**	**very high**
C-6 (silt)	very high	good	high	high	very high
E-4 (gravel)	very high	good	moderate	high	very high
E-5 (sand)	**very high**	**good**	**moderate**	**high**	**very high**
E-6 (silt)	very high	good	low	moderate	very high
F-4 (gravel)	**extreme**	**poor**	**very high**	**very high**	**moderate**
F-5 (sand)	very high	poor	very high	very high	moderate
F-6 (silt)	very high	fair	high	very high	moderate
G-4 (gravel)	extreme	very poor	very high	very high	high
G-5 (sand)	extreme	very poor	very high	very high	high
G-6 (silt)	very high	poor	high	high	high

[1] Stream types condensed to those evident on Purgatory Creek; prevelant types are in bold.
[2] Includes increases in streamflow magnitude and timing and/or sediment increases.
[3] Assumes natural recovery once cause of instability is corrected.
[4] Includes suspended and bedload sediment from channel sources and from adjacent to stream.
[5] Vegetation that influences width/depth ratio stability.

Table PC3 Purgatory Creek – Physical Classification Summary

Classification Parameter	Reference Reach															
	P-1		P-2		P-3		P-4		P-5		P-6		P-7		P-8	
	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003
Entrenchment Ratio[1]	4 Slight	3 Slight	16 Slight	17 Slight	2 Moder-ate	1 Severe	10 Slight	16 Slight	7 Slight	6 Slight	8 Slight	1 Severe	4 Slight	3 Slight	15 slight	5 Slight
Width/Depth[2]	11 Low	14 Moder-ate	8 Low	9 Low	8 Low	11 Low	11 Low	8 Low	9 Low	8 Low	10 Low	23 Moder-ate	10 Low	10 Low	3 Very low	4 Very Low
Sinuosity[3]	2.7 Very high	1.7 High	2.5 Very high	3.1 Very High	1.0 Very low	1.0 Very Low	1.7 High	1.6 High	1.6 High	1.7 High	1.2 Moder-ate	1.3 Moder-ate	1.5 High	1.5 High	1.1 Low	1.1 Low
Slope[4]	0.003 Low	0.003 Low	0.0005 Low	0.0009 Low	0.0002 Low	0.001 Low	0.002 Low	0.0015 Low	0.0006 Low	0.0005 Low	0.0018 Low	0.0036 Low	0.020 Moder-ate	0.012 Moder-ate	0.0034 Low	0.009 Low
Bed Material	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Gravel	Sand	Gravel	Sand	Sand
Rosgen Classification	C-5	C-5	E-5	E-5	B-5	B-5	E-5	E-5	E-5	E-5	C-5	F-4	C-5	C-4	E-5	E-5

[1] Entrenchment Ratio = Floodprone Width/Bankfull Channel Width
[2] Width/Depth = Bankfull Channel Width/Average Bankfull Channel Depth
[3] Sinuosity = Channel Length/Valley Length
[4] Slope = Change in Water Surface Elevation/Channel Length

Table PC4 Purgatory Creek – Physical Classification Parameters

Classification Parameter	Reference Reach															
	P-1		P-2		P-3		P-4		P-5		P-6		P-7		P-8	
	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003
Bankfull Width (ft)	18	19	19	18	19	20	16	12	14	15	13	18	10	11	4	4
Bankfull Area (s.f.)	29	28	44	35	48	37	22	16	21	27	17	14	10	12	6	4.3
Bankfull Depth (ft)	1.6	1.4	2.3	1.9	2.5	1.9	1.4	1.4	1.5	1.8	1.3	0.8	1.0	1.1	1.4	1.0
Max Depth (ft) @ x-sec	2.1	2.3	3.9	2.9	3.0	2.5	4.0	1.8	2.2	2.4	2.9	1.1	1.5	1.8	2.0	1.3
Floodprone Width (ft)	70	61	300	300	32	27	160	180	100	95	100	21	35	27	60	20
Entrenchment Ratio	4	3	16	17	2	1.4	10	16	7	6	8	1.2	4	3	15	5
Width/Depth	11	14	8	9	8	11	11	8	9	8	10	23	10	10	3	4
Meander Length (ft)	75	75	120	150	100	175	160	130	90	90	140	120	70	70	50	50
Belt Width (ft)	80	80	60	100	20	20	80	80	70	70	50	60	35	35	20	20
Meander Width Ratio	4.4	4.2	3.2	5.6	1.1	1.0	5.0	6.7	5.0	4.7	3.8	3.3	3.5	3.2	5.0	5.0
Sinuosity	2.7	1.7	2.5	3.1	1.0	1.0	1.7	1.6	1.6	1.7	1.2	1.3	1.5	1.5	1.1	1.1
Avg. Slope	0.003	0.003	0.0005	0.0009	0.0002	0.001	0.002	0.0015	0.0006	0.0005	0.0018	0.0036	0.020	0.012	0.0034	0.009
Bed Material	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Gravel	Sand	Gravel	Sand	Sand
Rosgen Classification	C-5	C-5	E-5	E-5	B-5	B-5	E-5	E-5	E-5	E-5	C-5	F-4	C-5	C-4	E-5	E-5

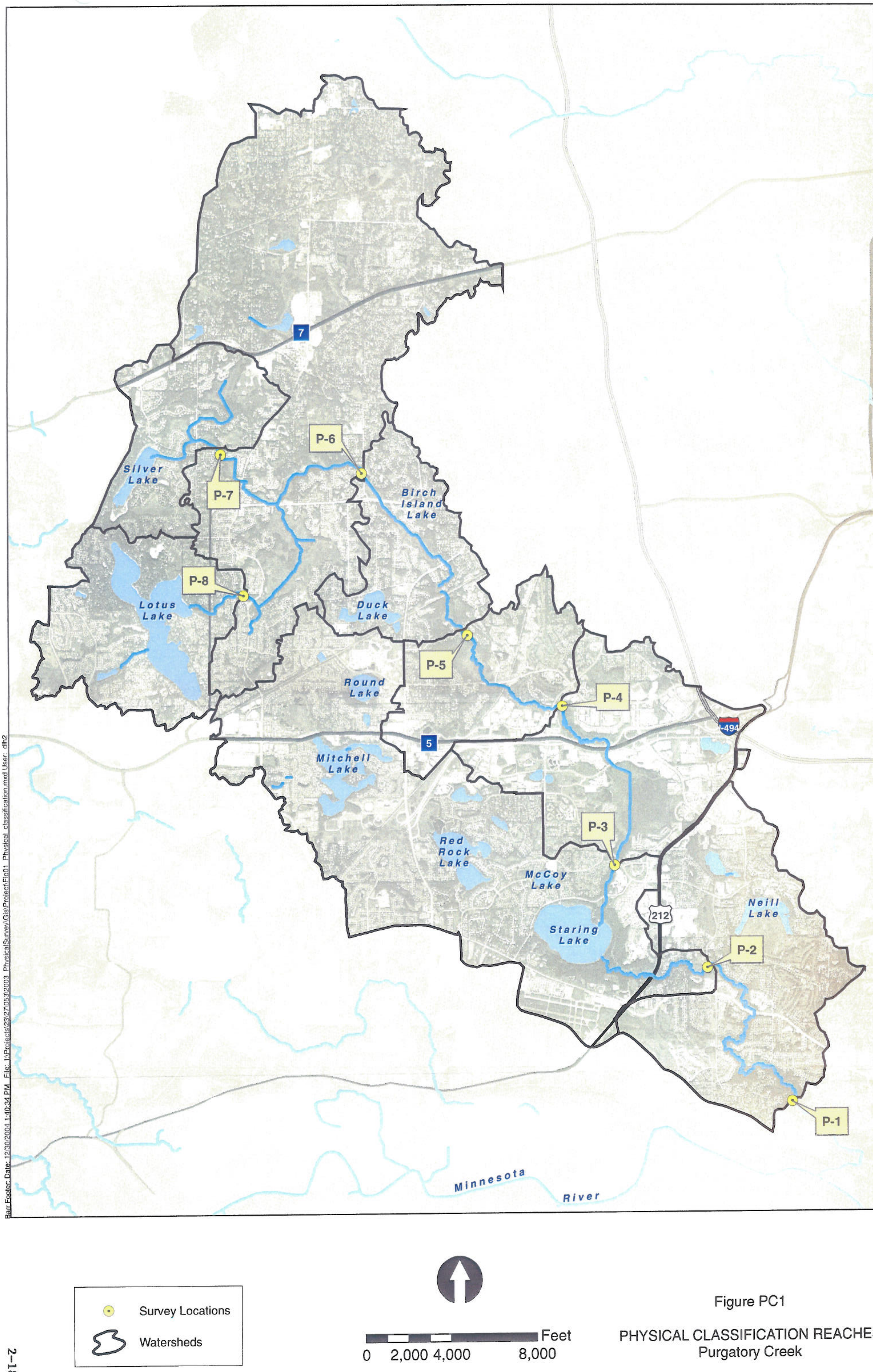


Figure PC1

PHYSICAL CLASSIFICATION REACHES
Purgatory Creek

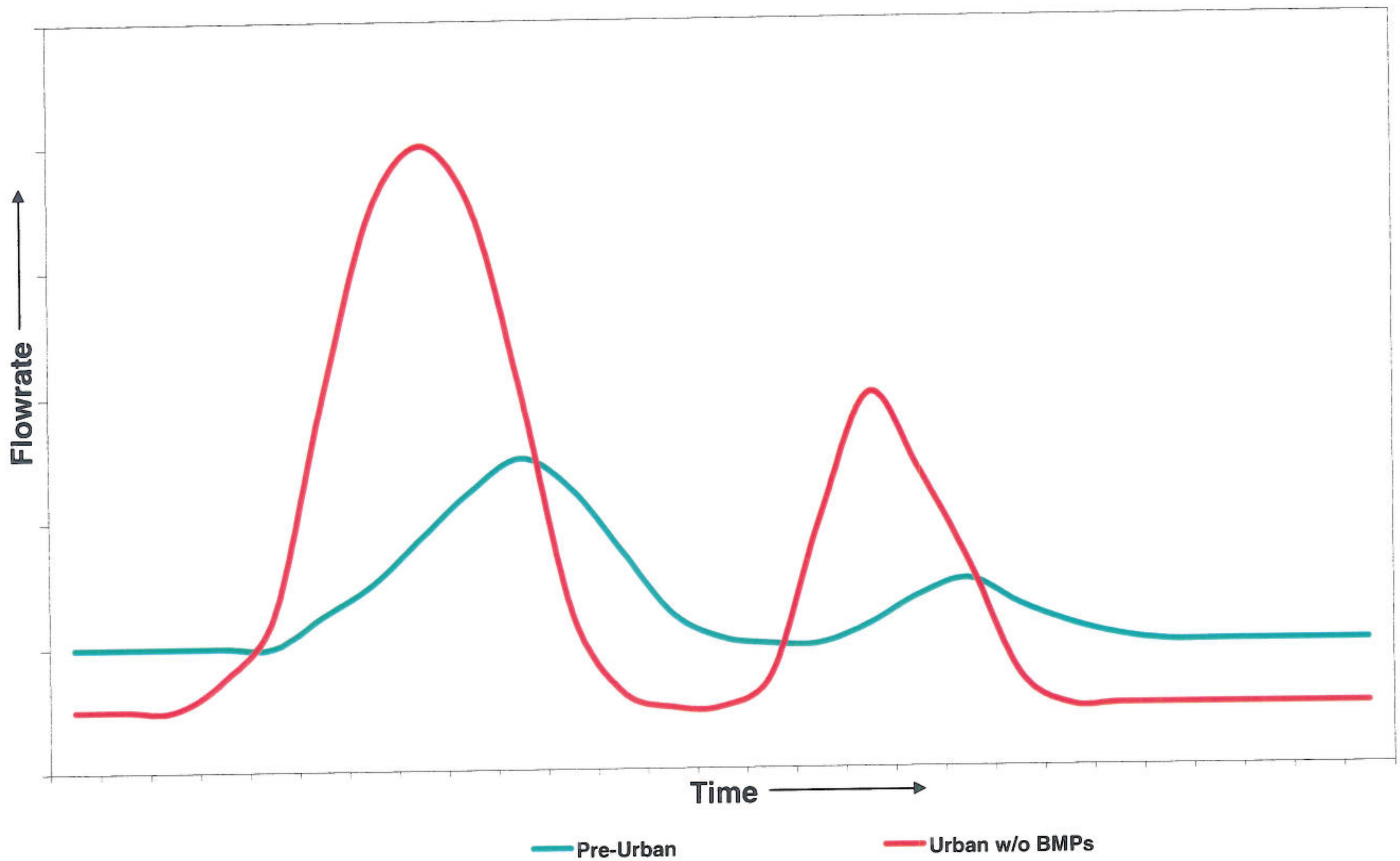


Figure PC2. Change in Streamflow Due to Urbanization

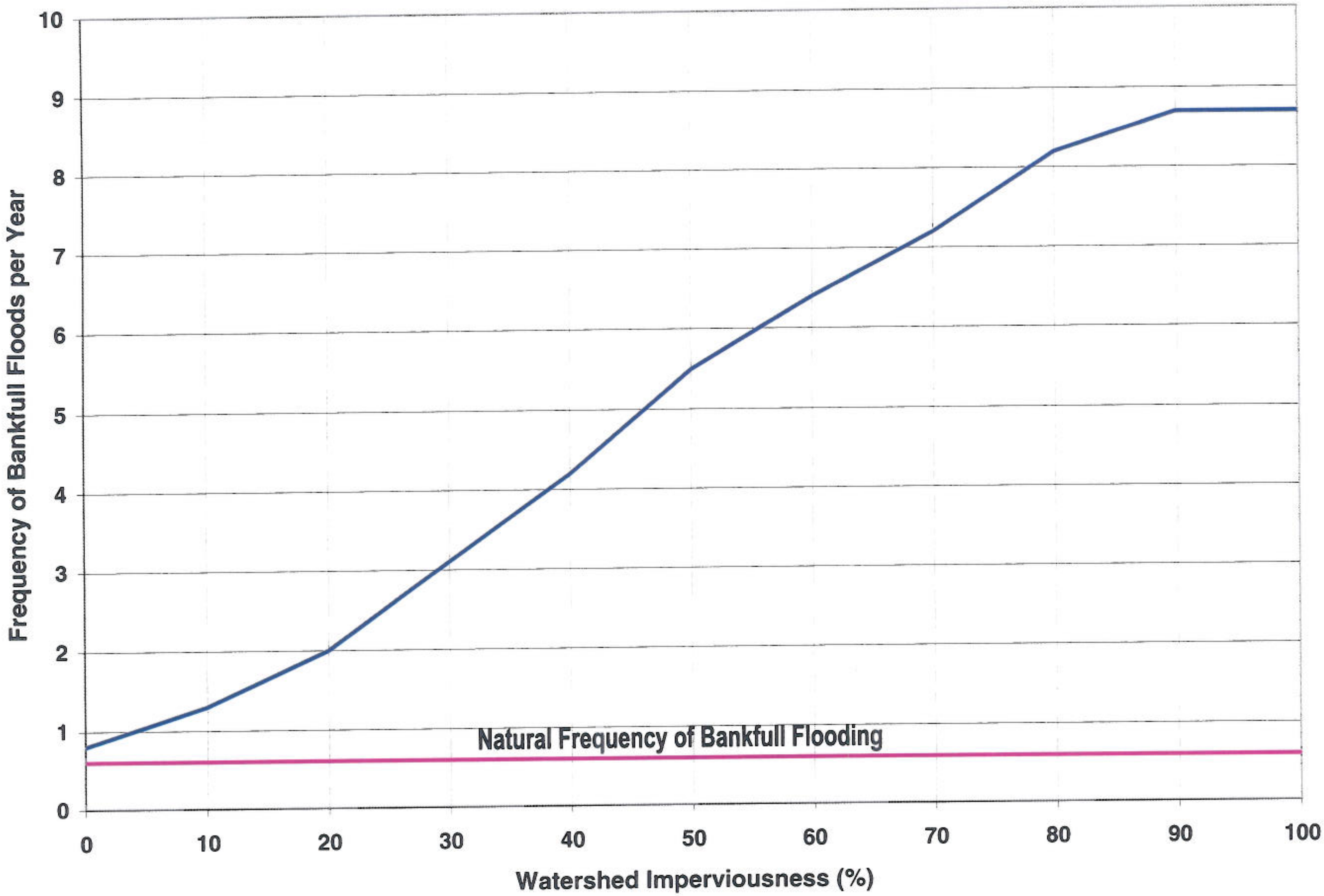


Figure PC3. Frequency of Bankfull Flooding as a Function of Imperviousness

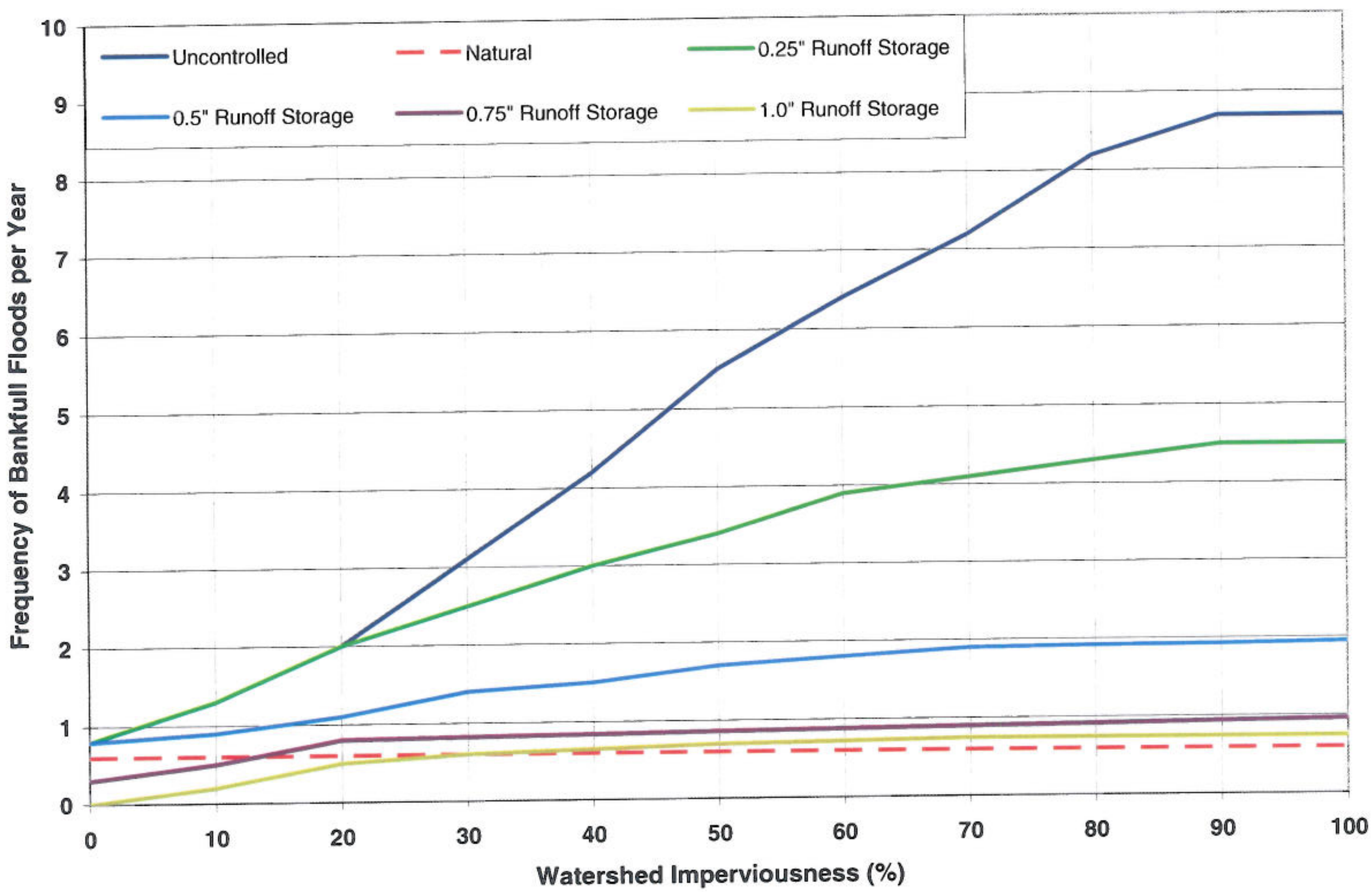


Figure PC4. Effect of Extended Detention on Post-Development Bankfull Flooding Frequency

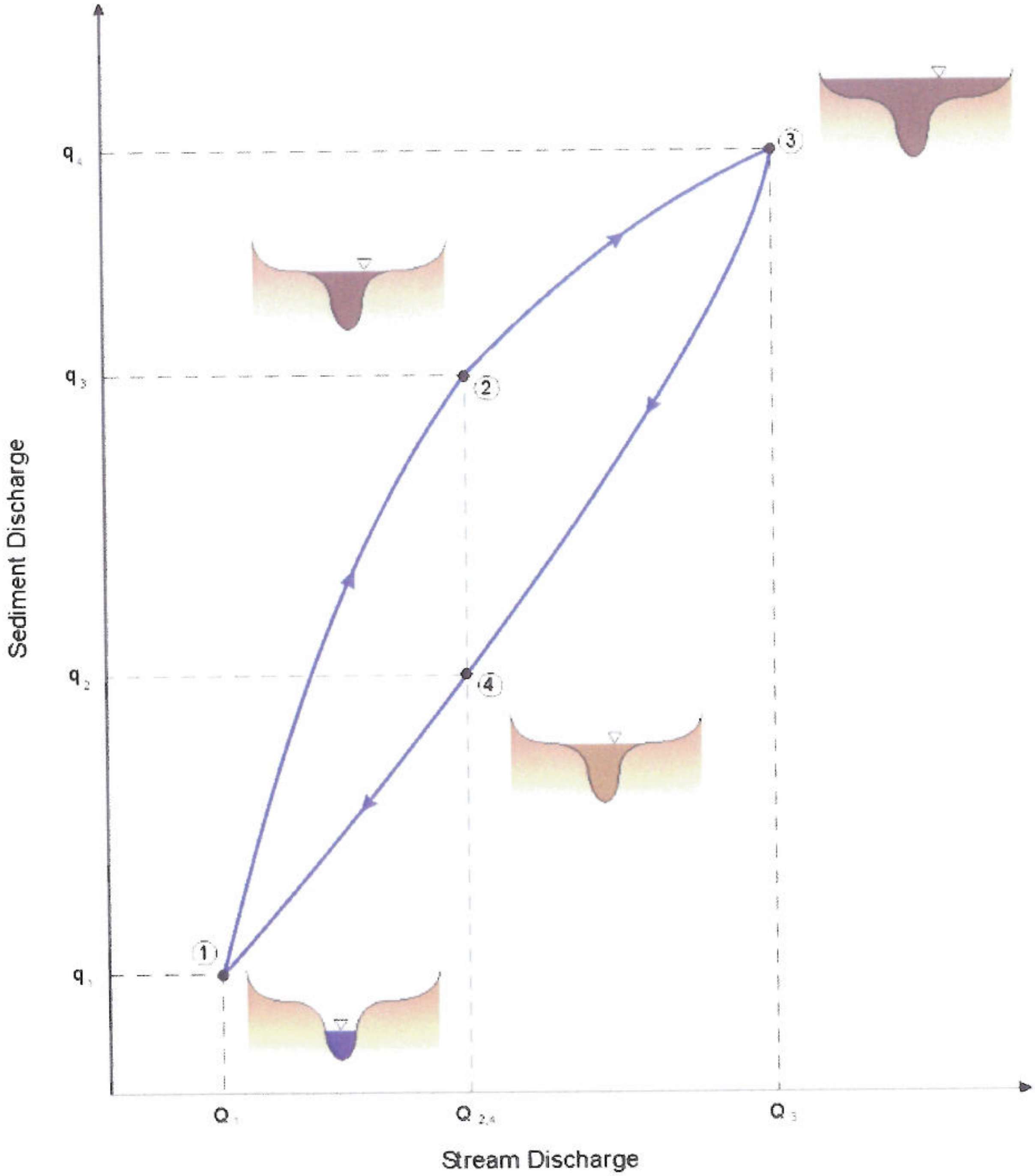


Figure PC5. Suspended Sediment Discharge for a Single Storm (from Dunn and Leopold)

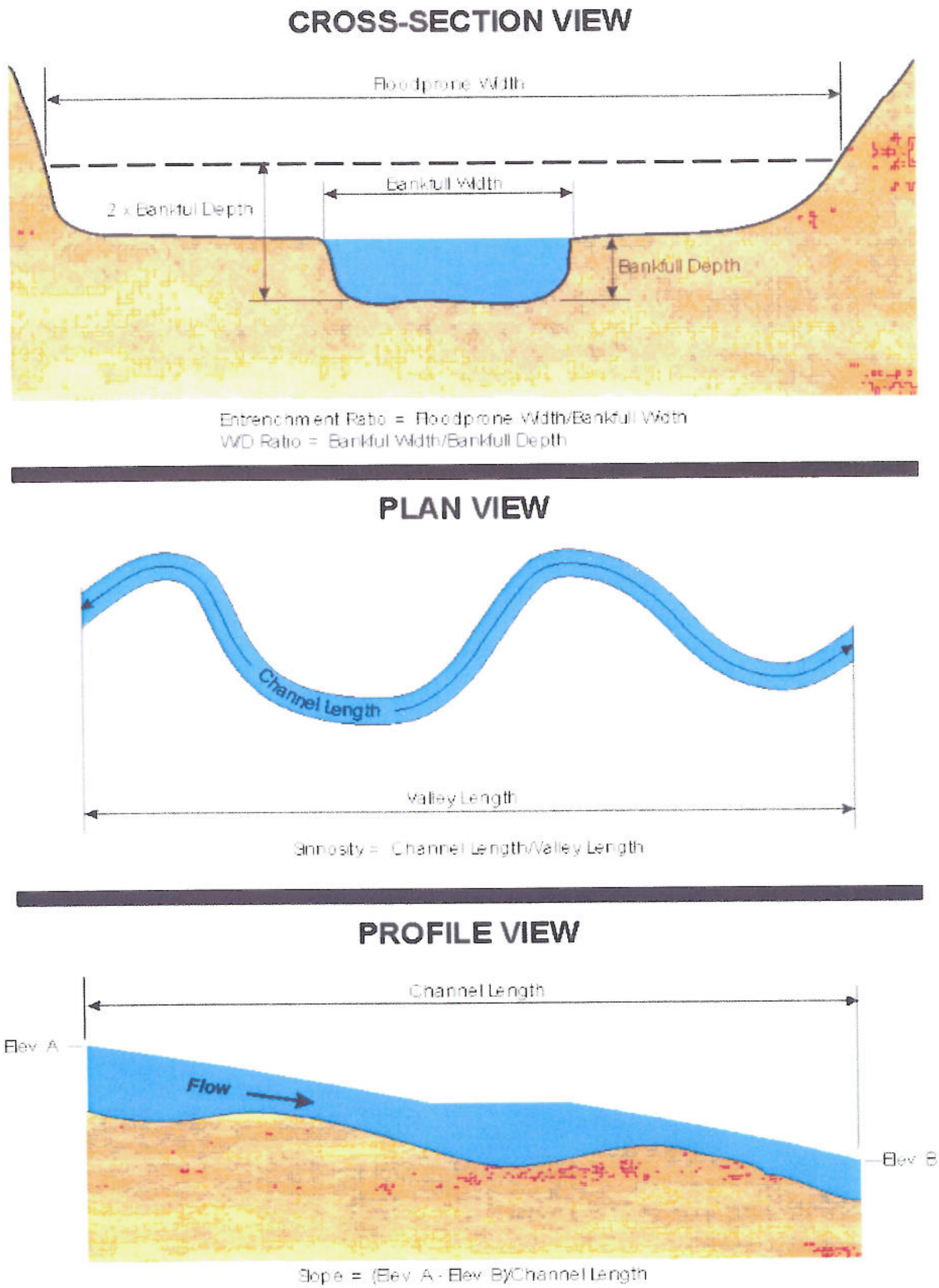


Figure PC6. Channel Parameters Defined

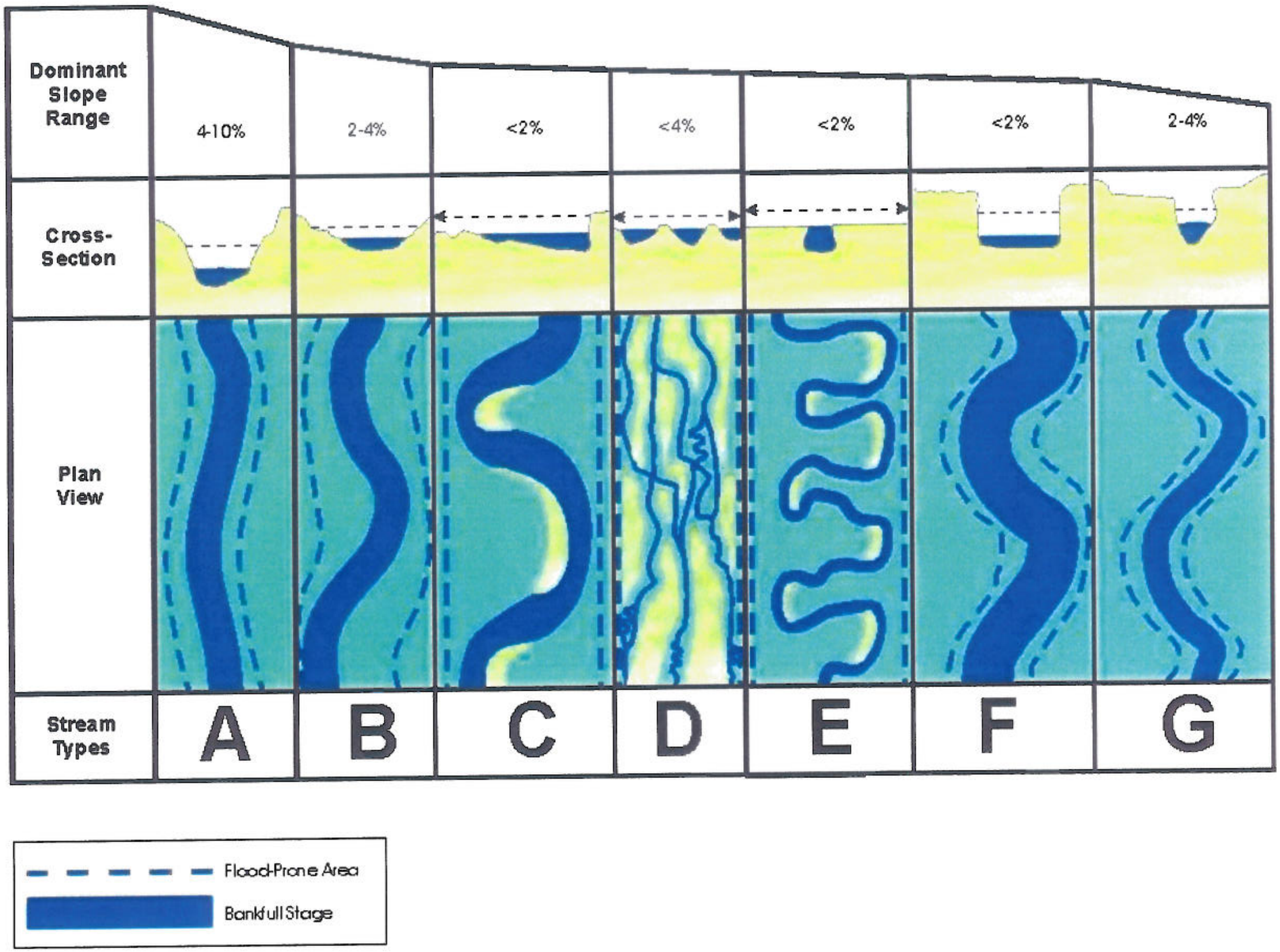


Figure PC7. Delineation of Major Stream Types (from Rosgen)

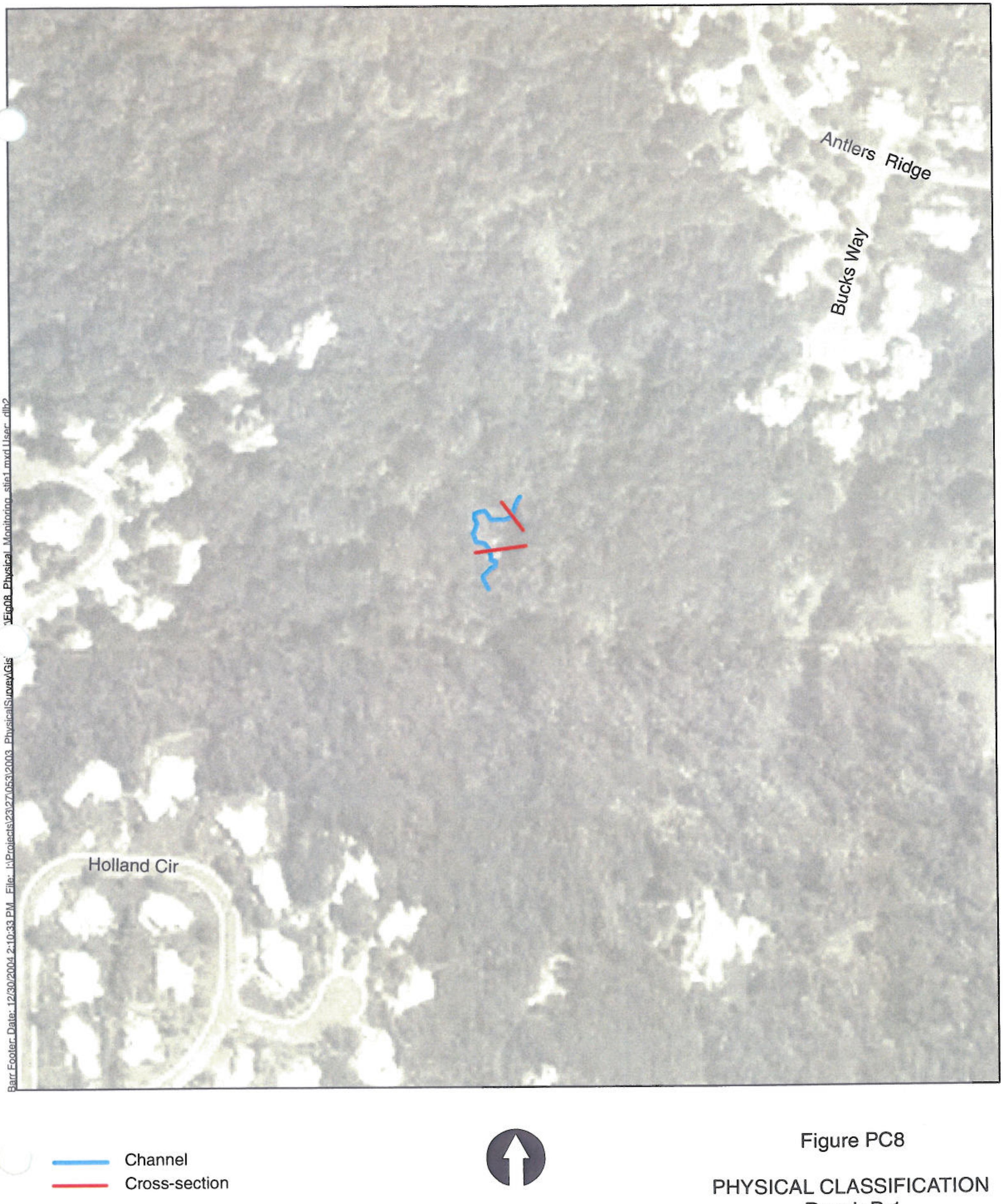


Figure PC8

PHYSICAL CLASSIFICATION
Reach P-1
Purgatory Creek

Figure PC9 - Reach P-1 Reed Canary Grass

Figure PC10 - Reach P-1 Gravel Bar

Channel
Cross-section

0 100 200 400 Feet

Figure PC11

PHYSICAL CLASSIFICATION
Reach PC-2
Purgatory Creek

Figure PC12 - Reach P-2 Bend

Figure PC13 - Reach P-2 Bank Erosion

Channel
Cross-section

0 100 200 400 Feet

Figure PC14

PHYSICAL CLASSIFICATION
Reach P-3
Purgatory Creek

Figure PC15 - Reach P-3 Looking Downstream

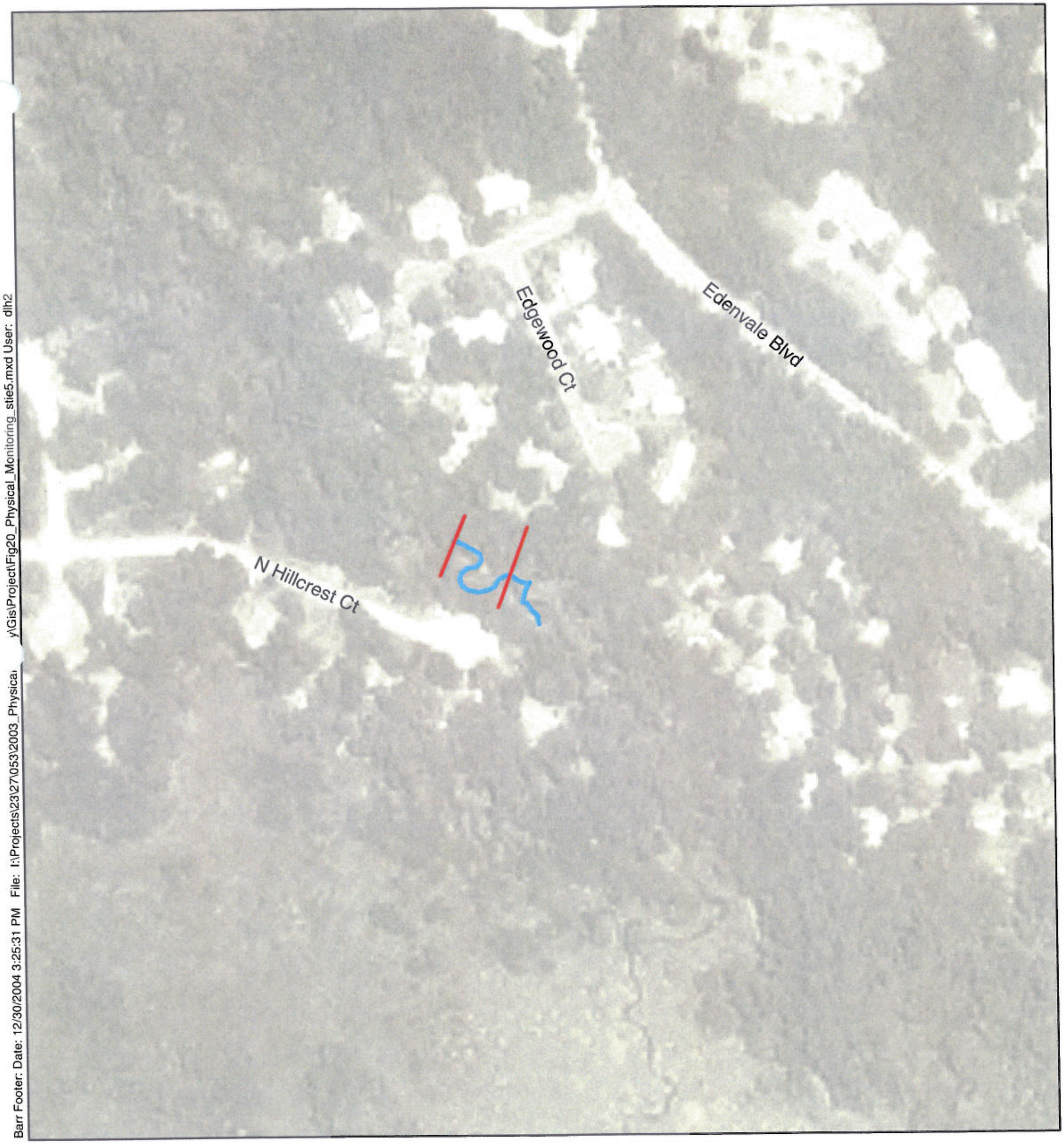
Figure PC16 – Reach P-3 Bank Erosion

Figure PC17

PHYSICAL CLASSIFICATION
Reach P-4
Purgatory Creek

Figure PC18 - Reach P-4 Narrow, Deep Channel

Figure PC19 - Reach P-4 Shaded Area



Channel
Cross-section

0 100 200 400 Feet

Figure PC20

PHYSICAL CLASSIFICATION
Reach P-5
Purgatory Creek

Figure PC21 - Reach P-5

Figure PC22 - Reach P-5 Riprap Weir Below Pedestrian Bridge

Figure PC23

PHYSICAL CLASSIFICATION
Reach P-6
Purgatory Creek

Figure PC24 - Reach P-6 Fieldstone at Old Bridge Site

Figure PC25 – Reach P-6 Erosion at Turf Yard

Figure PC26

PHYSICAL CLASSIFICATION
Reach P-7
Purgatory Creek

Figure PC27 - Reach P-7 Channel Bed

Figure PC28 - Reach P-7, Significant Downcutting at Pipe Inlet

Channel
Cross-section

0 100 200 400 Feet

Figure PC29

PHYSICAL CLASSIFICATION
Reach P-8
Purgatory Creek

Figure PC30 - Reach P-8 Narrow Channel

Figure PC31 - Reach P-8

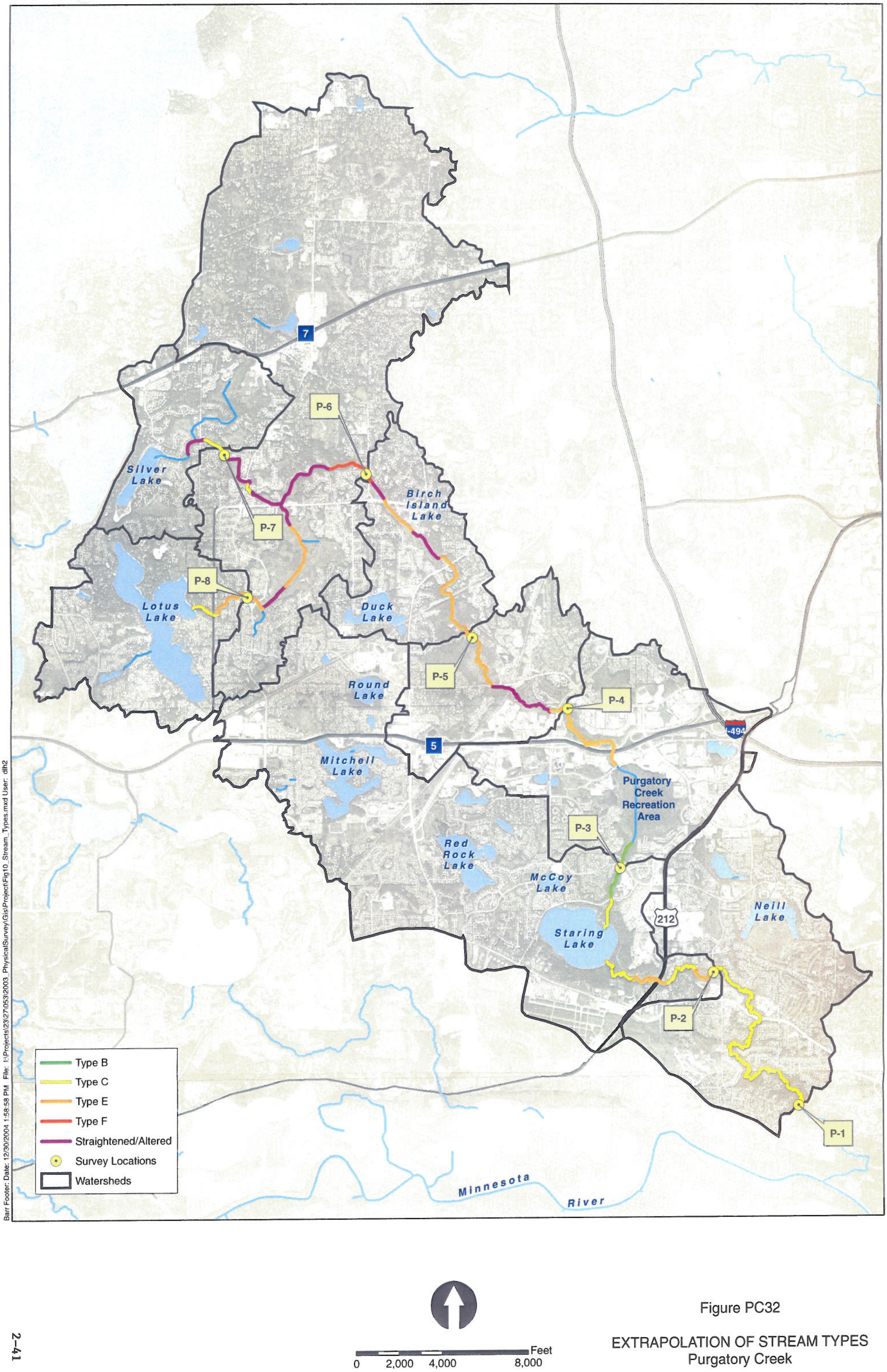


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Figure PC32

EXTRAPOLATION OF STREAM TYPES
Purgatory Creek

3.0 Attainable Ecological Use Classification

3.1 Introduction

An attainable ecological use classification of a stream classifies a stream based upon the average fish and aquatic life community that can reside in the stream. The classification is based upon the habitat (watershed, banks, bed, water volume), flow, water quality, and the average fish and aquatic life community residing in the stream currently and during the historical period of record. The purpose of the classification is to determine management goals and practices for the stream. The attainable ecological use classification determines the best average fish and aquatic life community that can be supported by a stream. Once a stream has been classified, its management goals focus on the protection or attainment of this community by maintaining or attaining the habitat, flow, and water quality conditions required for the support of this community.

Purgatory Creek was first classified as to attainable ecological use during 1996 (Barr, 1996). The classification was based upon historical flow and water quality data collected during 1972 through 1994 and a habitat survey completed during 1995. Following its classification, flow, water quality, and biological data collected during 1997 through 2002 were evaluated annually to determine whether the stream consistently attained its attainable ecological use (Barr, 1998, 1999, 2000, 2001, 2002, and 2003). During 2003, the stream's habitat, flow, water quality, and biological community were evaluated. In this report, 2003 habitat data, 1996 through 2003 flow and water quality data, and 1997 through 2003 biological data are used to classify the stream as to attainable ecological use. The 2003 classification is then compared with the 1996 classification to determine changes that have occurred and the reasons for these changes.

Stream management not only involves protection of the stream's fish and aquatic life community, but also meeting criteria established by regulatory agencies. A second stream classification focuses on stream attributes inherent to compliance with Federal criteria found in the Clean Water Act. The fish and aquatic life use classification determines the best fish and aquatic life species found in a stream. The best species found in a stream may differ from the best average stream community. While the majority of species supported by a stream may be tolerant to suboptimal conditions, a few species may require optimal conditions for survival. The presence of sensitive species in a stream indicates the stream has the habitat, flow, and water quality conditions required for their survival.

A fish and aquatic life use classification evaluates the current and historical biological community to determine the attributes of the best species supported by a stream. The evaluation includes the following attributes of a stream's fish and aquatic life community: (1) the presence of 2 or more gamefish; (2) the percent of fish and invertebrates requiring high levels of dissolved oxygen; (3) the percent of fish intolerant of pollutants; and (4) the percent of coolwater fish living in the stream. This evaluation determines whether the fish and aquatic life community contains species that are sensitive or whether the community contains only species that are tolerant or very tolerant to suboptimal conditions. A classification of sensitive indicates the stream meets Federal criteria while a classification of tolerant or very tolerant indicates the stream does not meet Federal criteria.

In 2003, Purgatory Creek was classified as to its fish and aquatic life use classification. The classification results were then used to determine the stream's compliance with Federal criteria. The results of the fish and aquatic life use classification (the best species) were compared with the ecological use classification (the average community).

3.1.1 Report Contents

This report begins with an evaluation of impervious cover in the Purgatory Creek watershed. The evaluation includes a discussion of the relationship between impervious cover and ecosystem impairment. The classification of Purgatory Creek's attainable ecological use from 2003 habitat data, 1996 through 2003 flow and water quality data, and 1997 through 2003 biological data is presented. The results of the stream's current classification are then compared with the results of its 1996 classification. The classification of Purgatory Creek's fish and aquatic life use from 1997 through 2003 biological data is presented. The best attainable average biological community (attainable ecological use) is compared with the best species found in the biological community (fish and aquatic life use).

3.2 Watershed Impervious Cover

The precise relationships between land-use conversion and ecological responses are difficult to establish because: (1) the types of land use, rates of conversion, and spatial distribution of land use vary considerably among watersheds and regions and across political boundaries, (2) changes in land use can drive channel morphology and hydrology into a state of flux that may take many decades to stabilize, (3) ecological responses may lag behind physical habitat modifications (for example, see Harding, et al, 1998) and we do not always know the duration of such lag effects, and (4) management actions have been introduced to mediate the effects of development on streams, yet we know little about their effectiveness. Thus, understanding and predicting the effects of land-use change on stream and river ecosystems are difficult scientific problems and major challenges for contemporary ecology (Strayer et al., 2003).

In 1994, the Center for Watershed Protection published "The Importance of Imperviousness," which outlined the scientific evidence for the relationship between impervious cover and stream quality (Schueler, 1994a). The Impervious Cover Model (ICM) was developed out of research studies that documented a reasonably strong relationship between watershed impervious cover and various indicators of stream quality. The research findings were subsequently integrated into the ICM (Schueler, 1994a and CWP, 2003). The ICM has also proven to be an extremely important tool for watershed planning, since it can rapidly project how streams will change in response to future land use. The ICM provides a framework for understanding and predicting stream quality changes in 1st through 4th order streams based upon watershed percent imperviousness. Figure EUC1 presents a graphical representation of the ICM. Streams in watersheds having less than 10 percent impervious cover can maintain good quality and include predominantly sensitive species in the aquatic assemblage. As impervious cover increases to 25 percent, the model predicts that sensitive species are lost – to be replaced by tolerant species. These streams generally are changing in ecological quality with the stream classification changing from Class C (intolerant forage fishery) to Class D (tolerant forage fishery). As impervious cover increases further, up to 60 percent or more, they become non-supporting (Class E, very tolerant macroinvertebrates or no aquatic life). Above 60 percent watershed impervious cover, they have become urban drainage systems with no ecological use remaining.

Recent urban stream research has greatly improved our understanding of urban streams and the watershed factors that influence them. A negative relationship between watershed development and stream quality indicators has been established over many regions and scientific disciplines. A second important pattern that has emerged from the research is that variability in forest cover is also a useful predictor of stream quality in urban watersheds, at least for humid regions of North America. In some regions, forest cover is simply the reciprocal of impervious cover (CWP, 2003). The forest cover of Purgatory Creek is discussed in Section 1.0 Purgatory Creek Riparian Corridor Plant Community Inventory and Bird Habitat Evaluation.

Most researchers have relied on total impervious cover as the basic unit to measure impervious cover at the subwatershed level. The case has repeatedly been made that effective impervious cover is probably a superior metric (e.g., only counting IC that is hydraulically connected to the drainage system). Notwithstanding, most researchers have continued to measure total impervious cover

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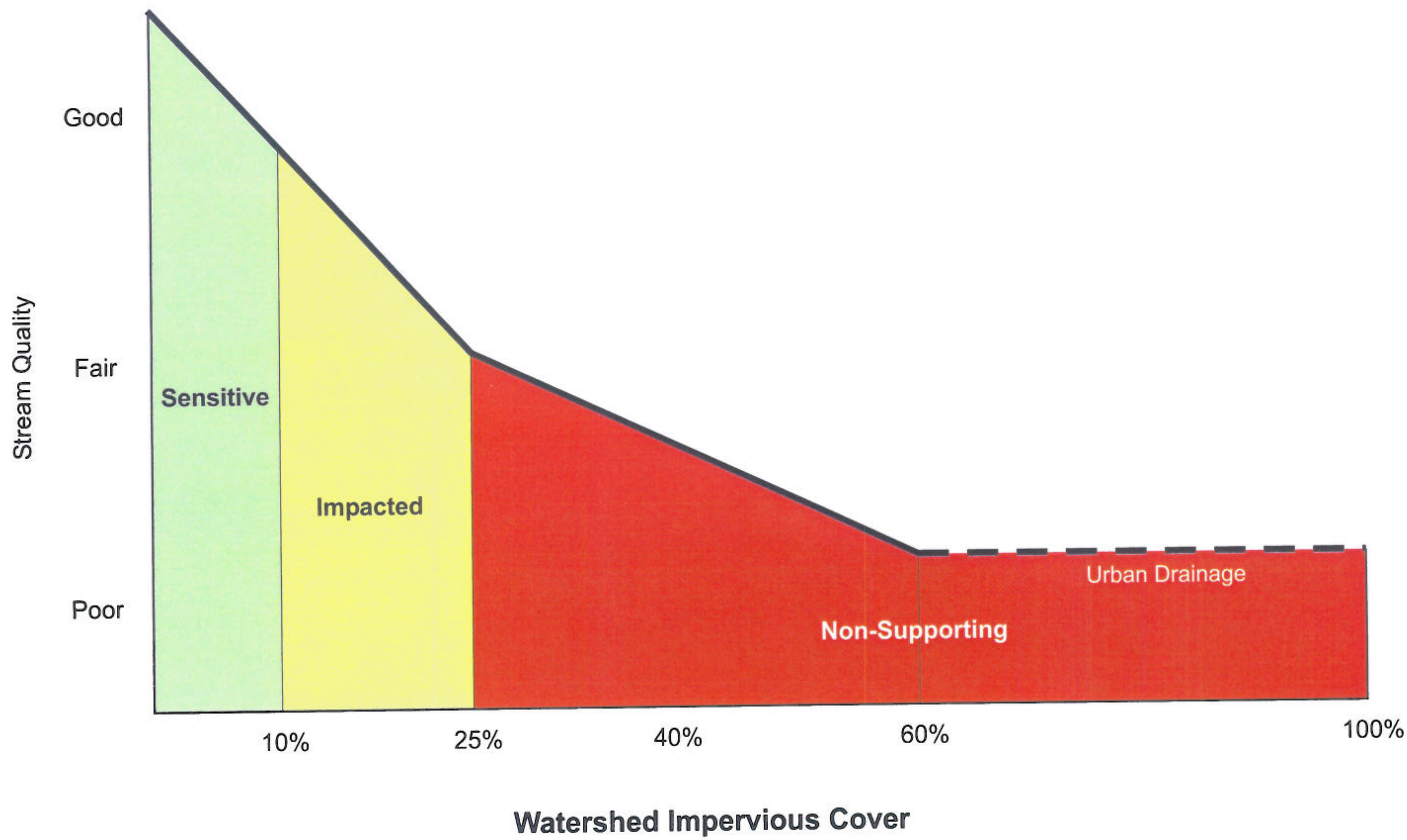


SOURCE: Center for Watershed Protection, 2003

Figure EUC 1

WATERSHED IMPERVIOUS COVER MODEL

because it is generally quicker and does not require extensive (and often subjective) engineering judgment as to whether it is connected or not. Researchers have used a wide variety of techniques to estimate subwatershed IC, including satellite imagery, analysis of aerial photographs, and derivation from GIS land use layers. Table EUC1 presents some standard land use/IC relationships that were developed for the Purgatory Creek Watershed.

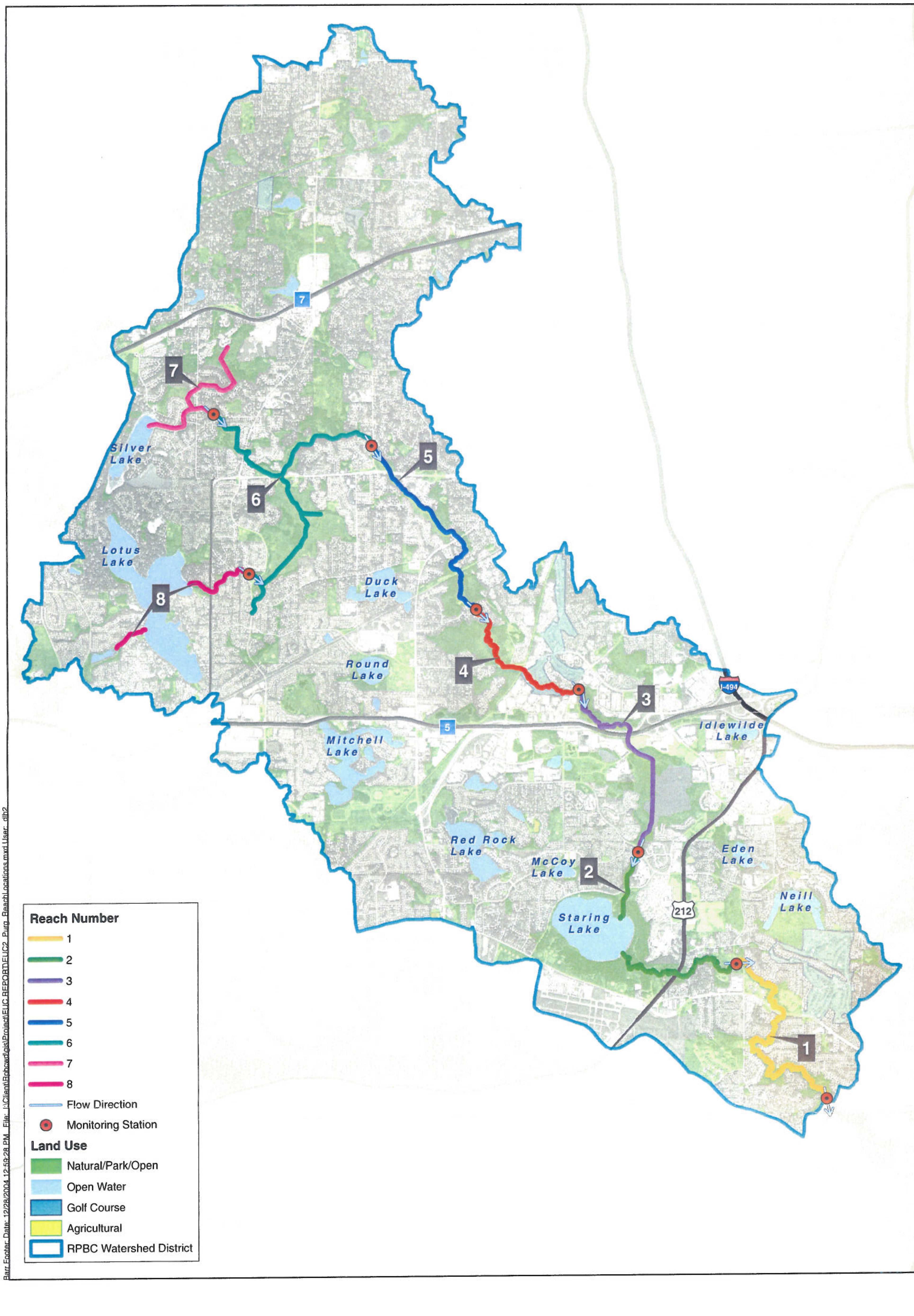
Table EUC1 Direct, Indirect, and Total Impervious Surface Based on Land Use

Land Use	Percent Direct Impervious	Percent Indirect Impervious	Percent Total Impervious
Natural/Park/Open	5%	5%	10%
Golf Course	2%	3%	5%
Agricultural	0%	5%	5%
Very Low Density Residential	8%	4%	12%
Low Density Residential	16%	9%	25%
Medium Density Residential	30%	8%	38%
High Density Residential	65%	10%	75%
Institutional	35%	5%	40%
Institutional - High Imperviousness	50%	20%	70%
Airport	80%	5%	85%
Industrial/Office	70%	2%	72%
Commercial	80%	5%	85%
Highway	45%	20%	65%
Open Water	0%	0%	0%
Wetland	0%	0%	0%
Other	0%	2%	2%
Developed Park	0%	10%	10%

3.2.1 Impervious Cover Evaluation of Purgatory Creek Watershed

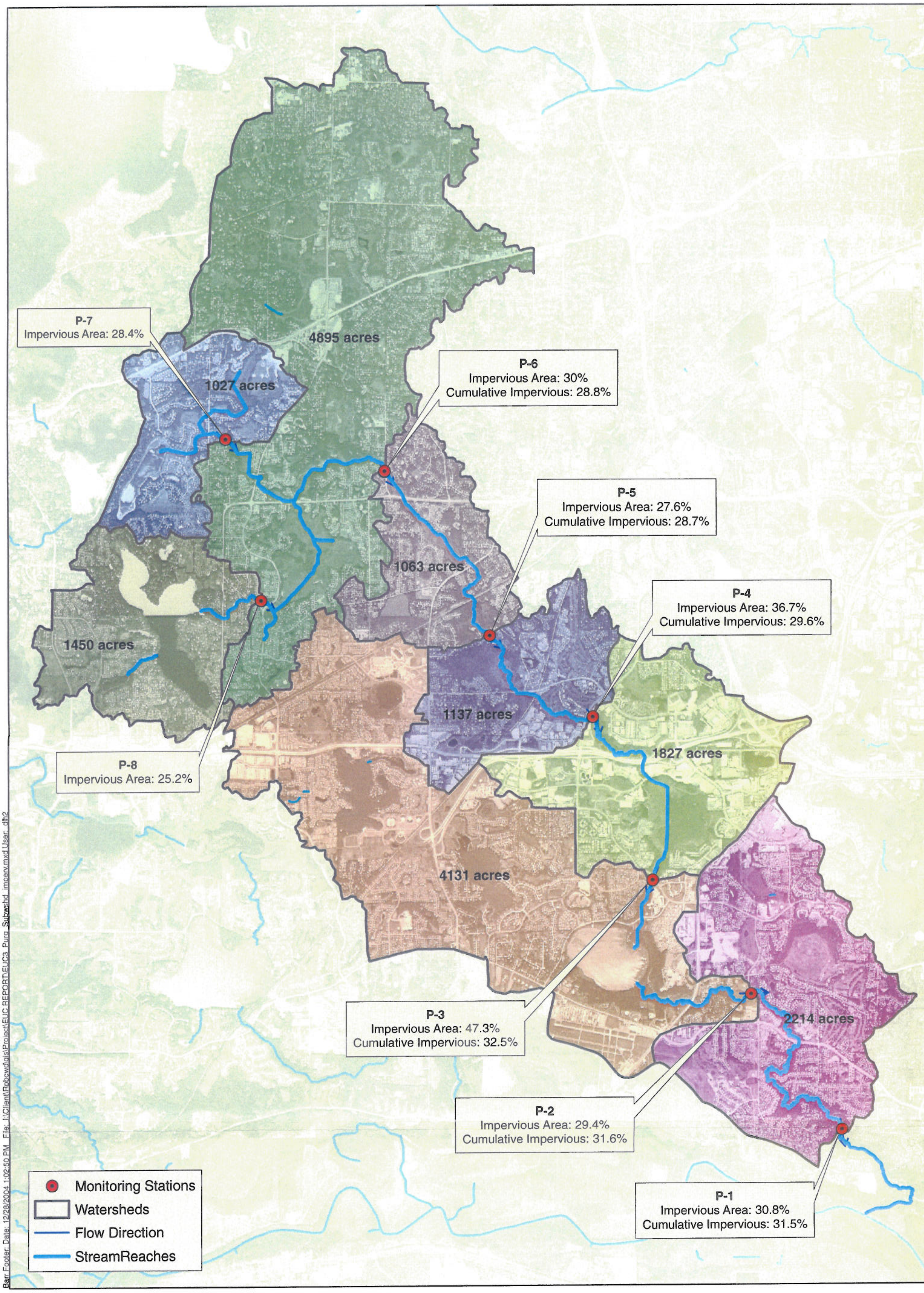
Purgatory Creek has a total watershed area of 17,744 acres (approximately 28 square miles).

The impervious cover of land areas tributary to Purgatory Creek was assessed using ArcGIS and Metropolitan Council land cover data. The stream's watershed was subdivided into subwatersheds corresponding to the stream reach locations shown in Figure EUC2. The land uses in each subwatershed were delineated from the Met Council land cover data, a percent impervious cover was applied to each land use, and the percent impervious cover was totaled for each watershed area. Percent impervious cover tributary to each stream reach is present in Table EUC2 and shown in Figure EUC3.



EUC2

Purgatory Creek
Ecological Use Classification
Reach Locations



0 2,000 4,000 8,000 Feet

EUC3

Purgatory Creek Subwatershed and Cumulative Imperviousness

Table EUC2 Percent Imperviousness for Subwatersheds and Cumulative Tributary Area

Stream Reach (listed from upstream down)	**Subwatershed Area** (in acres)	**Subwatershed Percent Impervious**	**Cumulative Tributary Area** (at downstream end; acres)	**Impervious Tributary Area**	**Cumulative Percent Impervious**
P-8	1,450	25%	1,450	365	25%
P-7	1,027	28%	1,027	292	28%
P-6	4,895	30%	7,372	2,126	29%
P-5	1,063	28%	8,435	2,419	29%
P-4	1,136	37%	9,572	2,836	30%
P-3	1,827	47%	11,399	3,700	33%
P-2	4,131	29%	15,530	4,913	32%
P-1	2,214	31%	17,744	5,596	32%

The percent imperviousness presented in Table EUC2 represents the percent of the contributing watershed area upstream from the stream reach that contributes to stormwater runoff volumes. The assessment of contributory watershed imperviousness for each of the stream reaches shows that watershed imperviousness of individual subwatersheds ranges from 25 percent to 47 percent in Purgatory Creek. Cumulative watershed imperviousness for reaches P1 through P8 ranges from 25 to 32 percent. The imperviousness for the contributory area to the entire creek is 32 percent. All of the stream reaches have watershed IC above the 25 percent threshold that predicts degraded stream conditions and non-supporting stream quality (CWP, 2003). Hence, the ICM predicts a stream classification of Class D for Purgatory Creek.

3.3 Attainable Ecological Use Classification of Purgatory Creek

Many factors affect a stream's capacity to attain a specific fish and aquatic life use. Some are natural and are a function of the watershed system in which the stream is embedded. Some are cultural and are a function of how people use the watershed lands and the stream. These natural and cultural factors affect use attainment by influencing the stream's water volume, habitat structure, or water quality. Uncontrollable factors, whether they are natural or cultural, ultimately determine attainable fish and aquatic life uses. Controllable factors and their impacts on surface waters are considered temporary, pending implementation of control measures. Natural factors and some cultural factors are considered uncontrollable because they cannot or are unlikely to be changed. Control is not reasonable due to lack of technology, cost, or social interest. Uncontrollable cultural factors may be due to activities over which regulatory agencies and the District have little or no control. In some cases these cultural factors and impacts may have, for all practical purposes, become irreversible stream characteristics due to cultural, social, or other institutional reasons. Uncontrollable natural and cultural factors include:

- **Uncontrollable Natural Factors**—depth, flow, gradient, volume, climate, wetlands, habitat structure, background water quality
- **Uncontrollable Cultural Factors**—temperature, land use (under good management), legally authorized hydrologic modifications (approved maintenance dredging and drainage projects, existing dams)

Ecological use classification is a scientific method for designating uses according to a stream's natural ability to support a certain average biological community. The objective of the classification system is to provide a basis for making and supporting water quality management decisions. The need for classifying surface waters is based upon the recognition that all surface waters will not support the same fish and aquatic life community (ecological use), and that different fish and aquatic life communities may require different levels of water quality to survive. The classification system assumes: (1) stream systems with similar habitat, flow, and water quality characteristics will support similar fish and aquatic life communities that can be described as a use class; and (2) if streams within a use class are managed in a similar way, they will support a similar use. Hence, all trout streams will be managed similarly, but a trout stream will be managed differently from a bass stream.

The ecological use classification of Purgatory Creek was based upon an evaluation of its ecosystem. The Purgatory Creek ecosystem is comprised of habitat (watershed, banks, bed, water volume), flow, water quality, fish, and aquatic life communities (e.g., macroinvertebrates such as crayfish and aquatic insects). The fish and aquatic life communities found in the stream are dependent upon the overall quality of its ecosystem components. The poorest ecosystem component generally controls the type of fish community and other aquatic life that can live in the stream. An ecosystem evaluation identifies each ecosystem component and determines the poorest component. The types of fish and other aquatic life that can live in the stream are then determined from the poorest component. This evaluation is called ecological use classification.

The classification of Purgatory Creek as to ecological use was based upon the division of stream fish and aquatic life communities into five categories:

A. Cold water fishery (e.g., trout)
B. Warm water sport fishery (e.g., bass and sunfishes)

C. Intolerant forage fishery (e.g., species, such as rosyface shiner, that are intolerant of environmental degradation)

D. Tolerant forage fishery (e.g., species, such as creek chub, which can tolerate a wide range of environmental degradation)

E. Very tolerant macroinvertebrates or no aquatic life

The attainable ecological use classification of Purgatory Creek determined which category of fish and aquatic life communities would be supported by the stream's habitat, flow, and water quality. A stream's attainable ecological use is its highest achievable use.

A use attainability analysis of Purgatory Creek was completed to determine the stream's attainable ecological use. The analysis identified factors limiting the stream's ecological use and determined whether the stream could be managed in ways to improve its use. Hence, the analysis determined whether the causes of impacts limiting stream use may be eliminated through the implementation of management practices and whether the impacts are reversible.

The analysis began with a comparison of the potential and actual (biological community) uses of Purgatory Creek. When no differences occurred, the stream's attainable use was the same as its potential and actual uses. If the actual use was better than the potential use, the attainable use was determined from the actual use. However, whenever the potential use was better than the actual use, an evaluation occurred to determine the factors affecting the use and whether they are controllable or uncontrollable. If the factors limiting the stream's actual use were considered uncontrollable (i.e., not possible or not feasible to change by management practices), the attainable use was based on the stream's biological evaluation (i.e., historical use). However, if implementation of feasible stream management practices was likely to result in attainment of the potential use, the attainable use was based on the stream's potential use rather than the stream's biological evaluation.

The stream's management goals are defined by the life requirements (i.e., habitat, flow, and water quality) of the fish and aquatic life communities associated with the stream's attainable ecological use. If the stream has already attained these life requirements, then the stream management goal is protection of its existing habitat, flow, and water quality. If the stream has not attained one or more of these life requirements, needed changes in the constraining component or components is the stream management goal.

The attainable ecological use classification of Purgatory Creek included a sequential, stepwise determination of the following:

- **Potential ecological use**—The potential ecological use of Purgatory Creek is the maximum attainable use of the stream under existing habitat, flow, and water quality conditions. It is based on the stream's potential to support a given fish or macroinvertebrate use and is not based on the present state of the biological community.

- **Existing ecological use**—The existing ecological use of the stream is determined from an evaluation of the current fishery and represents the present state of the biological community.

- **Historical ecological use**—The historical ecological use is determined from an evaluation of historical fishery data to determine the long-term average ecological use.

- **Attainable ecological use**—The attainable ecological use is the highest use Purgatory Creek is expected to attain. Use determination involves a comparison between potential, existing, and historical ecological uses. When no differences occur, the attainable use is the same as the three uses. When the biological community is better than the potential use, the attainable use is determined from the biological community. When the potential use is better than the biological community, an evaluation is completed to determine the factors affecting the use and whether they are controllable or uncontrollable. The attainable use is based upon the biological community if the factors are uncontrollable. The attainable use is based upon the potential use if the factors are expected to change with the implementation of feasible stream management practices.

The attainable ecological use classification of Purgatory Creek was determined from habitat data collected during 2003, flow and water quality data collected during 1996 through 2003, and fisheries data collected during 1997 through 2003. A discussion of the sequential, stepwise classification process follows in Sections 3.3.1 (Potential Use), 3.3.2 (Existing Use), 3.3.3 (Historical Use), and 3.3.4 (Attainable Use).

3.3.1 Potential Ecological Use

The potential ecological use of Purgatory Creek is the maximum attainable use of the stream under existing habitat, flow, and water quality conditions. It is based on the stream's potential to support a given fish or macroinvertebrate use and is not based on the present state of the fish and aquatic life communities living within the stream.

Habitat, flow, and water quality are the uncontrollable stream factors that determine the potential uses of a stream and, consequently, determine its ecological use classification. For classification, the uncontrollable factors, whether they are natural or cultural, ultimately determine a stream's potential or attainable use. Uncontrollable factors are irreversible even with the application of "reasonable" management. For example, urbanization impacts are unlikely to be completely reversed with remedial measures, even though positive changes are expected to occur. Therefore, urbanization impacts are considered uncontrollable for the purposes of potential or attainable use classification. The uncontrollable cultural factors impose a new set of physical and chemical conditions on the stream that represent the current "natural" characteristics of a stream.

Although all factors are important, low flow conditions may restrict a stream's use despite good water quality and habitat conditions. Flow determines whether fish and aquatic life organisms have sufficient water to survive in a stream. Flow also determines the size of fish and other aquatic life organisms that may inhabit a stream. It is an obvious fact that large fish species require a higher level of flow than small fish species to survive in a stream. Without adequate flow, large fish would not have room to move, feed, or reproduce. Therefore, minimum stream flow is directly correlated to the classes of organisms, or uses, a stream can support.

Habitat quality and diversity determine the type of biological community (i.e., ecological use) a stream may support. Habitat is comprised of the physical structure (substrate, pools and riffles, water depth, erosion and deposition areas) and flow of water in a stream. The results of many studies show that more diverse habitats support more abundant and more diverse aquatic communities. Conversely, a stream with poor habitat structure will support fewer organisms, to the extent that the life support requirements of only very tolerant fish or insects may be met. Therefore, habitat structure analysis is a primary component in stream classification.

Water quality is also a primary component in stream classification. Water quality parameters important to biological communities include dissolved oxygen, temperature, pH, and the presence or absence of toxic substances. Water quality extremes are very important because deviations from water quality requirements, even for a short time, may stress aquatic communities beyond recovery. Minimum dissolved oxygen levels, maximum temperature, range of pH values (i.e., both minimum and maximum values), and the presence or absence of toxic substances at acute levels determine the organisms capable of living in a stream. Therefore, these values are used in potential stream use classification.

The Wisconsin Department of Natural Resources (WDNR) ecological use classification (Ball 1982) divides steams into the following use classes based upon flow, habitat, and water quality:

A. **Cold water fishery (e.g., trout):** Streams capable of supporting a cold water fishery, or serving as spawning area for salmonid species.

B. **Warm water sport fishery (e.g., bass and sunfishes):** Streams capable of supporting a warm water sport fishery or serving as a spawning area for warm water sport fish.

C. Intolerant forage fishery (e.g., species, such as rosyface shiner, that are intolerant of environmental degradation): Streams capable of supporting an abundant, and usually diverse, population of intolerant forage fish or intolerant macroinvertebrates. Intolerant species are those that are sensitive to many types of environmental stress and are absent in the presence of environmental degradation. These streams are generally too small to support cold or warm water sport fish, but have natural water quality and habitat sufficient to support forage fish or macroinvertebrates. Streams capable of supporting valuable populations of tolerant fish are included in Class C.

D. Tolerant forage fishery (e.g., species, such as creek chub, which can tolerate a wide range of environmental degradation): Streams capable of supporting only a small population of tolerant forage fish, very tolerant fish, or tolerant macroinvertebrates. Tolerant species are able to tolerate a wide range of environmental conditions and are often common in highly degraded environments. The aquatic community in such a stream is usually limited due to naturally poor water quality or habitat deficiencies.

E. Very tolerant macroinvertebrates or no aquatic life: Streams capable at best of supporting very tolerant macroinvertebrates, or an occasional very tolerant fish. Such streams are small and severely limited by water quality or habitat.

The WDNR determined requisite criteria for the support of each use class (see Table EUC3).

3.3.1.1 2003 Potential Ecological Use

Purgatory Creek data were compared with the criteria shown in Table EUC3 to determine the stream's potential ecological use classification. 2003 habitat data used in the classification are presented in Appendix 3A. Minimum flow, minimum dissolved oxygen, maximum temperature, and range of pH values from 1996 through 2003 and long-term averages used in the classification are presented in Appendix 3B. The 2003 potential ecological use classification of Purgatory Creek is presented in Table EUC4 and Figure EUC4.

Purgatory Creek's potential ecological use is consistent with the impervious cover of the stream's watershed. All of the stream reaches have watershed IC above 25 percent, which is the stream degradation threshold. Hence, the impervious cover model (ICM) predicts that Purgatory Creek exhibits degraded stream conditions and non-supporting stream quality (CWP, 2003). Most stream reaches noted a potential ecological use of Class D (P-1, P-2, P-4, P-5, P-6, and P-7) and the remaining stream reaches noted a potential ecological use of Class E (P-3 and P-8).

An evaluation of the parameters constraining the stream's ecological use indicates habitat was the primary constraining parameter. Minimum flow was a second constraining parameter for Station P-7, a stream reach with intermittent flow, located at the stream's headwaters.

Table EUC3 Physical and Chemical Guidelines for Determination of Ecological Use Classes

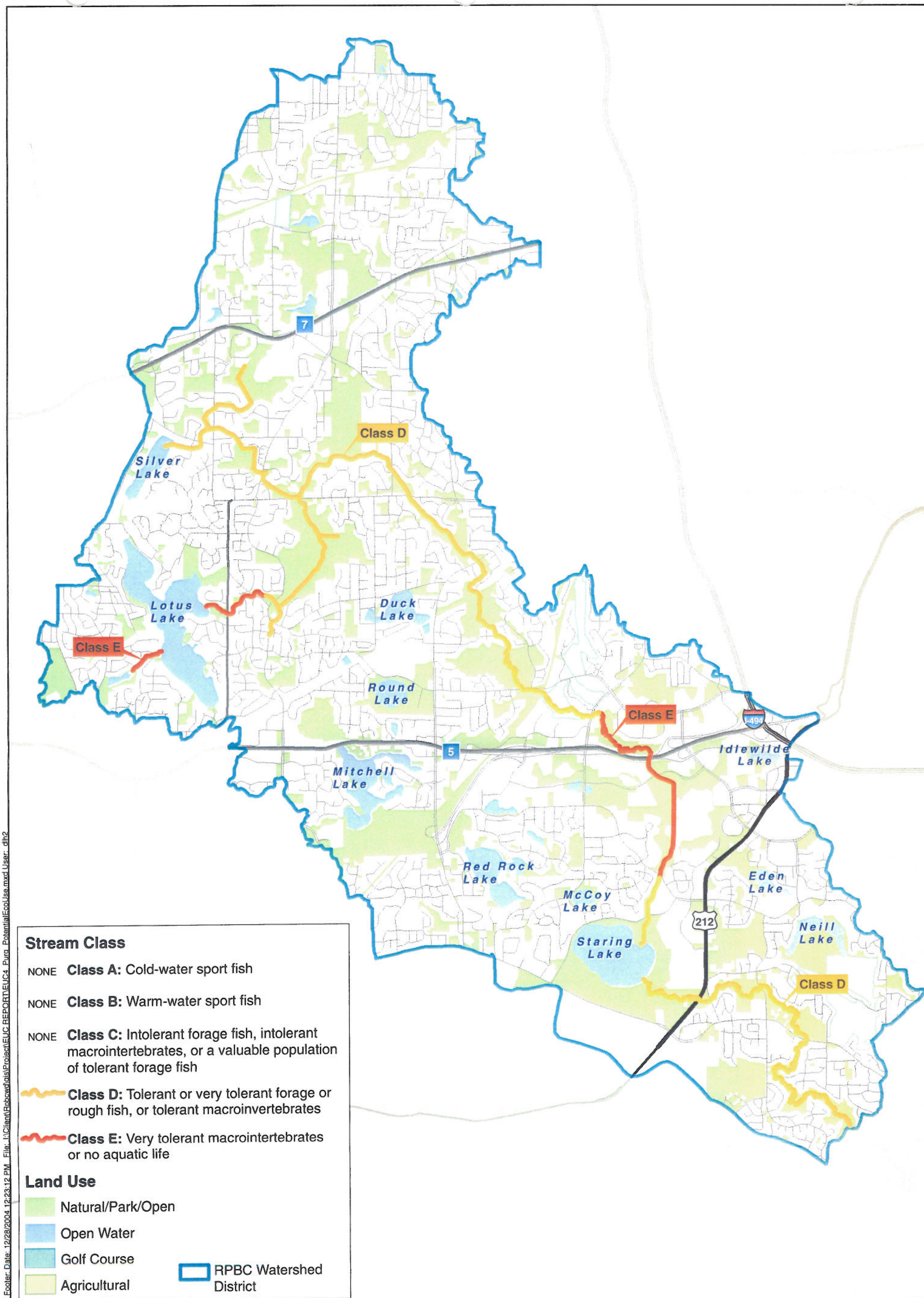
		Parameters					
				Water Quality Variables			
Use Class	Description	Habitat Rating [1]	Minimum Flow (cfs) [2]	Minimum Dissolved Oxygen (mg/L) [3,4]	Maximum Temperature (°F) [4]	pH Range (S.U.) [4]	Toxic Substances [5]
A	Cold water sport fish		>0.5	>4	<75	5<pH<9.5	
B	Warm water sport fish		>3				
C	Intolerant forage fish, intolerant macroinvertebrates, or a valuable population of tolerant forage fish	Excellent to Fair (Fair (∑n<144)	>0.2	>3	<86	<5pH<10.5	<acute
D	Tolerant or very tolerant forage or rough fish, or tolerant macroinvertebrates	Fair (200> ∑n<144)	>0.1	>1	<90	4<pH<11	acute
E	Very tolerant macroinvertebrates or no aquatic life	Poor (∑n>200)	>0.0	<1	>90	1<pH<14	>acute

[1] Habitat Column Scores:
Excellent = [∑n<70] Good = [71≤ ∑n ≤ 129] Fair = [130 ≤ ∑n≤200] Poor = [∑n>200]
[2] Wis. DNR (1982).
[3] U.S. EPA (1977).
[4] Alabaster and Lloyd (1980).
[5] U.S. EPA (1980).

Table EUC4 2003 Potential Ecological Use Classification of Purgatory Creek Locations

	Purgatory Creek Locations							
Classification Parameter	**P-1**	**P-2**	**P-3**	**P-4**	**P-5**	**P-6**	**P-7**	**P-8**
2003 Potential Ecological Use	D	D	E	D	D	D	D	E
2003 Physical Habitat Rating	155	182	218	169	161	170	200	203
Minimum Flow[a] (cfs)	3.9	3.0	1.7	1.2	1.4	1.4	0.2	0.8
Water Quality								
Min. Dissolved Oxygen[a] (mg/L)	7.2	6.2	2.9	4.4	5.9	6.2	4.1	2.6
Max. Temperature[b] (Degrees F)	73.5	78.5	78.3	76.8	74.3	73	74.9	74.4
pH (S.U.) Range of Values[a,b]	7.4-8.2	7.7-8.5	7.5-8.2	7.4-8.1	7.5-8.2	7.5-8.1	7.3-8.0	7.2-8.0
Toxics[c]	< acute	< acute	< acute	< acute	< acute	< acute	< acute	< acute

[a] The minimum values represent the mean of annual minimum values during 1996 through 2003.
b The maximum values represent the mean of annual maximum values during 1996 through 2003.
c Assumption based upon the absence of point source discharges containing toxic substances and on the results of a heavy metals discharge monitoring program during 1992 through 1995.



EUC4

Purgatory Creek
Extrapolated 2003 Potential
Ecological Use

A further evaluation of the specific habitat components constraining ecological use indicates dry climatic conditions adversely impacted habitat conditions in many portions of Purgatory Creek during 2003. The dry conditions reduced the:

- Average depth of pools to a poor rating for Stations P-2, P-3, P-4, P-6, and P-8.
- Depth of riffles and runs to a poor rating for Station P-3.
- Flow to a poor rating at Stations P-7 and P-8.

These precipitation dependent components of the stream's habitat are expected to fluctuate with precipitation. Hence, an improved habitat score is expected to occur when precipitation is higher and a poorer score is expected when precipitation is lower.

2003 habitat constraints not associated with dry climatic conditions include:

- Poor rating for bottom substrate/available cover at Station P-2
- Poor rating for bank erosion failure and bank vegetative protection at Stations P-3 and P-7
- Poor rating for Pool/Riffle, Run/Bend Ratio at Station P-3

3.3.1.2 1996 and 2003 Potential Ecological Use Comparison

Data used for the 1996 and 2003 potential ecological use classifications were compared to identify changes and the reasons changes occurred. Habitat data used in the 1996 and 2003 classifications are presented in Appendices 3C and 3A, respectively. Flow and water quality data used in the 1996 and 2003 classifications are presented in Appendices 3D and 3B, respectively. Comparisons of the habitat, flow, and water quality data used in the 1996 and 2003 classifications are presented graphically in Appendices 3E, 3F, and 3G, respectively.

A comparison of the data used for the 1996 and 2003 potential ecological use classifications indicates habitat degradation in 2003 reduced the stream's potential ecological use at the five most downstream reaches of Purgatory Creek. Four stream reaches (P-1, P-2, P-4, and P-5) degraded from a potential ecological use of Class A in 1996 to a Class D use in 2003. One stream reach (P-3) degraded from a potential ecological use of Class D in 1996 to a Class E use in 2003. Upstream reaches, located near the stream's headwaters, were degraded in 1996 and changed little during the 1996 through 2003 period. P-6 and P-8 noted potential ecological uses of Class D and Class E , respectively, during 1996 and 2003. A very slight improvement (1.5 percent) in habitat at reach P-7 resulted in an improvement from a potential ecological use of Class E in 1996 to a Class D use in 2003. A discussion of individual stations follows.

P-1: Habitat degradation in 2003 changed the potential ecological use of this stream reach from Class A in 1996 to Class D in 2003. Half of the degradation resulted from dry climatic conditions which reduced the average depth of pools, riffles, and runs within the stream. If the climatic changes in habitat had not occurred, the stream reach would have retained its potential ecological use of Class A.

Habitat changes unrelated to climate did not result in a change in ecological use, but caused some degradation of the stream reach. These changes include bottom scouring and deposition, lower bank deposition, watershed erosion, and an unfavorable change in the pool/riffle, run/bend ratio.

Flow and water quality variables, both long-term and annual values, were consistently within Class A or Class B use criteria during the 1996 through 2003 period.

The potential ecological use of this stream is primarily determined from habitat (poorest component), which is heavily influenced by climatic conditions.

P-2: Habitat degradation in 2003 changed the potential ecological use of this stream reach from Class A in 1996 to Class D in 2003. Around 40 percent of the habitat degradation resulted from dry climatic conditions which reduced the average depth of pools, riffles, and runs. Other types of habitat degradation include bank erosion failure, bottom scouring and deposition, and unfavorable changes in the pool/riffle, run/bend ratio and in bottom substrate/available cover.

Water quality variables, both long-term average and annual values, were consistently within Class A or Class B criteria during the 1996 through 2003 period. Long-term flow was within Class A criteria during this period. However, minimum flow during dry years (1996 and 2003) was within Class E criteria, thereby limiting the stream's ecological use to no fish.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component), which is heavily influenced by climatic conditions. Although habitat is the primary determinant of ecological use, minimum flow is a second constraining parameter during dry years.

P-3: Habitat degradation in 2003 changed the potential ecological use of this stream reach from Class D in 1996 to Class E in 2003. Around 40 percent of the habitat degradation resulted from dry climatic conditions which reduced the average depth of pools, riffles, and runs. Other types of habitat degradation include bank erosion and unfavorable changes in bank vegetative protection and the pool/riffle, run/bend ratio.

Water quality and flow variables indicated a higher ecological use for P-3 than habitat. Long-term average flow and pH values were within Class A criteria. Long-term average temperature was within Class B criteria. Long-term average oxygen was within Class D criteria.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component), which is heavily influenced by climatic changes. During favorable climatic conditions, dissolved oxygen may become a second constraining parameter.

P-4: Habitat degradation in 2003 changed the potential ecological use of this stream reach from Class A in 1996 to Class D in 2003. Around two thirds of the habitat degradation resulted from dry climatic conditions which reduced the average depth of pools, riffles, and runs. Other types of habitat degradation include bank erosion failure and unfavorable changes in bank vegetative protection.

Water quality and flow variables generally indicated a higher ecological use for P-4 than habitat. Both long-term and annual water quality variables were within Class A criteria (dissolved oxygen, and pH) or Class B criteria (temperature). Long-term flow was within Class A criteria. However, minimum flow during dry years (1996 and 2003) was within Class E criteria.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component), which is heavily influenced by climatic conditions. During dry climatic conditions, minimum flow is a second constraining parameter.

P-5: Habitat degradation in 2003 changed the potential ecological use of this stream reach from Class A in 1996 to Class D in 2003. Approximately half of the degradation was an unfavorable change in bottom substrate/available cover and a quarter of the degradation resulted from bottom scouring and deposition. Other types of degradation include watershed erosion and bank erosion failure. Hence, habitat degradation at this stream reach was not due to changing climatic conditions.

Water quality and flow variables indicated a higher ecological use for P-5 than habitat. Both long-term and annual water quality variables from this stream reach were within either Class A or Class B criteria. Long-term flow was within Class A criteria. However, minimum flow during dry years (1996, 2000, and 2003) was within either Class C or Class D criteria.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component). During dry climatic conditions, minimum flow is a second constraining parameter.

P-6: A stable habitat, water quality, and flow during 1996 through 2003 resulted in a stable potential ecological use for this stream reach. The potential ecological use of P-6 was Class D during both 1996 and 2003. Although habitat, the constraining variable, was stable during this period, degradation of three habitat variables and improvement in three habitat variables occurred. Variables noting degradation include bank erosion failure, bank vegetative protection, bottom scouring and deposition. Variables noting improvement include watershed erosion, lower bank deposition, and bottom substrate/available cover.

Water quality and flow variables indicated a higher ecological use for P-6 than habitat. Both long-term and annual water quality variables from this stream reach were within Class A criteria. Long-term flow was within Class A criteria. However, minimum flow during dry years (2000 and 2003) was within Class C criteria.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component), which has been fairly stable during the 1996 through 2003 period.

P-7: Due to a very slight improvement (1.5 percent) in habitat, the potential ecological use of P-7 improved from Class E in 1996 to Class D in 2003. The overall change in habitat score resulted from degradation for three habitat parameters (bank erosion failure, bank vegetative protection, and average depth of riffles and runs) and improvement for two habitat parameters (aesthetics and bottom substrate and available cover). The net change in habitat was a slight improvement.

Habitat at this location is heavily influenced by climatic conditions. Nearly half of the habitat degradation resulted from dry climatic conditions which reduced the average depth of riffles, and runs.

Although habitat is the primary determinant of the potential ecological use of this stream reach, minimum flow is a second constraining parameter when little outflow occurs from Silver Lake. The long-term average minimum flow was within Class D, but annual minimum flow values ranged from Class C (1999 and 2002) to Class E (2003). Flow in this stream reach primarily results from Silver Lake outflow. Hence, when little lake outflow occurs, flow becomes a second constraining parameter.

Although most water quality variables indicated a higher ecological use than habitat and flow, dissolved oxygen occasionally becomes a third constraining parameter. Long-term average water quality values of P-7 were within Class A criteria. Annual pH values were consistently within Class A criteria and annual temperature values were within either Class A or Class B criteria. Dissolved oxygen values appear to be heavily influenced by flow. Annual dissolved oxygen values ranged from Class A to Class D, with lowest values occurring during periods of low flow.

The potential ecological use of this stream reach is primarily determined from habitat (poorest component). When little outflow occurs from Silver Lake, flow and dissolved oxygen become additional constraining parameters.

P-8: The potential ecological use of this stream reach was Class E during both 1996 and 2003. However, the constraining variable for the use changed from minimum flow during 1996 to habitat during 2003. A 34 percent degradation in habitat changed the habitat rating from fair in 1996 to poor in 2003. About half of the habitat degradation resulted from dry climatic conditions which reduced the average depth of pools, riffles, and runs. Other types of habitat degradation included bank erosion failure, lower bank deposition, and an unfavorable change in the pool/riffle, run/bend ratio and lower bank channel capacity.

Although the potential ecological use of this stream reach was primarily determined from habitat (poorest component) in 2003, constraints from other parameters have occurred in previous years. When little flow occurs, flow and dissolved oxygen become additional constraining parameters. Minimum flow and dissolved oxygen values in 1998 and 2002 were within Class E criteria.

Temperature and pH values indicated a higher ecological use than habitat, flow, and dissolved oxygen. Annual maximum temperature values were within Class A or Class B criteria and annual pH values were within Class A criteria during the 1996 through 2003 period.

3.3.2 Existing Ecological Use

The potential ecological use represents a use that potentially may be attained in the stream reaches of Purgatory Creek. This means that the stream reaches have the habitat, flow, and water quality conditions during baseflow to support the uses identified by the classification. However, the classification does not necessarily indicate the present uses of the stream. The existing ecological use of the stream is determined from an evaluation of the current fishery and represents the present state of the biological community. The results of the 2003 fishery survey are summarized in Table EUC5 (Barr, 2004). Included in the table are the numbers of each species collected and the ecological use classification (A-E) for each fish species. The existing ecological use, determined from the fish data, is presented, and compared with the stream's potential use.

The stream's existing ecological use is presented in Figure EUC5. Additional details regarding fish data collected during 2003 are presented in Appendix 3H (Barr, 2004). A discussion of the 2003 potential and existing uses of surveyed stream reaches follows.

Half of the stream reaches (P-2, P-3, P-5, and P-7) have a biological community that is better than expected from its habitat and from its long-term flow and water quality data. The difference

Table EUC5 Purgatory Creek Fish Survey Results and Existing Ecological Use Classifications – 2003

Species	Ecological Use[(1)]	Purgatory Creek							
		P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8
Catos tomus commersoni (white sucker)	D						2	S	S
Cypri nus carpio (carp)	D	38	43	69	7	3	1	t	t
Ictiobus cyprinellus (bigmouth buffalofish)	E			1				a	a
Lepomis gibbosus (pumpkinseed sunfish)	B	3					4	t	t
Lepomis hybrid (hybrid sunfish)	B		13			5		i	i
Lepomis cyanellus (green sunfish)	B				19			o	o
Micropterus salmoides (largemouth bass)	B	1						n	n
Esox lucius (northern pike)	B						1		
Notemigonus crysoleucas (golden shiner)	D		1					D	D
Cyprinella spiloptera (spotfin shiner)	D		1					r	r
Notropis atherinoides (emerald shiner)	D	2						y	y
Rhinichthys atratulus (blacknose dace)	C	1			3		44		
Pimephales promelas (northern fathead minnow)	D			1			2	N	N
Pimephales notatus (bluntnose minnow)	D						1	o	o
Semotilus atromaculatus (creek chub)	D				17	2	50		
Ictalurus natalis (yellow bullhead)	B		1	5	1			F	F
Ictalurus melas (black bullhead)	B		5	2	4	1		I	I
Perca flavescens (yellow perch)	B			1				s	s
Umbra limi (central mudminnow)	D				1	6		h	h
Aplodinotus grunniens (freshwater drum)	D			1					
Etheostoma flabellare (fantail darter)	C	9							
Etheostoma nigrum (Johnny darter)	D		1	1	10	1	14		
Total Number of Fish	—	54	65	81	62	18	119	0	0
Existing Ecological Use (2003)	—	D	D	D	D	D[(2)]	D	E	E
Potential Ecological Use	—	D	D	E	D	D	D	D	E
Historical Ecological Use		D	D	C	D	D	D	D	E

(1) Ecological uses include:

Class A, cold water fish

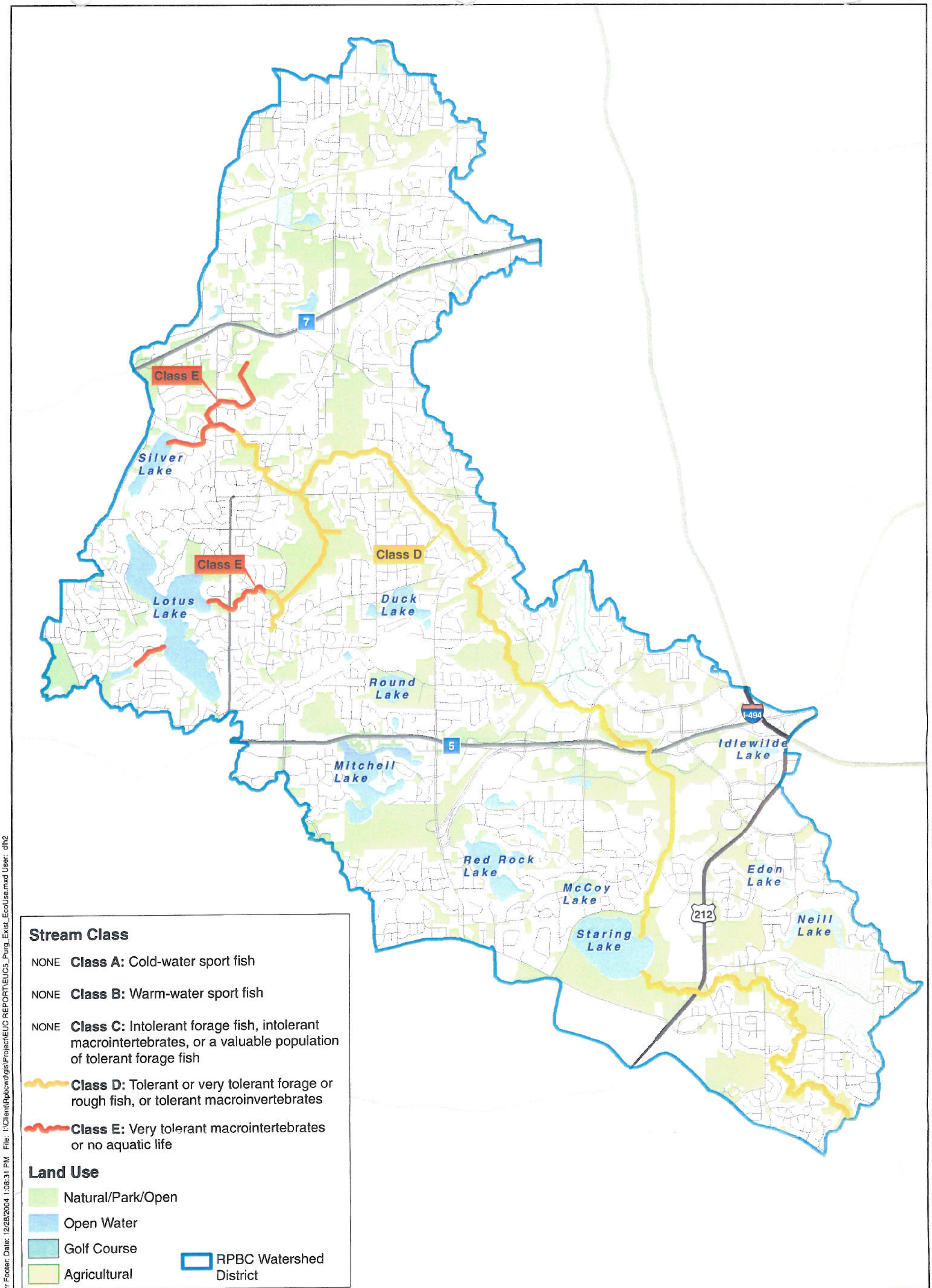
Class B, warm water sport fish

Class C, intolerant forage fish

Class D, tolerant forage fish

Class E, tolerant macroinvertebrates

(2) Average actual ecological use class D assigned whenever less than a total of 50 fish are collected at a station.



Feet
0 2,000 4,000 8,000

EUC5

Purgatory Creek Extrapolated Existing Ecological Use

indicates the stream's suboptimal habitat or water quality conditions for the stream's fish community do not prevent their survival in the stream.

Only one stream reach (P-7) has a poorer biological community than expected from its habitat and from its long-term flow and water quality data. P-7 was dry during September and October. In addition, the habitat score for this stream reach (200) was at the threshold of the next poorest ecological use. Hence, the stream's lack of water during a portion of the year and suboptimal habitat conditions prevented fish from inhabiting the stream during a portion of 2003.

The remaining three stream reaches (P-1, P-6, and P-8) have biological communities consistent with their potential ecological use. This similarity indicates the biological community of these stream reaches is constrained by the stream's habitat, flow, or water quality conditions.

3.3.3 Historical Ecological Use

The existing ecological use represents the stream's present use, but does not indicate long-term changes. Evaluation of a stream's historical ecological use provides an indication of the average long-term use. Factors impacting long-term use include annual climatic changes that create more or less favorable environments for the stream's fishery. Consequently, changes in the fisheries community may occur concurrently with climatic changes. A long-term average considers the impacts of climatic changes. Fisheries data collected from Purgatory Creek during 1997 through 2003 were used to determine the stream's historical ecological use (See Figures EUC 6 and EUC 7). Table EUC5 compares the stream's historical use with its existing and potential uses.

The historical ecological use of Purgatory Creek was generally the same as the stream's existing and potential uses. The historical, existing, and potential ecological use at reaches:

- P-1, P-2, P-4, P-5, and P-6 was Class D, tolerant forage fish;
- P-8 was Class E, no fish.

The similarity between uses indicates the biological community of these stream reaches is constrained by the stream's habitat, flow, or water quality conditions.

The historical ecological use of Class C at reach P-3 was better than its existing ecological use (Class D) and much better than its potential ecological use (Class E). The difference indicates the stream's suboptimal habitat or water quality conditions for the stream's fish community do not prevent their survival in the stream.

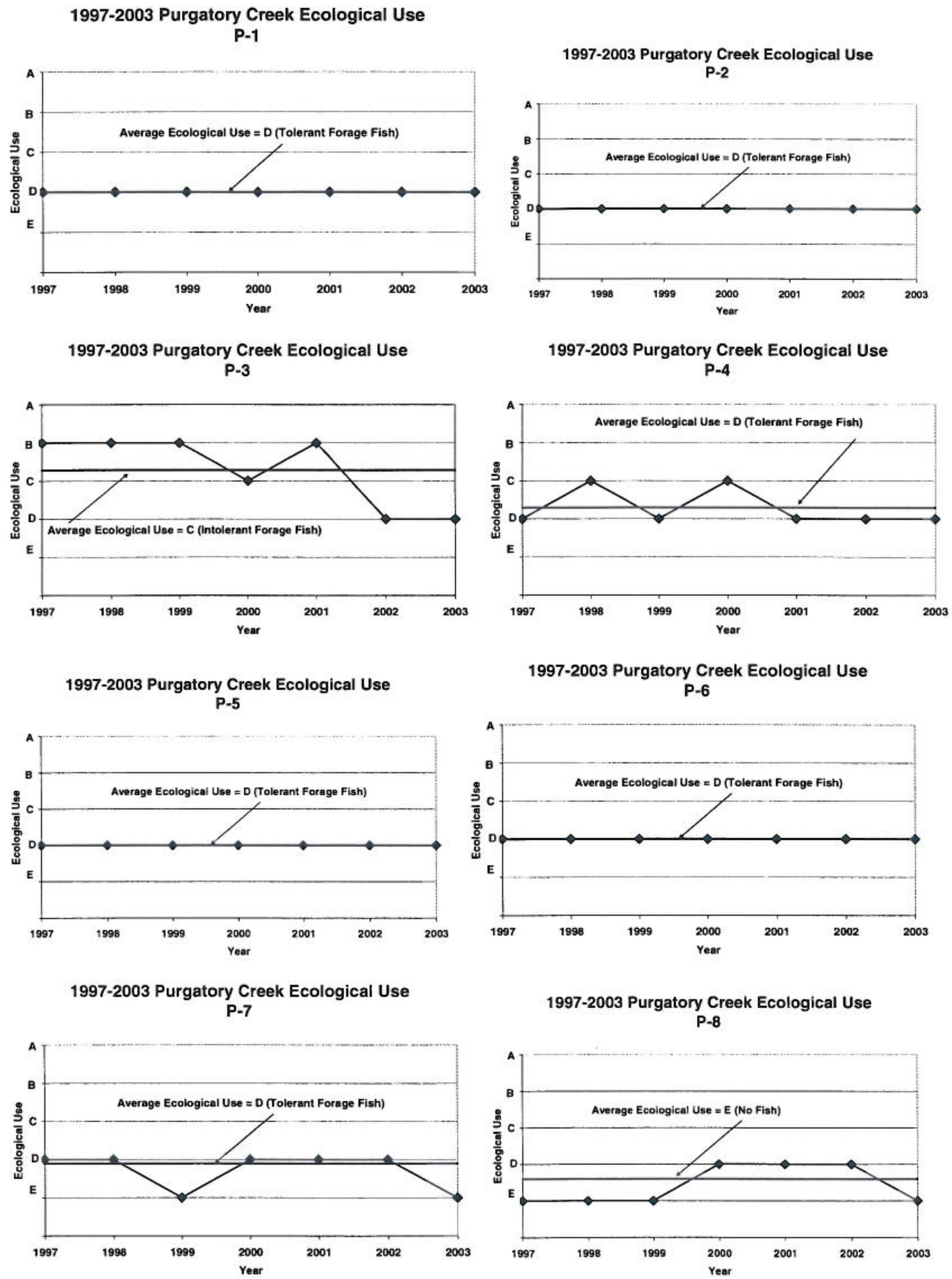
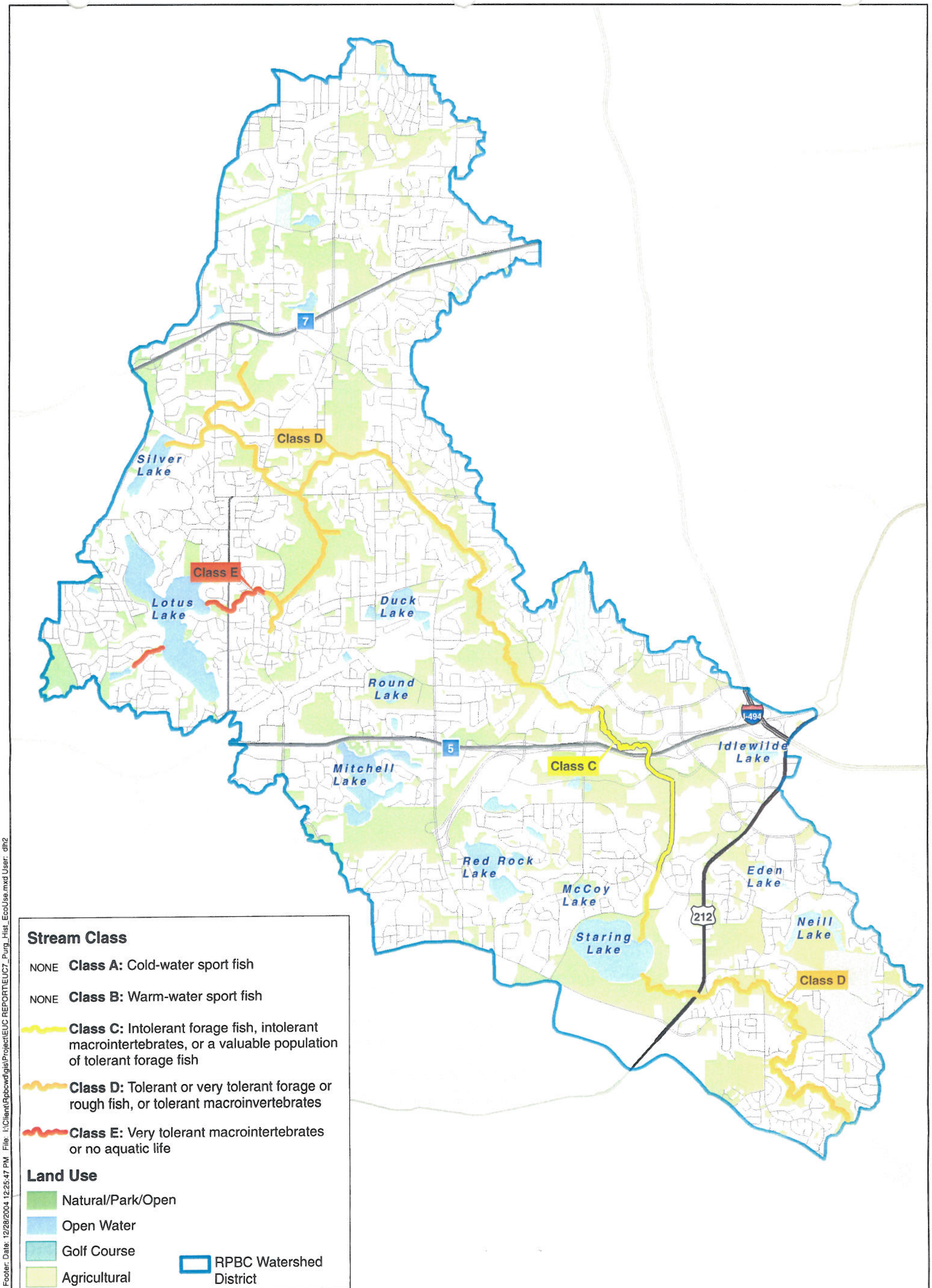


Figure EUC6 Purgatory Creek Historical Ecological Uses (1997-2003)



0 2,000 4,000 8,000 Feet

EUC7

Purgatory Creek Extrapolated Historical Ecological Use

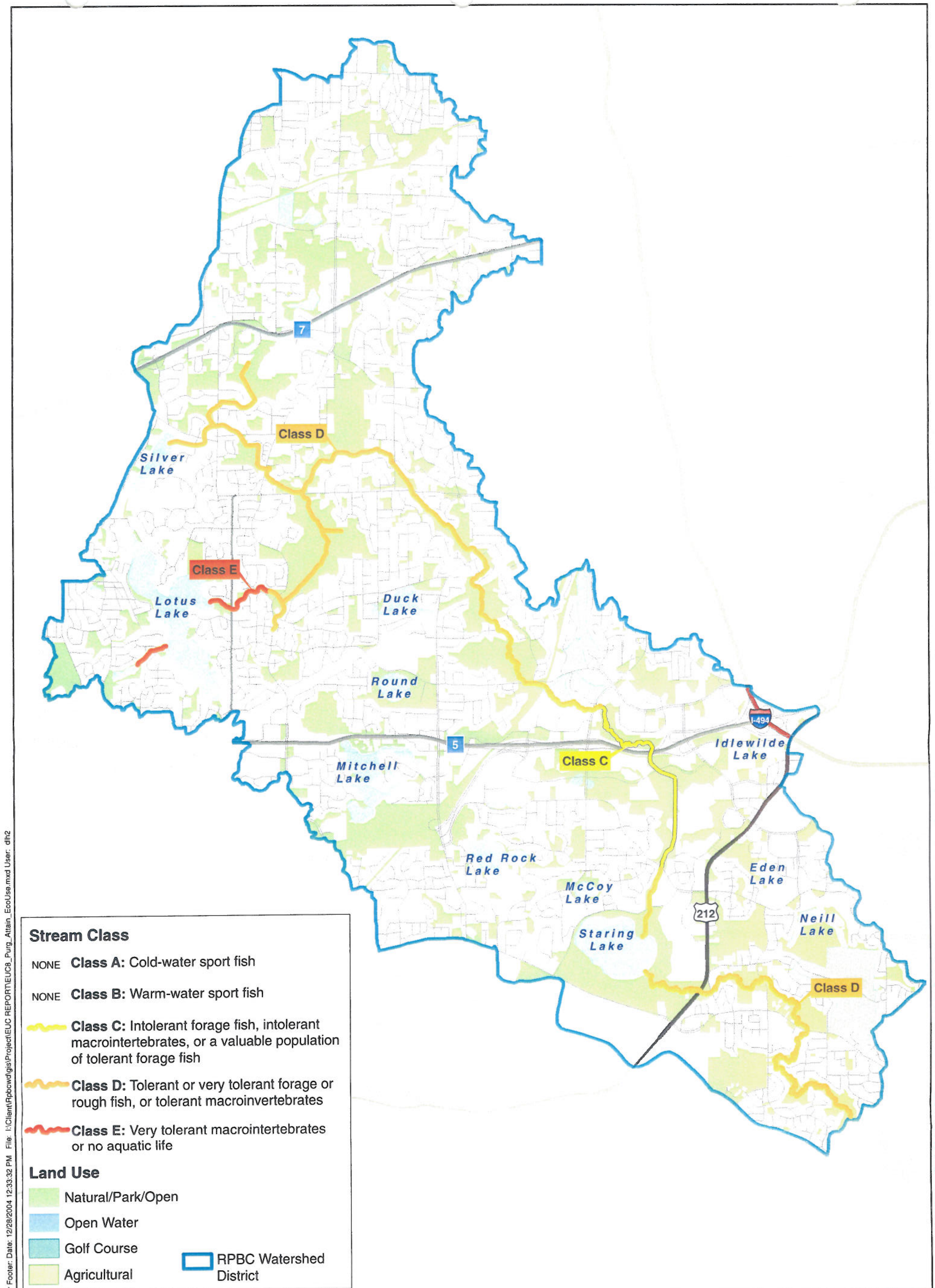
The historical ecological use of P-7 was the same as its potential use (Class D). However, the stream's lack of water during a portion of 2003 prevented fish from inhabiting the stream. Hence, the stream reach's existing use, Class E, differed from its historical and potential uses.

3.3.4 Attainable Ecological Use

A stream's attainable ecological use is its highest achievable use. A use attainability analysis identifies differences between potential (based upon habitat, flow, and water quality) and actual (based upon biological community) stream uses. When actual uses are poorer than potential uses, feasible management practices are identified, whenever possible, to bridge the gap between actual and potential uses.

A use attainability analysis of Purgatory Creek was completed. The analysis began with a comparison of the existing, historical, and potential uses. When no differences occurred, the stream's attainable use was the same as the existing, historical, and potential uses. However, whenever the potential use was higher than the stream's biological use (existing and/or historical), an evaluation was completed to determine whether the constraining variables were controllable or uncontrollable. If the constraining variables were considered uncontrollable (i.e., not possible or not feasible to change by management practices), the attainable use was based on the stream's historical biological use. However, if implementation of feasible stream management practices is expected to attain the potential use, the attainable use was based on the stream's potential use rather than the stream's historical biological use. Whenever the stream's historical biological use was better than the stream's potential use, the historical use became the attainable use. The attainable use classification of Purgatory Creek is summarized in Figure EUC8 and Table EUC6.

The stream's attainable ecological use is generally consistent with the impervious cover of the stream's watershed. All of the stream reaches have watershed IC above 25 percent, which is the stream degradation threshold. Hence, the impervious cover model (ICM) predicts that Purgatory Creek exhibits degraded stream conditions and non-supporting stream quality (CWP, 2003). Most stream reaches noted an attainable ecological use of Class D (P-1, P-2, P-4, P-5, P-6, and P-7) and the remaining stream reaches noted a Class C use (P-3) or a Class E use (P-8). Only reach P-3 noted an attainable ecological use that is better than predicted by the ICM (See Section 3.3.1 Impervious Cover of Purgatory Creek Watershed). The long-term fish community of this reach indicates fish are able to survive despite suboptimal habitat or water quality conditions.



Feet
0 2,000 4,000 8,000

EUC8

Purgatory Creek Extrapolated Attainable Ecological Use

Table EUC6 Purgatory Creek Ecological Use Classes: Potential, Existing 2003, Historical, and Attainable

Stream Reach*	Potential	Existing (2003)	Historical**	Attainable
P-1	D	D	D	D
P-2	D	D	D	D
P-3	E	D	C	C
P-4	D	D	D	D
P-5	D	D	D	D
P-6	D	D	D	D
P-7	D	E	D	D
P-8	E	E	E	E

Ecological uses include:

Class A, cold water fish
Class B, warm water sport fish
Class C, intolerant forage fish
Class D, tolerant forage fish
Class E, tolerant macroinvertebrates

*See Figure EUC 1 for sampling station locations.
** Average of fisheries data collected from Purgatory Creek during 1997 through 2003

3.4 Fish and Aquatic Life Use Classification

Because a current national focus for stream management is compliance with regulatory criteria, a second classification system was used to evaluate Purgatory Creek. The fish and aquatic life use classification is designed to determine whether or not streams comply with Federal Water Quality Standards Regulations. The Federal Clean Water Act requires that surface waters "provide, wherever attainable, water quality for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water." The regulations require that the most sensitive use attained in a surface water at anytime since November 1975 is the attainable and designated use. This use cannot generally be changed to a less sensitive use designation unless an approved water quality standards review shows the more sensitive use is no longer attainable.

The fish and aquatic life use classification is intended to evaluate attributes of a stream's fish and aquatic life community to determine whether species sensitive to suboptimal conditions reside in a stream. The classification results indicate whether or not a stream complies with Federal criteria.

The fish and aquatic life use classification is similar to the ecological use classification in the use of a stream's present and historical fish community for stream classification. However, differences distinguish the classifications.

- The ecological use classification focuses on the average community while the fish and aquatic life use classification determines the best fish and aquatic life species found in a stream. The best species found in a stream may differ from the best average stream community. While the majority of species supported by a stream may be tolerant to suboptimal conditions, a few species may require optimal conditions for survival. The presence of sensitive species in a stream indicates the stream has the habitat, flow, and water quality conditions required for their survival.

- The results of the ecological use classification are used to determine stream management goals and practices for a stream. The results of the fish and aquatic life use classification are used to determine compliance with Federal criteria.

Details of the fish and aquatic life use classification follows.

3.4.1 Classification of Fish and Aquatic Life Uses

Four fish and aquatic life use categories are used in the fish and aquatic life use classification (Ball, 2004).

- **Cold Water (CW)** use (Corresponds with Class A of the ecological use classification)
- **Diverse Fish and Aquatic Life (DFAL)** use (Corresponds with Classes B and C of the ecological use classification)
- **Tolerant Fish and Aquatic Life (TFAL)** use (Corresponds with Class D of the ecological use classification)
- **Very Tolerant Aquatic Life (VTAL)** use (Corresponds with Class E of the ecological use classification)

CW and DFAL uses are full fish and aquatic life uses under the Clean Water Act and indicate the stream meets Federal criteria. TFAL and VTAL uses are not defined as full fish and aquatic life uses under the Clean Water Act. However, in most cases, a TFAL or VTAL use is the best that can be attained by these resources due to natural or irretrievable habitat or water quality limitations. Following are situations in which a stream's attainable use is TFAL or VTAL:

- Naturally occurring water quality conditions prevent the attainment of a DFAL community. This condition would occur where vegetative growth and decay causes dissolved oxygen depletion due to respiration or biological oxygen demand. An example is a wetland stream or a wetland draining into a small stream.
- Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of a DFAL. Low flow and the resulting lack of aquatic habitat is a common cause that prevents the potential to attain a DFAL.
- Human caused conditions or sources of pollution prevent the attainment of a DFAL and cannot be remedied or would cause more environmental damage than to leave in place.
- Dams, diversions, or other types of hydrologic modifications preclude the attainment of a DFAL community, and it is not feasible to restore the water body to its original condition or to attain a DFAL community.
- Physical conditions related to the natural features of the water body, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude the attainment of a DFAL community. This condition stresses that the natural condition of the habitat is so naturally poor that the system never supported, and does not have the potential to ever support a DFAL community as a natural condition.
- Conditions required to attain a DFAL community would result in widespread adverse social and economic impacts to the community.

Criteria for the fish and aquatic life use classification for streams are discussed in the following paragraphs. Because Purgatory Creek does not support a Cold Water use, the discussion is limited to DFAL, TFAL, and VTAL uses.

3.4.1.1 Diverse Fish and Aquatic Life (DFAL)

DFAL surface waters are generally warm and coolwater ecosystems with the potential to contain fish and macroinvertebrate communities with some species that are not tolerant to low dissolved oxygen. Criteria for DFAL use are subdivided into 6 categories: (1) Game fish waters; (2) Non-game fish waters; (3) Macroinvertebrate waters; (4) Endangered, threatened, or special concern species waters; (5) Intolerant fish species waters; and (6) Coolwater fish species waters. The community characteristics described below are generally minimally attainable expectations for a DFAL designated use.

- **Game Fish Waters (DFAL-GF):** Warm or cool water ecosystems containing, or having the potential to contain more than two game fish, of one or more species, except salmonids, green sunfish (*Lepomis cyanellus*), black bullheads, or yellow bullheads in a 100 meter stream segment. Game fish species are defined as all varieties of fish except rough fish and minnows. In these guidelines, green sunfish, black bullheads, and yellow bullheads are not considered game fish because they are considered tolerant to low dissolved oxygen. Game fish streams will generally be continually flowing with low flows greater than 1 cfs. Streams containing or having the potential to contain game fish communities are all classified DFAL waters.

- **Non-game Fish Waters (DFAL-NG)**: Warm water ecosystems capable of attaining a rough fish and minnow species community with 5 to 25 percent or more individuals not tolerant to low dissolved oxygen. Non-game fish are defined as minnows and as rough fish. Non-game fish community waters designated DFAL are generally small streams with continuous flow, or maintain water in pools during dry periods. Non-continuous streams that can periodically meet the minimum community expectations can be seasonally designated DFAL waters. Meeting the non-game fish expectations as an existing condition would generally indicate the appropriate designated use as DFAL. However, under some conditions meeting the community expectations may not always justify the DFAL designated use, especially where one to three species and a community of less than 50 fish per 100 meter stream length are found.
- **Macroinvertebrate Waters (DFAL-MC)**: Warm, cool and coldwater (i.e., coldwaters without the potential to contain a fish community could be classified as DFAL-MC waters) ecosystems that may not contain habitat to support the minimum DFAL or CW fish community expectations, but contain water quality and natural habitat sufficient to support macroinvertebrates not tolerant to low dissolved oxygen. A macroinvertebrate community containing 5 to 25 percent or more individuals with Hilsenhoff tolerance values of 5 or less (Hilsenhoff, 1987) may indicate DFAL-MC surface water.
- **Endangered, Threatened, or Special Concern Species Waters (DFAL-ETSC)**: Warm, cool and coldwater (without potential to contain salmonids) ecosystems that contain any aquatic (e.g. mussel, fish, macroinvertebrate) or semi-aquatic (e.g., herptile) species that are considered endangered, threatened or special concern by either the United States or the State.
- **Intolerant Fish Species Waters (DFAL-IF)**: Warm and coolwater ecosystems that contain or have the potential to contain intolerant fish species. Intolerant fish species are particularly sensitive to environmental degradation such as habitat modifications. They are among the first species lost as a surface water becomes degraded, and are excellent indicators of the overall health of surface waters. This community type represents some of the highest quality DFAL waters in the state. As a general guidance, waters containing or having the potential to contain 10 percent or more individuals listed as intolerant fish species should be designated DFAL-IF waters. A Warmwater IBI score of "10" for the intolerant species metric indicates a DFAL-IF community.
- **Coolwater Fish Species Waters (DFAL-CC):** Coolwater ecosystems that contain or have the potential to contain coolwater fish species as part of the aquatic community. The summer daily maximum temperature range in coolwater ecosystems is about 22-25 degrees Celsius (72-77 degrees Fahrenheit) (Lyons, per. Comm.). These waters may contain a unique fish

community. Several fish species reach maximum abundance in coolwater systems and are considered coolwater indicator species. Coolwater systems may also contain a mix of coldwater indicator species such as sculpins and warmwater species such as sunfish. Coolwater systems represent an intermediate condition between cold and warmwater, and consequently are difficult to precisely define. Temperature data in concert with the presence of coolwater indicator fish species is justification for a DFAL-CC use designation. In the absence of temperature data, the presence of 5 percent or more individual cool or coldwater indicator fish species in a sample may justify a DFAL-CC use designation.

DFAL habitat and water quality characteristics are as follows. Summer maximum temperatures in warm DFAL surface waters will normally range from greater than 25 degrees Celsius (77 degrees Fahrenheit) to a maximum of about 31 degrees Celsius (87 degrees Fahrenheit). Summer maximum temperatures in cool DFAL surface waters will normally range from about 22-25 degrees Celsius (72-77 degrees Fahrenheit). The dissolved oxygen criterion for all DFAL waters is 5 mg/L. Periodic dissolved oxygen concentrations less than 5 mg/L do not exclude a surface water from the DFAL use category as long as the minimum species and population criteria can be attained and maintained at least seasonally.

3.4.1.2 Tolerant Fish and Aquatic Life (TFAL)

TFAL surface water ecosystems have the potential to support fish and macroinvertebrate species that are tolerant to low dissolved oxygen concentrations. Criteria for TFAL waters are divided into two categories: (1) Tolerant Fish Waters (TFAL-F); and (2) Tolerant Macroinvertebrate Waters (TFAL-M).

- **Tolerant Fish Waters (TFAL-F)**: Ecosystems that contain or have the potential to contain a fish community dominated by species tolerant to low dissolved oxygen are TFAL-F. A fish community containing 75 to 100 percent low dissolved oxygen individuals is considered a tolerant fish community.
- **Tolerant Macroinvertebrate Waters (TFAL-M)**: Ecosystems without the potential to contain a fish community, but with the potential to contain a macroinvertebrate community dominated by species tolerant to low dissolved oxygen are TFAL-M. A macroinvertebrate community containing no more than 5 percent individuals with Hilsenhoff tolerance values of 5 or less and containing 75 to 100 percent individuals with Hilsenhoff tolerance values between 5 and 8 is considered a tolerant community.

TFAL water quality and habitat characteristics are as follows. TFAL waters are generally small warmwater streams with normal low flows less than 0.1 cfs or shallow water bodies, containing natural or irretrievably limited water quality or habitat. Water quality or habitat quality in these surface waters is generally capable of supporting a few fish and aquatic insects, but cannot support a DFAL community. The dissolved oxygen criterion for TFAL waters is 3 mg/L. The temperatures in TFAL waters are generally similar to temperatures in DFAL waters.

3.4.1.3 Very Tolerant Aquatic Life (VTAL)

VTAL ecosystems do not have the potential to maintain a fish community and have limited natural or irretrievable capacity to support fully aquatic life forms. These waters may contain macroinvertebrate communities dominated by very tolerant species. VTAL surface waters may periodically contain a few stray fish during high flow periods when water quality and habitat conditions allow for their brief existence. Criteria for VTAL waters are divided into two categories: (1) Very Tolerant Macroinvertebrate Waters (VTAL-M) and No Aquatic Life Waters (VTAL-NA).

- **VTAL-M:** Ecosystems with the potential to contain a macroinvertebrate community dominated by very tolerant species are VTAL-M. A macroinvertebrate community containing 75 to 100 percent individuals with the Hilsenhoff tolerance values from 8 to 10 is considered a very tolerant community.
- **VTAL-NA:** Ecosystems that are defined as waters of the state but are generally dry except during run-off or discharge events, or the habitat conditions are such that aquatic life cannot exist, such as high velocity waters are VTAL-NA.

VTAL water quality and habitat characteristics are as follows. VTAL waters are generally small streams or stream channels that may be dry except during rainy periods, or may contain pooled water and little if any flow. Habitat will generally be limited due to the lack of permanent water or cover for fish and macroinvertebrates. The dissolved oxygen criterion for VTAL waters is 1 mg/L, and is based on maintaining aerobic conditions. There is no in-stream aquatic life based criterion for temperature.

3.4.1.4 Fish and Aquatic Life Use Classification of Purgatory Creek

Data collected from eight stream reaches were used to classify Purgatory Creek as to fish and aquatic life uses per the criteria described in the previous three sections (Sections 3.4.1.1, 3.4.1.2, and 3.4.1.3). Classification results follow.

Fisheries data collected during 1997 through 2003 from Purgatory Creek indicate most of the stream is classified as DFAL-GF (diverse fish and aquatic life—game fish). The use indicates that most of the stream supports a diverse fish and aquatic life community, including game fish. The stream's game fish (GF) designation indicates more than 2 game fish have generally been collected annually from reaches P-1 through P-6 (See Appendix 3I). The classification of all but the stream's headwaters as DFAL-GF (diverse fish and aquatic life—game fish) indicates that the stream, except for its headwaters reaches, complies with Federal criteria,

The stream's headwaters reaches (P-7 and P8, Figure EUC1) are intermittent streams with little or no flow. These reaches generally had a flow insufficient for the life requirements of gamefish. The reaches were dry for periods of time during the 1997 through 2003 monitoring period. The presence or absence of aquatic life at these locations was dependent upon flow.

Variable flow conditions at P-7 resulted in variable fish and invertebrate communities during the 1997 through 2003 period. In 1998, the presence of more than 2 gamefish at P-7 indicated a classification of DFAL-GF (diverse fish and aquatic life—game fish) would be appropriate. In 2002, more than 25 percent of the invertebrate community required high concentrations of oxygen for survival (i.e., Hilsenhoff Biotic Index values of 5 or less). Hence, the high quality invertebrate community indicated a classification of DFAL-MC (diverse fish and aquatic life—macroinvertebrate community) would be appropriate. The data indicated the stream complied with Federal criteria during 1998 and 2002. During most years, however, a classification of TFAL (tolerant fish and aquatic life) was appropriate because most fish and invertebrates at P-7 were tolerant to low dissolved oxygen concentrations. During 2003, the stream bed was dry and no fish or invertebrates were collected. Hence, a classification of VTAL-NA (no aquatic life waters--dry stream) would be appropriate. Because of the great year to year variability at this location, a classification based upon the average condition during the seven year period of data collection is appropriate. The classification of P-7 is TFAL (tolerant fish and aquatic life).

A dry stream bed at reach P-8 prevented the collection of either fish or invertebrate samples or both during six of the seven years of data collection. Both fish and invertebrate samples were collected during 2002, a very wet year, because flow was observed during both July (fish collection period) and October (invertebrate collection period). All of the fish and nearly two thirds of the invertebrates collected from P-8 during 2002 are tolerant to low levels of dissolved oxygen. Hence, the classification of P-8 is VTAL (very tolerant aquatic life).

Flow limitations in the headwaters reaches of Purgatory Creek prevent these reaches from meeting Federal criteria. These reaches have a limited natural capacity to support aquatic life due to flow limitations. Hence, a classification of TFAL for P-7 and VTAL for P-8 is the best that can be attained by these resources due to habitat limitations resulting from low flow conditions.

3.4.1.5 Comparison of Fish and Aquatic Life Use Classification and Ecological Use Classification of Purgatory Creek

Purgatory Creek was classified using two very different classification methods. Comparing the results of the two methods provides a more complete picture of the stream than solely looking at the results of either method. The first method, ecological use classification (See Section 3.3 of this report), determined the average biological community supported by Purgatory Creek. The second method, fish and aquatic life use (See Section 3.4 of this report), determined the best biological species supported by Purgatory Creek and whether or not the stream meets Federal criteria.

With the exception of a couple of reaches (P-3 and P-8), Purgatory Creek notes an average fish community that is tolerant to poor habitat, flow, and water quality conditions. Although the average fish community of the stream is generally tolerant to suboptimal conditions, all reaches of the stream, except its headwaters, support game fish and a diverse aquatic life community requiring optimal oxygen conditions. The discovery that a portion of the stream's aquatic life community has stringent habitat, flow, or water quality requirements puts the stream in a more favorable light than the average condition. Hence, while the stream's developed watershed has impacted its habitat, flow, and water quality, prudent stream management practices have retained the stream's ability to support gamefish and a high quality invertebrate community. Despite habitat degradation resulting from an impervious cover in excess of 25 percent, the stream meets Federal criteria, except for its headwaters reaches. The headwaters reaches have a limited natural capacity to support aquatic life due to flow limitations.

Nearly all of Purgatory Creek has an attainable ecological use classification of Class D (tolerant forage fishery) and a fish and aquatic life use of DFAL-GF (diverse fish and aquatic life—game fish). The DFAL-GF classification is comparable to a Class B (warm water sport fishery) or Class C (intolerant forage fishery) ecological use classification. Hence, comparison of the results of the two classification methods indicates the average fish community is a Class D, but the stream may support Class B or Class C fish. Reach P-3 has an average fish community of Class C which is more similar to its fish and aquatic life use classification of DFAL-GF.

The ecological use classification of the stream's headwaters reaches was comparable to its fish and aquatic life use classification. The average fish community at P-7 was Class D (tolerant forage fishery) and its fish and aquatic life use classification was Tolerant Aquatic Life (comparable to a Class D). On average, P-8 is unable to support aquatic life due to a dry stream bed. Its ecological use classification of Class E (no aquatic life) was comparable to the fish and aquatic life use classification of Very Tolerant Aquatic Life, which includes no aquatic life due to a dry stream bed.

3.5 Recommendations

Although the average fish community in Purgatory Creek is tolerant to suboptimal habitat, flow, and water quality conditions, most of the stream has retained its ability to support gamefish species. With the exception of the stream's headwaters reaches, the stream's fish and aquatic life uses meet Federal criteria.

Stabilization of the stream's habitat is necessary to protect the stream's current biological community. Habitat appears to be the primary limiting variable for the stream's biological community. Habitat changes occurring since 1995 indicate deterioration has occurred in most Purgatory Creek stream reaches. The deterioration indicates the stress associated with the urban nature of the watershed. Continued degradation would negatively impact the stream's biological community.

Implementation of the recommendations in Section 2 of this report will improve the physical characteristics of Purgatory Creek and reduce degradation of the stream's habitat. Improving the physical characteristics of the stream will improve the ability of the stream to continue to meander naturally without excessive bank erosion. Improving stream bank and riparian vegetation throughout the stream system will improve the resistance of the stream to erosion. These improvements are necessary to curtail the habitat degradation from bank erosion that occurred in all eight reaches and the degradation in stream bank vegetation occurring at reaches P-3, P-4, P-6, and P-7 during the 1995 through 2003 period.

Watershed management measures to reduce the frequency and rate of runoff are recommended to further stabilize the stream's habitat. Stormwater basins may be used to reduce the discharge rates and volumes of runoff from the stream's watershed. Rainwater gardens can be used to infiltrate runoff, thereby reducing the volume and rate of runoff to the stream. Implementation of these management measures can reduce the frequency of bankfull flooding, and help maintain the stability of the stream. These measures are necessary to curtail the various types of habitat degradation observed in Purgatory Creek during 1995 through 2003. Specifically, these measures will reduce:

- Bottom scouring and deposition occurring at reaches P-1, P-2, and P-6
- Lower bank deposition occurring at reaches P-1 and P-8
- Watershed erosion occurring at reaches P-1 and P-5 and the
- Unfavorable change in bottom substrate/available cover occurring at reach P-2

Regular evaluation of the stream's habitat is recommended to detect degradation and determine the effectiveness of management measures to slow or curtail stream degradation. An annual habitat survey is recommended for a five year period to determine habitat changes.

Although limiting factors may be changed by remedial measures, these measures do not ensure attainment of a higher ecological use class. The adverse temperature impacts of warm stormwater runoff and low base discharge in the creek will continue to reduce ecological use. Nonetheless, management projects are recommended to preserve and/or improve existing habitat conditions. The projects will also improve flow and water quality conditions.

3.6 References

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Appendix 3-A

2003 Purgatory Creek Habitat Survey Data

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-1 (path from N of 10216 Antlers Ridge) Reach Score/Rating 155

County Hennepin Date 10/16/03 Evaluator HTD Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10	**Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14**	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16**	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9**	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition Comment: Change in Creek Course from 1997	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat. 7**	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	**6" to 1' 6** 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2' 24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	**1-2 cfs 6** 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat. 8**	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	**Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8**	High natural beauty. Trees, historic site. Some development may be visible. 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	8	46	61	24

Column Scores **E 8 +G 46 +F 61 +P 40 = 155 = Score**
<70 = Excellent, 71-129 = Good, **130-200 = Fair**, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-2 (Homeward Hills below Sunnybrook) Reach Score/Rating 182

County Hennepin Date 10/14/03 Evaluator HTD Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16**	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9**	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	**Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22**
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 **6" to 10" 18**	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 **<3' 24**
Flow, at Rep. Low Flow	Cold >2 cfs **Warm >5 cfs**	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	**15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16**	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible. 10**	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	39	81	62

Column Scores E 0 +G 39 +F 81 +P 62 = 182 = Score
<70 = Excellent, 71-129 = Good, **130-200 = Fair**, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory   Reach Location P-3 (between Staring Lk Pkwy & Anderson Lk Rd)   Reach Score/Rating 218

County Hennepin   Date 10/14/03   Evaluator HTD   Classification Poor

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	**Many eroded areas. "Raw" areas frequent along straight sections and bends.** 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	**<50% density. Many raw areas. Thin grass, few if any trees and shrubs.** 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.** 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable.** 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' 0 Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 **<6"** 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 **<3'** 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 **<1 cfs** 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	**>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat.** 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	39	51	146

Column Scores E 0 +G 39 +F 33 +P 146 = 218 = Score
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-4 (Marshall N of Hwy 5) Reach Score/Rating 169

County Hennepin Date 10/14/03 Evaluator HTD Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow.** 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health.** 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat.** 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 **6" to 10"** 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 **<3'** 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 **<1 cfs** 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	71	52	64

Column Scores E 0 +G 71 +F 34 +P 64 = 169 = Score
<70 = Excellent, 71-129 = Good, **130-200 = Fair**, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory   Reach Location P-5 (Hillcrest Court)   Reach Score/Rating 161

County Hennepin   Date 10/16/03   Evaluator HTD   Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10	**Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14**	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16**
Bank Erosion, Failure (Very undercut)	No evidence of significant erosion or bank failure. Little potential for future problem. 4	**Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8**	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	**90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6**	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition (no point bars, silt deposition)	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	**Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22**
Avg. Depth Riffles and Runs	**Cold >1'** Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	**Cold >4'** Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs 24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	**15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16**	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	**Common setting, not offensive. Developed but uncluttered area. 14**	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	6	18	75	62

Column Scores **E 6 +G 18 +F 75 +P 62 = 161= Score**
<70 = Excellent, 71-129 = Good, **130-200 = Fair**, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-6 (N of 62 on Scenic Hts Rd) Reach Score/Rating 170

County Hennepin Date 10/21/03 Evaluator HTD Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** **10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** **16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow.** **16**	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	**50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding.** **15**	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** **10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** **9**	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.** **16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	**Greater than 50% rubble, gravel or other stable habitat.** **2**	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	**6" to 1'** **6** 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2'** **24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs** **24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** **8**	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	**Common setting, not offensive. Developed but uncluttered area.** **14**	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	**2**	**43**	**61**	**64**

Column Scores E 2 +G 43 +F 61 +P 64 = 170= Score
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-7 (off Covington Rd.) (Creek is completely dry) Reach Score/Rating 200

County Hennepin Date 10/21/03 Evaluator HTD Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields), residential (yard debris dumping) 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	**Many eroded areas. "Raw" areas frequent along straight sections and bends. 20**
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	**<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18**
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel/sand. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat. 5**	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs (Dry)	Cold >1' Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	**<3" 24** **<6" 24**
Avg. Depth of Pools (Dry)	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2' 24** **<3' 24**
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs 24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat. 8**	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible. 10**	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	43	31	126

Column Scores E 0 +G 43 +F 31 +P 126 = **200= Score**
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-8 (Duck Lk Trail off Dell Rd.) Reach Score/Rating 203

County Hennepin Date 10/21/03 Evaluator HTD Classification Poor

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads -- Hwy. 212, urban area, farm fields), 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods.8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16**	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9**	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	Adequate. Overbank flows rare. W/D ratio 8-15. 10	**Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14**	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel/sand. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8**	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or sand or other stable habitat. Habitat (muck) availability less than desirable. 17**	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs (Partly dry)	Cold >1' Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	**<3" 24** <6" 24
Avg. Depth of Pools (Partly dry)	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2' 24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs 24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	**15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16**	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible. 10**	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	37	78	88

Column Scores **E 0 +G 37 +F 78 +P 88 = 203 = Score**
<70 = Excellent, 71-129 = Good, 130-200 = Fair, **>200 = Poor**

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Appendix 3-B

1996-2003 Purgatory Creek Flow and Water Quality Values

1996-2003 Purgatory Creek Flow and Water Quality Values

		Parameters									
Station ID	Year	Low Flow (cfs)	Avg. Low Flow (cfs)	Min. Oxygen (mg/L)	Avg. Min. Oxygen (mg/L)	Max. Temp. (°F)	Avg. Max. Temp. (°F)	Min. pH (std. units)	Avg. Min. pH (std. units)	Max. pH (std. units)	Avg. Max. pH (std. units)
P-1	1996	2.1		6.1		71.0		6.6		8.1	
P-1	1997	3.3		6.3		73.0		7.5		8.2	
P-1	1998	5.3		6.9		78.0		7.5		8.2	
P-1	1999	5.0		6.8		72.5		7.5		8.3	
P-1	2000	1.2		8.7		68.4		7.1		8.2	
P-1	2001	2.4		8.5		69.4		7.8		8.2	
P-1	2002	10.2		6.1		79.7		7.9		8.2	
P-1	2003	1.6	**3.9**	8.1	**7.2**	76.3	**73.5**	7.5	**7.4**	8.3	**8.2**
P-2	1996	0.0		5.3		79.0		7.6		8.0	
P-2	1997	2.6		5.1		79.0		7.2		8.1	
P-2	1998	3.3		4.9		81.0		7.4		8.4	
P-2	1999	3.3		5.2		77.5		8.1		8.9	
P-2	2000	0.1		7.4		72.9		7.5		8.5	
P-2	2001	2.2		7.2		76.8		7.8		9.1	
P-2	2002	7.4		6.3		81.9		8.0		8.5	
P-2	2003	5.5	**3.0**	8.4	**6.2**	79.7	**78.5**	7.7	**7.7**	8.8	**8.5**
P-3	1996	0.0		2.7		76.0		7.3		7.9	
P-3	1997	1.9		3.1		75.0		7.2		7.8	
P-3	1998	0.8		4.6		79.0		7.4		8.2	
P-3	1999	1.6		1.2		76.3		7.7		8.2	
P-3	2000	1.2		2.2		79.3		7.4		8.2	
P-3	2001	1.4		1.9		77.7		7.5		8.3	
P-3	2002	6.3		3.9		81.1		7.2		8.3	
P-3	2003	0.1	**1.7**	3.6	**2.9**	81.9	**78.3**	7.9	**7.5**	8.7	**8.2**
P-4	1996	0.0		4.0		77.0		7.5		8.3	
P-4	1997	2.0		3.9		77.0		7.1		8.0	
P-4	1998	0.8		5.8		74.0		6.8		8.0	
P-4	1999	0.6		5.0		75.9		7.8		8.2	
P-4	2000	0.5		5.0		75.2		7.5		8.1	
P-4	2001	0.2		3.5		78.6		7.5		8.0	
P-4	2002	5.2		3.2		79.3		7.4		8.1	
P-4	2003	0.0	**1.2**	5.0	**4.4**	77.4	**76.8**	7.5	**7.4**	8.4	**8.1**
P-5	1996	0.3		4.0		74.0		7.7		8.1	
P-5	1997	2.1		4.2		73.0		7.0		8.0	
P-5	1998	1.3		6.6		78.0		6.9		8.1	
P-5	1999	1.2		6.1		71.8		7.8		8.3	
P-5	2000	0.2		6.2		70.2		7.6		8.2	
P-5	2001	1.0		6.5		74.1		7.6		8.1	
P-5	2002	4.9		5.7		77.9		7.6		8.1	
P-5	2003	0.2	**1.4**	7.6	**5.9**	75.7	**74.3**	7.6	**7.5**	8.5	**8.2**
P-6	1996	0.6		7.1		73.0		7.5		7.9	
P-6	1997	1.8		4.8		70.0		7.1		8.0	
P-6	1998	1.0		5.5		76.0		7.0		8.0	
P-6	1999	1.5		5.7		70.0		7.9		8.4	
P-6	2000	0.4		8.0		67.6		7.6		8.2	
P-6	2001	0.9		7.2		72.9		7.6		8.0	
P-6	2002	5.0		4.4		77.9		7.5		7.9	
P-6	2003	0.3	**1.4**	7.2	**6.2**	76.3	**73.0**	7.6	**7.5**	8.3	**8.1**

1996-2003 Purgatory Creek Flow and Water Quality Values

(Continued)

		Parameters									
Station ID	Year	Low Flow (cfs)	Avg. Low Flow (cfs)	Min. Oxygen (mg/L)	Avg. Min. Oxygen (mg/L)	Max. Temp. (°F)	Avg. Max. Temp. (°F)	Min. pH (std. units)	Avg. Min. pH (std. units)	Max. pH (std. units)	Avg. Max. pH (std. units)
P-7	1996	0.2		3.5		74.0		7.3		8.0	
P-7	1997	0.2		3.0		76.0		7.0		7.9	
P-7	1998	0.2		2.1		77.0		6.9		7.9	
P-7	1999	0.4		3.4		72.0		7.5		8.6	
P-7	2000	0.1		6.2		64.6		7.4		7.8	
P-7	2001	0.1		4.3		73.8		7.4		8.1	
P-7	2002	0.4		4.3		81.3		7.3		7.9	
P-7	2003	0.0	**0.2**	5.9	**4.1**	80.4	**74.9**	7.4	**7.3**	7.8	**8.0**
P-8	1996	1.5		2.6		76.0		7.2		7.8	
P-8	1997	0.2		1.8		76.0		7.0		7.6	
P-8	1998	0.1		0.4		78.0		7.0		8.1	
P-8	1999	2.4		2.4		71.0		7.4		8.4	
P-8	2000	0.3		5.6		66.6		7.2		8.0	
P-8	2001	1.5		4.4		70.7		7.3		7.9	
P-8	2002	0.1		0.6		80.4		6.8		8.0	
P-8	2003	0.3	**0.8**	3.1	**2.6**	76.8	**74.4**	7.4	**7.2**	8.0	**8.0**

Appendix 3-C

1995 Purgatory Creek Habitat Survey Data

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-1 Reach Score/Rating 108

County Hennepin Date 10/10/95 Evaluator TEM Classification Good

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow.** 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	**90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system.** 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition Comment: Change in Creek Course from 1997	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat.** 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	**Cold >1'** Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	**3' to 4' 6** 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	**1-2 cfs 6** 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	**5-7. Variety of habitat. Deep riffles and pools.** 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	10	66	16	16

Column Scores **E 10 +G 66 +F 16 +P 16 = 108 = Score**
<70 = Excellent, **71-129 = Good**, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-2 Reach Score/Rating 133

County Hennepin Date 10/10/95 Evaluator TEM Classification Good

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16**
Bank Erosion, Failure	**No evidence of significant erosion or bank failure. Little potential for future problem. 4**	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9**	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel. 9**	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8**	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17**	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	**Cold >1'** Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	**2' to 3' 18** 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	**.5-1 cfs 18** 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	**5-7. Variety of habitat. Deep riffles and pools. 4**	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible. 10**	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	8	56	53	16

Column Scores E 8 +G 56 +F 53 +P 16 **= 133 = Score**
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

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Stream System Habitat Rating Form

Stream Purgatory Reach Location P-3 Reach Score/Rating 173

County Hennepin Date 10/11/95 Evaluator TEM Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** **10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** **16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	**Infrequent, small areas, mostly healed over. Some potential in extreme floods.** **8**	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health.** **9**	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** **10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** **9**	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.** **16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable.** **17**	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' 0 Warm >1.5'	**6" to 1'** **6** 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2'** **24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	**.5-1 cfs** **18** 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	**15-25. Occasional riffle or bend. Bottom contours provide some habitat.** **16**	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	**Common setting, not offensive. Developed but uncluttered area.** **14**	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	53	81	40

Column Scores **E 0 +G 52 +F 81 +P 40 = 173= Score**
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

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Stream System Habitat Rating Form

Stream Purgatory Reach Location P-4 Reach Score/Rating 124

County Hennepin Date 10/11/95 Evaluator TEM Classification Good

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	**No evidence of significant erosion or bank failure. Little potential for future problem.** 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	**90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system.** 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat.** 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	**Cold >1'** Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	**2' to 3' 18** 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	**.5-1 cfs 18** 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	10	62	36	16

Column Scores E10 +G 62 +F 36 +P 16 = 124 = Score
<70 = **Excellent, 71-129** = Good, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-5 Reach Score/Rating 121

County Hennepin Date 10/11/95 Evaluator TEM Classification Good

Rating Item	Category: Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** <u>10</u>	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** <u>16</u>
Bank Erosion, Failure	**No evidence of significant erosion or bank failure. Little potential for future problem.** <u>4</u>	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health.** <u>9</u>	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** <u>10</u>	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition (no point bars, silt deposition)	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel.** <u>9</u>	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** <u>8</u>	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	**30-50% rubble, gravel or other stable habitat. Adequate habitat.** <u>7</u>	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	**Cold >1'** Warm >1.5'	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	**3' to 4'** <u>6</u> 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs** <u>24</u> <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** <u>8</u>	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** <u>10</u>	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	<u>4</u>	<u>77</u>	<u>0</u>	<u>40</u>

Column Scores **E 4 +G 77 +F 0 +P 40 = 121= Score**
<70 = **Excellent, 71-129 = Good,** 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-6 Reach Score/Rating 173

County Hennepin Date 10/12/95 Evaluator TEM Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10	**Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion.** 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	**Infrequent, small areas, mostly healed over. Some potential in extreme floods.** 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health.** 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15.** 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars.** 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable.** 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	**6" to 1' 6** 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2' 24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm>5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs 24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	**Common setting, not offensive. Developed but uncluttered area.** 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	49	60	64

Column Scores E0 +G 49 +F 60 +P 64 = 173= Score
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

Stream System Habitat Rating Form

Stream Purgatory Reach Location P-7 Reach Score/Rating 203

County Hennepin Date 10/12/95 Evaluator TEM Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion 10**	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields), residential (yard debris dumping) 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16**
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	**Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16**	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health. 9	**50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15**	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	**Adequate. Overbank flows rare. W/D ratio 8-15. 10**	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel/sand. 9	**Moderate deposition of new gravel and coarse sand on old and some new bars. 15**	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	**30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16**	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 5	**10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17**	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs (Dry)	Cold >1' Warm >1.5'	6" to 1' 6 10" to 1.5' 6	**3" to 6" 18** 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools (Dry)	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	**<2' 24** <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs 24** <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat. 8**	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	**Common setting, not offensive. Developed but uncluttered area. 14**	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	0	28	111	64

Column Scores **E 0 +G 28 +F 111 +P 64 = 203= Score**
<70 = Excellent, 71-129 = Good, 130-200 = Fair, **>200 = Poor**

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Stream System Habitat Rating Form

Stream Purgatory   Reach Location P-8   Reach Score/Rating 151

County Hennepin   Date 10/12/95   Evaluator TEM   Classification Fair

Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	**Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion** 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any runoff. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads -- Hwy. 212, urban area, farm fields), 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	**Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment).** 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	**Infrequent, small areas, mostly healed over. Some potential in extreme floods.** 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	**70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally health.** 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	**Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7.** 8	Adequate. Overbank flows rare. W/D ratio 8-15. 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	**Some new increase in bar formation, mostly from coarse gravel/sand.** 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	**5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.** 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	**10-30% rubble, gravel or sand or other stable habitat. Habitat (muck) availability less than desirable.** 17	Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' Warm >1.5'	**6" to 1'** 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' Warm >5'	3' to 4' 6 4' to 5' 6	**2' to 3'** 18 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs Warm >5 cfs	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	**<.5 cfs** 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	**7-15. Adequate depth in pools and riffles. Bends provide habitat.** 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	**High natural beauty. Trees, historic site. Some development may be visible.** 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	8	68	35	40

Column Scores E 8 +G 68 +F 35 +P 40 = 151 = Score
<70 = Excellent, 71-129 = Good, **130-200 = Fair**, >200 = Poor

Appendix 3-D

Purgatory Creek Flow and Water Quality Data Used in 1996 Ecological Use Classification

Long-Term Average Flow and Water Quality Data From Purgatory Creek Used in 1996 Ecological Use Classification

Classification Parameter	Station 15	Station 16	Station 17	Station 18
Minimum Flow (cfs)*	3.4	1.2	0.7	0.2
Water Quality				
Minimum Dissolved Oxygen (mg/L)*	7.3	5.4	3.5	1.6
Maximum Temperature (°F)	73	74	72	71
pH (S.U.) Range of Values	6.7-9.5	6.6-9.2	5.9-8.9	6.6-8.8
Toxicities	<acute	<acute	<acute	<acute
Period of Record	1972-1994	1972-1994	1972-1994	1972-1994

Determination of Representative Flow Values for Purgatory Creek For 1996 Ecological Use Classification

Gaging Station (Present 1995 Study)		Nearby Routine Monitoring Station (1972-1994)			Ratio of Current Discharge at Corresponding Stations (Present 1995 Study:Routine Monitoring Program)	Representative Low Flow at Present Study Gaging Station (cfs)***
Location	Current* Discharge (cfs)	Location	Current* Discharge	Mean Annual Low Flow** (cfs)		
P-1	37.8	15	38.5	3.4	0.98	3.3 (P-1)
P-2	16.4	16	23.6	1.2	0.69	0.8 (P-2)
P-3	27.6	16	23.6	1.2	1.17	1.4 (P.3)
P-4	22.1	16	23.6	1.2	0.94	1.1 (P-4)
P-5	18.9	16	23.6	1.2	0.80	1.0 (P-5)
P-6	18.6	17	19.5	0.7	0.95	0.7 (P-6)
P-7	3.7	18	12.2	0.2	0.30	0.1 (P-7)
P-8	5.0	18	12.2	0.2	0.41	0.1 (P-8)

*Flows were measured on 11/1-11/2/95

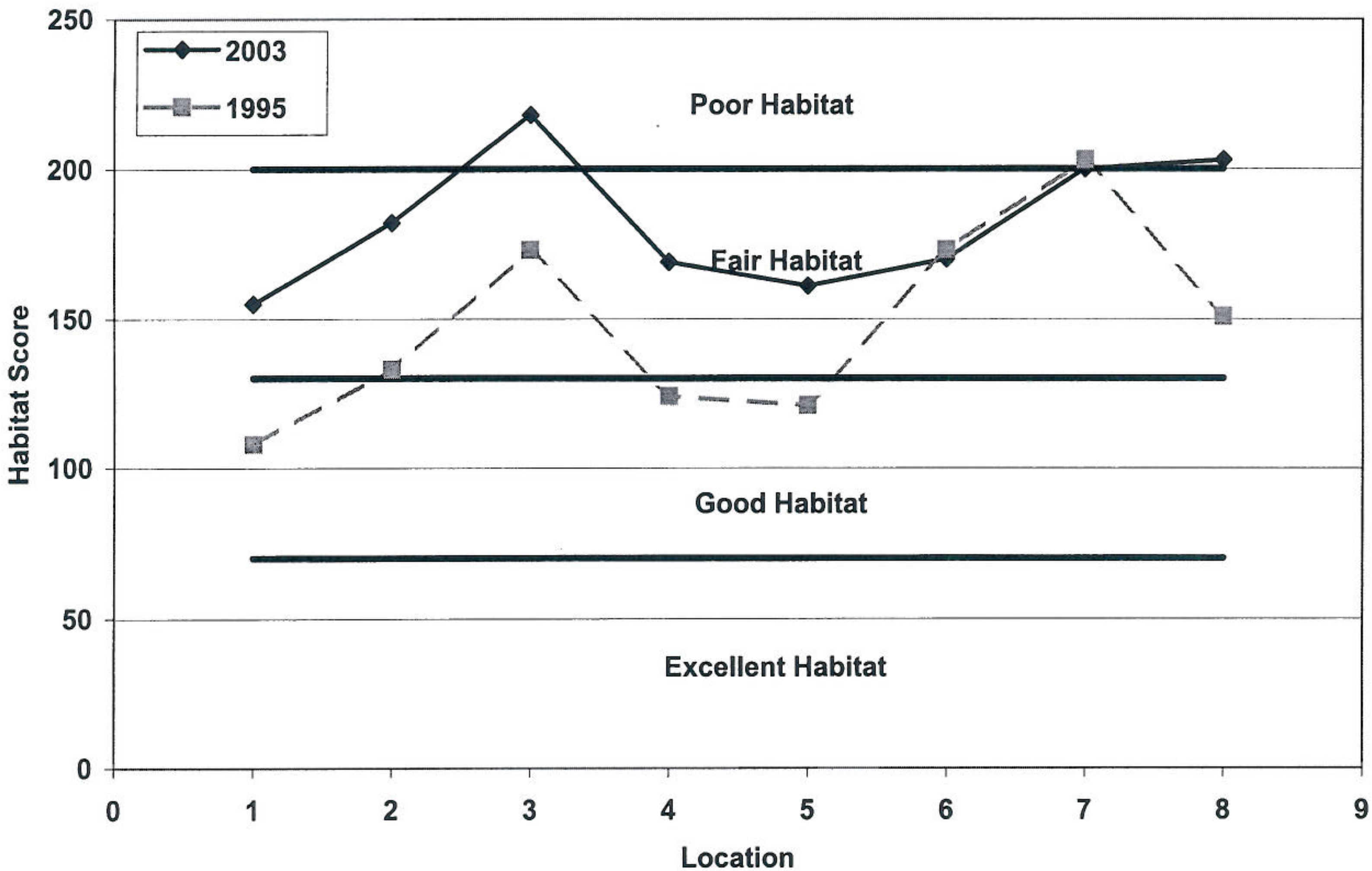
**Determined at nearby historical station by averaging annual low flow values throughout the period of record.

***Determined by multiplying the ratio and the mean annual flow.

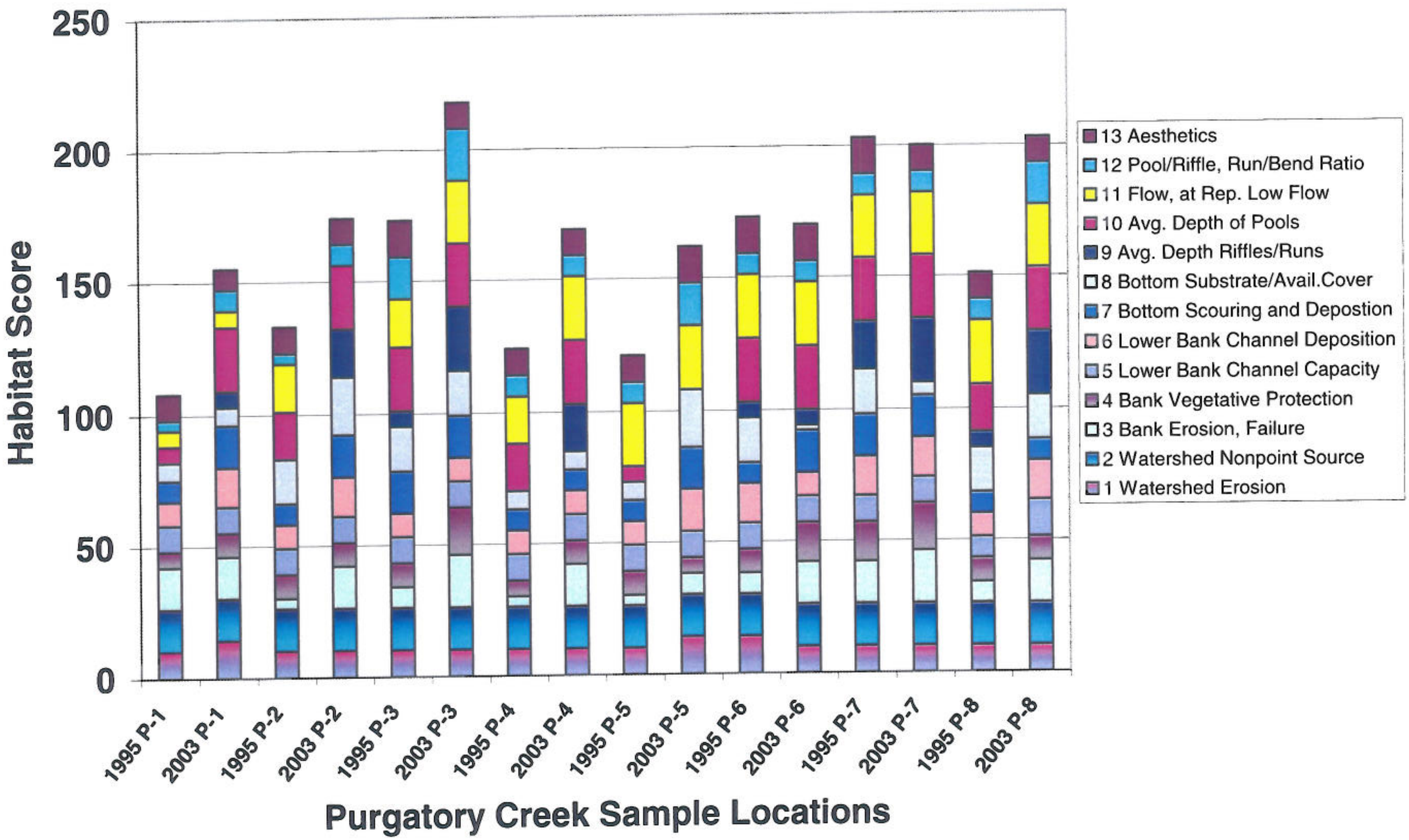
Appendix 3-E

Comparison of 1995 and 2003 Purgatory Creek Habitat Data

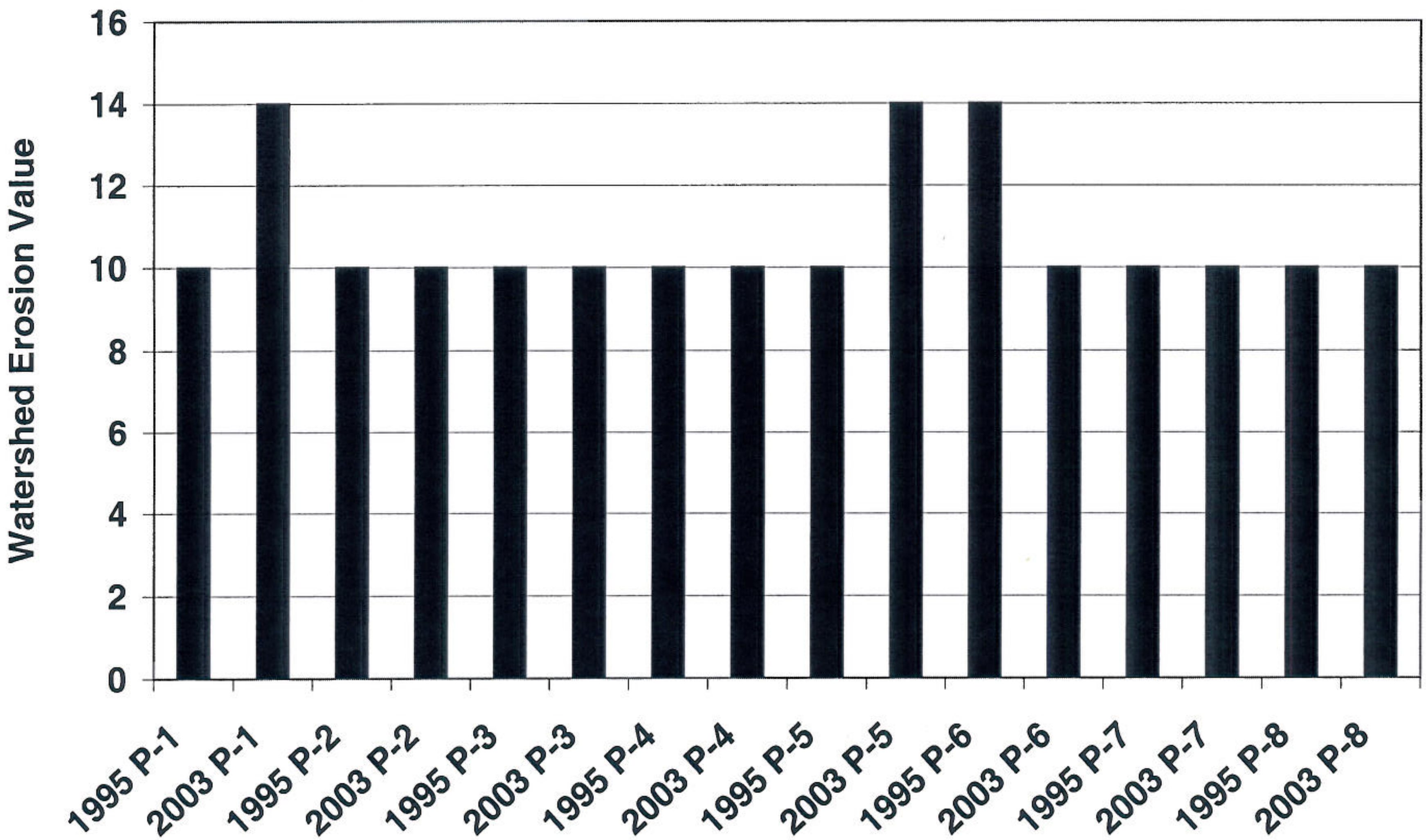
Purgatory Creek Habitat: 2003 and 1995



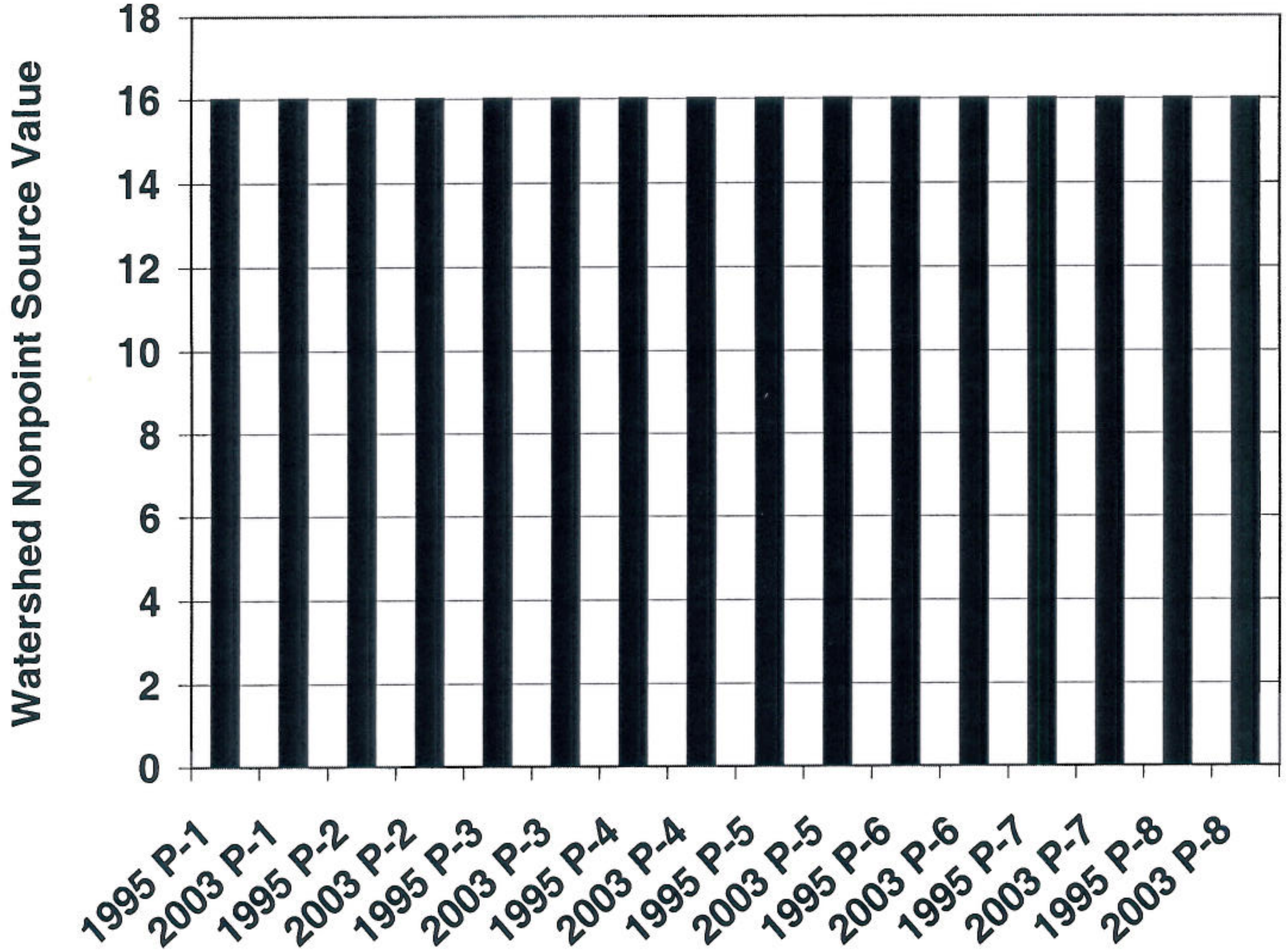
Purgatory Creek Habitat: 1995 and 2003



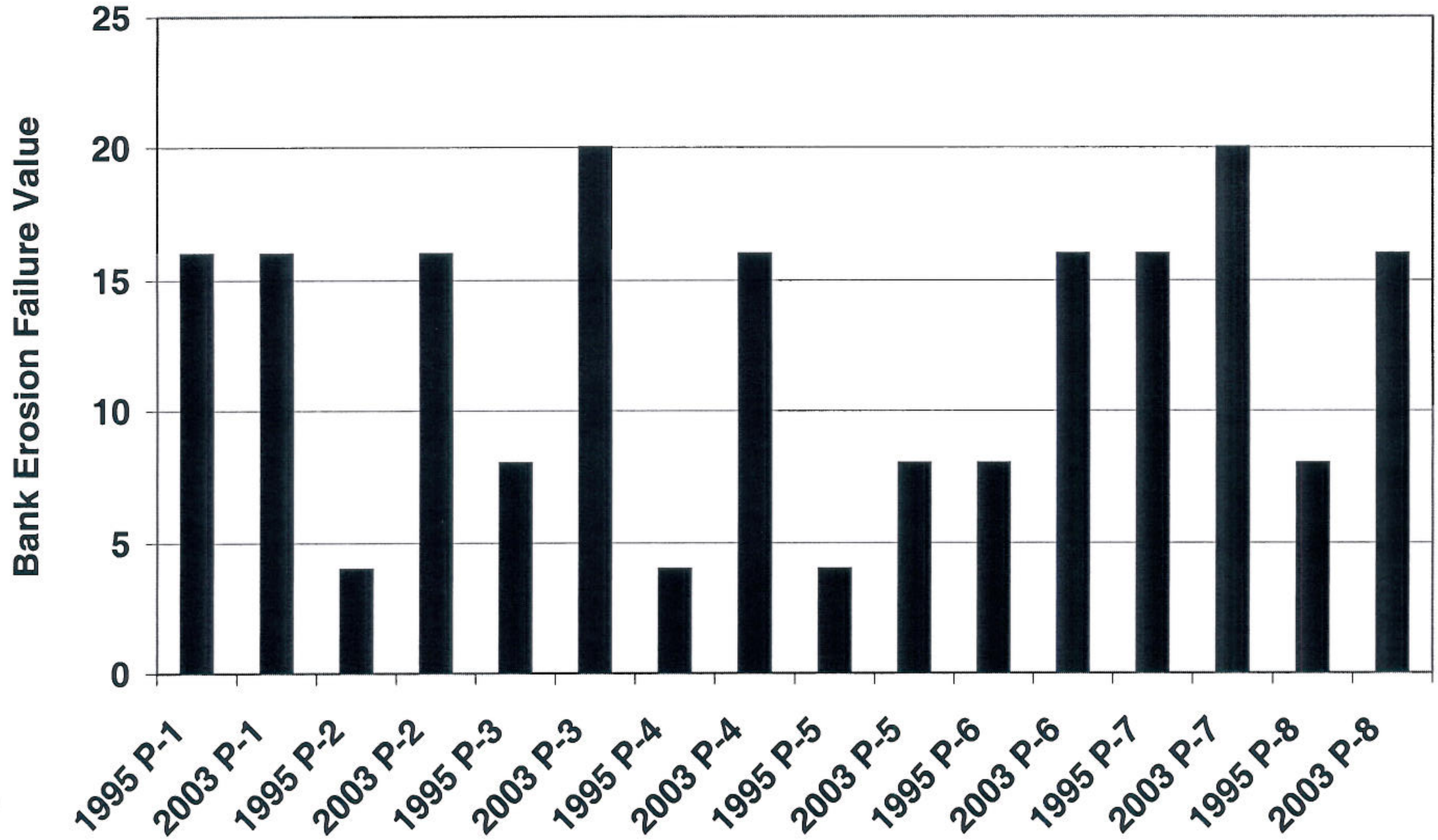
Purgatory Creek Watershed Erosion



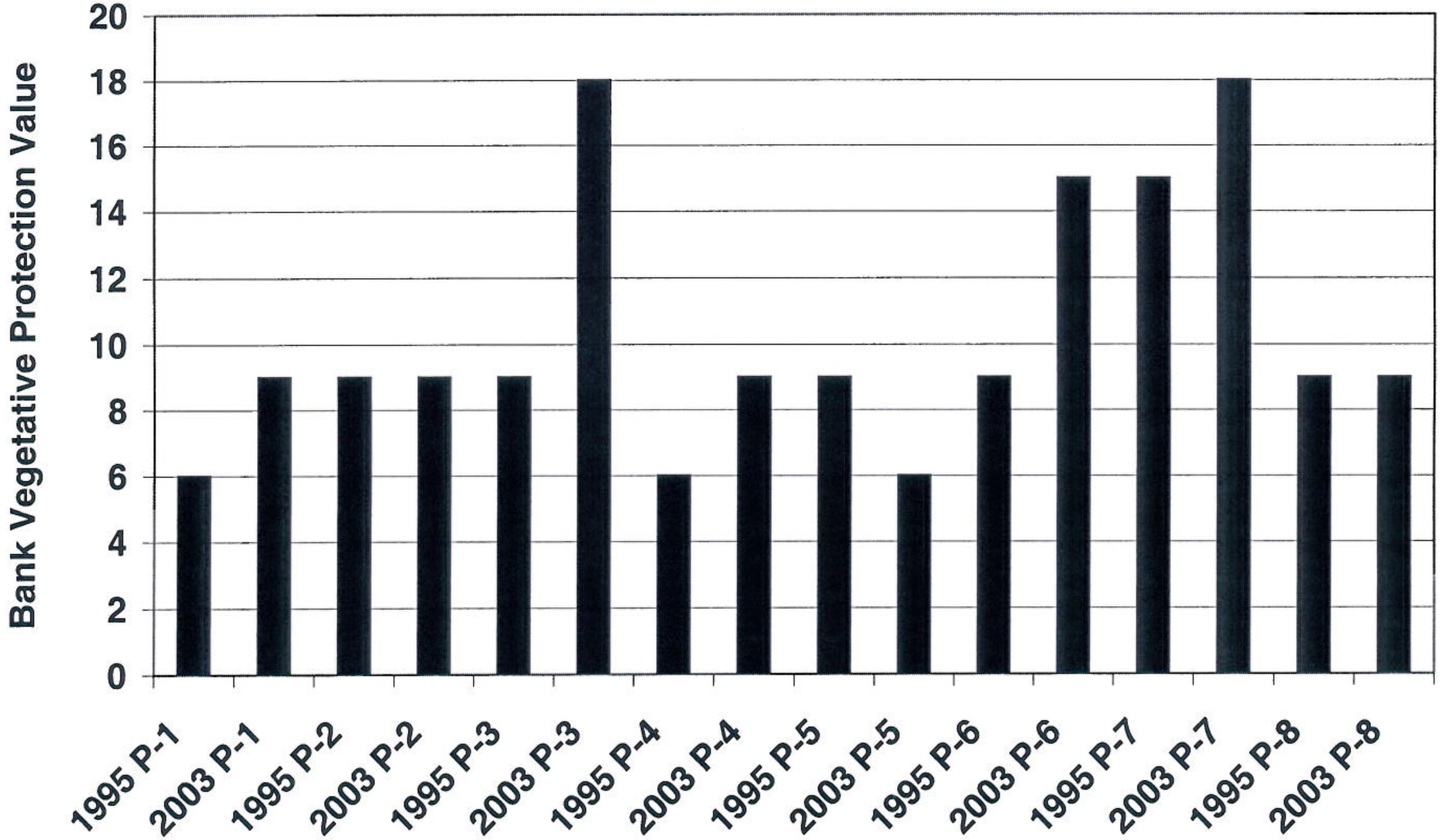
Purgatory Creek Watershed Nonpoint Source



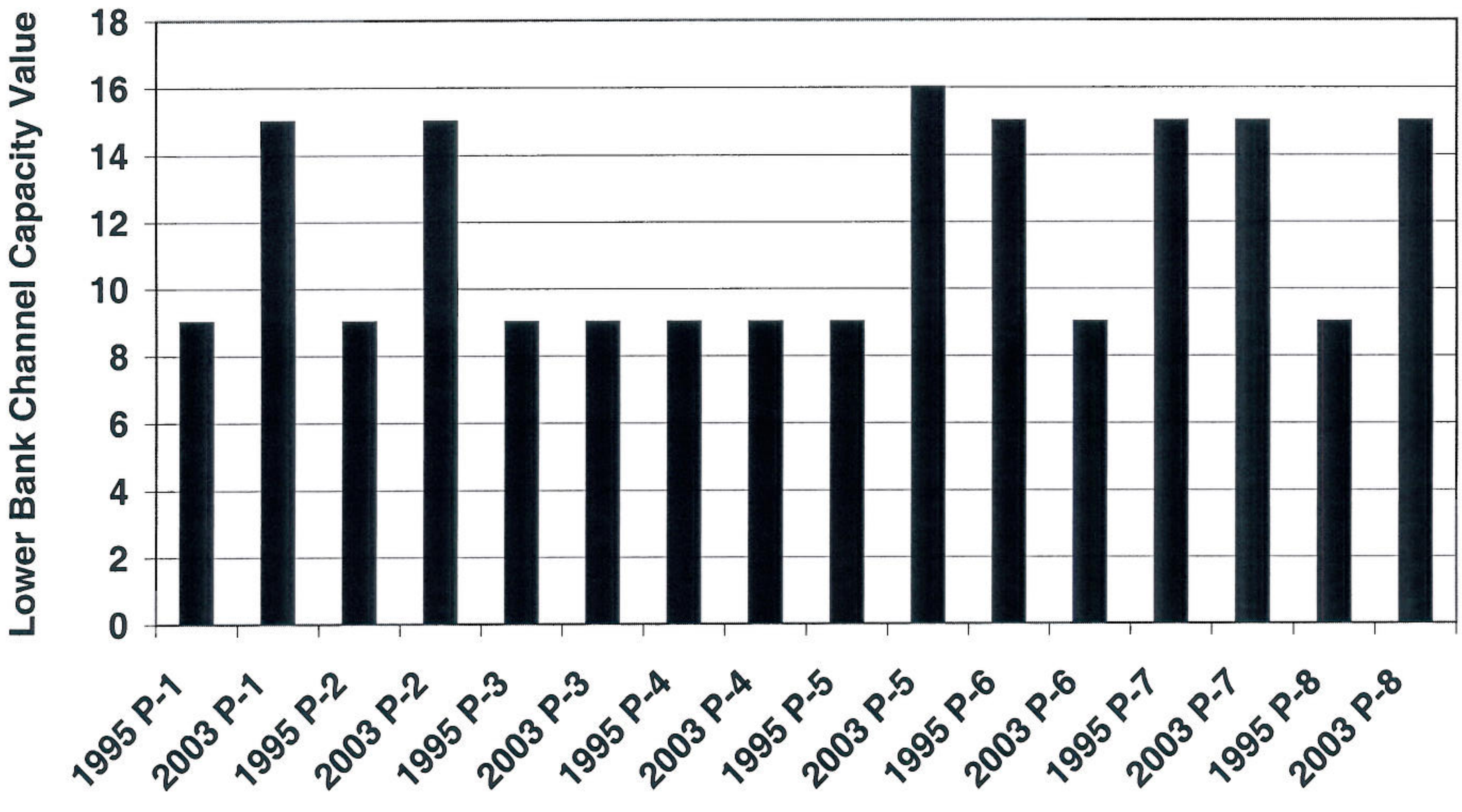
Purgatory Creek Bank Erosion Failure



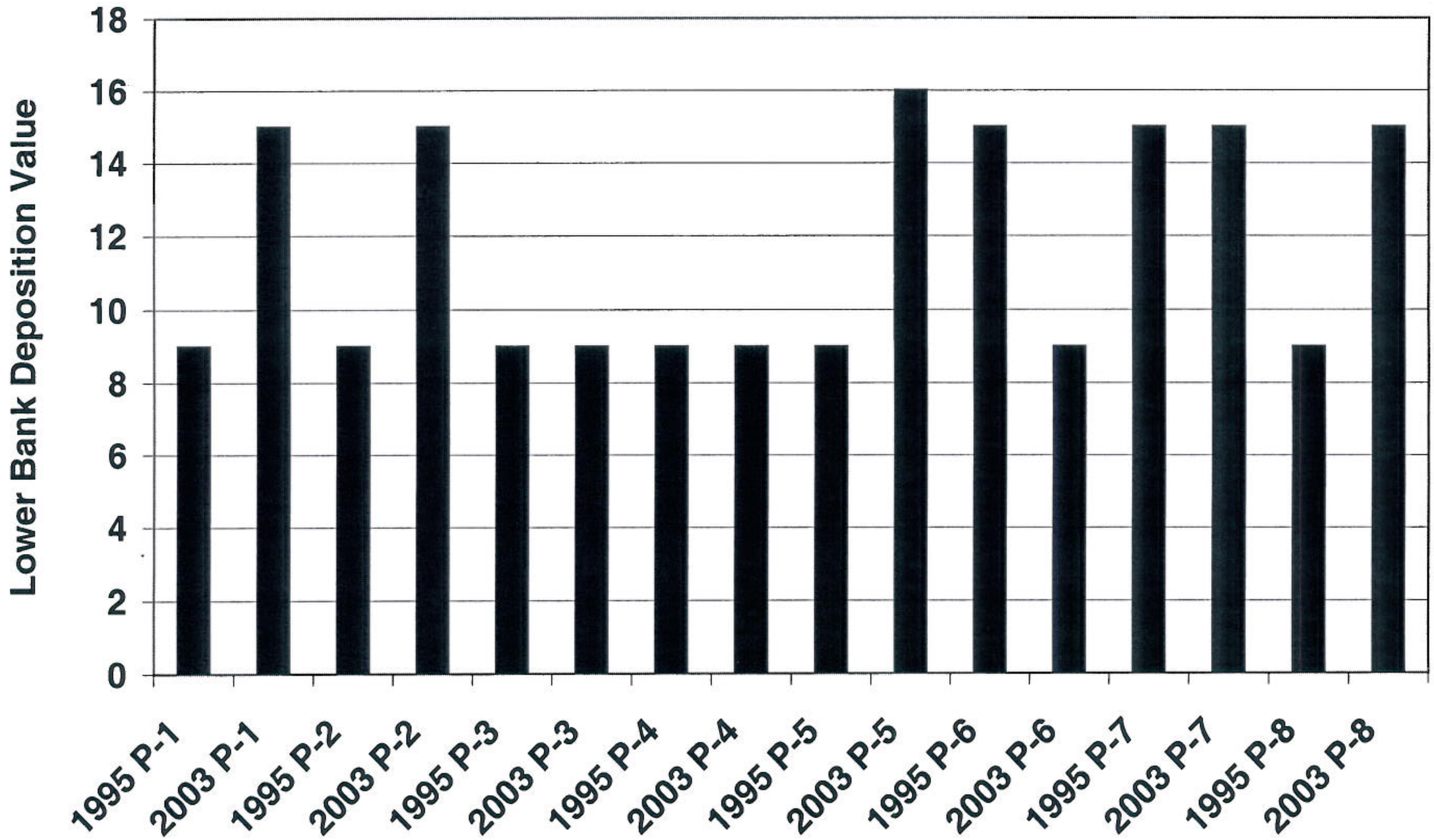
Purgatory Creek Bank Vegetative Protection



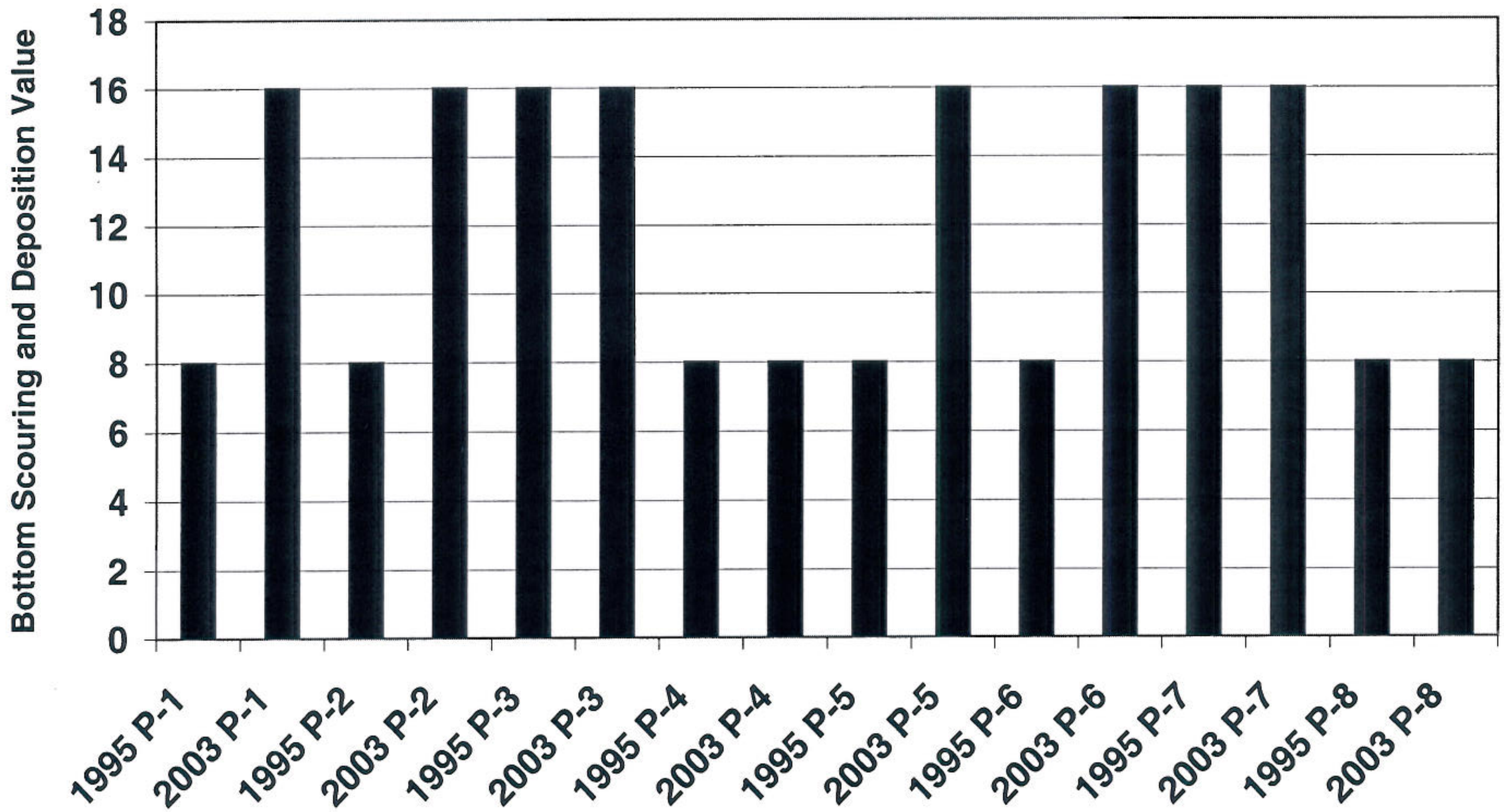
Purgatory Creek Lower Bank Channel Capacity



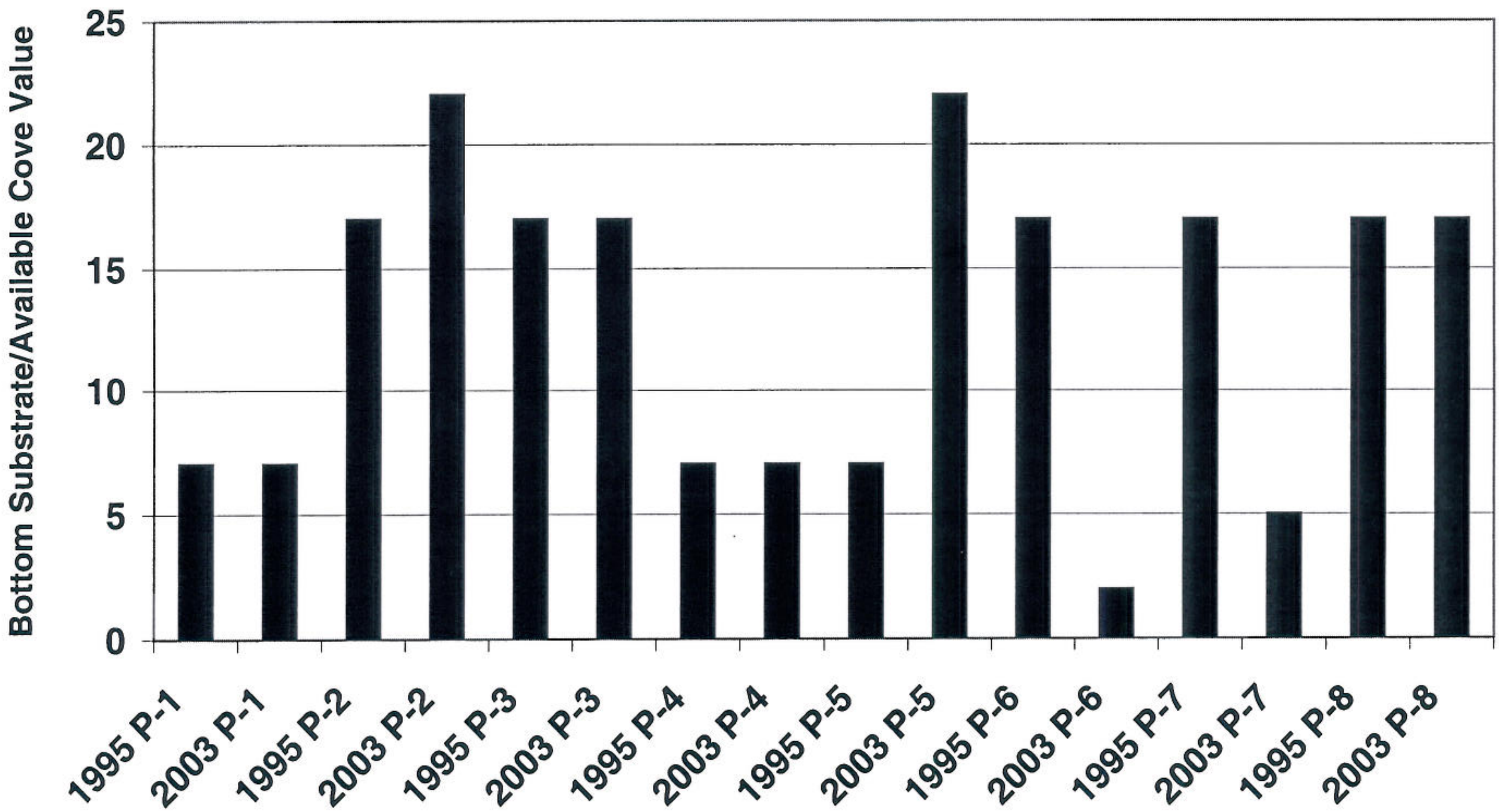
Purgatory Creek Lower Bank Deposition



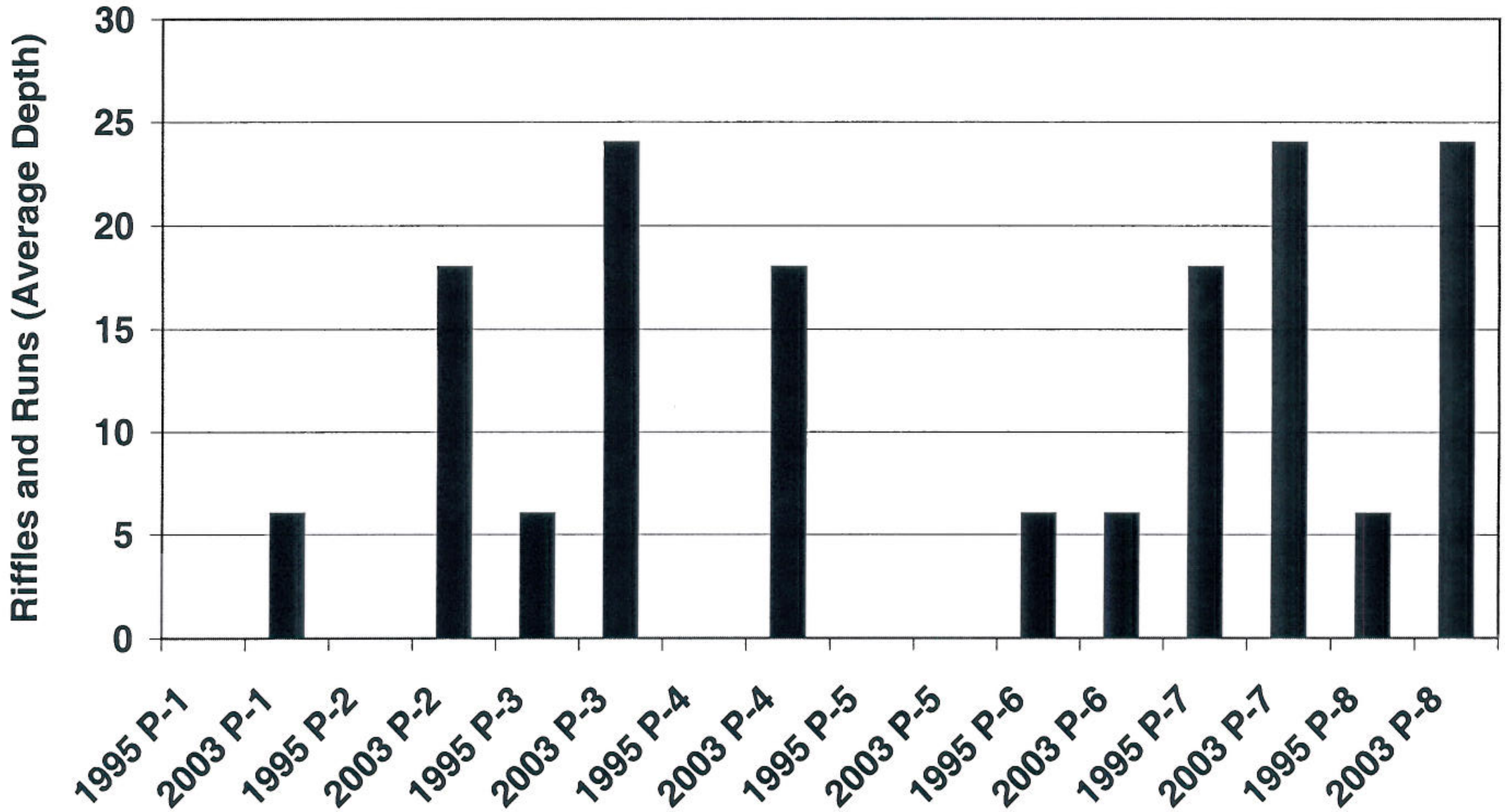
Purgatory Creek Bottom Scouring and Depostion



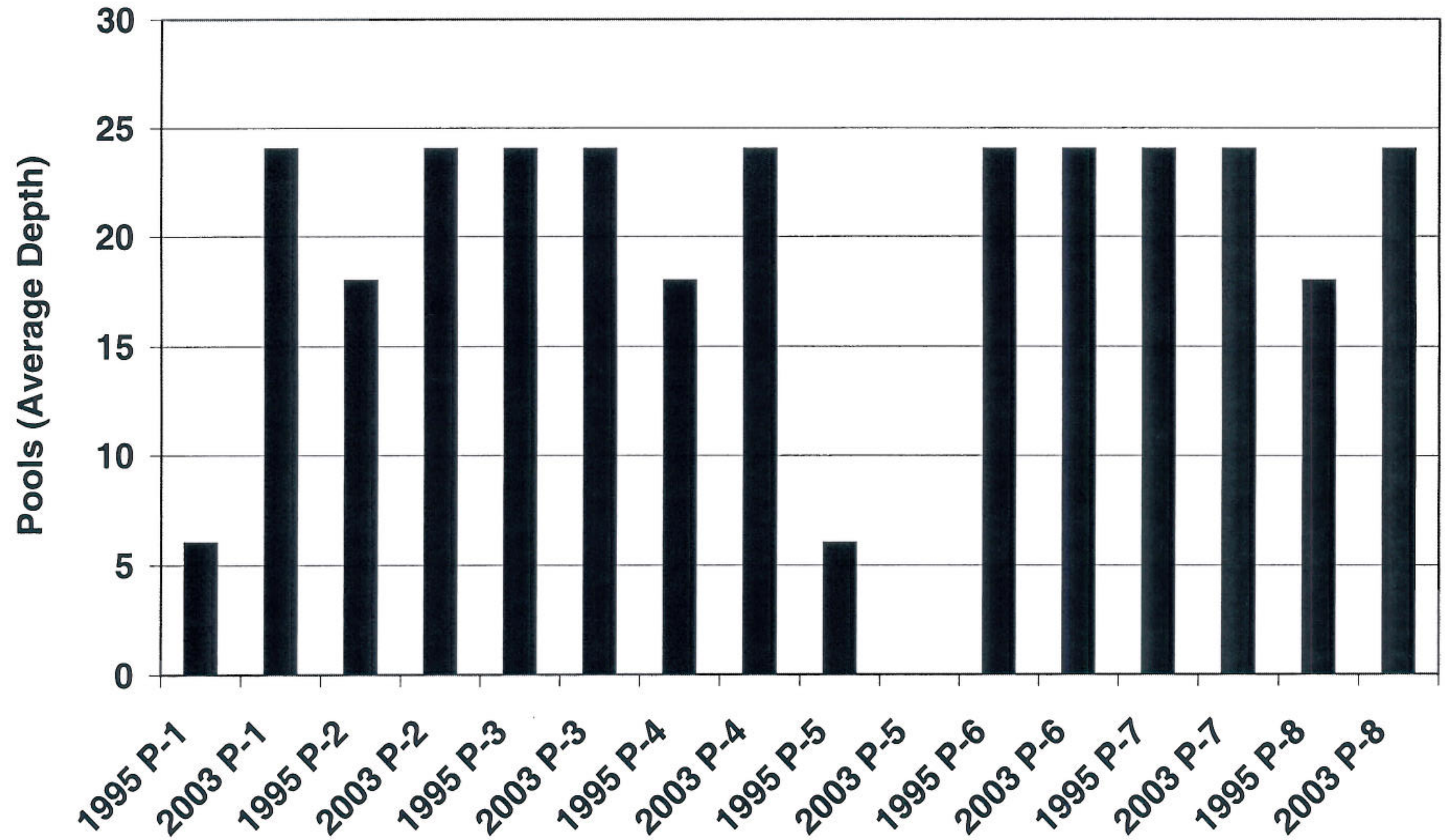
Purgatory Creek Bottom Substrate/Available Cover



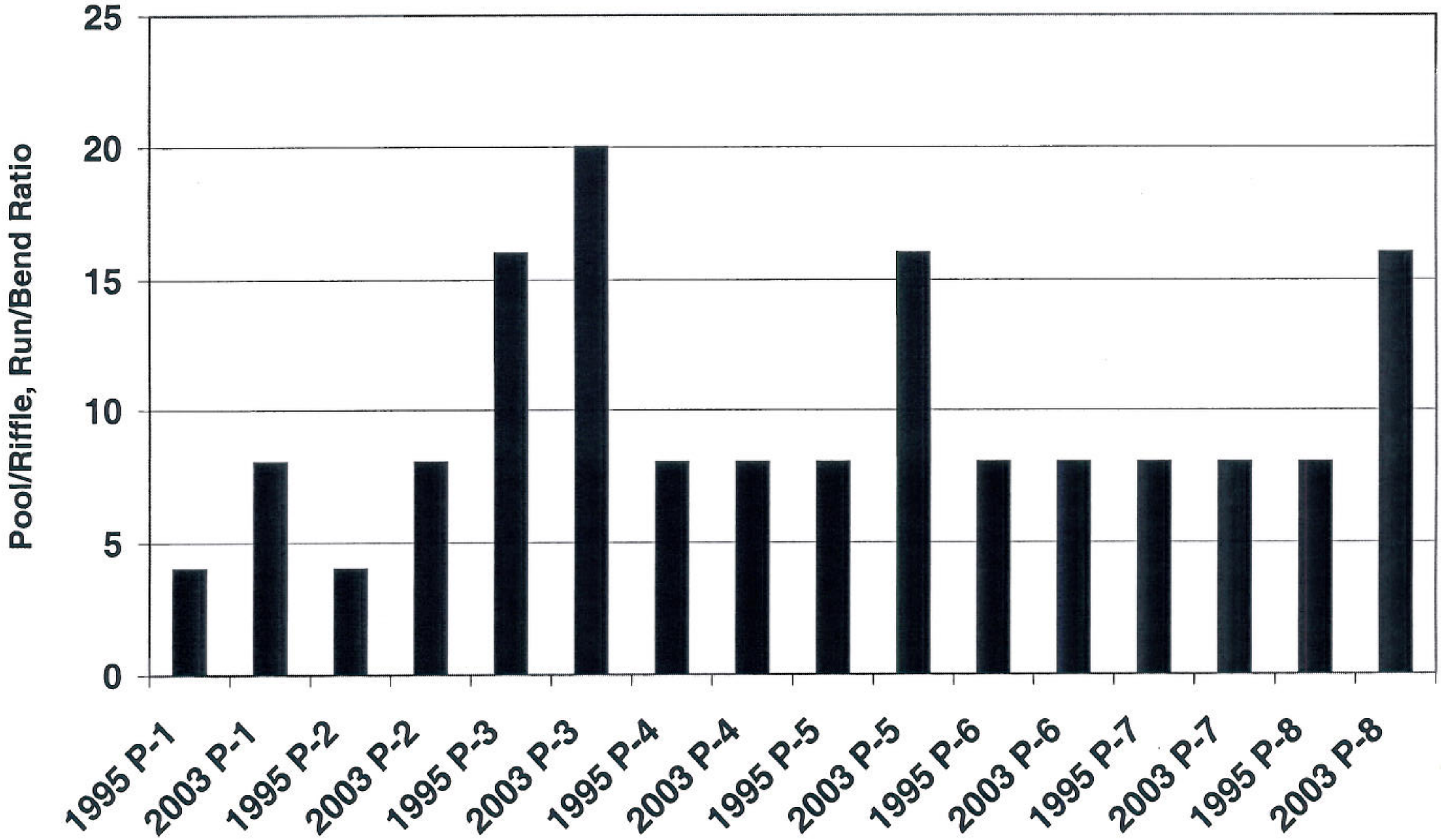
Purgatory Creek Riffles and Runs (Average Depth)



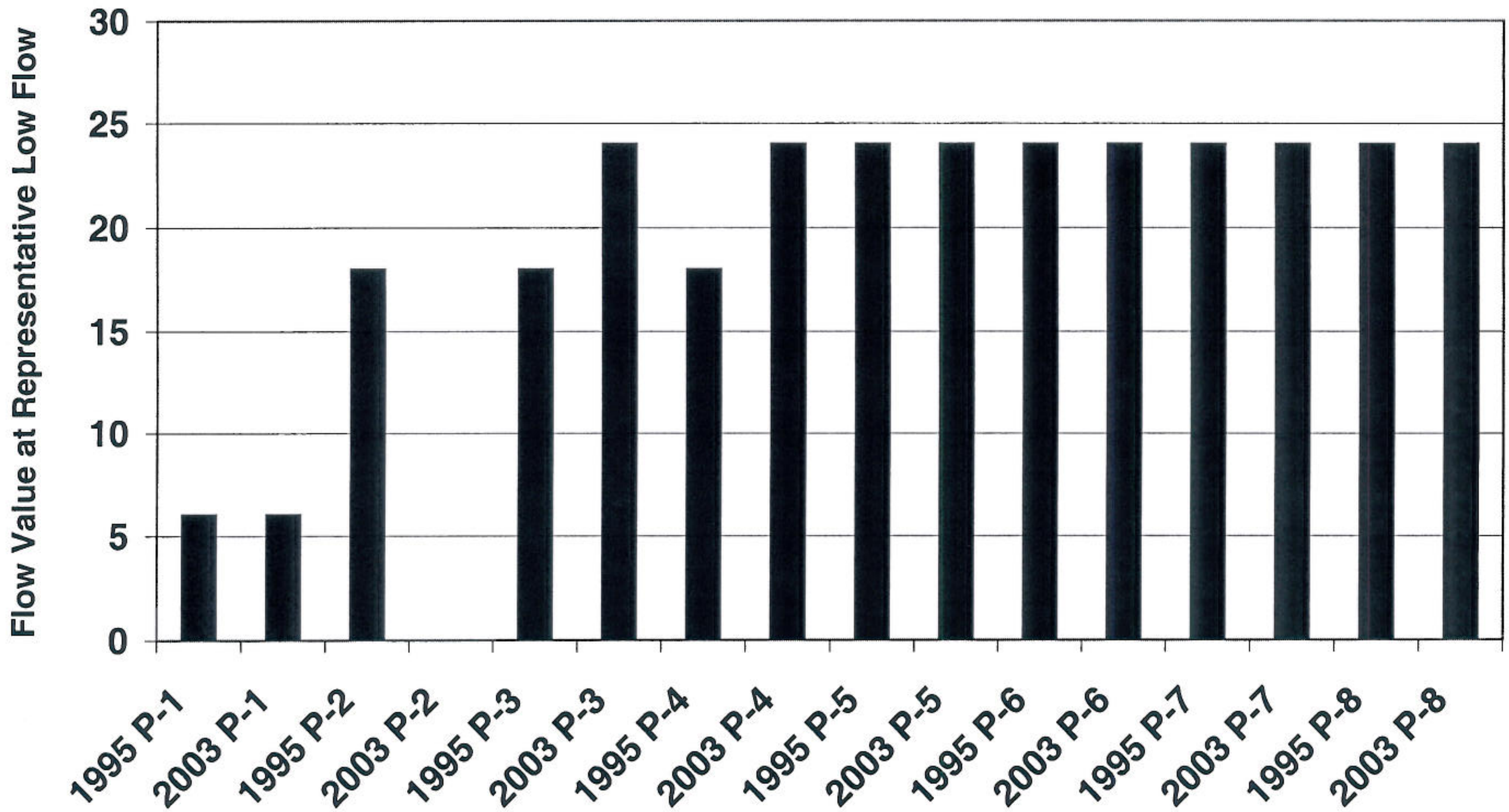
Purgatory Creek Pools (Average Depth)



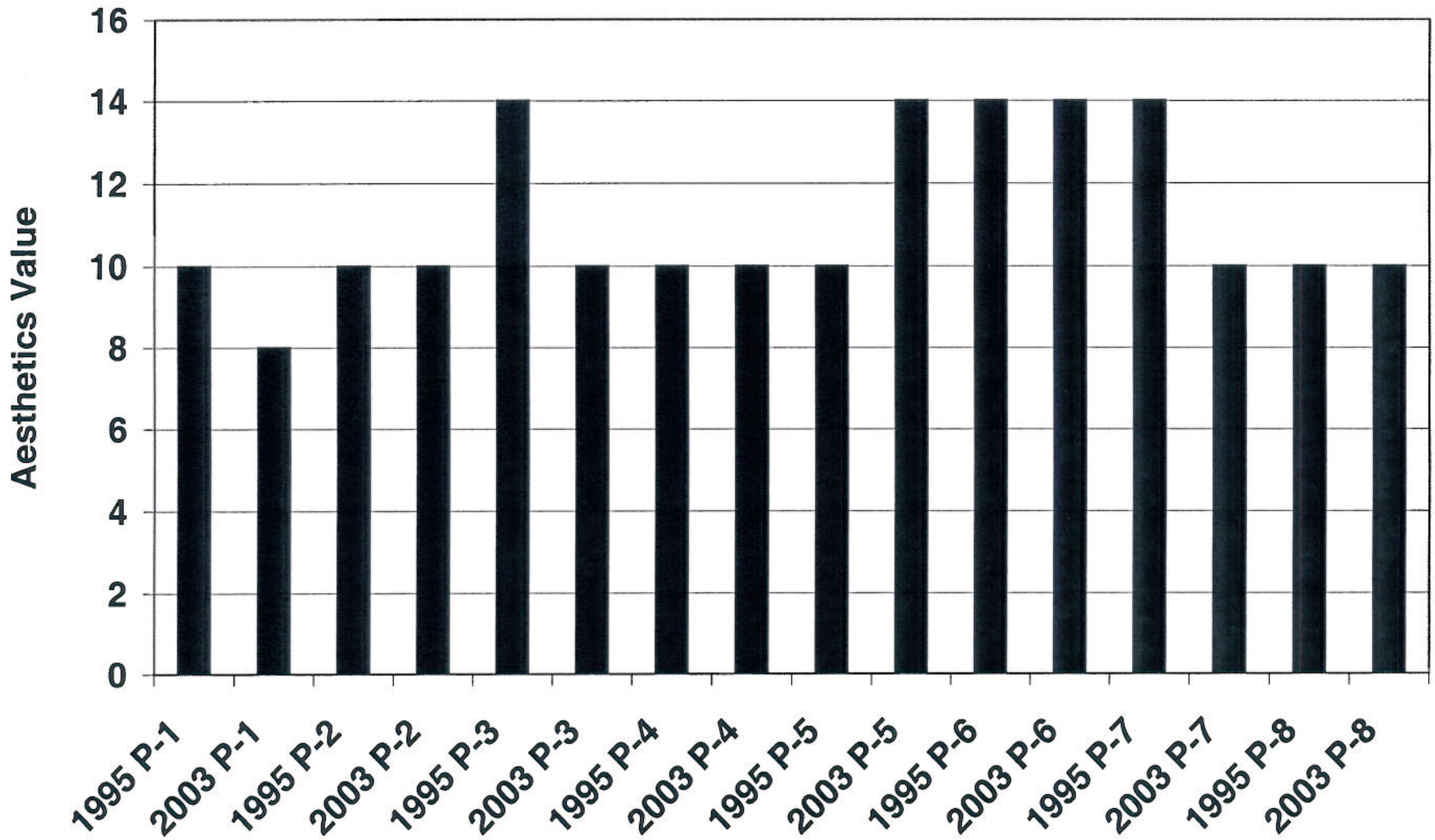
Purgatory Creek Pool/Riffle, Run/Bend Ratio



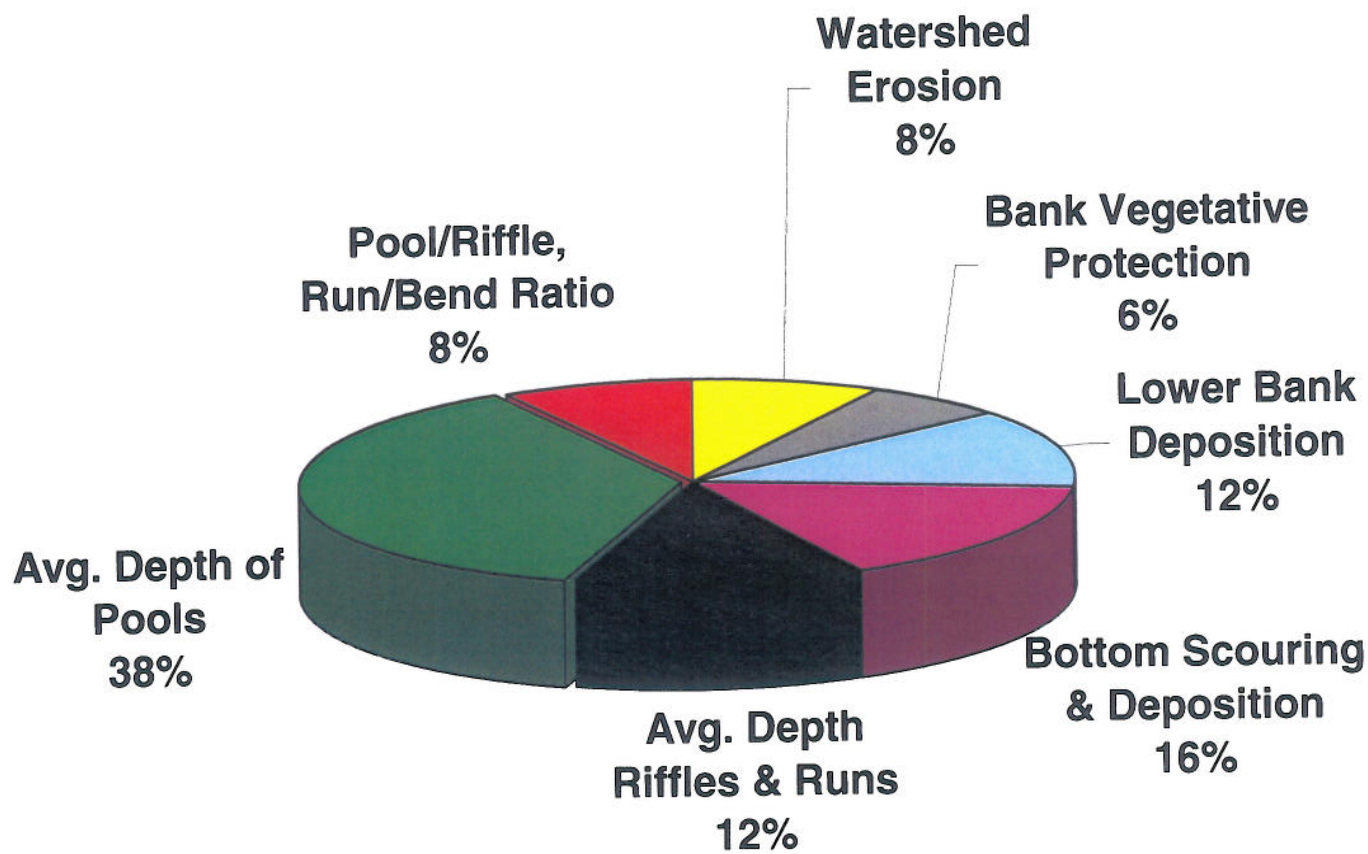
Purgatory Creek Flow at Representative Low Flow



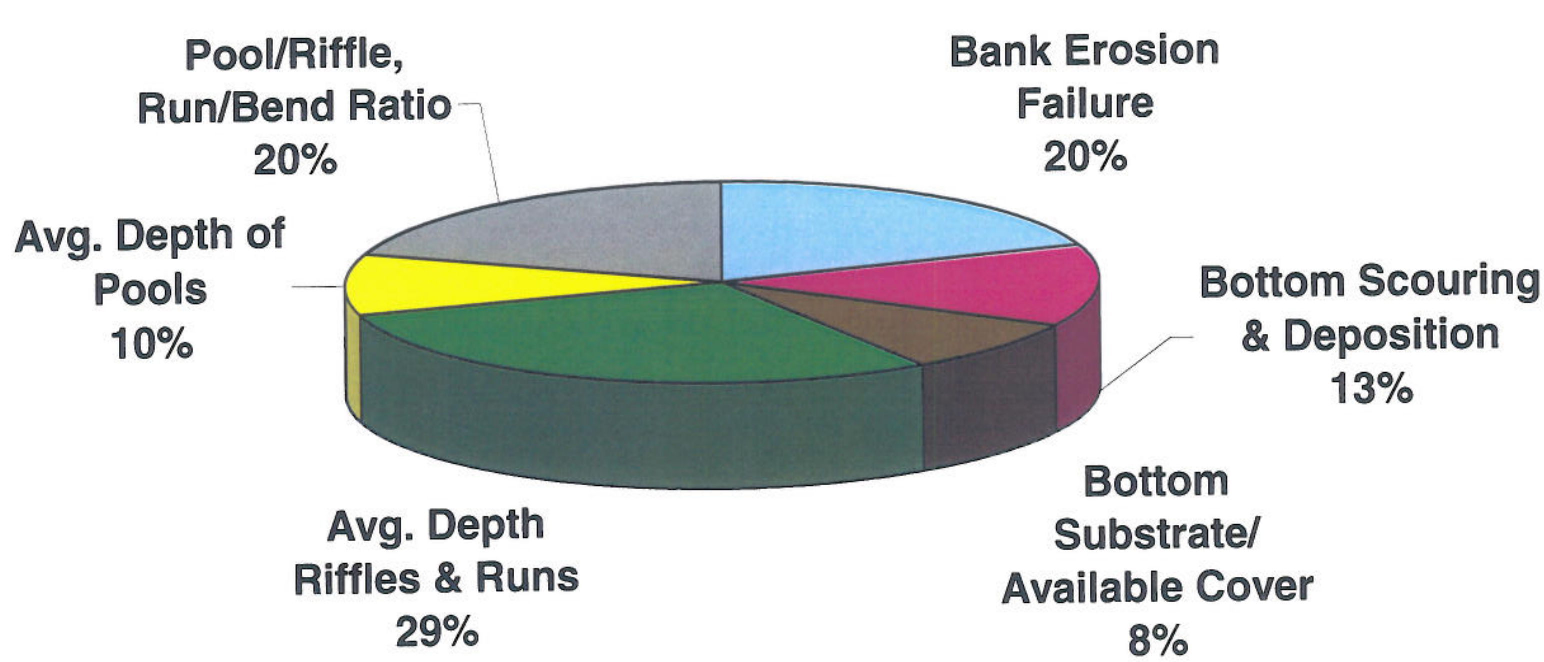
Purgatory Creek Aesthetics



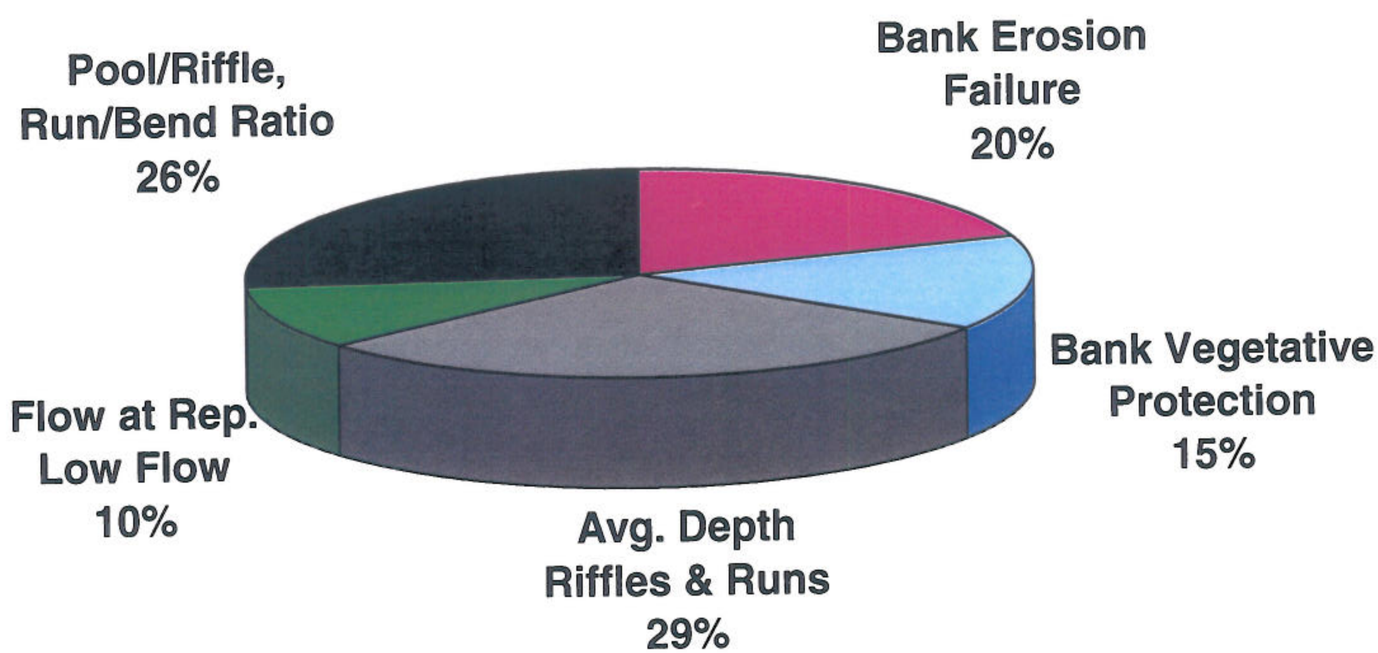
P-1 Habitat Degradation in 2003: Percent of Total



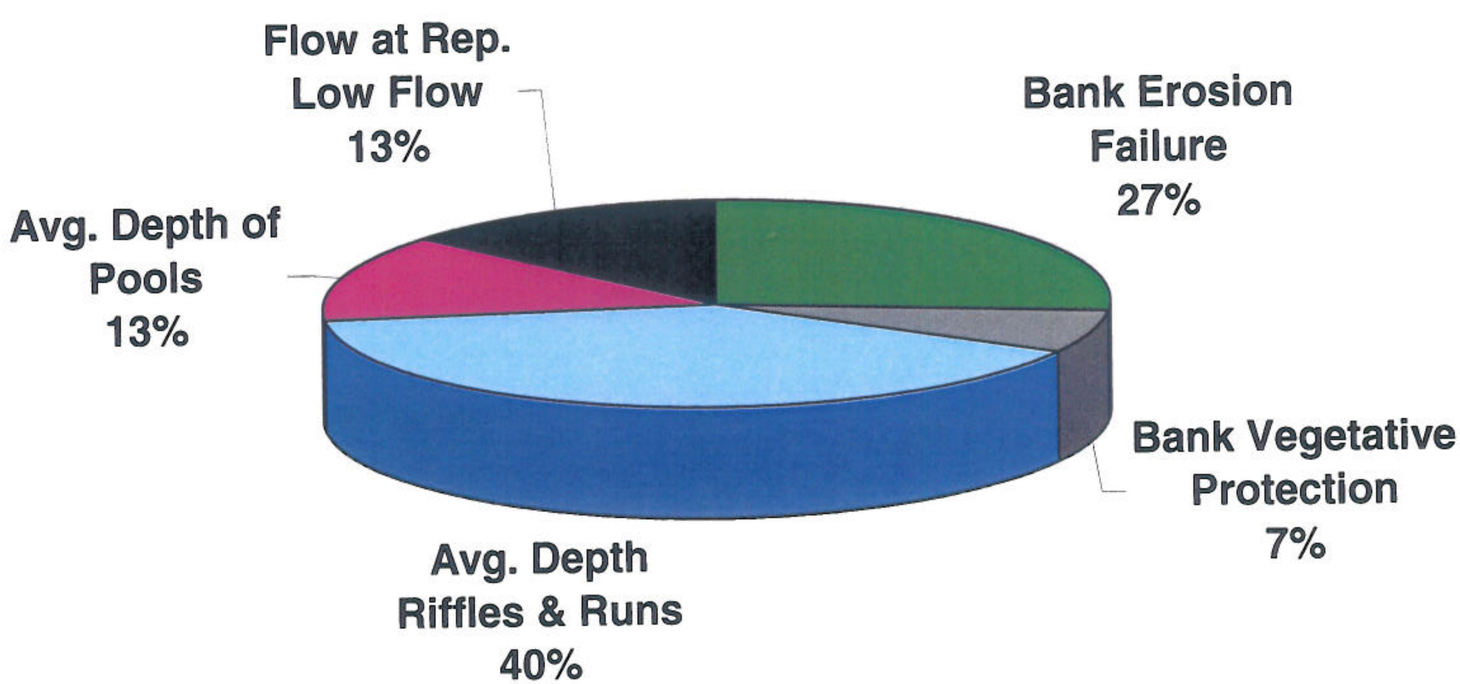
P-2 Habitat Degradation in 2003: Percent of Total



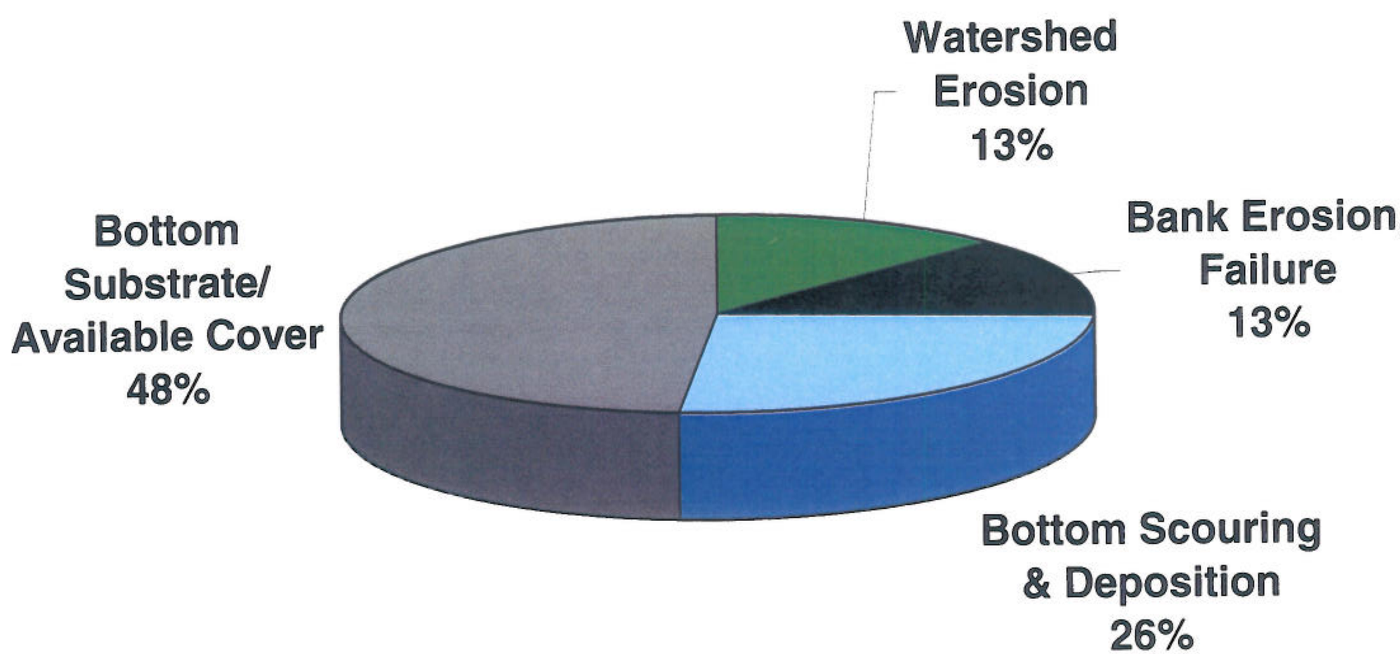
P-3 Habitat Degradation in 2003: Percent of Total



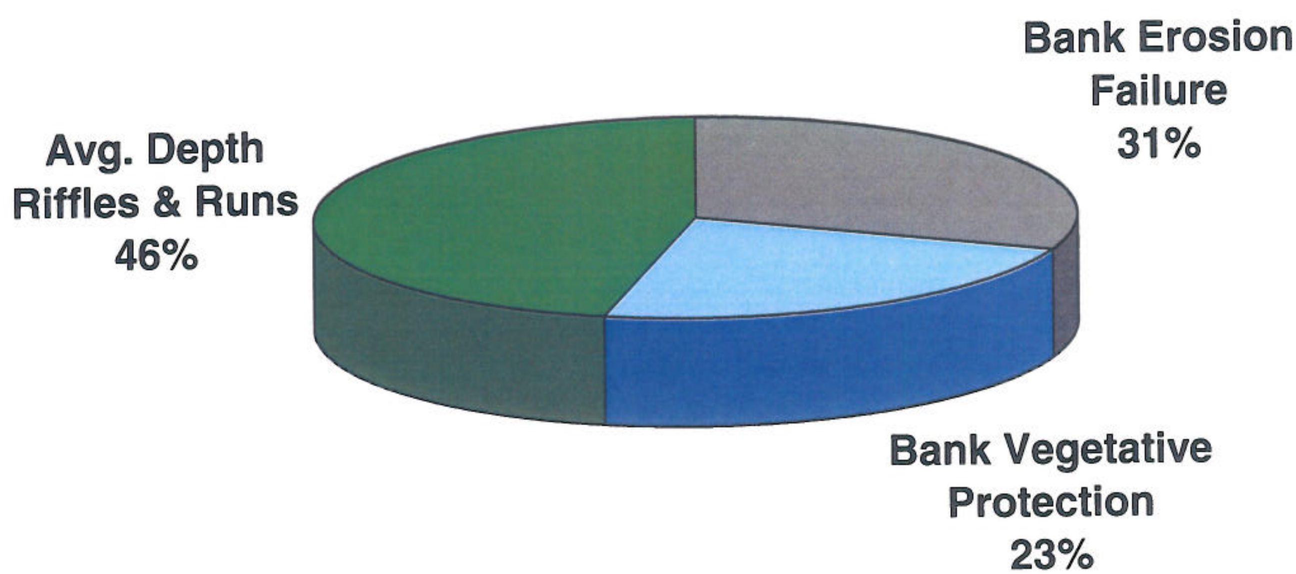
P-4 Habitat Degradation in 2003: Percent of Total



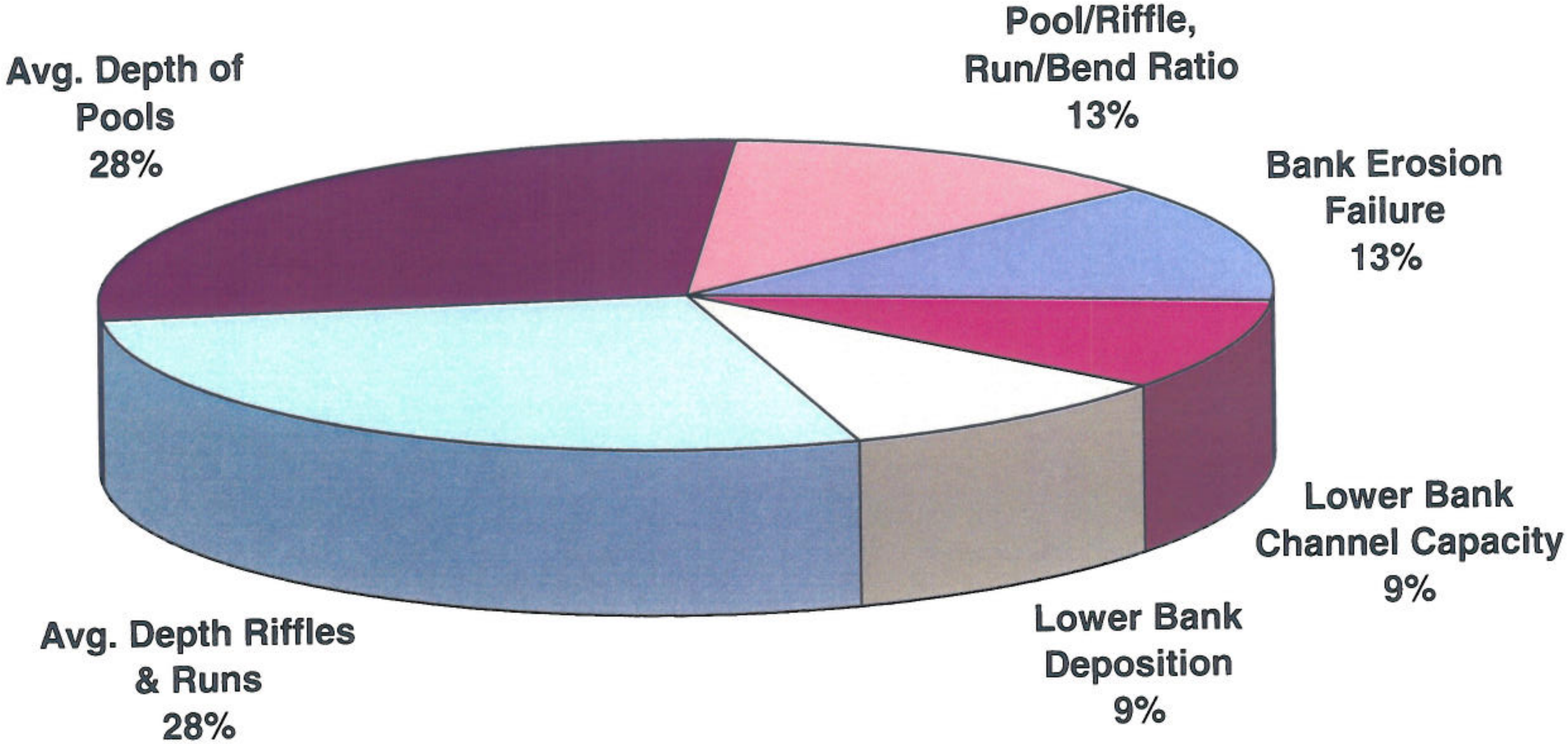
P-5 Habitat Degradation in 2003: Percent of Total



P-7 Habitat Degradation in 2003: Percent of Total



P-8 Habitat Degradation in 2003: Percent of Total



1996-2003 Purgatory Creek Habitat Changes % of Habitat Degradation Caused by Climatic Effects

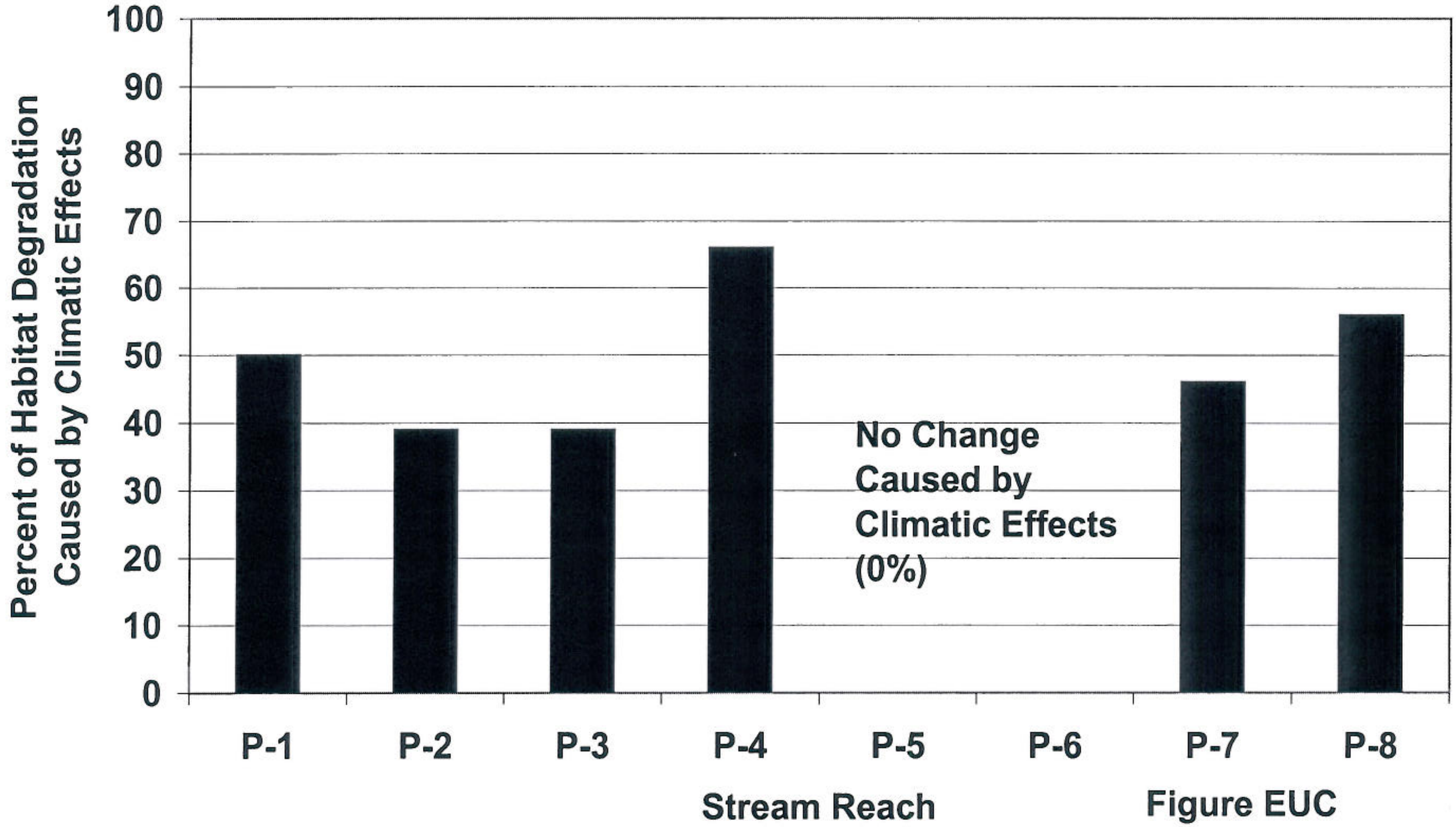
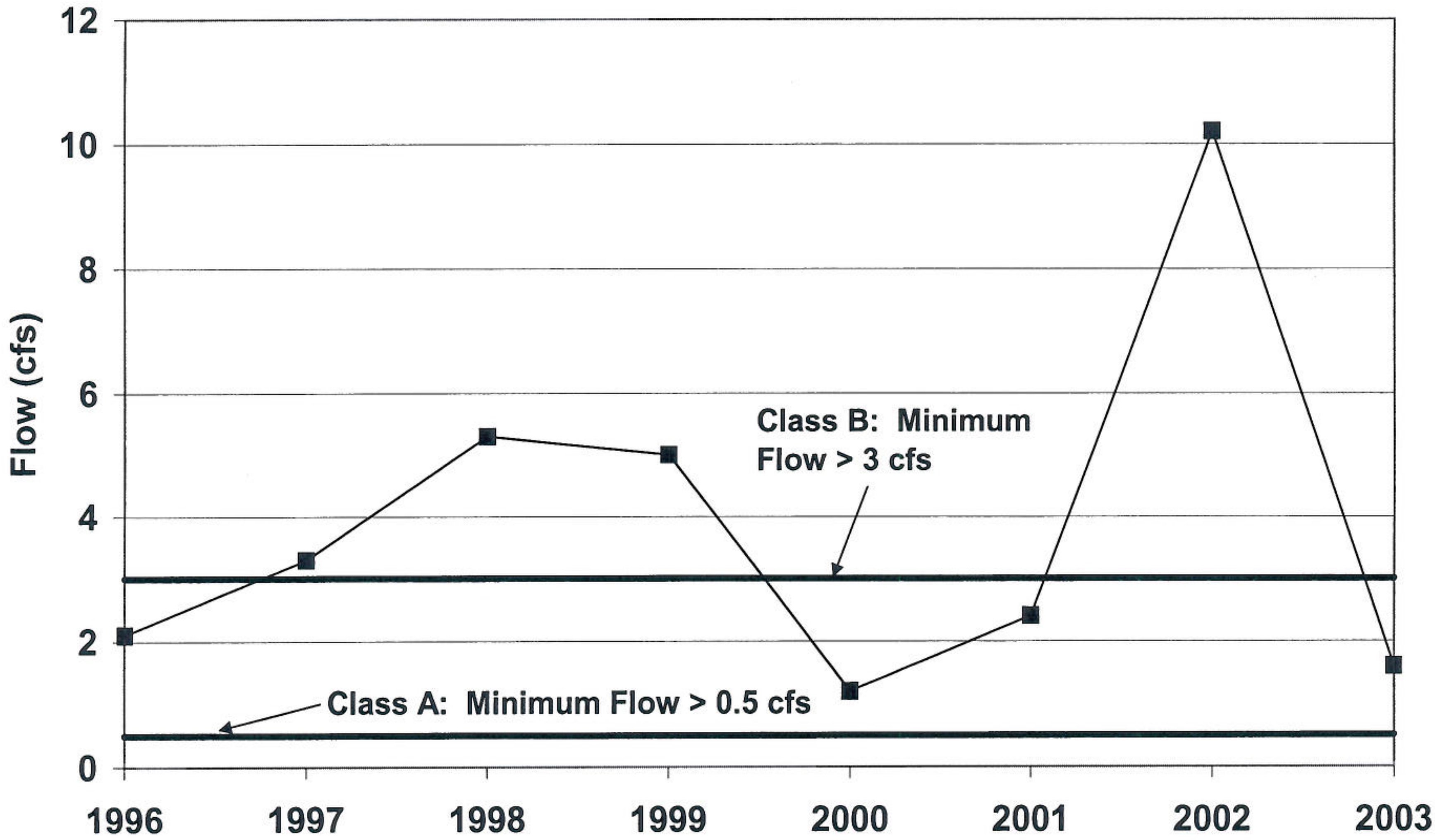


Figure EUC

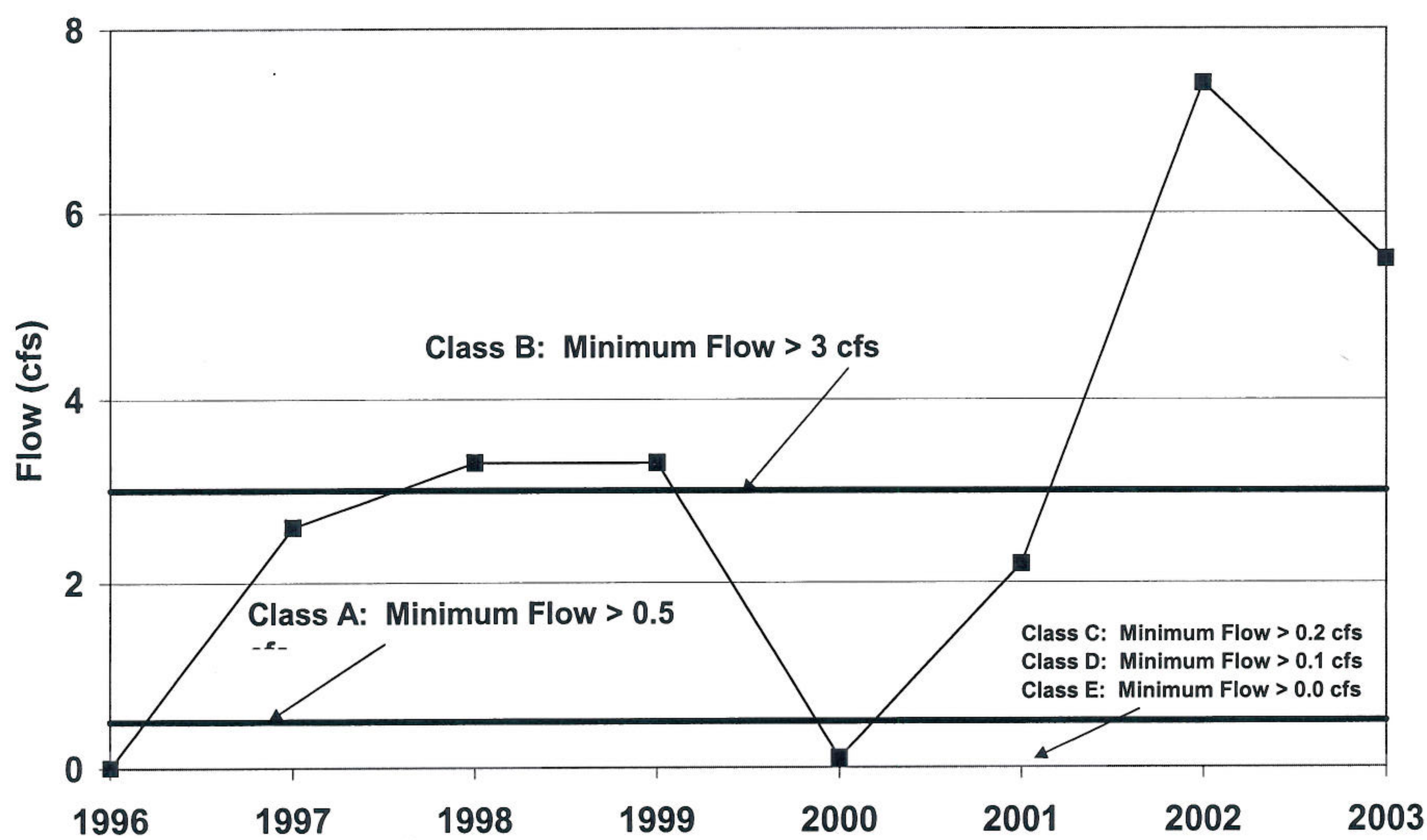
Appendix 3-F

1996-2003 Purgatory Creek Minimum Flow Data

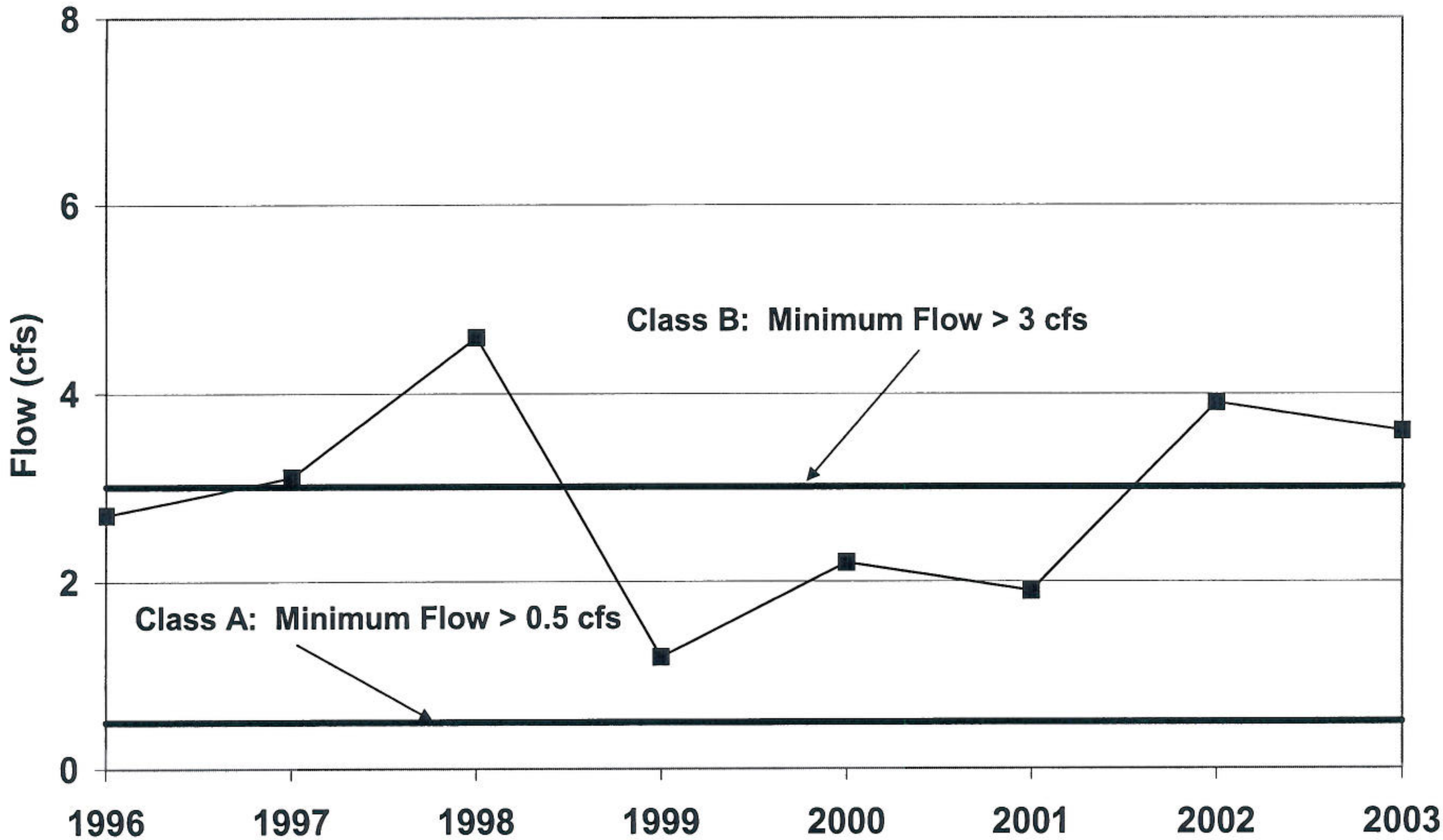
P-1: 1996-2003 Minimum Flow



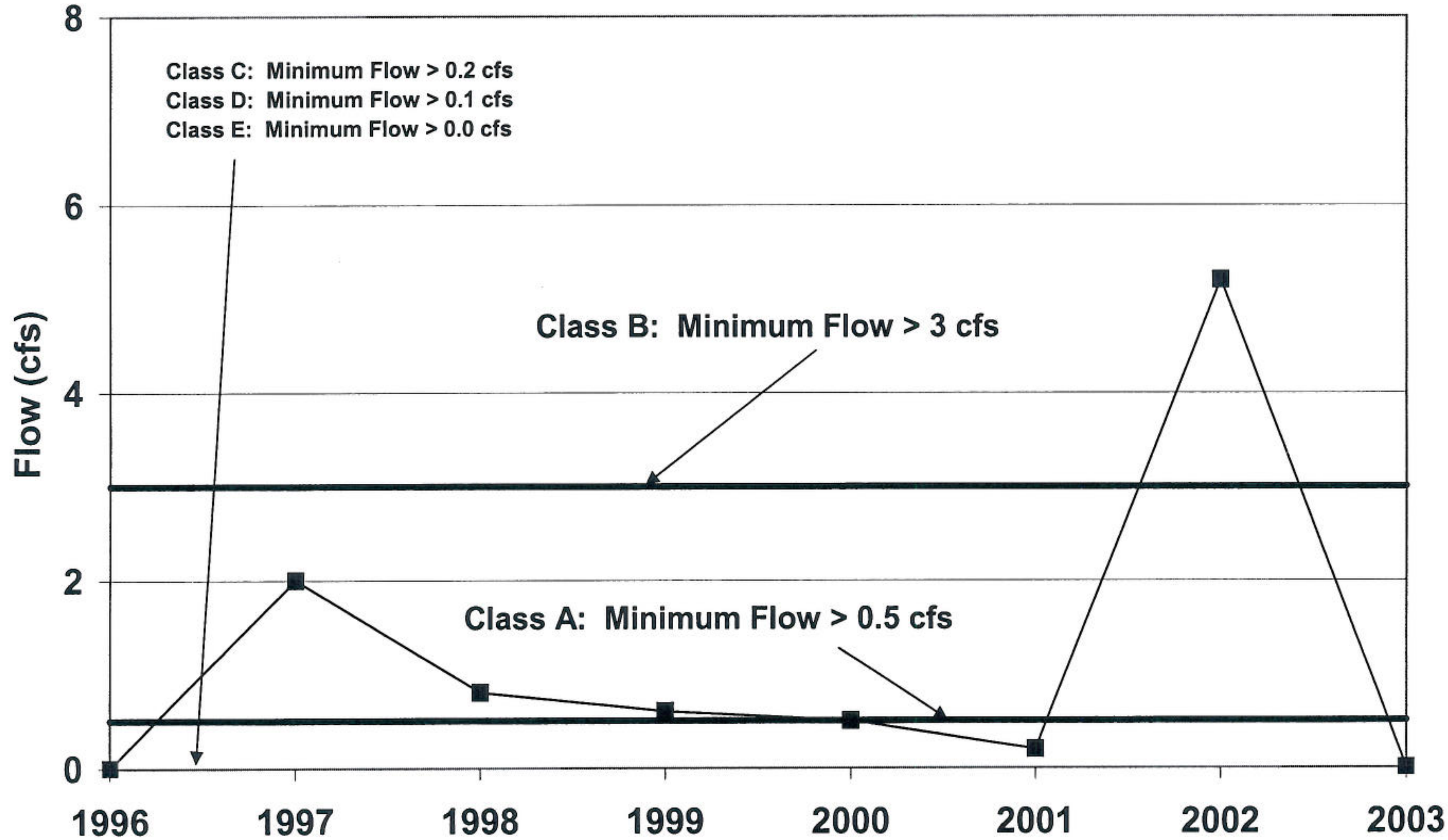
P-2: 1996-2003 Minimum Flow



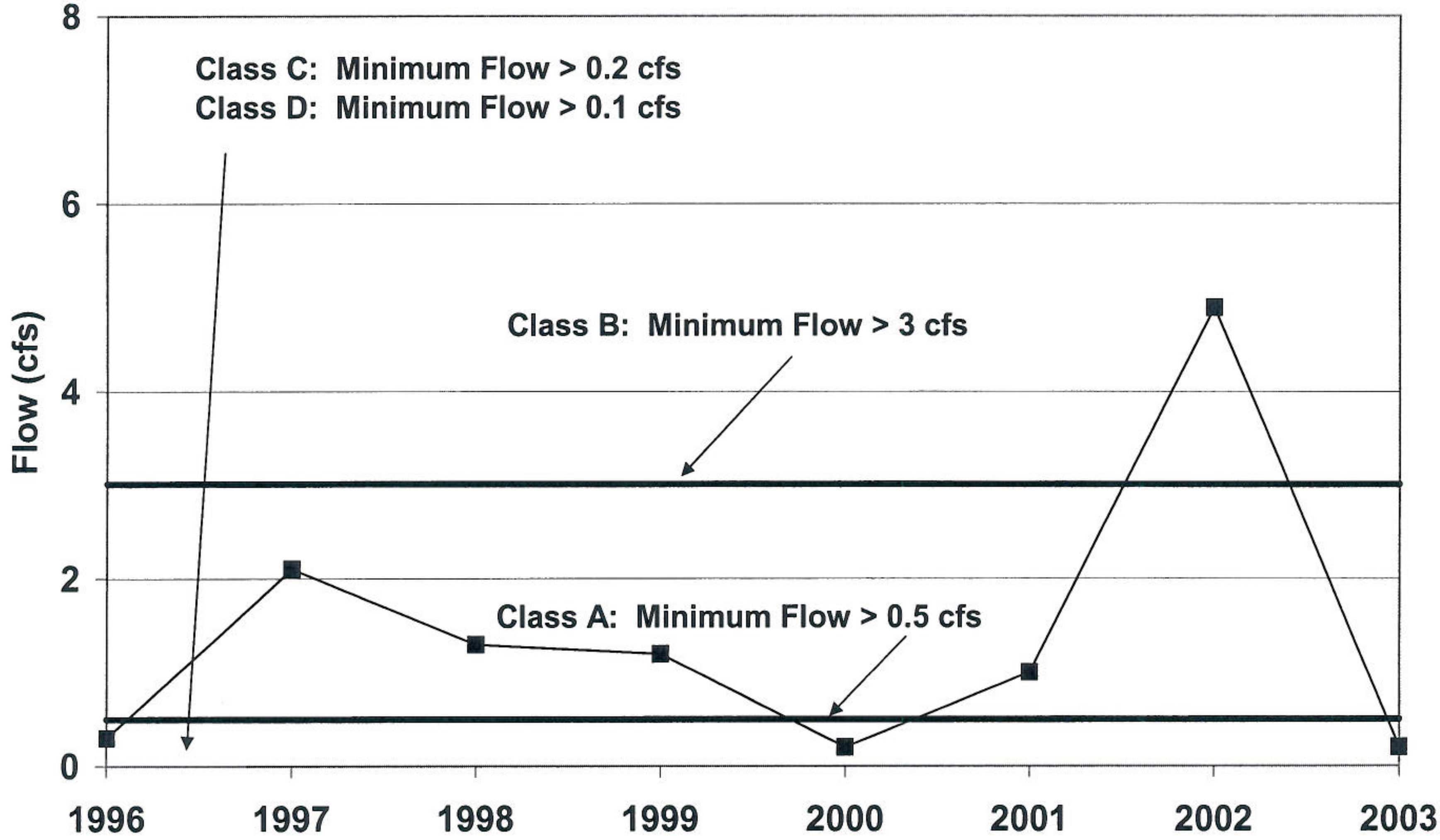
P-3: 1996-2003 Minimum Flow



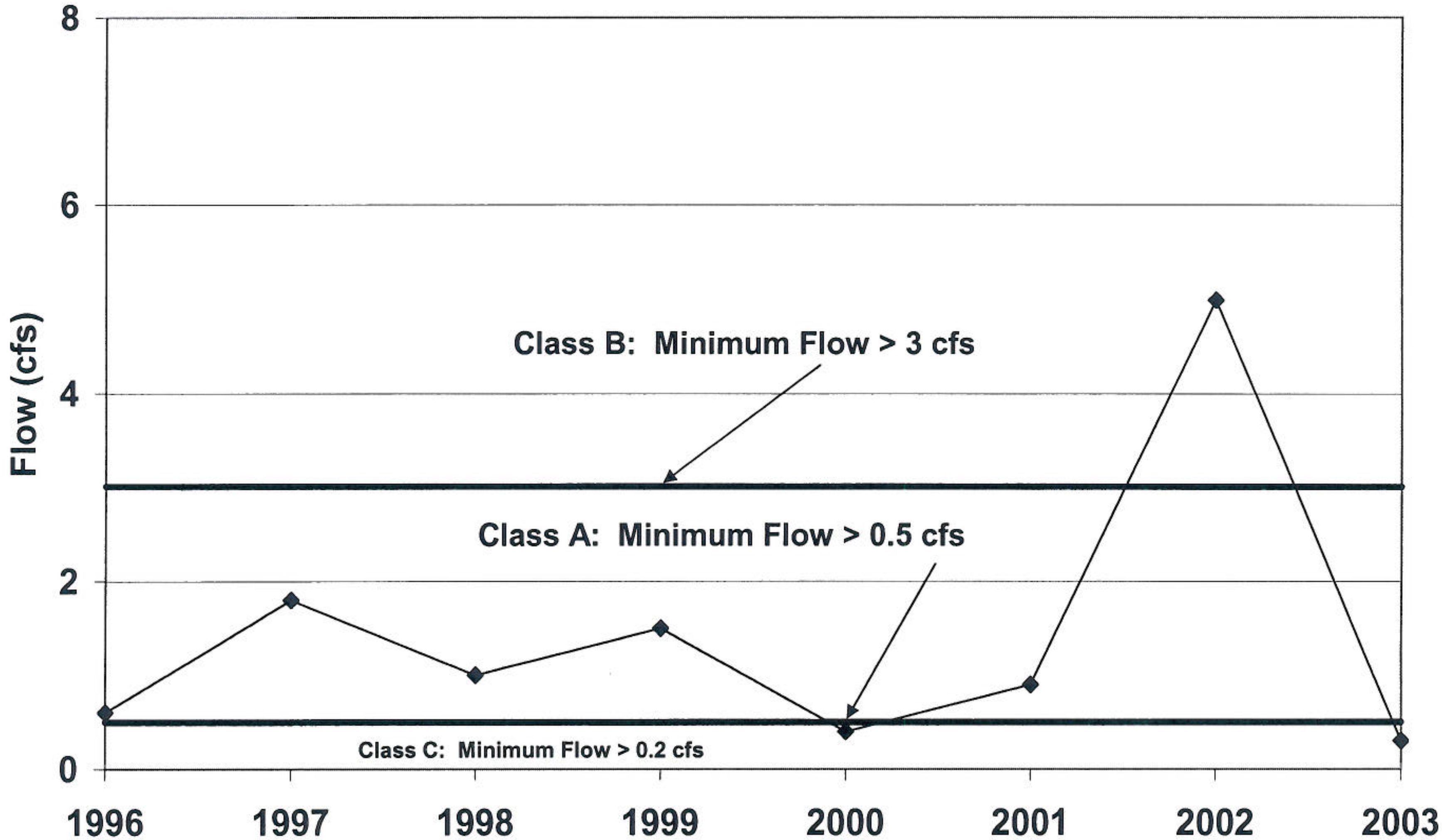
P-4: 1996-2003 Minimum Flow



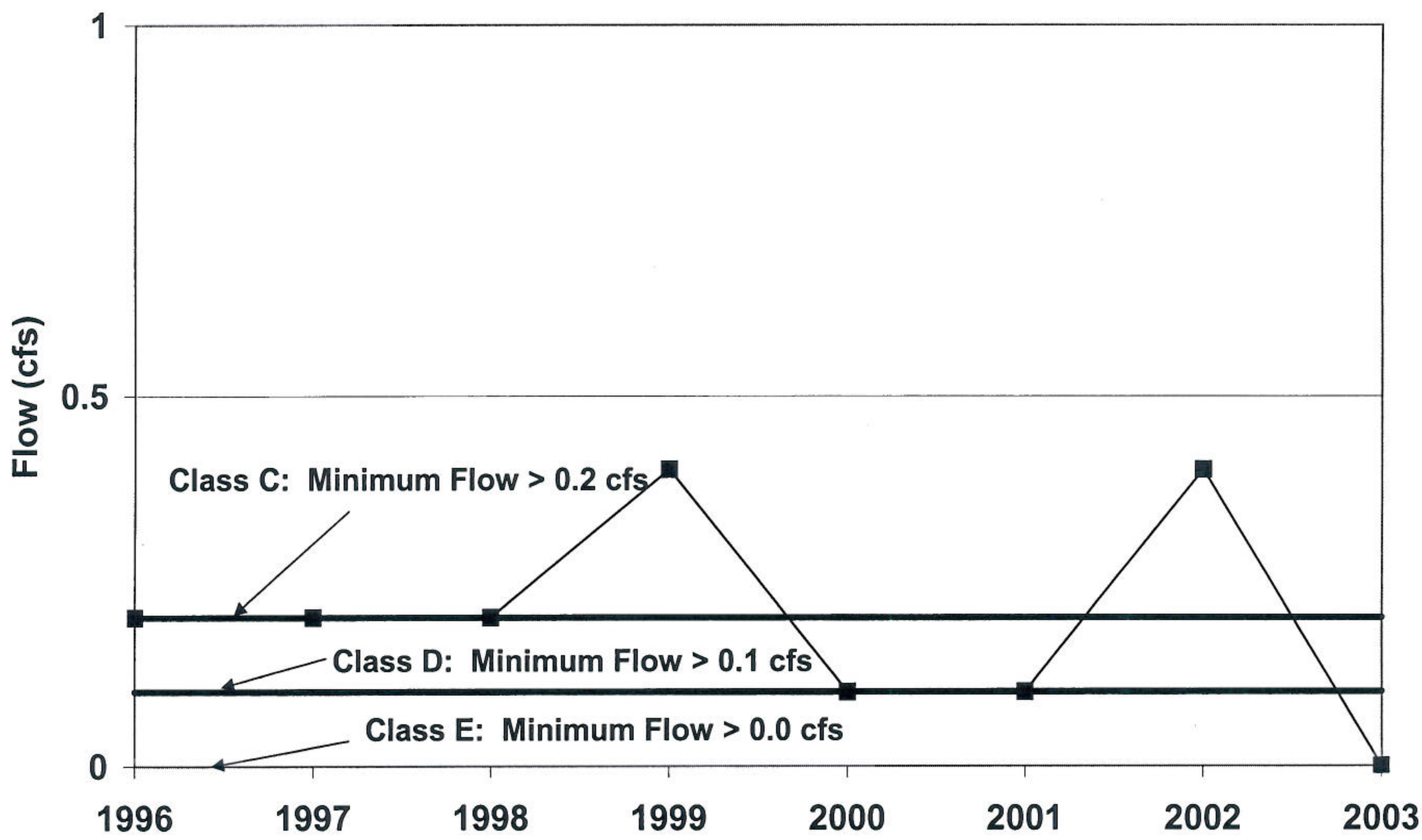
P-5: 1996-2003 Minimum Flow



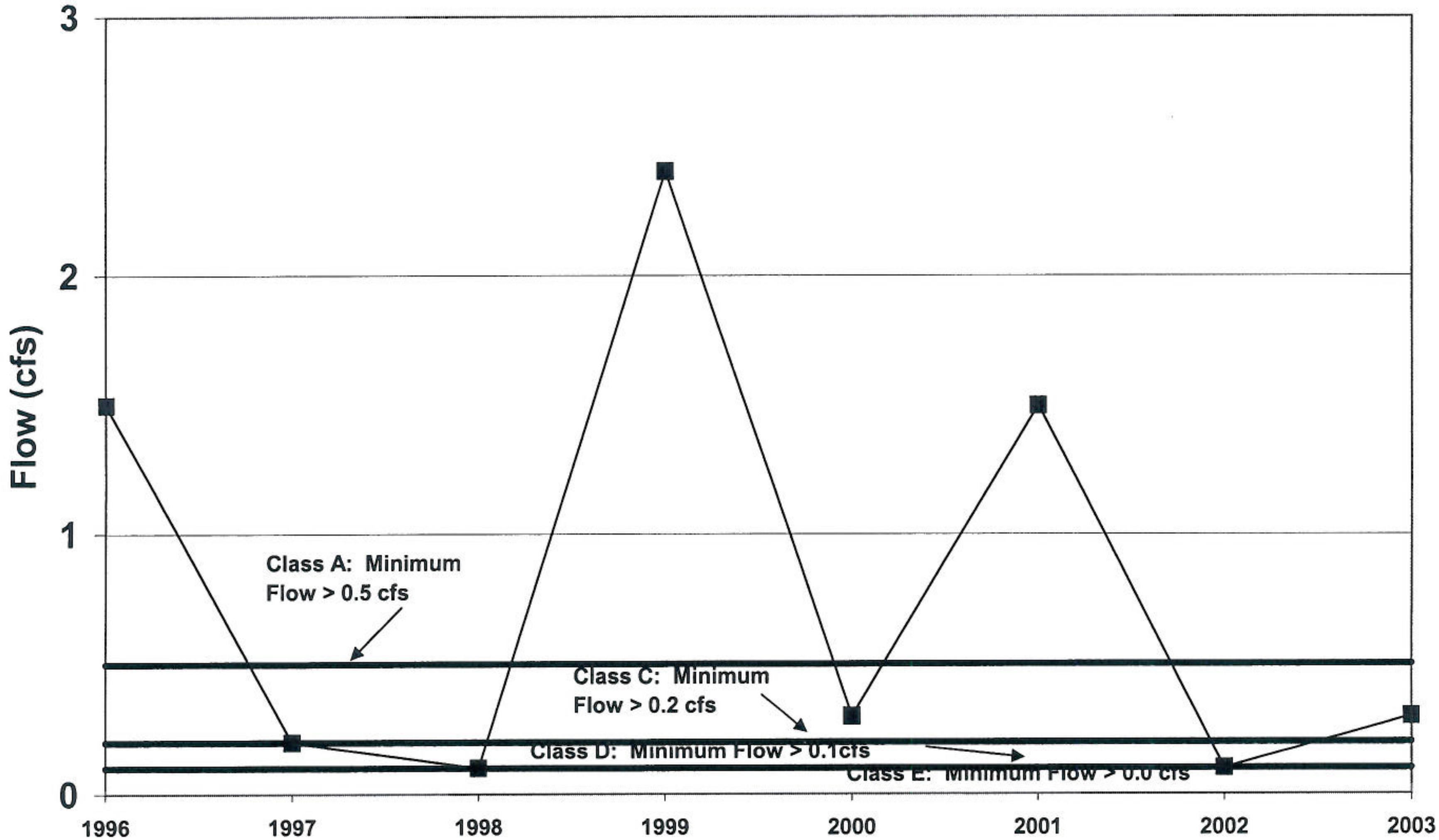
P-6: 1996-2003 Minimum Flow



P-7: 1996-2003 Minimum Flow



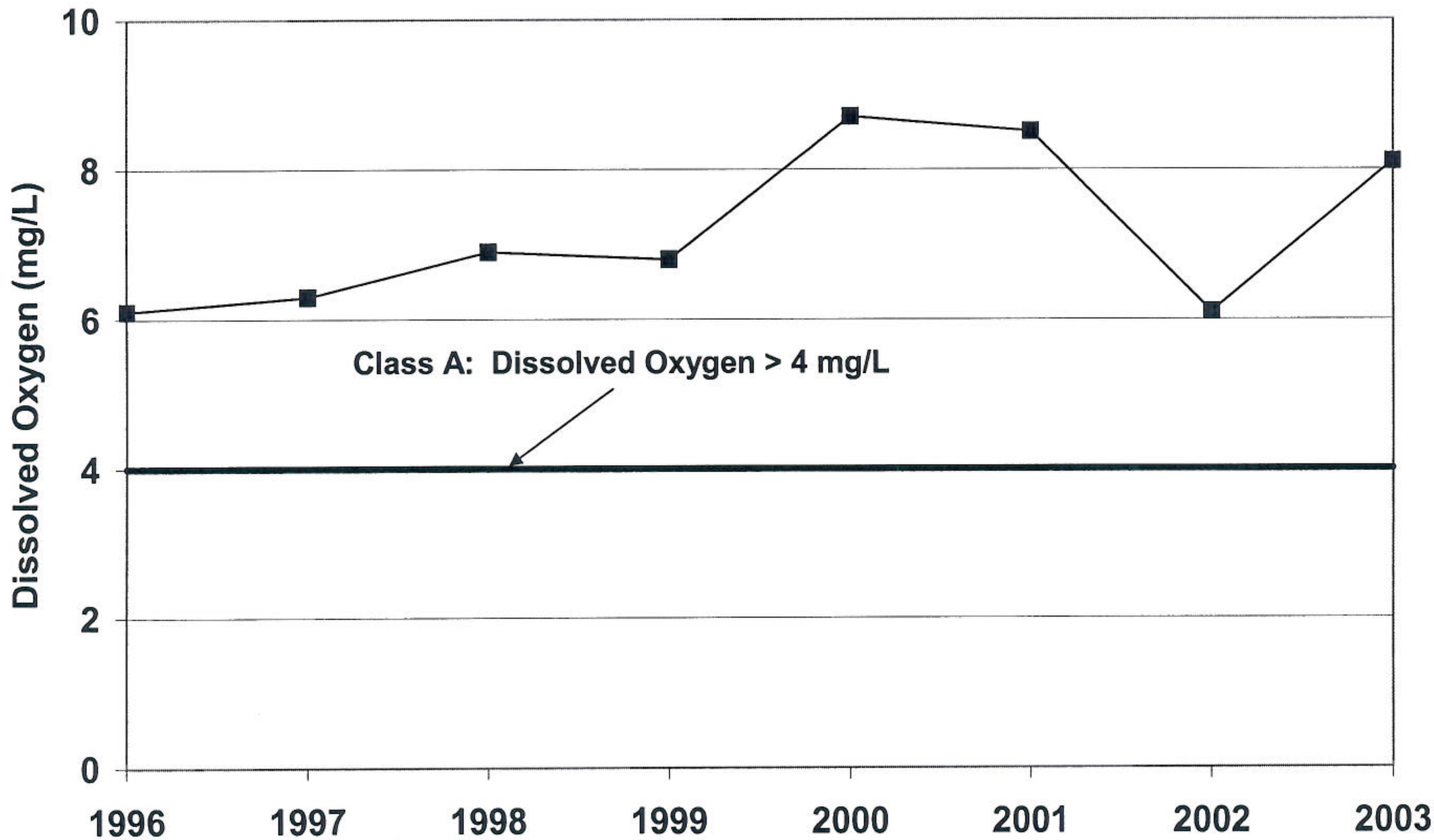
P-8: 1996-2003 Minimum Flow



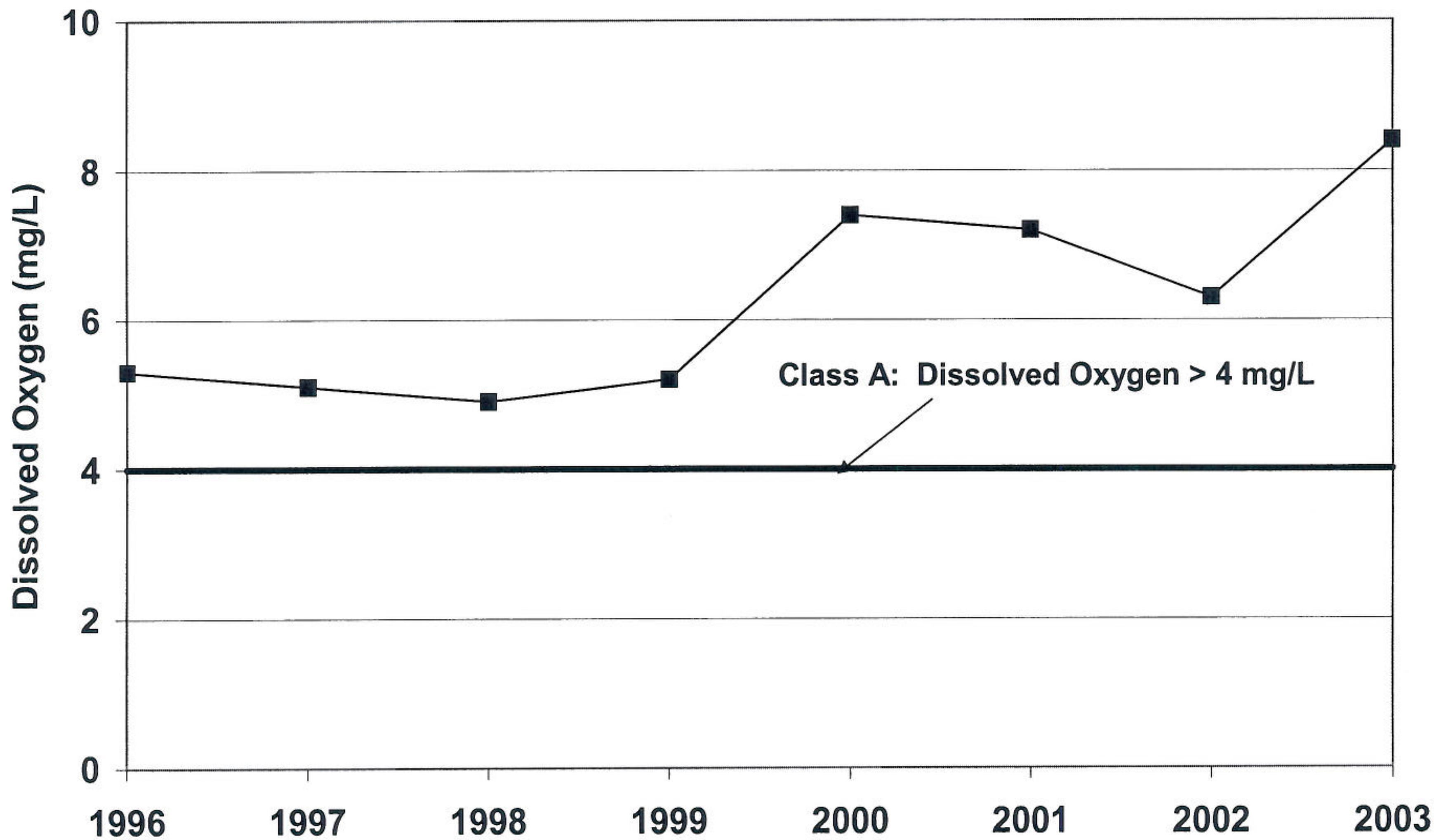
Appendix 3-G

1996-2003 Purgatory Creek Water Quality Data

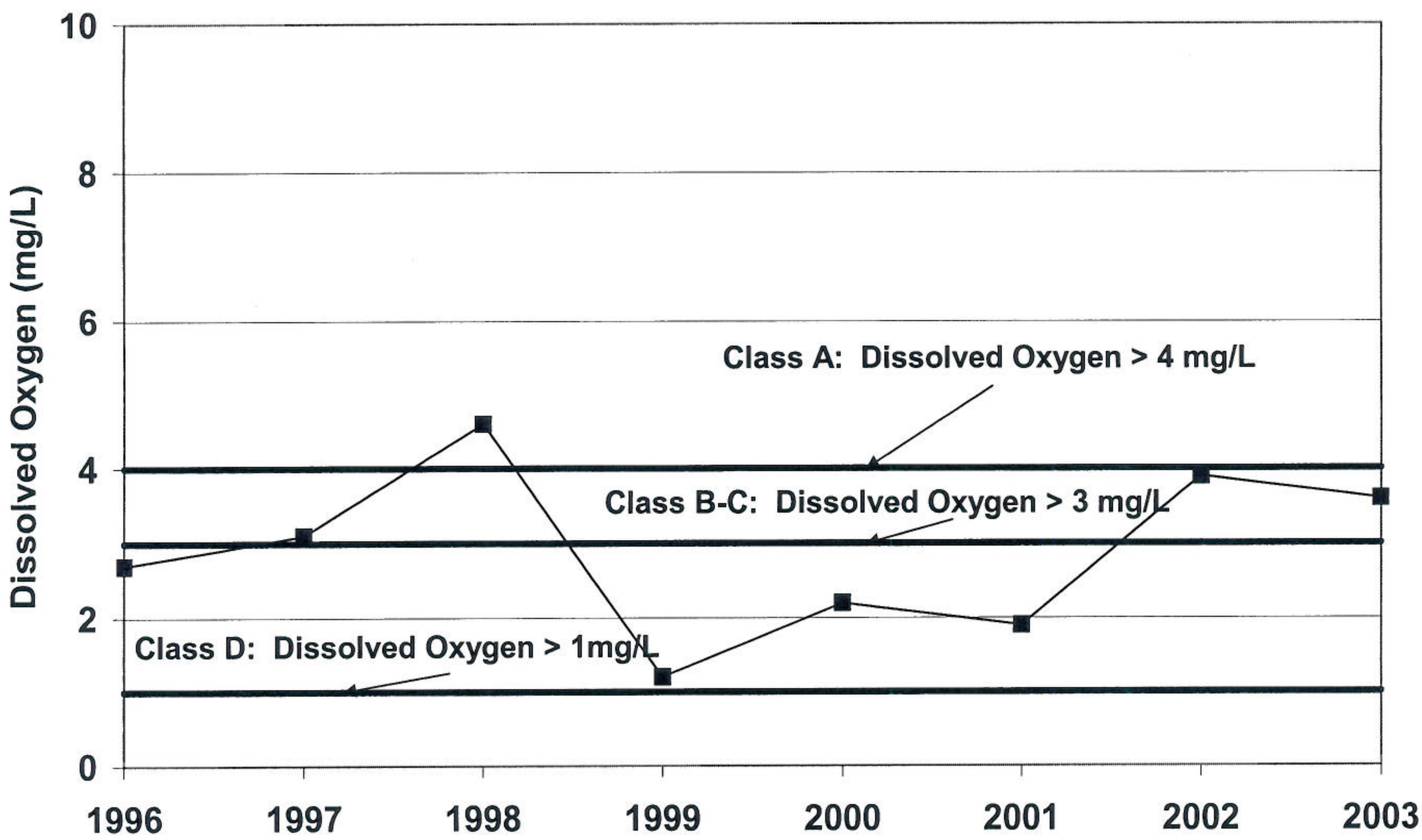
P-1: 1996-2003 Minimum Dissolved Oxygen



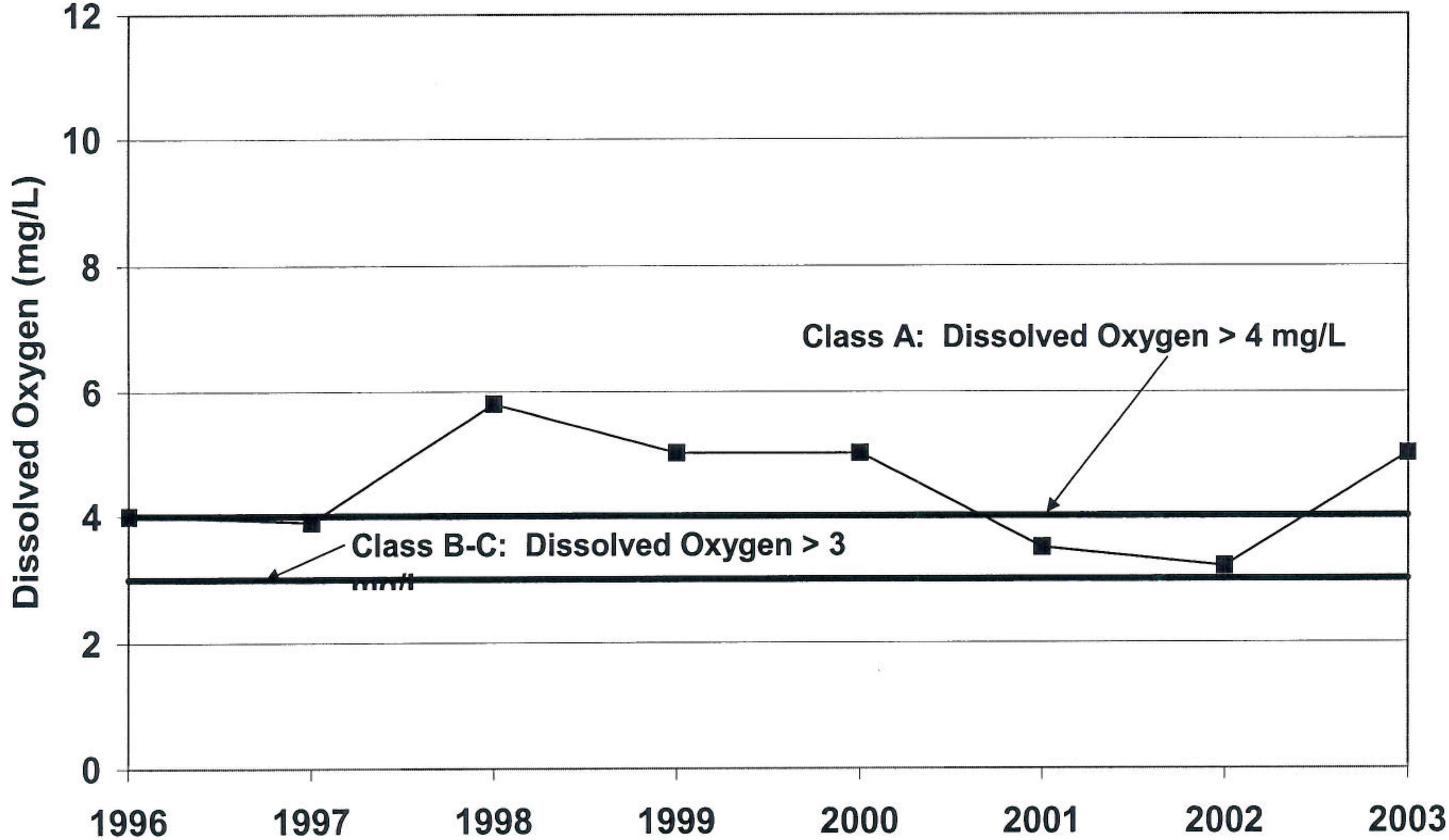
P-2: 1996-2003 Minimum Dissolved Oxygen



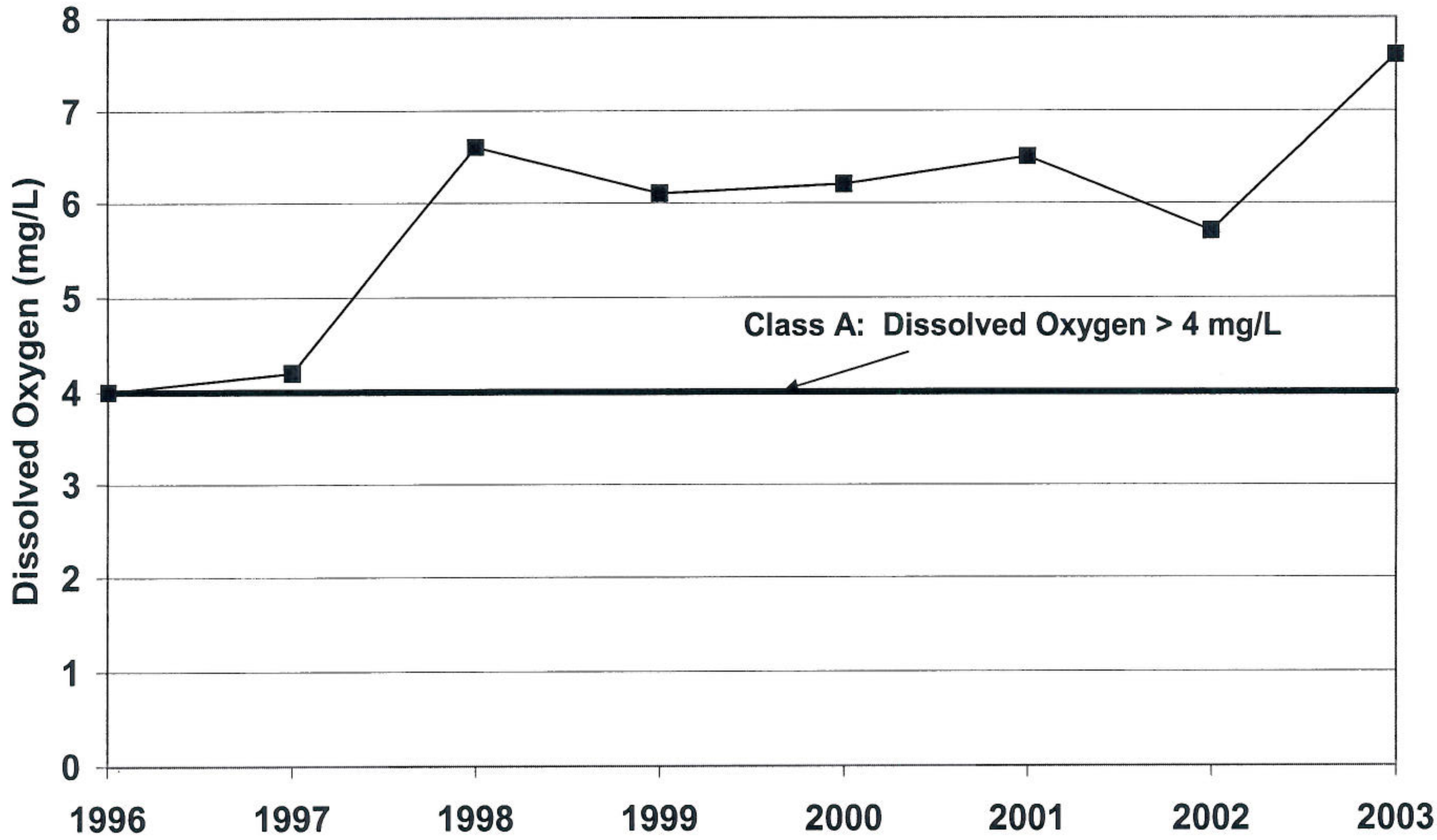
P-3: 1996-2003 Minimum Dissolved Oxygen



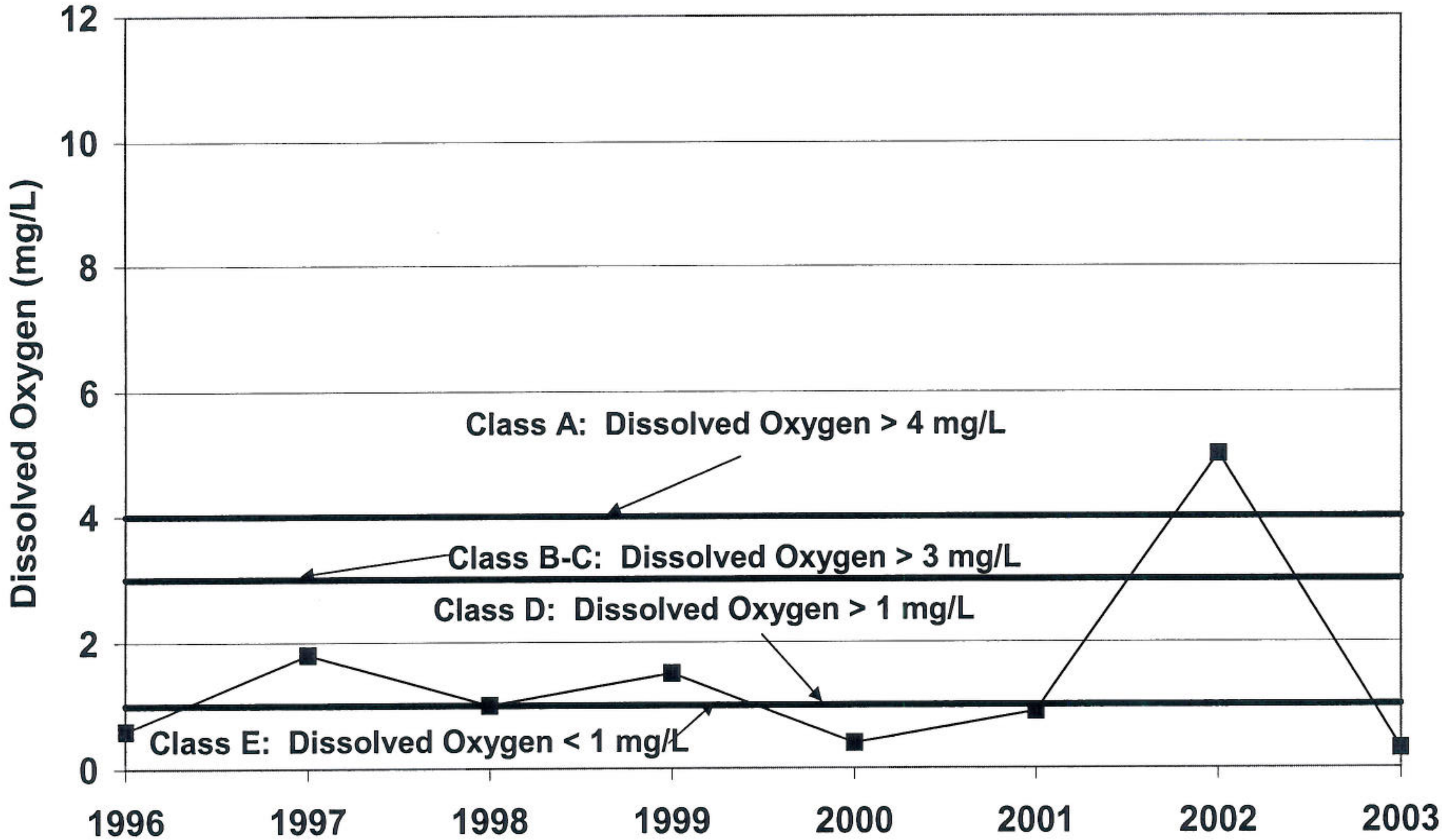
P-4: 1996-2003 Dissolved Oxygen



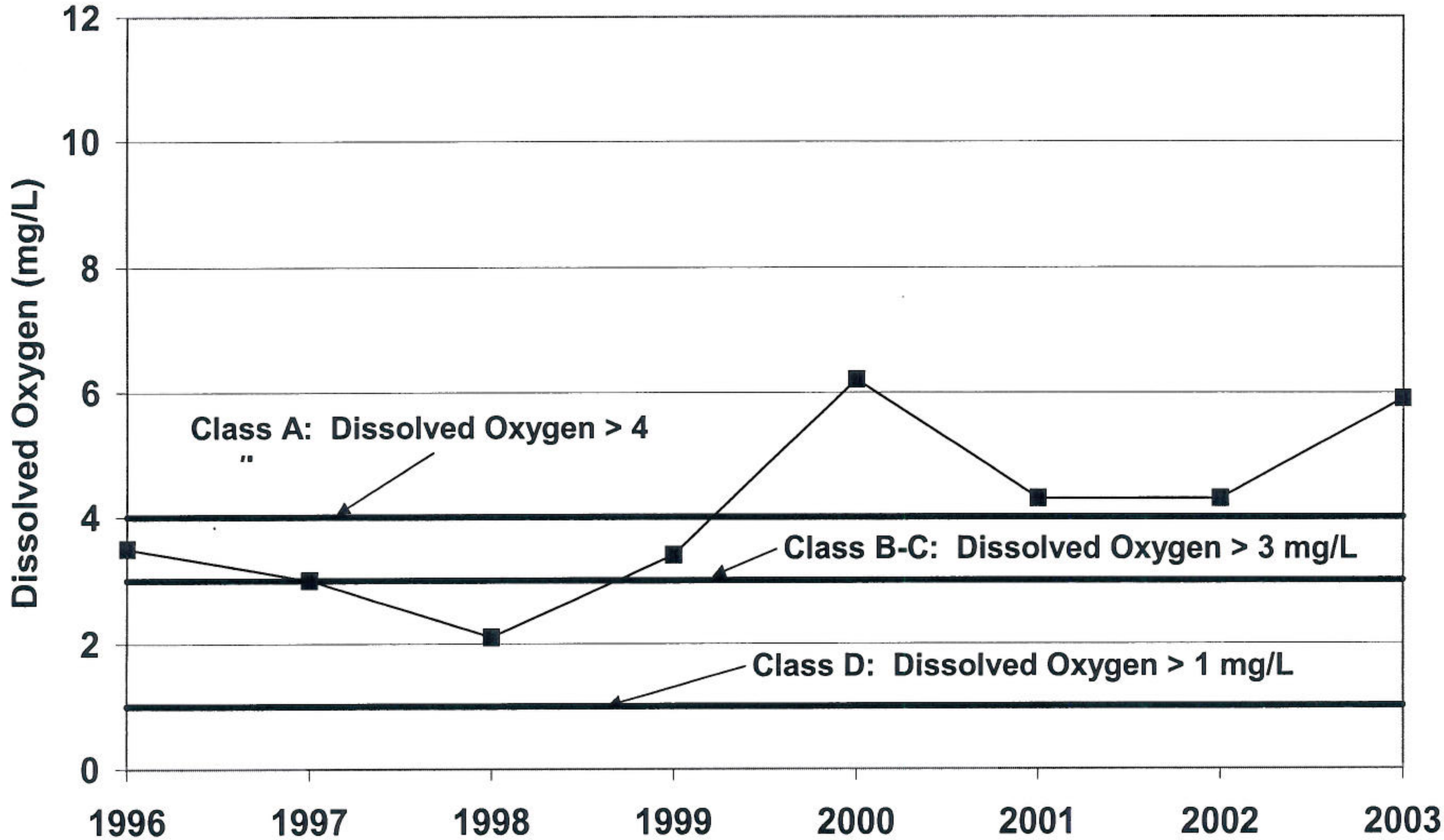
P-5: 1996-2003 Minimum Dissolved Oxygen



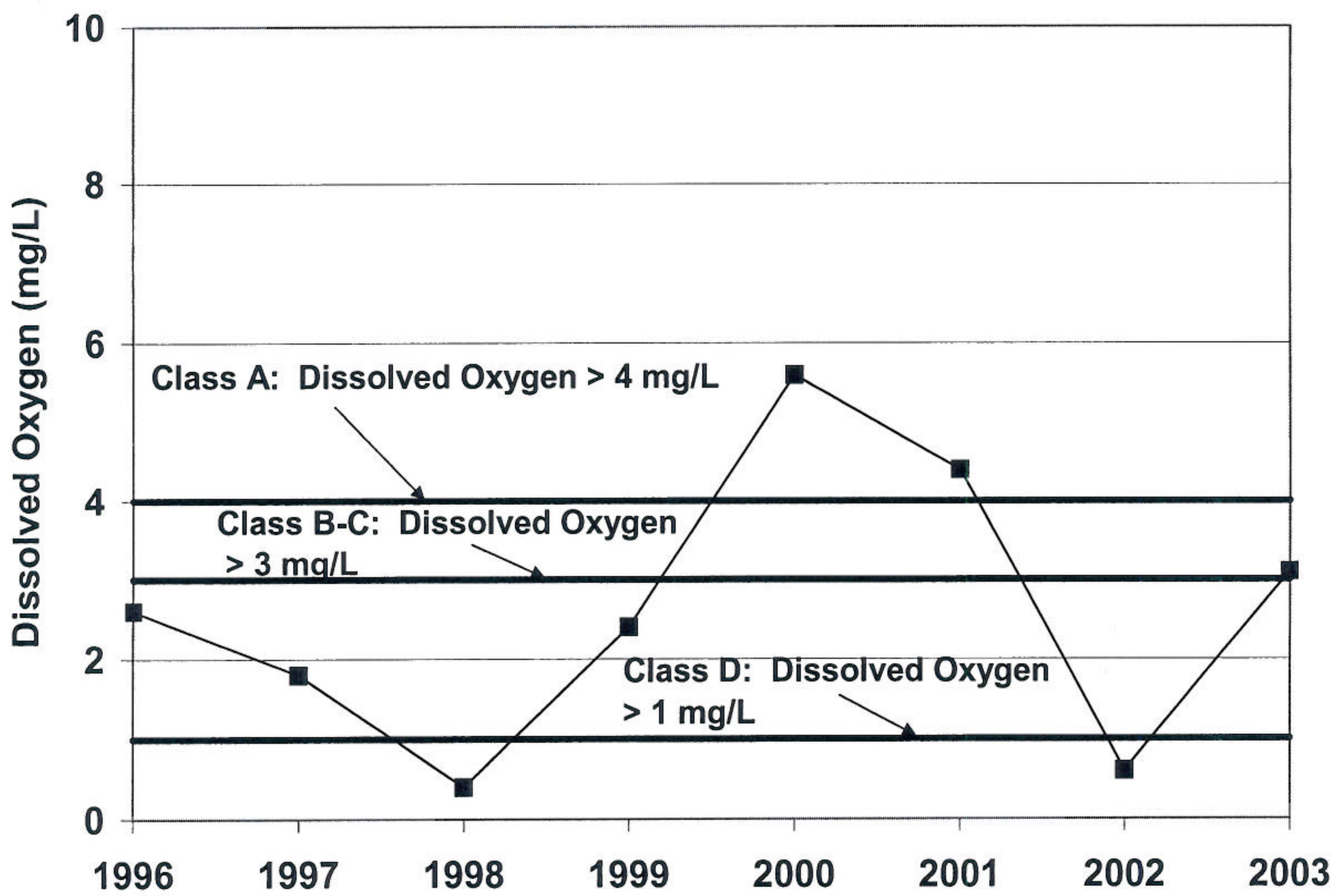
P-6: 1996-2003 Minimum Dissolved Oxygen



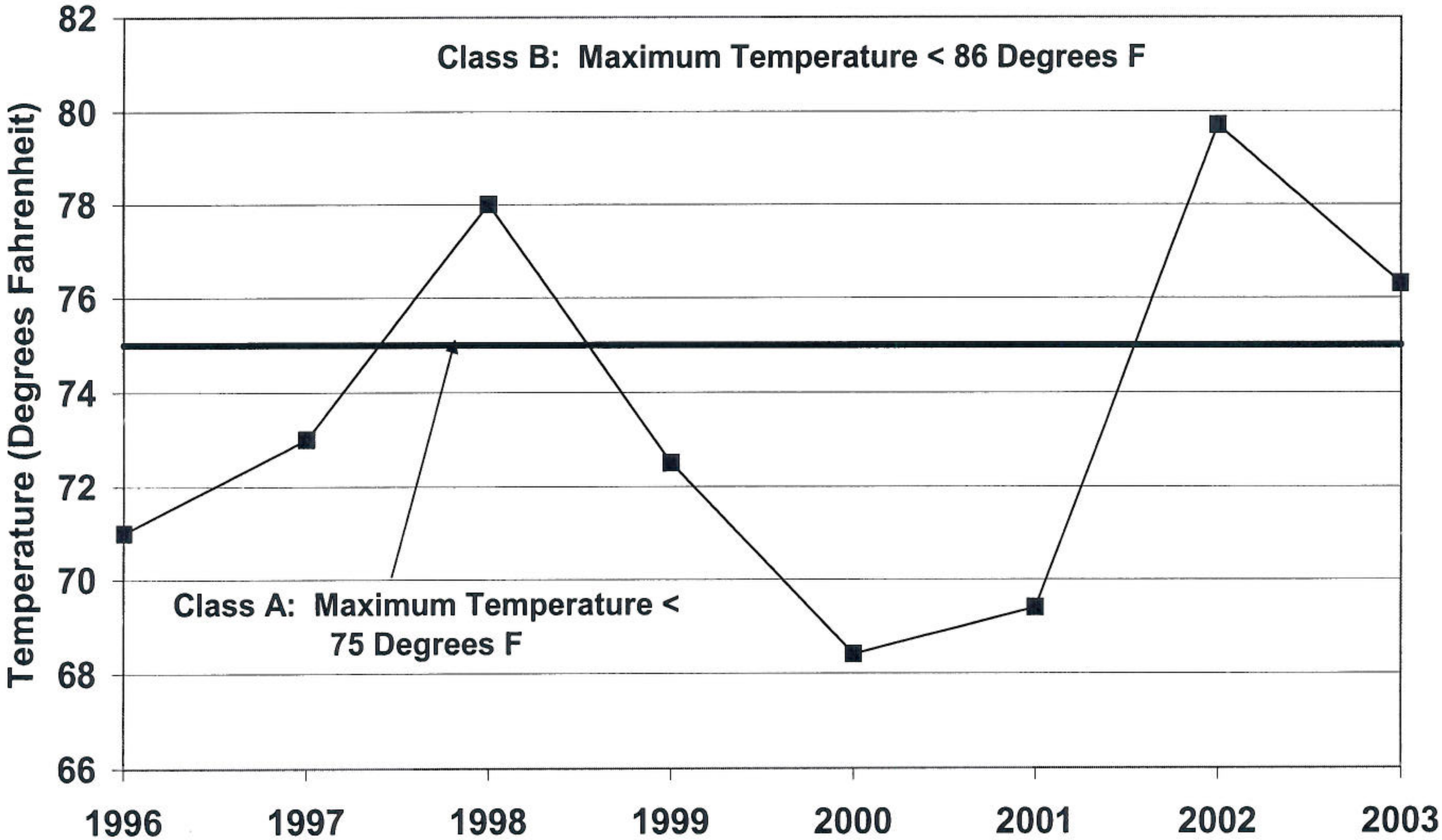
P-7: 1996-2003 Minimum Dissolved Oxygen



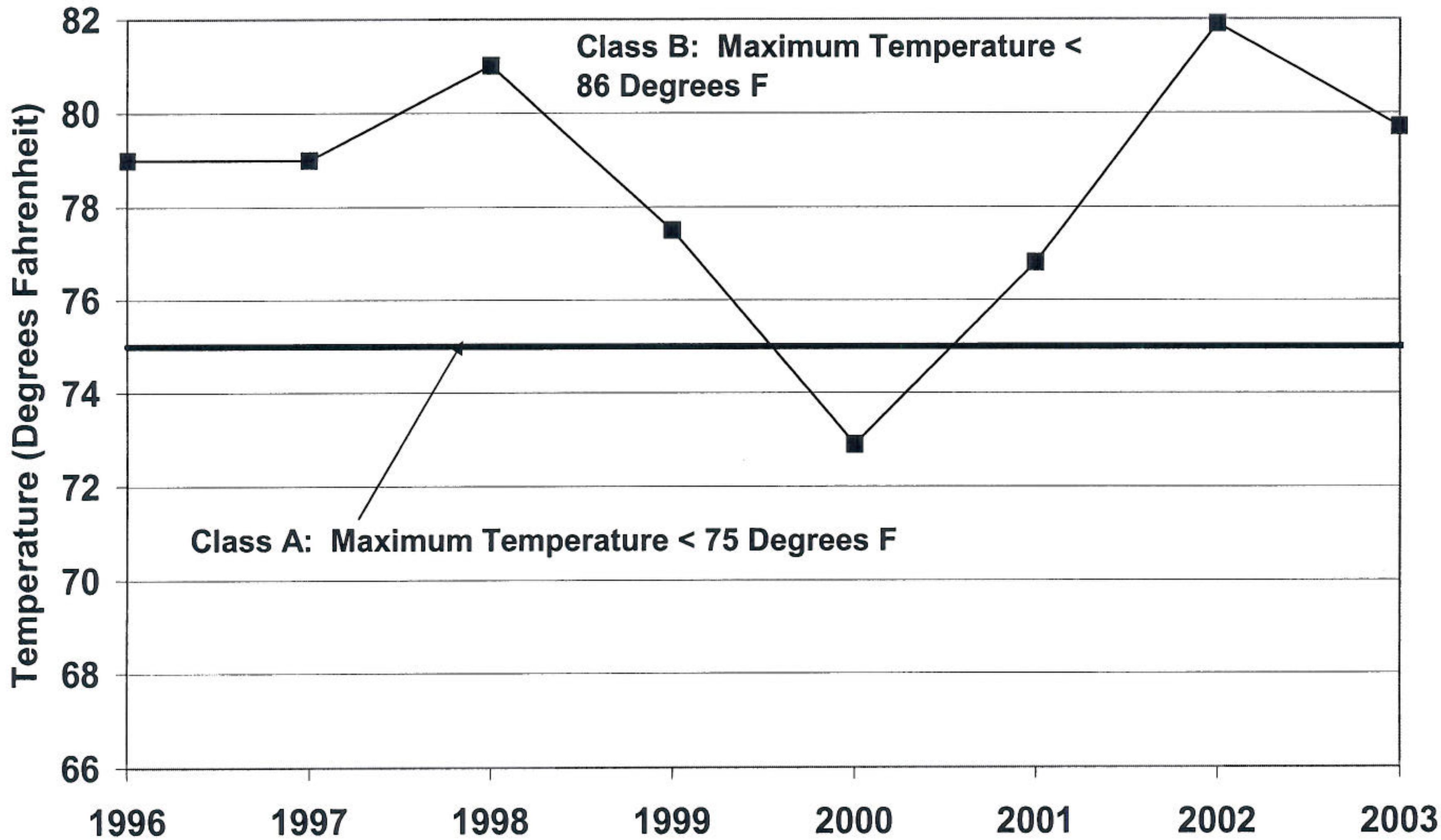
P-8: 1996-2003 Minimum Dissolved Oxygen



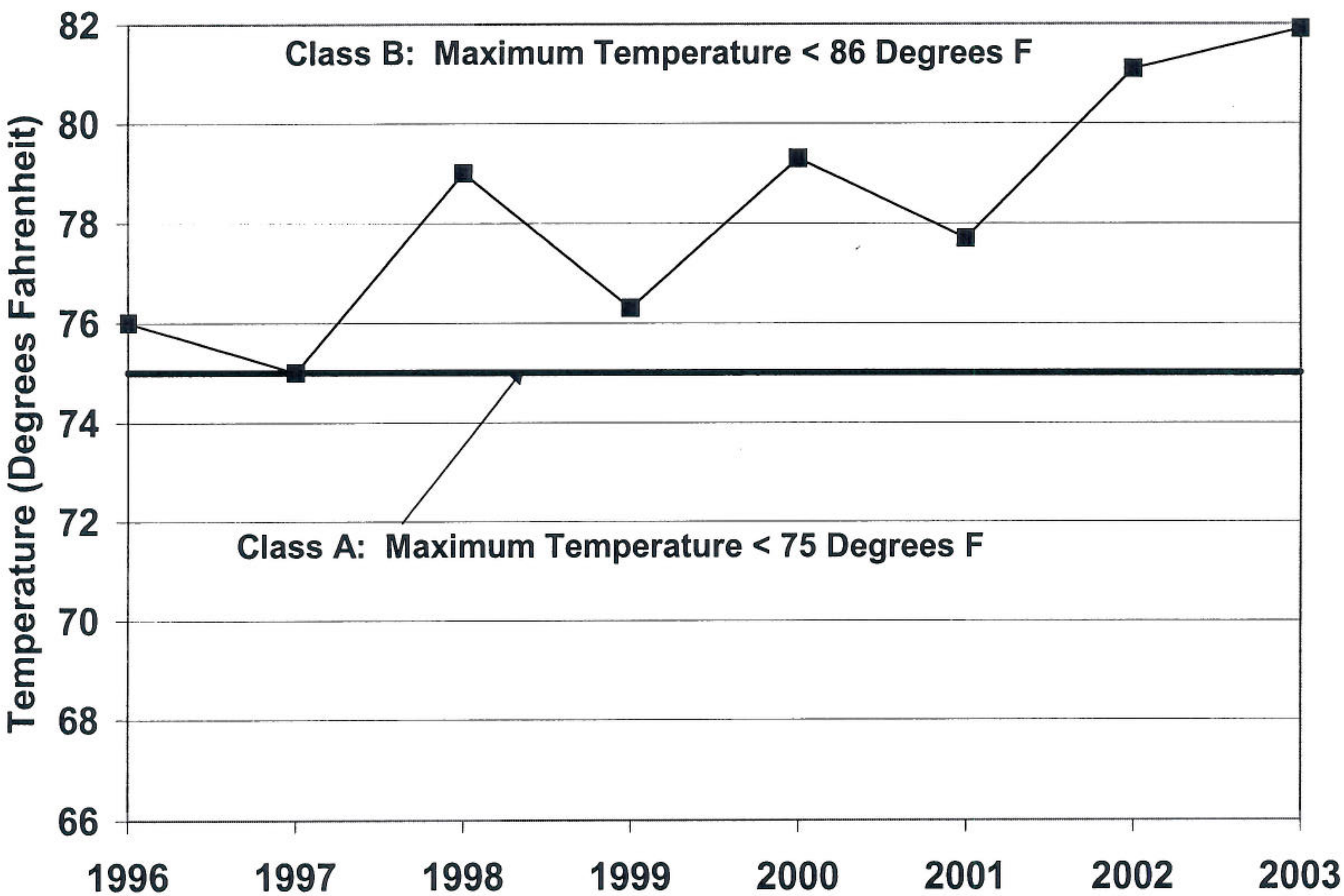
P-1: 1996-2003 Maximum Temperature



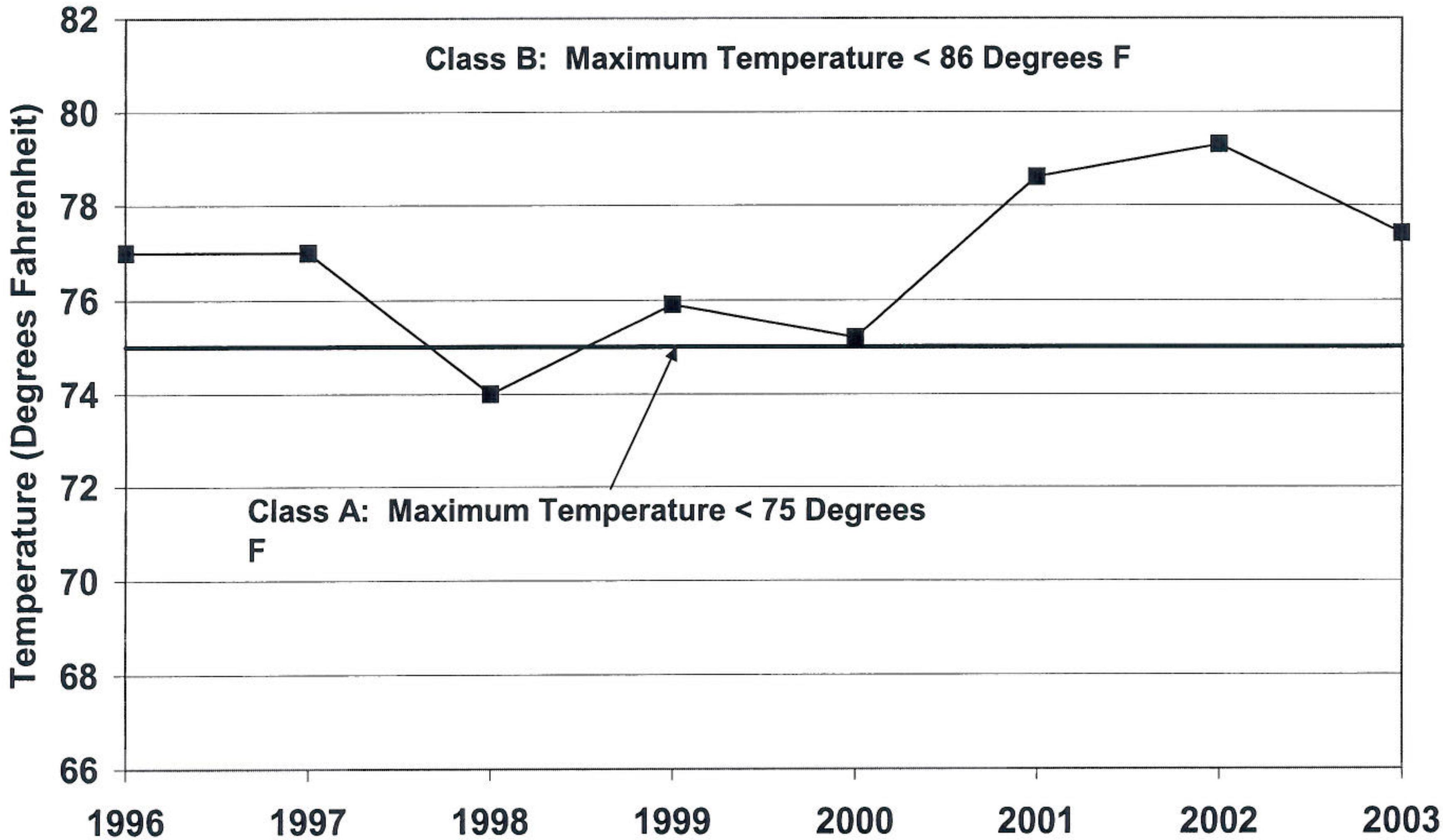
P-2: 1996-2003 Maximum Temperature



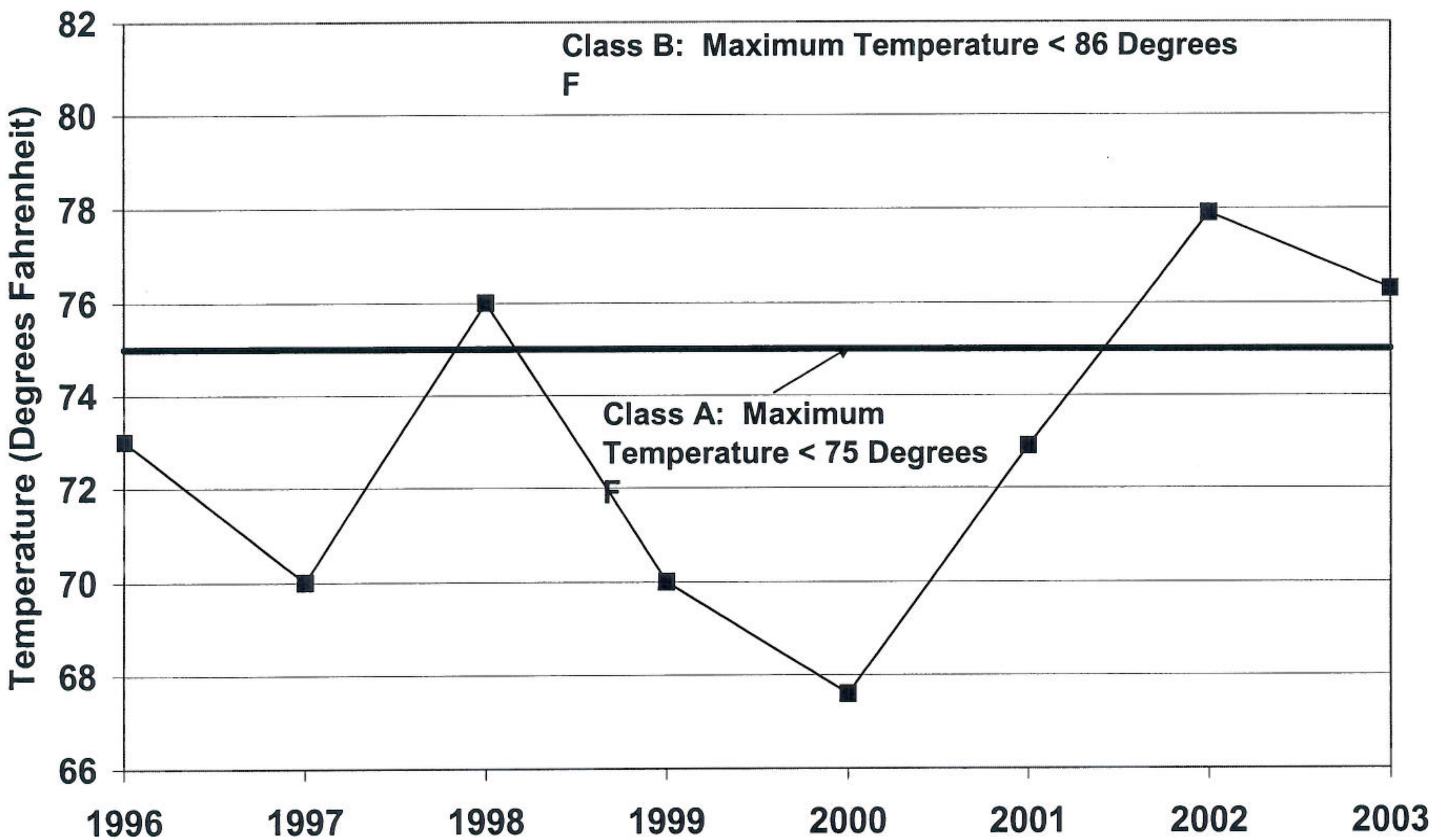
P-3: 1996-2003 Maximum Temperature



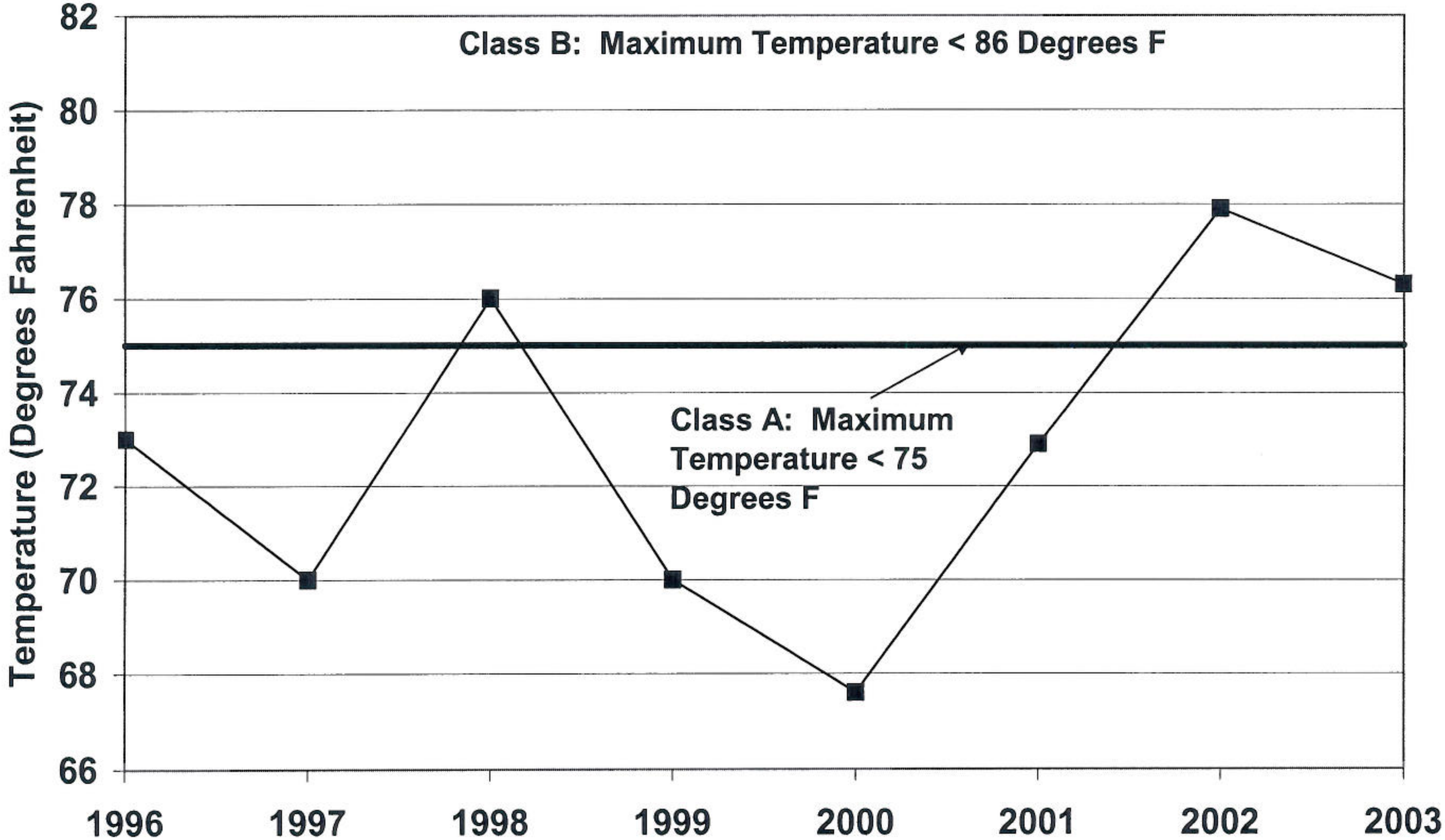
P-4: 1996-2003 Maximum Temperature



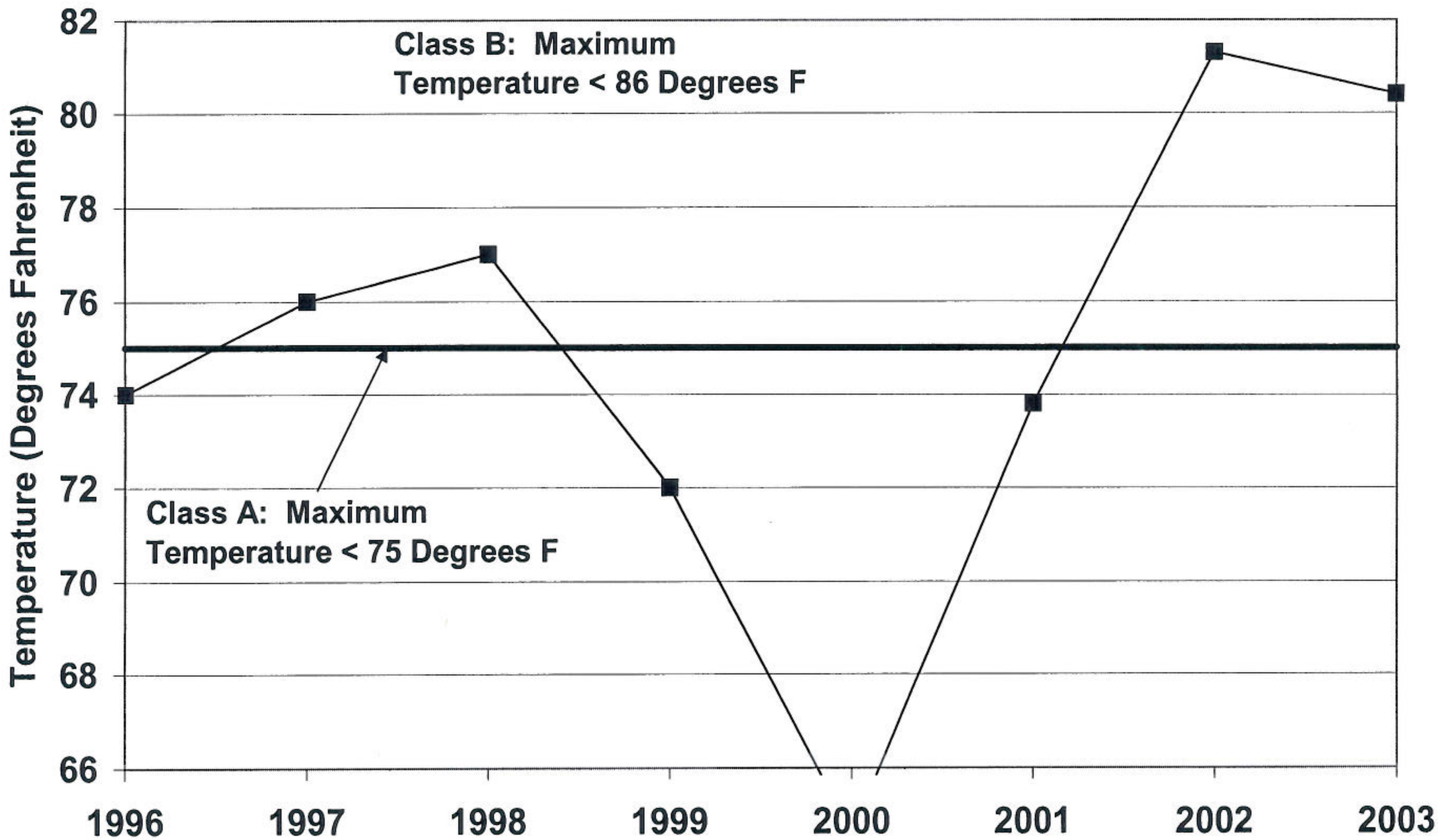
P-5: 1996-2003 Maximum Temperature



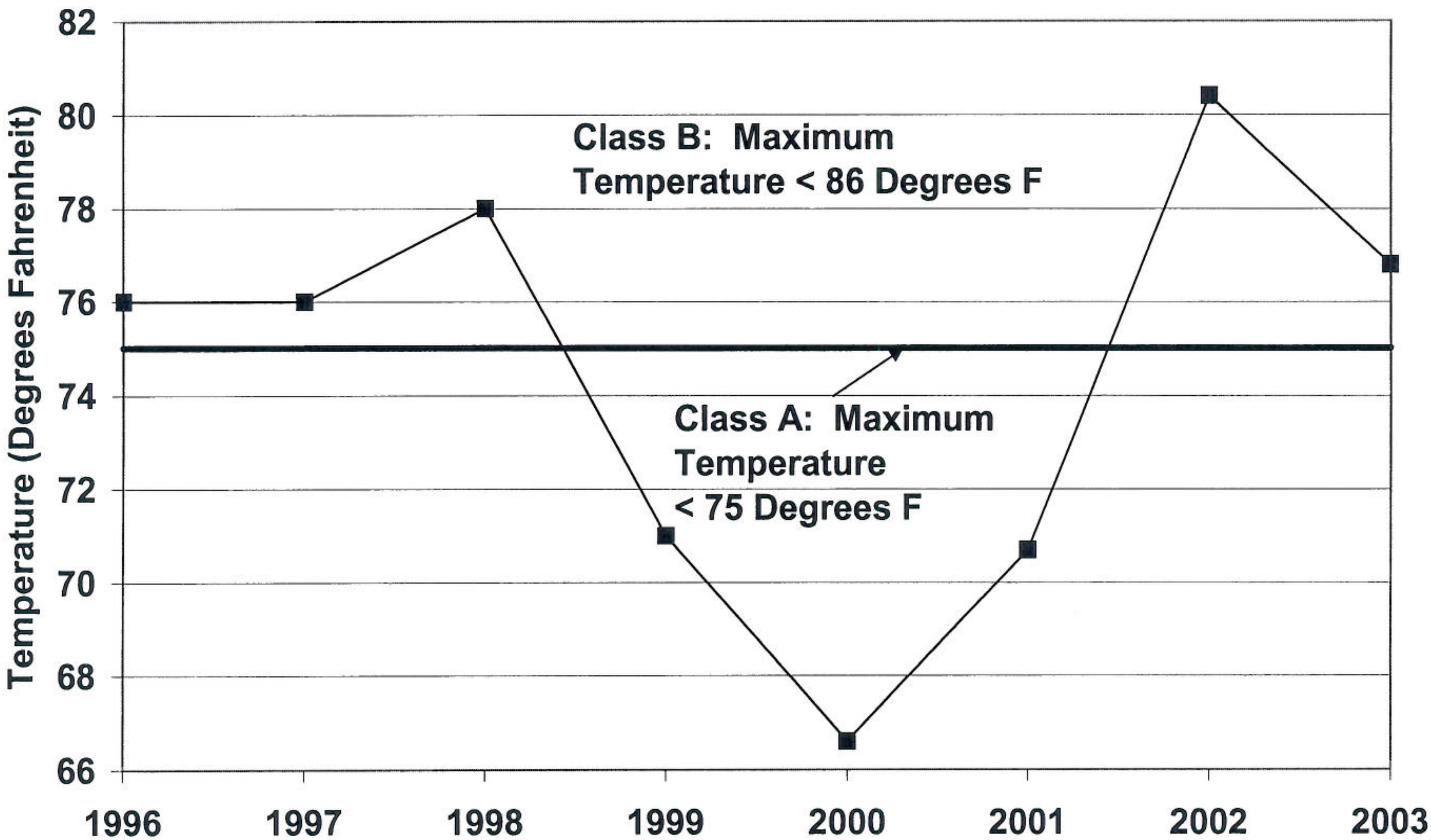
P-6: 1996-2003 Maximum Temperature



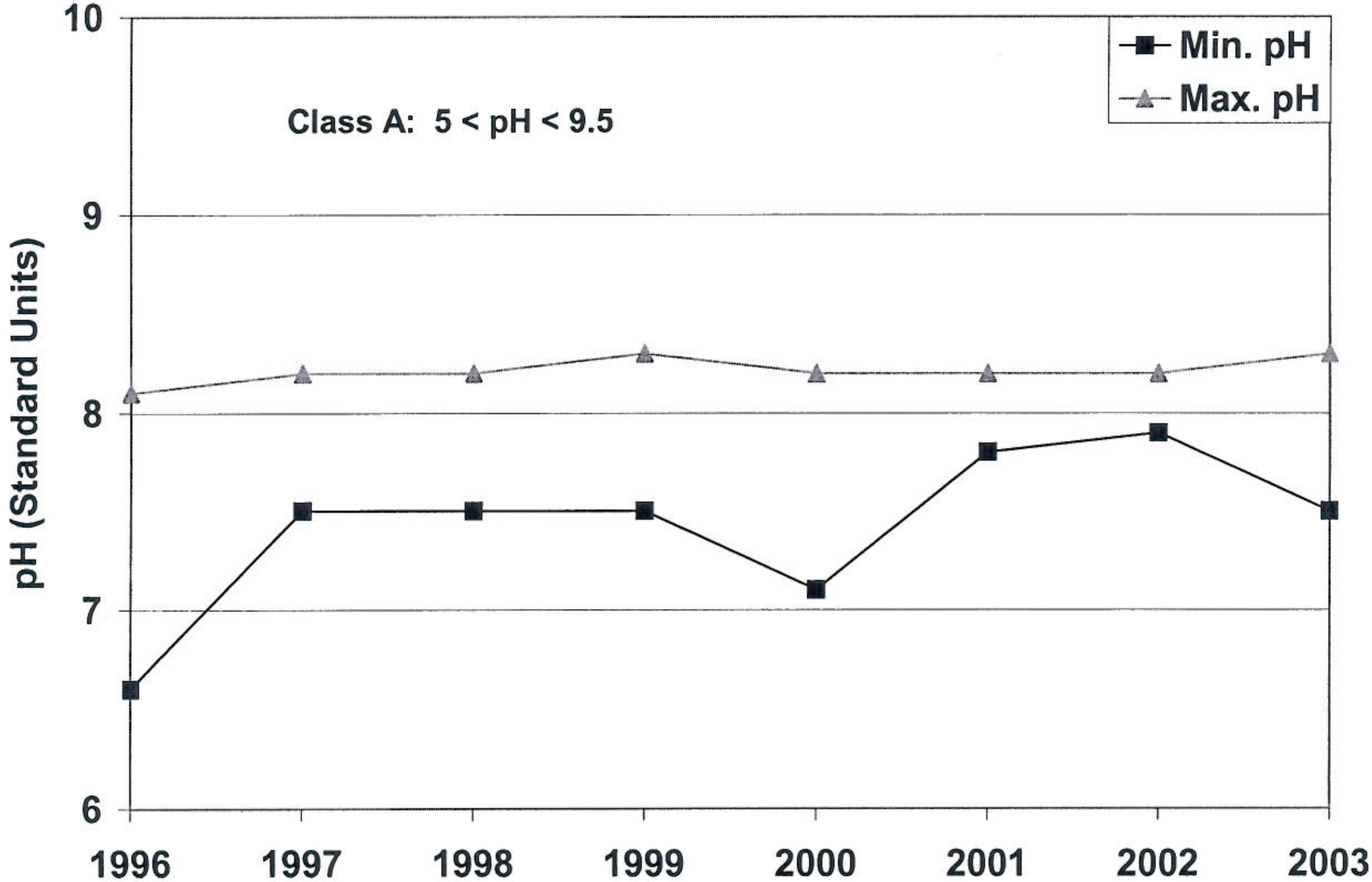
P-7: 1996-2003 Maximum Temperature



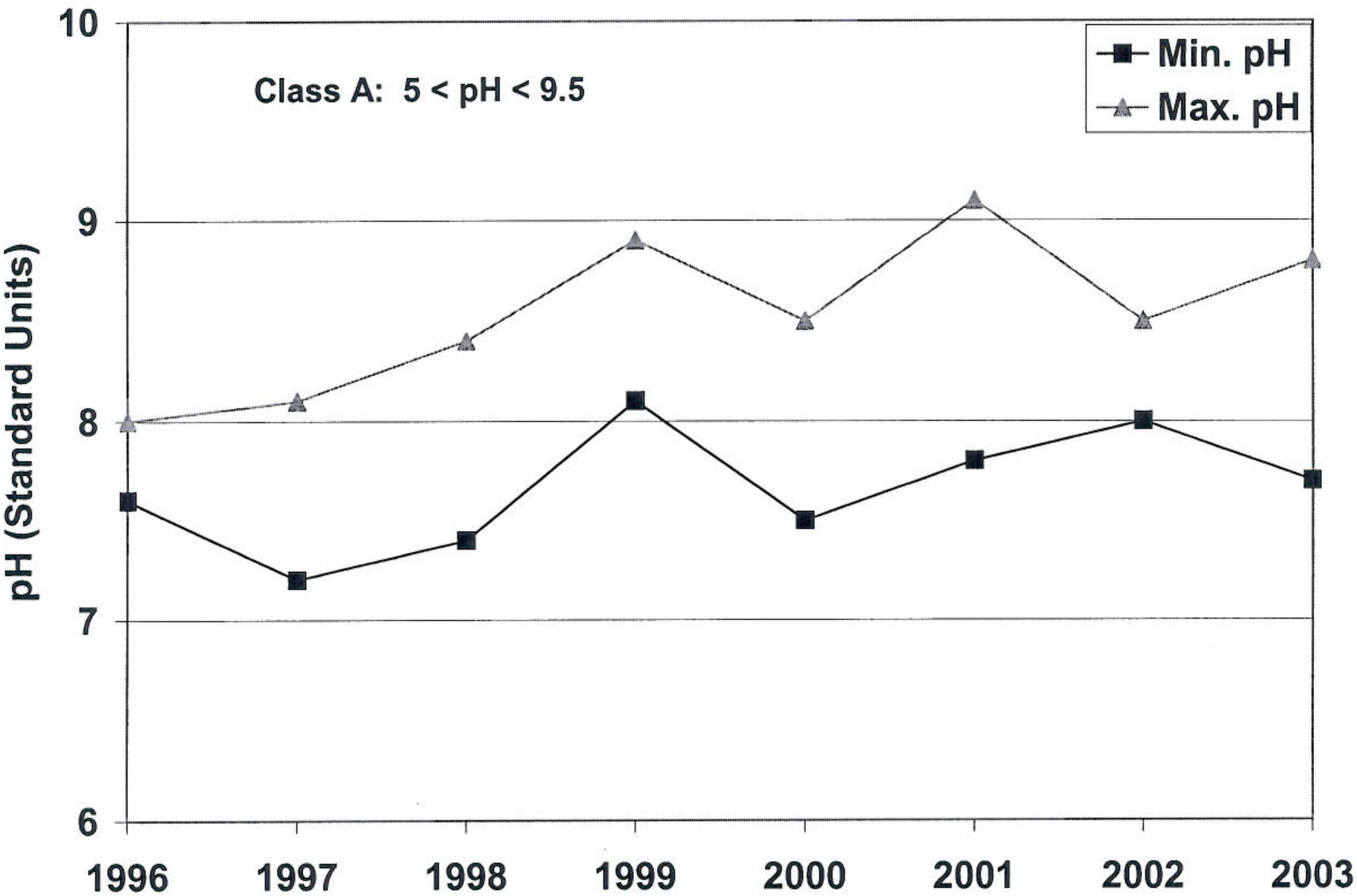
P-8: 1996-2003 Maximum Temperature



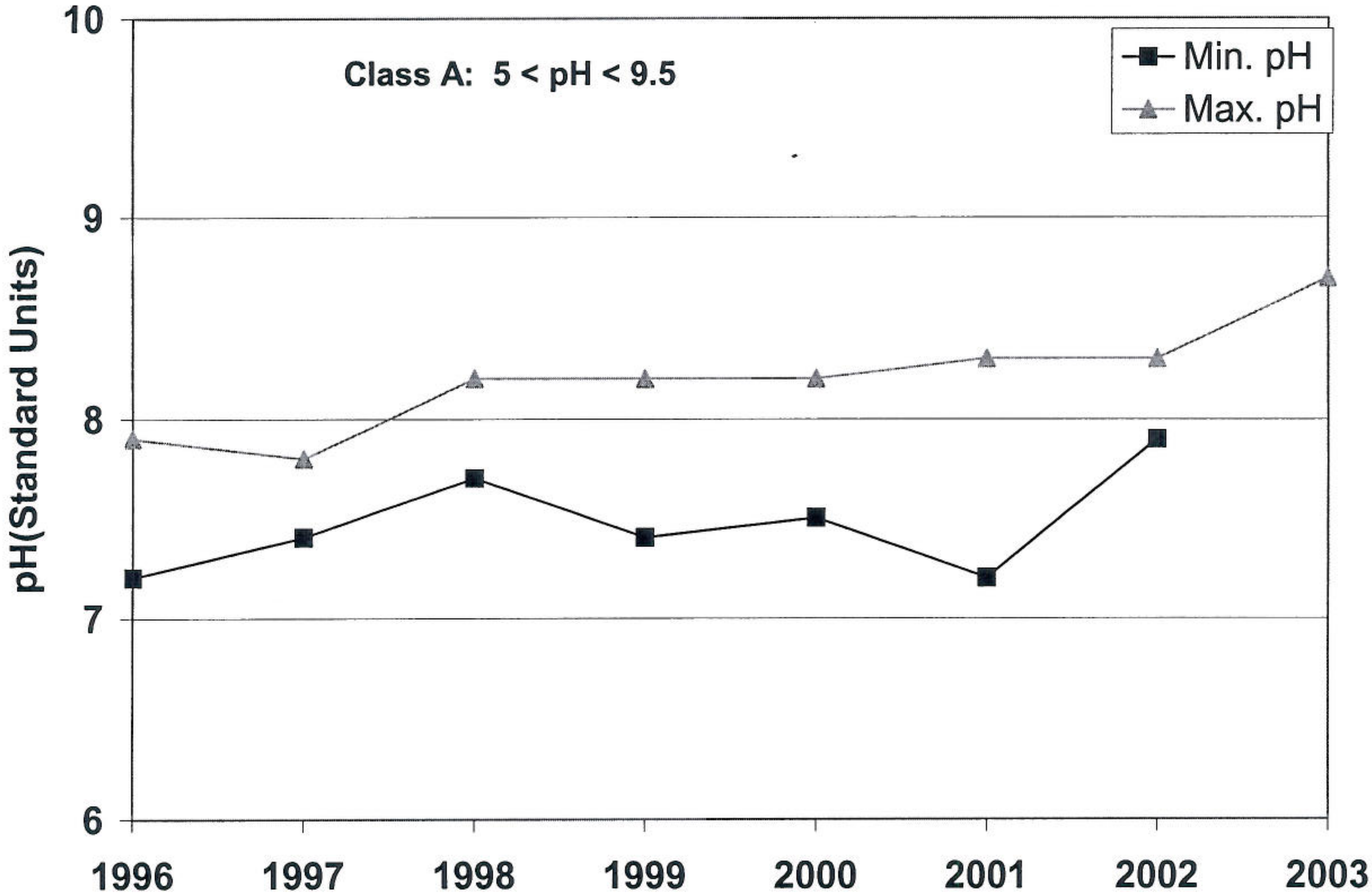
P-1: 1996-2003 Minimum and Maximum pH



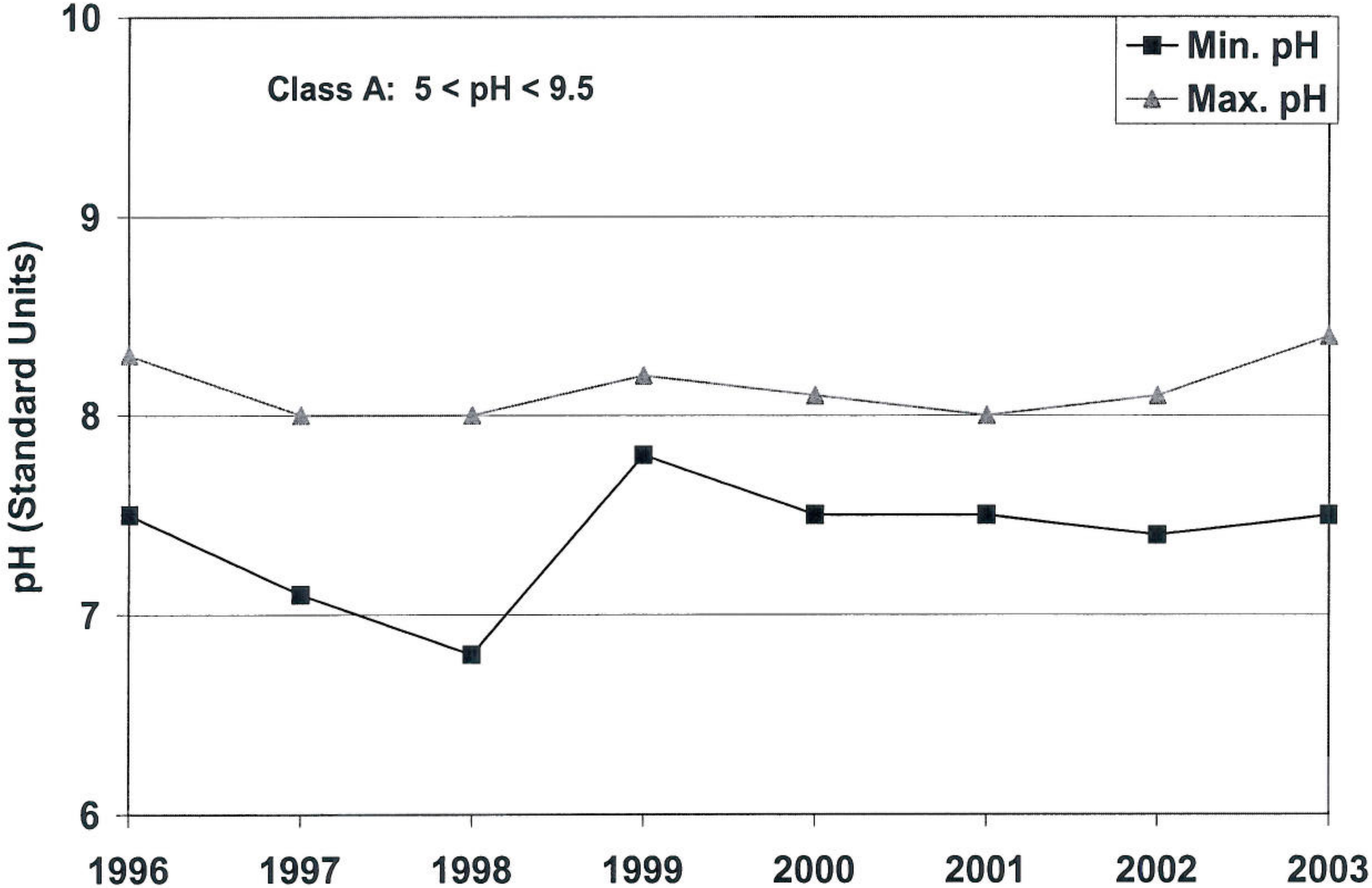
P-2: 1996-2003 Minimum and Maximum pH



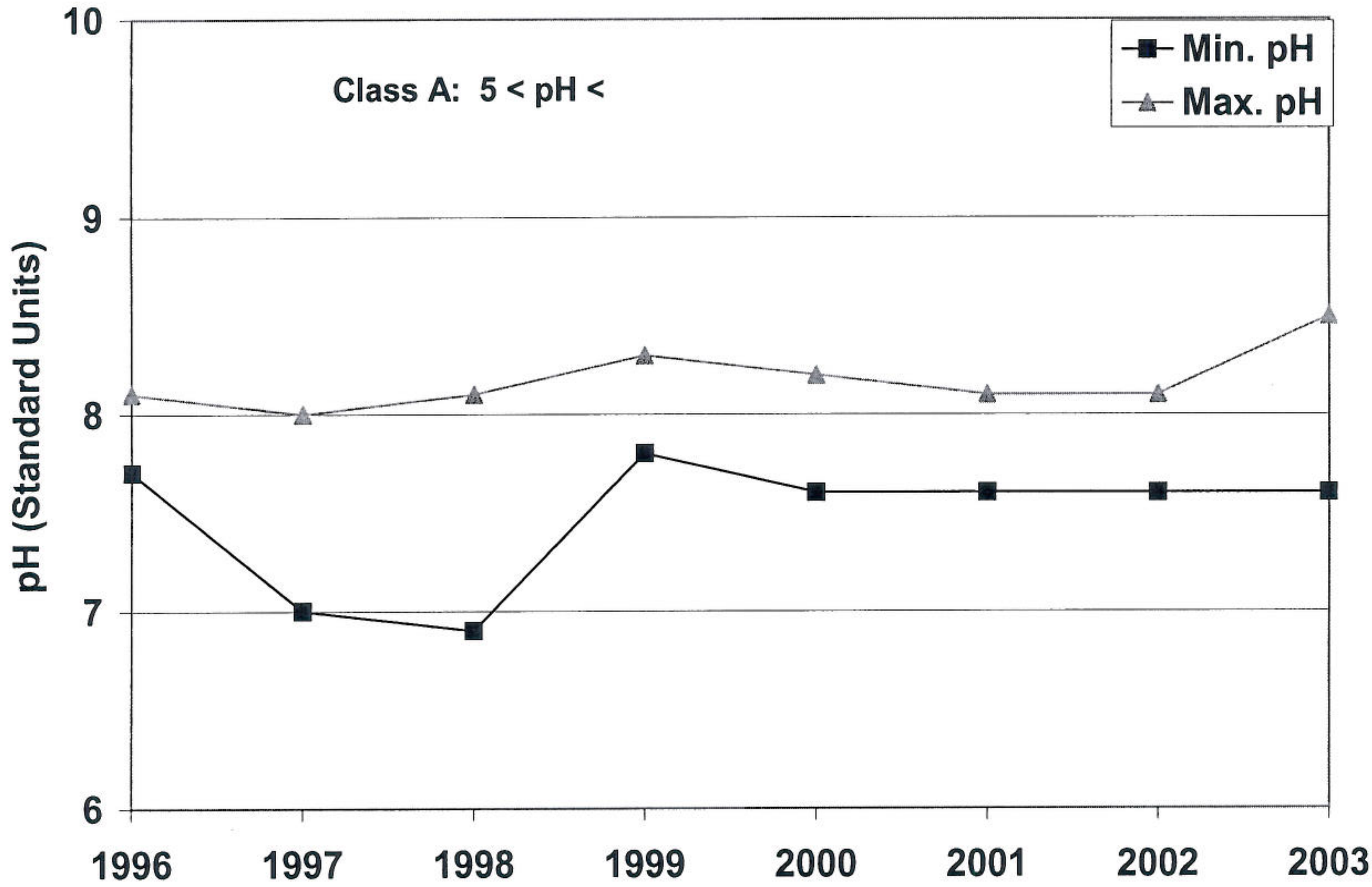
P-3: 1996-2003 Minimum and Maximum pH



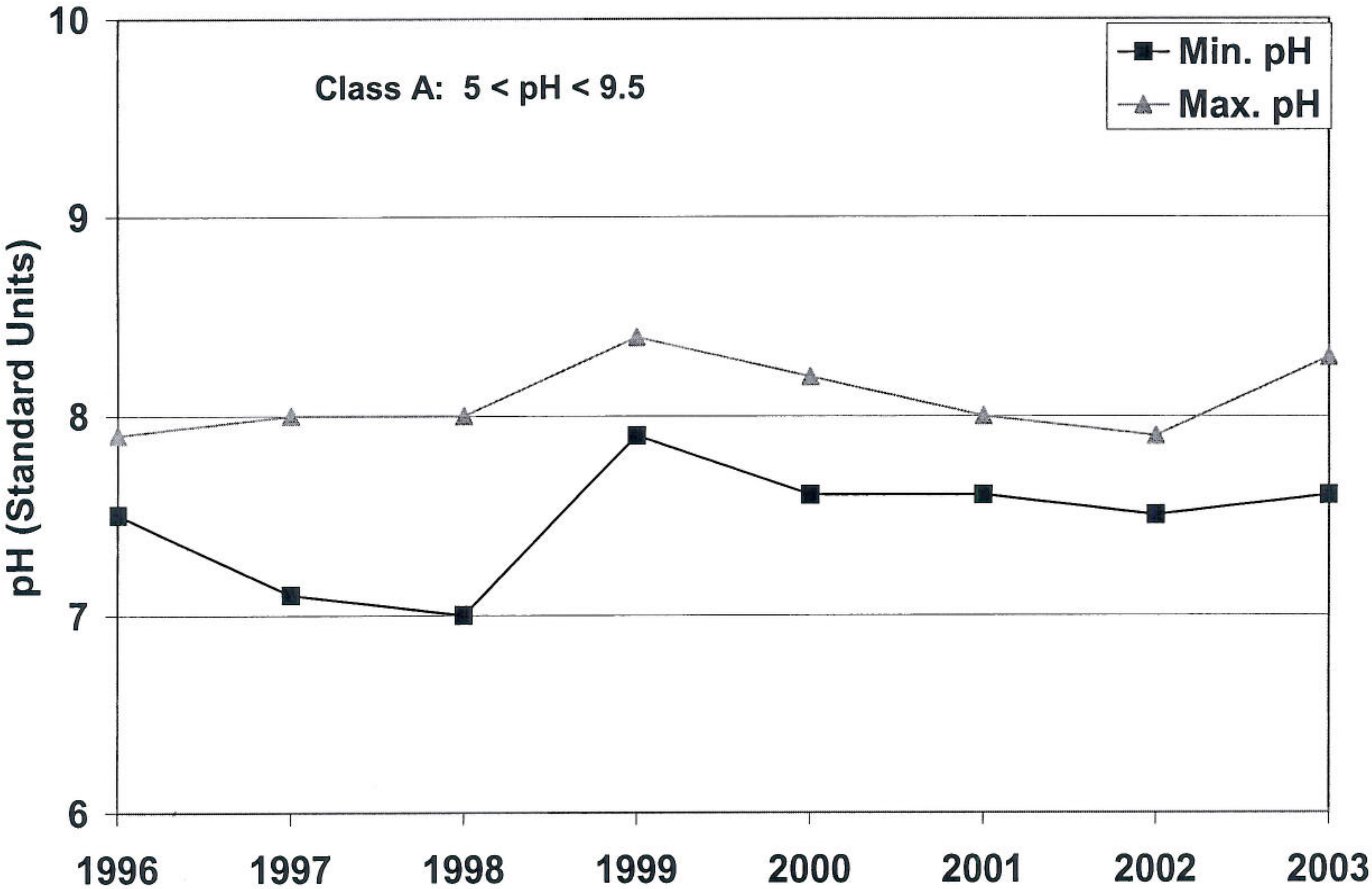
P-4: 1996-2003 Minimum and Maximum pH



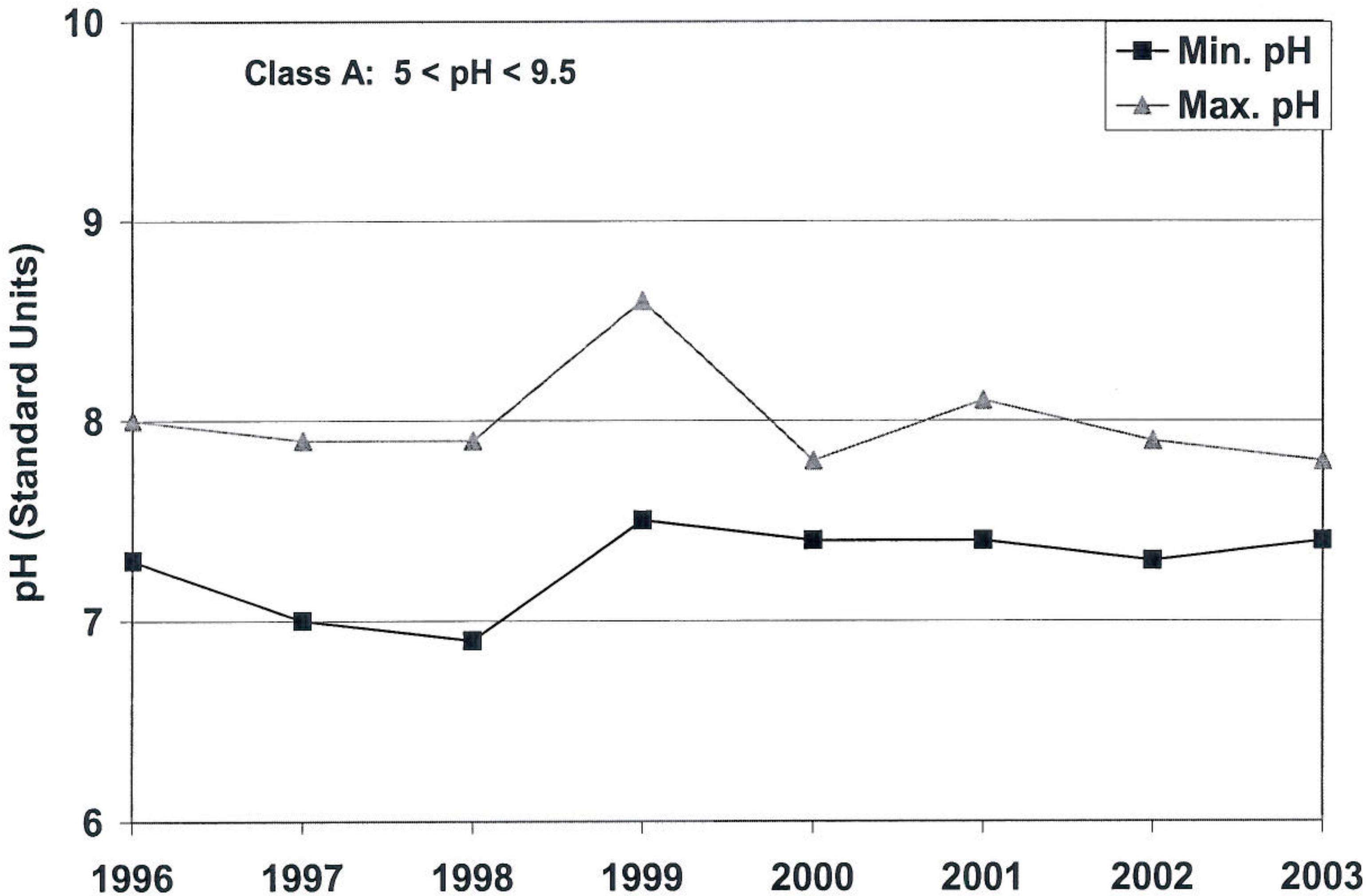
P-5: 1996-2003 Minimum and Maximum pH



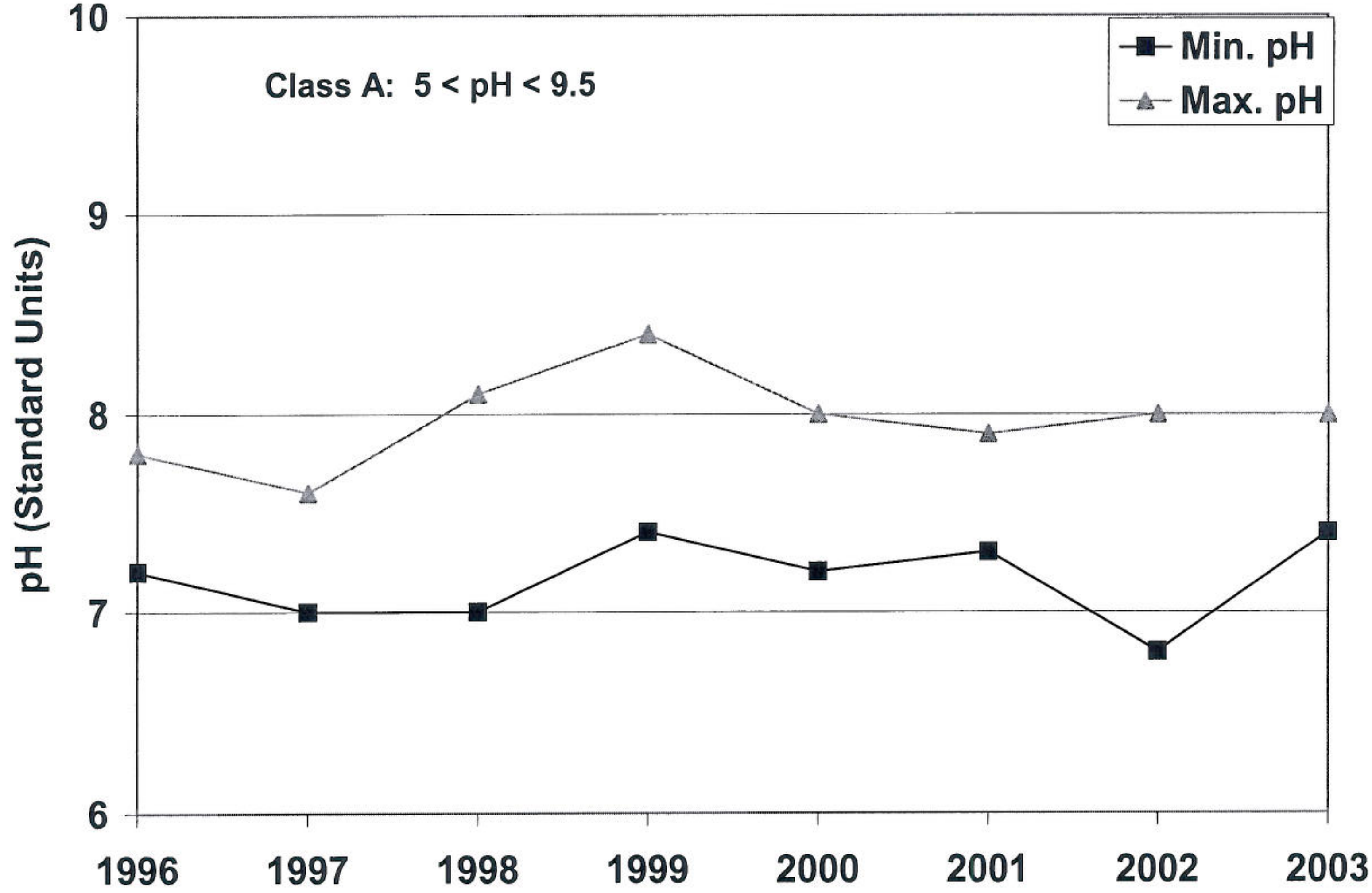
P-6: 1996-2003 Minimum and Maximum pH



P-7: 1996-2003 Minimum and Maximum pH



P-8: 1996-2003 Minimum and Maximum pH



Appendix 3-H

2003 Purgatory Creek Fish Data

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P1

Date (mm/dd/yy): 7/24/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-1 is located east of Branching Horn , X-site (mid reach) is located at 18" stormsewer pipe. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 16.2 (cfs)

Distance (m): 196

Time Fished (sec): 1913

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Pumpkinseed sunfish	48-82	19	3	--	--
2. Common carp	290-450	3064	38	L,E	2--B
3. Largemouth bass	66	4	1	--	--
4. Fantail Darter	36-65	17	9	--	2—A
5. Emerald shiner	68-71	5	2	--	1—C
6. Blacknose dace	70	4	1	--	1—D
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P2

Date (mm/dd/yy): 7/25/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-2 is located upstream and downstream of Homeward Hills Road. X-site (mid reach) is located 17.4M upstream from bridge center. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 9.7 (cfs)

Distance (m): 192

Time Fished (sec): 1719

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Johnny darter	45	.5	1	--	--
2. Common carp	57-97	421	43	Z—missing scales	2—C
3. Hybrid sunfish	50-120	146	13	--	2—D
4. Black bullhead	39-195	245	5	--	1-A
5. Yellow bullhead	42	1	1	--	1—A
6 Spotfin shiner	55	2	1	--	1—B
7. Golden shiner	28	<1	1	--	1--B
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FIX SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P3

Date (mm/dd/yy): 7/30/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-3 is located downstream of Anderson Lakes Parkway. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 3.2 (cfs)

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Distance (m): 198

Time Fished (sec): 1277

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Black bullhead	131-196	156	2	--	Photo
2. Yellow bullhead	175-215	593	5	P, L	Photo
3 Yellow perch	195	109	1	--	Photo
4. Freshwater drum	86	6	1	--	Photo
5. Bigmouth buffalo	101	19	1	--	1—B
6 Northern fathead minnow	37	<1	1	--	1—A
7. Common carp	62-97	603	69	E	2—D
8. Johnny darter	57	2	1	--	1—C
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P4

Date (mm/dd/yy): 8/04/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-4 is located downstream of Mitchell Road. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 1.5 (cfs)

Distance (m): 150

Time Fished (sec): 1418

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Black bullhead	115-160	141	4	--	1--A
2. Yellow bullhead	120	24	1	--	--
3 Central mudminnow	77	4	1	--	Photo
4. Common carp	65-135	98	7	E, missing scales	--
5. Green sunfish	56-90	165	19	--	1—B
6. Creek chub	34-132	121	17	--	3—D
7. Johnny darter	36-41	6	10	--	--
8 Blacknose dace	28-42	1	3	--	2—C
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P5

Date (mm/dd/yy): 8/07/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-5 is located downstream of Mitchell Road. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 2.4 (cfs)

Distance (m): 150

Time Fished (sec): 1466

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Common carp	385-500	3090	3	E,PL	Photo
2. Johnny darter	33	<.5	1	--	--
3 Black bullhead	201	139	1	--	--
4. Central mudminnow	68-110	39	6	--	Photo
5. Creek chub	121-138	51	2	--	--
6. Hybrid sunfish	79-100	76	5	--	--
7.					
8					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P5

Date (mm/dd/yy): 8/07/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-5 is located downstream of Mitchell Road. (Eden Prairie)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 2.4 (cfs)

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Distance (m): 150

Time Fished (sec): 1466

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Common carp	385-500	3090	3	E,PL	Photo
2. Johnny darter	33	<.5	1	--	--
3 Black bullhead	201	139	1	--	--
4. Central mudminnow	68-110	39	6	--	Photo
5. Creek chub	121-138	51	2	--	--
6. Hybrid sunfish	79-100	76	5	--	--
7.					
8					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P6

Date (mm/dd/yy): 8/08/03

Stream Name: Purgatory Creek

County: Hennepin

Location: P-6 is located upstream of Scenic Heights Road. (Minnetonka)

Crew: DJM, TWG,KSJ

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 1.1 (cfs)

Distance (m): 150

Time Fished (sec): 1628

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. Common carp	250	244	1	E	--
2. Northern pike	230	73	1	E	--
3 Creek chub	35-235	2107	50	E	3—F
4. Bluntnose minnow	59	2	1	--	1—A
5. White sucker	122-140	47	2	--	1—B
6. Pumpkinseed sunfish	80-92	47	4	--	--
7. Johnny darter	34-65	12	14	--	3-C
8 Blacknose dace	28-93	230	44	--	2-D
9. Northern fathead minnow	50-58	3	2	--	2--E
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD

BARR ENGINEERING

Field Number: ECU-P7—**Streambed Dry**

Date (mm/dd/yy): 8/14/03 **Streambed dry**

Stream Name: Purgatory Creek

County: Hennepin

Location: P-7 is located downstream of Covington Road. (Minnetonka)

Crew: DJM

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 0 (cfs) --DRY

Distance (m): 150

Time Fished (sec):

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. **STREAMBED DRY**					
2.					
3					
4.					
5.					
6.					
7.					
8					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

FISH SURVEY RECORD **BARR ENGINEERING**

Field Number: ECU-P8—**Streambed Dry**

Date (mm/dd/yy): 8/14/03 **Streambed dry**

Stream Name: Purgatory Creek

County: Hennepin

Location: P-8 is located upstream of Dell Road and Duck Lake Trail. 52m downstream fro x-site (mid reach) is a 5.8m submerged unshockable cmp. Extended stream reach 23m downstream from end of cmp. (Minnetonka)

Crew: DJM

Gear Type: Backpack, LR-24 Smith-Root Electrofisher

Stream Discharge on Electrofishing Date: 0 (cfs) --DRY

Distance (m): 150

Time Fished (sec):

Identified By: field identifications by--DJM, voucher's and photo's sent to U of M for identification by Andrew Simon's, Ph. D., Dept. of Fisheries and Wildlife

Species (common name)	Length Range (mm)	Weight (g)	Number	Anomalies	Voucher
1. **STREAMBED DRY**					
2.					
3					
4.					
5.					
6.					
7.					
8					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; N-blind; P=parasites; PL-parasite lesion; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other. (Heavy (H) or Light (L) code may be combined with above codes.)

Appendix 3-I

Purgatory Creek Biological Data Analysis

Appendix 3-I-1

Summary of Fish Data Analysis

Taxa	P1	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							3
Centrarchidae										
Catostomus commersoni	white sucker	D	1	1	1	1		3		
Lepomis cyanellus	green sunfish	B	3	8						
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3							
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3							1
Cyprinus carpio	carp	D	1	1		1				38
Etheostoma flabellare	fantail darter									9
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							2
Notropis heterodon	blackchin shiner	C	2	7						
Notropis dorsalis	central big mouth shiner		1.5		8					
Notropis emiliae	pugnose minnow		1.5			1	33			
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2					6		
Notemigonus crysoleucas	golden shiner	D	1				1			
Rhinichthys atratulus	blacknose dace	C	2							1
Pimephales promelas	northern fat head minnow	D	1							
Pinephales notatus	bluntnose minnow	D	1						8	
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	1	8					
Esox lucius	northern pike	B	3							
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3							
Ictalurus melas	black bullhead	B	3					1		
Ictalurus melas	brown bullhead	B	3			2				
Perca flavescens	yellow perch	B	3						1	
Etheostoma nigrum	Johnny darter	D	1		1					
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							
Total Number of Fish				18	18	5	34	10	9	54
Average Ecological Use				2.28	1.22	1.90	1.49	1.80	1.22	1.00
Long Term Use				1.56	1.56	1.56	1.56	1.56	1.56	1.56
percent tolerant to low DO				50	0	20	3	10	0	70
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				11	50	20	0	30	89	2
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				7	0	0	0	6	0	0
percent intolerant species				39	0	0	0	60	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				1	2	1	0	3	1	13
gamefish criteria				2	2	2	2	2	2	2

Taxa	P2	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							
Centrarchidae										
Catostomus commersoni	white sucker	D	1		2	1	1	100		
Lepomis cyanellus	green sunfish	B	3	1						
Lepomis sp.	sunfish	B	3							13
Lepomis macrochirus	blue gill	B	3						4	
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3		1					
Micropterus salmoides	largemouth bass	B	3			1	1			
Cyprinus carpio	carp	D	1	10	2					43
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							1
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1						8	1
Rhinichthys atratulus	blacknose dace	C	2							
Pimephales promelas	northern fat head minnow	D	1		1				11	
Pinephales notatus	bluntnose minnow	D	1							
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	1	1					
Esox lucius	northern pike	B	3					1		
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3						1	1
Ictalurus melas	black bullhead	B	3	1	4		6	18		5
Ictalurus melas	brown bullhead	B	3			3				
Perca flavescens	yellow perch	B	3					1	7	
Etheostoma nigrum	Johnny darter	D	1							1
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							
Total Number of Fish				13	11	5	8	120	31	65
Average Ecological Use				1.31	1.91	2.60	2.75	1.33	1.77	1.60
Long Term Use				1.90	1.90	1.90	1.90	1.90	1.90	1.90
percent tolerant to low DO				92	64	0	75	15	65	77
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				8	27	20	13	83	0	0.0
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	0	0	0
percent intolerant species				0	0	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				0	3	2	2	102	11	14
gamefish criteria				2	2	2	2	2	2	2

Taxa	P3	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3			3				
Centrarchidae										
Catostomus commersoni	white sucker	D	1		1		2			
Lepomis cyanellus	green sunfish	B	3	149	9	7				
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3	8					3	
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3	6	7	11	1			
Micropterus salmoides	largemouth bass	B	3	3	1					
Cyprinus carpio	carp	D	1				4		1	69
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							1
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1					3		
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1					1		
Rhinichthys atratulus	blacknose dace	C	2							
Pimephales promelas	northern fat head minnow	D	1				32			1
Pinephales notatus	bluntnose minnow	D	1							
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1						3	
Esox lucius	northern pike	B	3	1				2		
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3						1	5
Ictalurus melas	black bullhead	B	3	2	70		56	18	5	2
Ictalurus melas	brown bullhead	B	3			90				
Perca flavescens	yellow perch	B	3					113	2	1
Etheostoma nigrum	Johnny darter	D	1							1
Aplodinotus grunniens	freshwater drum								1	1
Umbra limi	central mud minnow	D	1							
Total Number of Fish				169	88	111	95	137	16	81
Average Ecological Use				3.00	2.98	3.00	2.20	2.94	2.31	1.19
Long Term Use				2.52	2.52	2.52	2.52	2.52	2.52	2.52
percent tolerant to low DO				89	90	6	97	16	44	95
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				0	1	0	2	0	19	0
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	0	0	0
percent intolerant species				0	0	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				18	9	14	3	115	6	4
gamefish criteria				2	2	2	2	2	2	2

Taxa	P4	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							
Centrarchidae										
Catostomus commersoni	white sucker	D	1	3	2					
Lepomis cyanellus	green sunfish	B	3				2			19
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3		2				2	
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3							
Cyprinus carpio	carp	D	1							7
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2						14	
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1							
Rhinichthys atratulus	blacknose dace	C	2							3
Pimephales promelas	northern fat head minnow	D	1			4	34	3		
Pinephales notatus	bluntnose minnow	D	1							
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	27	8		6	1	2	17
Esox lucius	northern pike	B	3		1	1		4		
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3		4					1
Ictalurus melas	black bullhead	B	3		12		31	10		4
Ictalurus melas	brown bullhead	B	3			8				
Perca flavescens	yellow perch	B	3					1		
Etheostoma nigrum	Johnny darter	D	1	11		8	18		10	10
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1	1					1	1
Total Number of Fish				42	29	21	91	19	29	62
Average Ecological Use				1.00	2.31	1.86	1.73	2.58	1.62	1.82
Long Term Use				1.84	1.84	1.84	1.84	1.84	1.84	1.84
percent tolerant to low DO				2	55	19	74	68	3	52
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				71	34	0	7	5	7	32
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	0	0	0
percent intolerant species				0	0	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				14	5	9	18	5	12	10
gamefish criteria				2	2	2	2	2	2	2

Taxa	P5	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3		2					
Centrarchidae										
Catostomus commersoni	white sucker	D	1	5	4	5	1	3	9	
Lepomis cyanellus	green sunfish	B	3				2			
Lepomis sp.	sunfish	B	3							5
Lepomis macrochirus	blue gill	B	3						5	
Pomoxis nigromaculatis	black crappie	B	3						1	
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3				1			
Cyprinus carpio	carp	D	1							3
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1							
Rhinichthys atratulus	blacknose dace	C	2							
Pimephales promelas	northern fat head minnow	D	1							
Pinephales notatus	bluntnose minnow	D	1						3	
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	55	22	11	13	3	55	2
Esox lucius	northern pike	B	3		1		1	3		
Eucalia inconstans	brook stickleback	D	1				7			
Ictalurus natalis	yellow bullhead	B	3							
Ictalurus melas	black bullhead	B	3		6					1
Ictalurus melas	brown bullhead	B	3			1				
Perca flavescens	yellow perch	B	3							
Etheostoma nigrum	Johnny darter	D	1	3	16	8	25		10	1
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							6
Total Number of Fish				63	51	25	50	9	83	18
Average Ecological Use				1.00	1.35	1.08	1.16	1.67	1.14	1.67
Long Term Use				1.30	1.30	1.30	1.30	1.30	1.30	1.30
percent tolerant to low DO				0	12	0	18	0	0	56
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				95	51	64	28	67	81	11
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	0	0	0
percent intolerant species				0	0	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				8	23	13	28	6	25	6
gamefish criteria				2	2	2	2	2	2	2

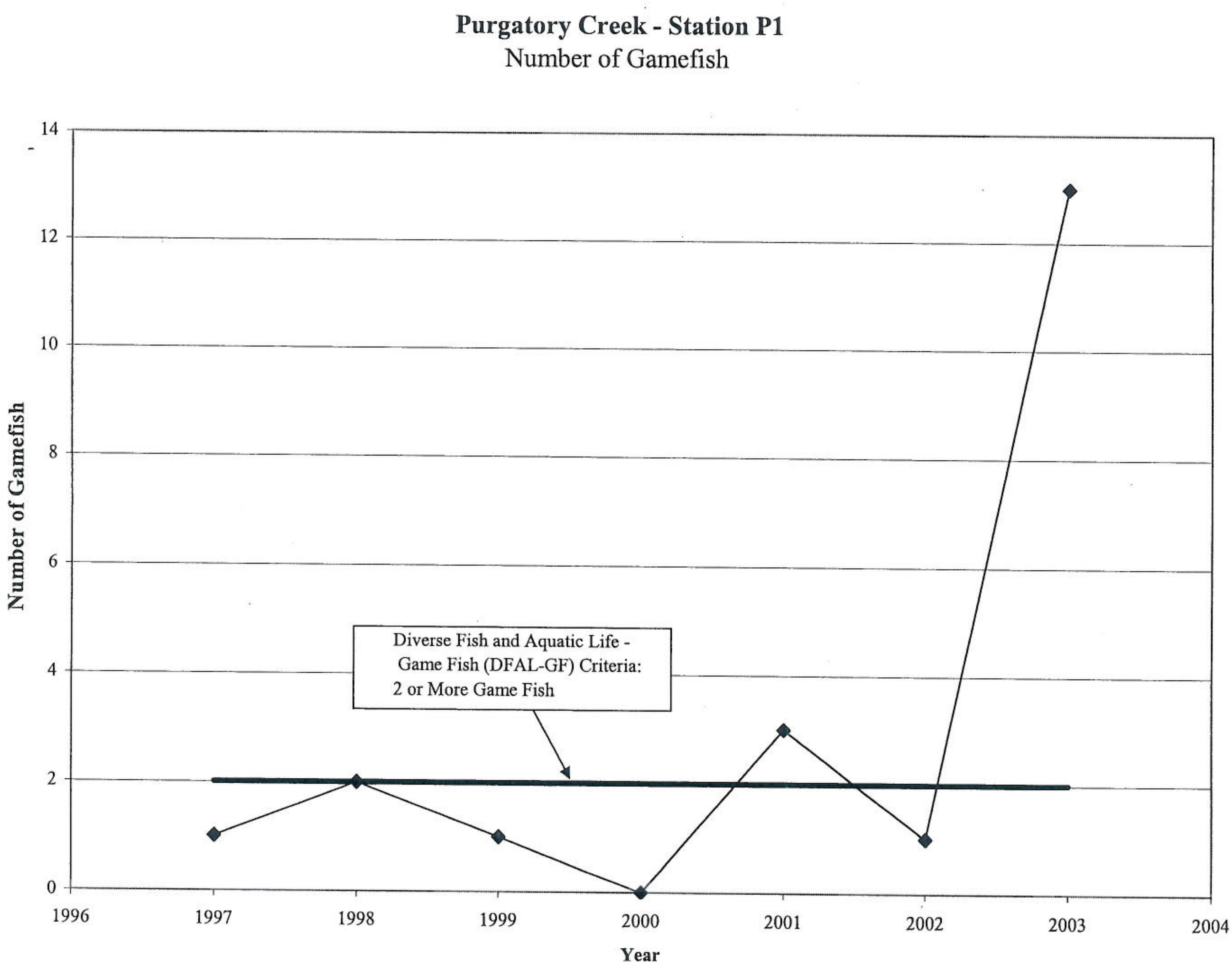
Taxa	P6	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							4
Centrarchidae										
Catostomus commersoni	white sucker	D	1	9	2	1	3	2	3	2
Lepomis cyanellus	green sunfish	B	3					1	3	
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3			1			1	
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3		1					
Cyprinus carpio	carp	D	1							1
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2	1	1					
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2		1					
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1							
Rhinichthys atratulus	blacknose dace	C	2						2	44
Pimephales promelas	northern fat head minnow	D	1			24	53	15	2	2
Pinephales notatus	bluntnose minnow	D	1							1
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	89	60	17	16	14	17	50
Esox lucius	northern pike	B	3							1
Eucalia inconstans	brook stickleback	D	1				1			
Ictalurus natalis	yellow bullhead	B	3							
Ictalurus melas	black bullhead	B	3							
Ictalurus melas	brown bullhead	B	3							
Perca flavescens	yellow perch	B	3							
Etheostoma nigrum	Johnny darter	D	1	23	3	6	8	4	7	14
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							
Total Number of Fish				122	68	49	81	36	35	119
Average Ecological Use				1.01	1.06	1.04	1.00	1.06	1.29	1.45
Long Term Use				1.13	1.13	1.13	1.13	1.13	1.13	1.13
percent tolerant to low DO				0	0	49	67	44	14	3
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				80	91	37	23	44	63	82
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				1	2	0	0	0	0	0
percent intolerant species				1	3	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				32	6	8	11	6	11	21
gamefish criteria				2	2	2	2	2	2	2

Taxa	P7	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							
Centrarchidae				1						
Catostomus commersoni	white sucker	D	1				1			
Lepomis cyanellus	green sunfish	B	3						3	
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3		1				1	
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3		1					
Cyprinus carpio	carp	D	1							
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2							
Notemigonus crysoleucas	golden shiner	D	1							
Rhinichthys atratulus	blacknose dace	C	2							
Pimephales promelas	northern fat head minnow	D	1				14	22		
Pinephales notatus	bluntnose minnow	D	1							
Phoxinus eos	northern redbelly dace	C	2							
Semotilus atromaculatus	creek chub	D	1	15	42				15	
Esox lucius	northern pike	B	3							
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3							
Ictalurus melas	black bullhead	B	3							
Ictalurus melas	brown bullhead	B	3							
Perca flavescens	yellow perch	B	3							
Etheostoma nigrum	Johnny darter	D	1		7					
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							
Total Number of Fish				16	51	0	15	22	19	0
Average Ecological Use				0.94	1.08	0.00	1.00	1.00	1.42	0.00
Long Term Use				1.09	1.09	1.09	1.09	1.09	1.09	1.09
percent tolerant to low DO				0	0	0	93	100	16	0
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				94	82	0	7	0	79	0
percent stenothermal coolwater fish species				0	0	0	0	0	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	0	0	0
percent intolerant species				0	0	0	0	0	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				1	9	0	1	0	1	0
gamefish criteria				2	2	2	2	2	2	2

Taxa	P8	Ecological Use	Ecological Use by #	1997	1998	1999	2000	2001	2002	2003
Lepomis gibbosus	pumpkinseed	B	3							
Centrarchidae										
Catostomus commersoni	white sucker	D	1							
Lepomis cyanellus	green sunfish	B	3						1	
Lepomis sp.	sunfish	B	3							
Lepomis macrochirus	blue gill	B	3							
Pomoxis nigromaculatis	black crappie	B	3							
Pomoxis sp.	crappie	B	3							
Micropterus salmoides	largemouth bass	B	3							
Cyprinus carpio	carp	D	1							
	fantail darter									
Ictiobus cyprinellus	bigmouth buffalo	D	1							
Notropis atherinoides	emerald shiner	D	1							
Notropis heterodon	blackchin shiner	C	2							
Notropis dorsalis	central big mouth shiner		1.5							
Notropis emiliae	pugnose minnow		1.5							
Notropis rubellus	rosyface shiner	C	2							
Carrassius auratus	goldfish	D	1							
Cyprinella spiloptera	spotfin shiner	C	2							
Notropis hudsonius	spottail shiner	C	2					1		
Notemigonus crysoleucas	golden shiner	D	1							
Rhinichthys atratulus	blacknose dace	C	2							
Pimephales promelas	northern fat head minnow	D	1				1		2	
Pinephales notatus	bluntnose minnow	D	1							
Phoxinus eos	northern redbelly dace	C	2					2		
Semotilus atromaculatus	creek chub	D	1				1			
Esox lucius	northern pike	B	3							
Eucalia inconstans	brook stickleback	D	1							
Ictalurus natalis	yellow bullhead	B	3							
Ictalurus melas	black bullhead	B	3							
Ictalurus melas	brown bullhead	B	3							
Perca flavescens	yellow perch	B	3							
Etheostoma nigrum	Johnny darter	D	1							
Aplodinotus grunniens	freshwater drum									
Umbra limi	central mud minnow	D	1							
Total Number of Fish				0	0	0	2	3	3	0
Average Ecological Use				0.00	0.00	0.00	1.00	2.00	1.67	0.00
Long Term Use				1.56	1.56	1.56	1.56	1.56	1.56	1.56
percent tolerant to low DO				0	0	0	50	0	100	0
low DO criteria				75	75	75	75	75	75	75
percent tolerant to disturbed habitat				0	0	0	50	0	0	0.0
percent stenothermal coolwater fish species				0	0	0	0	67	0	0
coolwater criteria				5	5	5	5	5	5	5
number of intolerant species				0	0	0	0	1	0	0
percent intolerant species				0	0	0	0	33	0	0
intolerant criteria				10	10	10	10	10	10	10
number of gamefish				0	0	0	0	0	0	0
gamefish criteria				2	2	2	2	2	2	2

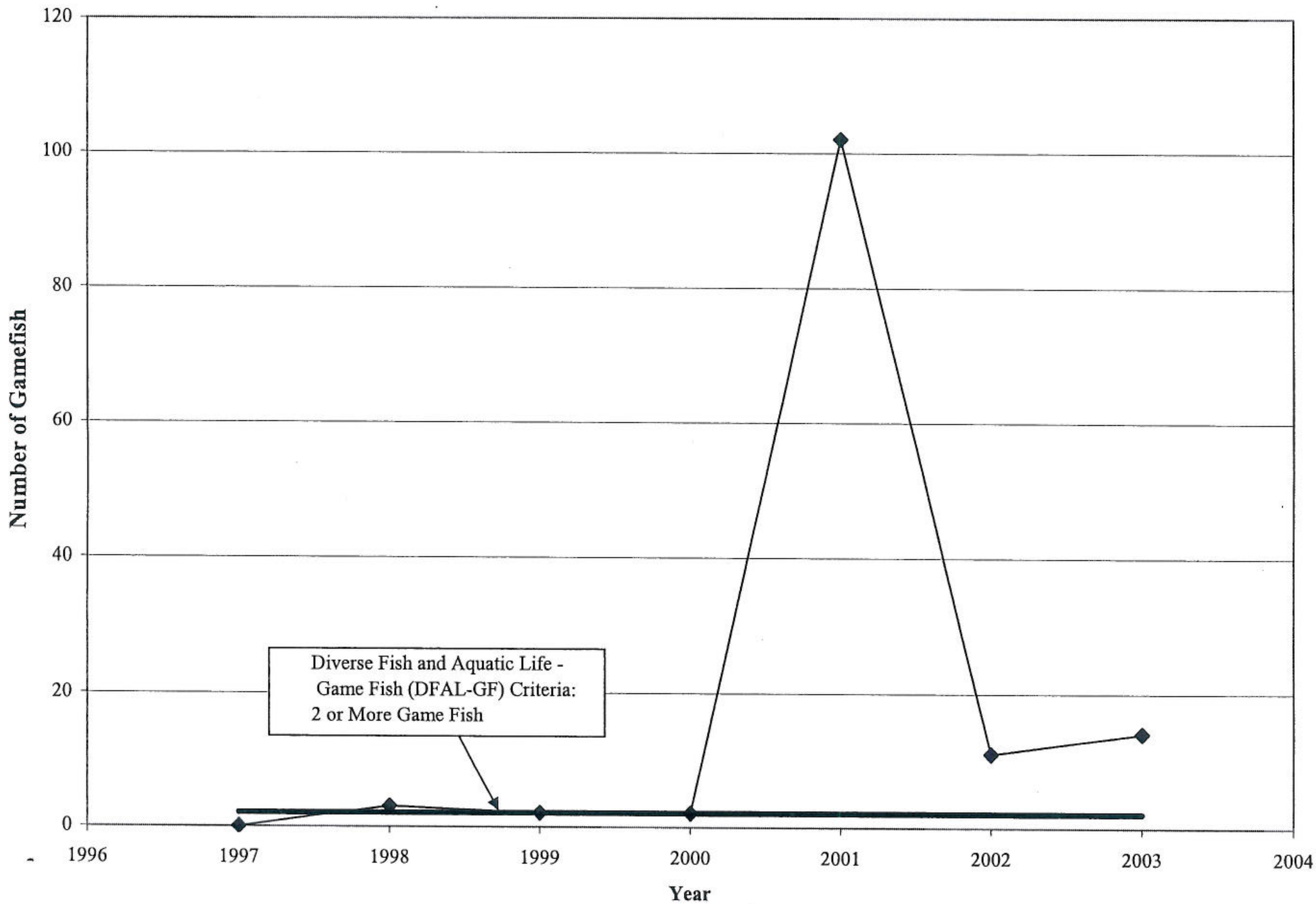
Appendix 3-I-2

Number of Gamefish



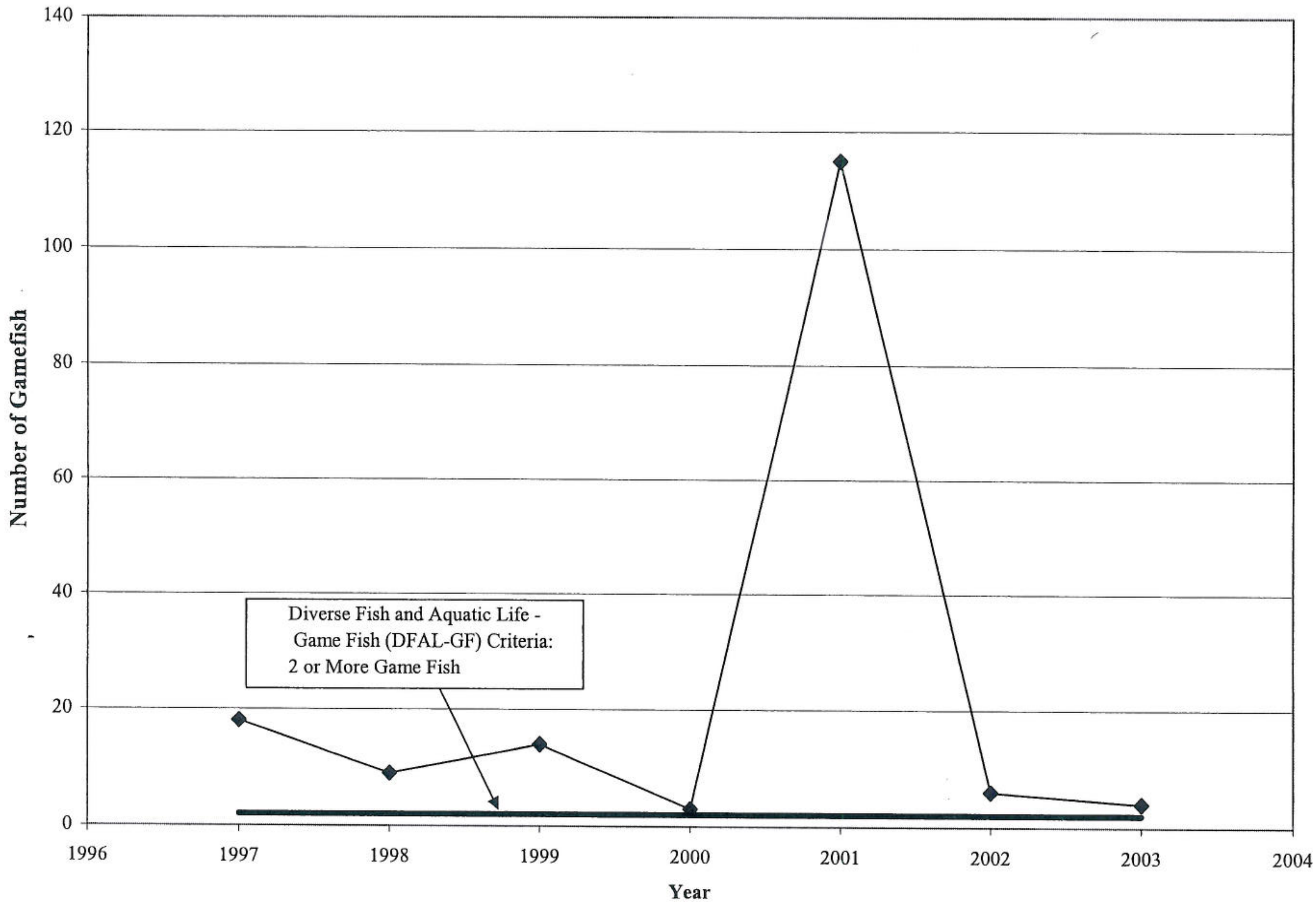
P:\23\27\053\RPBCECU\purg_fish_charts.xlsP1 game

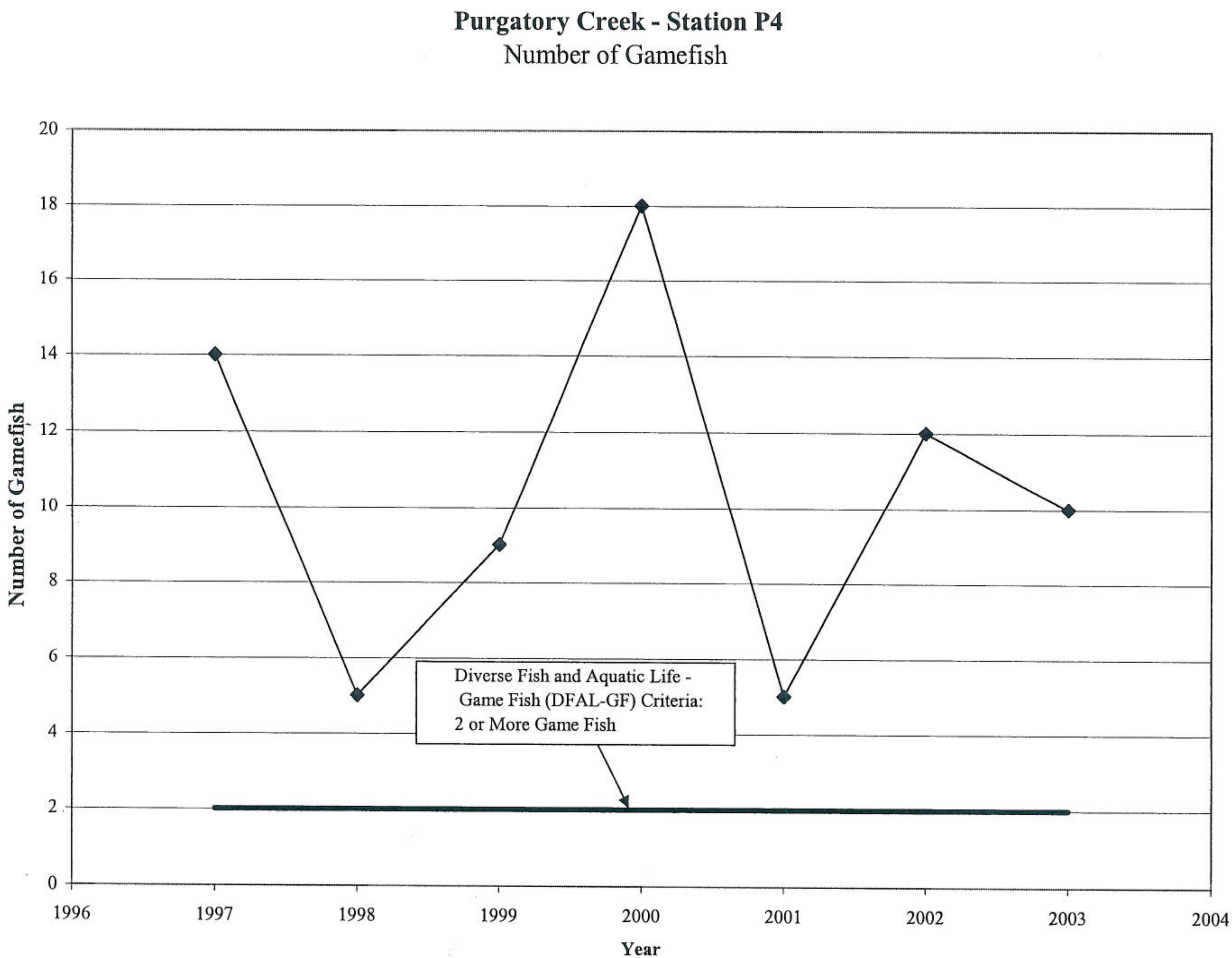
Purgatory Creek - Station P2
Number of Gamefish



P:\23\27\053\RPBCECU\purg_fish_charts.xlsP2 game

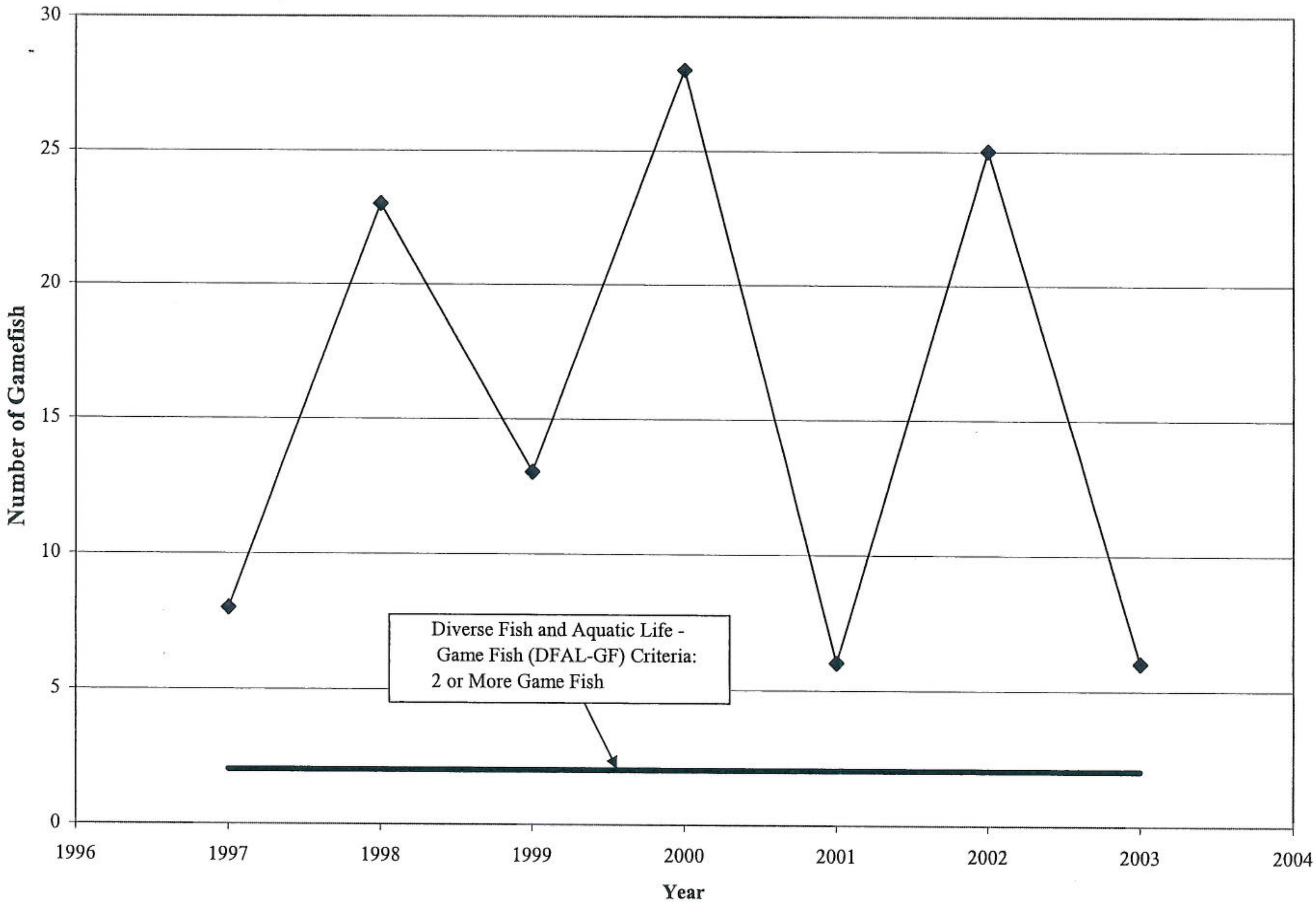
Purgatory Creek - Station P3
Number of Gamefish



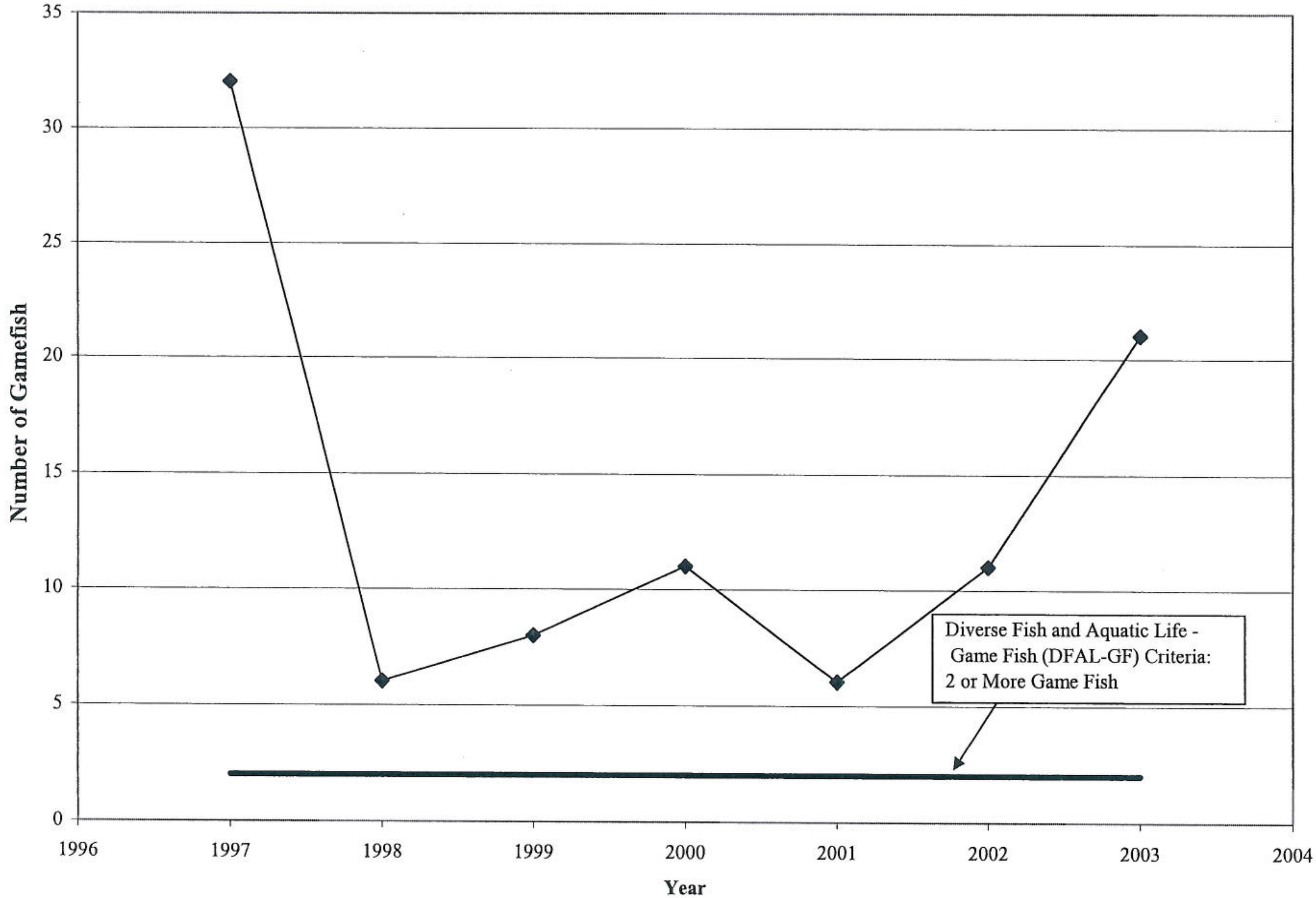

Purgatory Creek - Station P4
Number of Gamefish
Number of Gamefish
20
18
16
14
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year
Diverse Fish and Aquatic Life - Game Fish (DFAL-GF) Criteria: 2 or More Game Fish

Purgatory Creek - Station P5

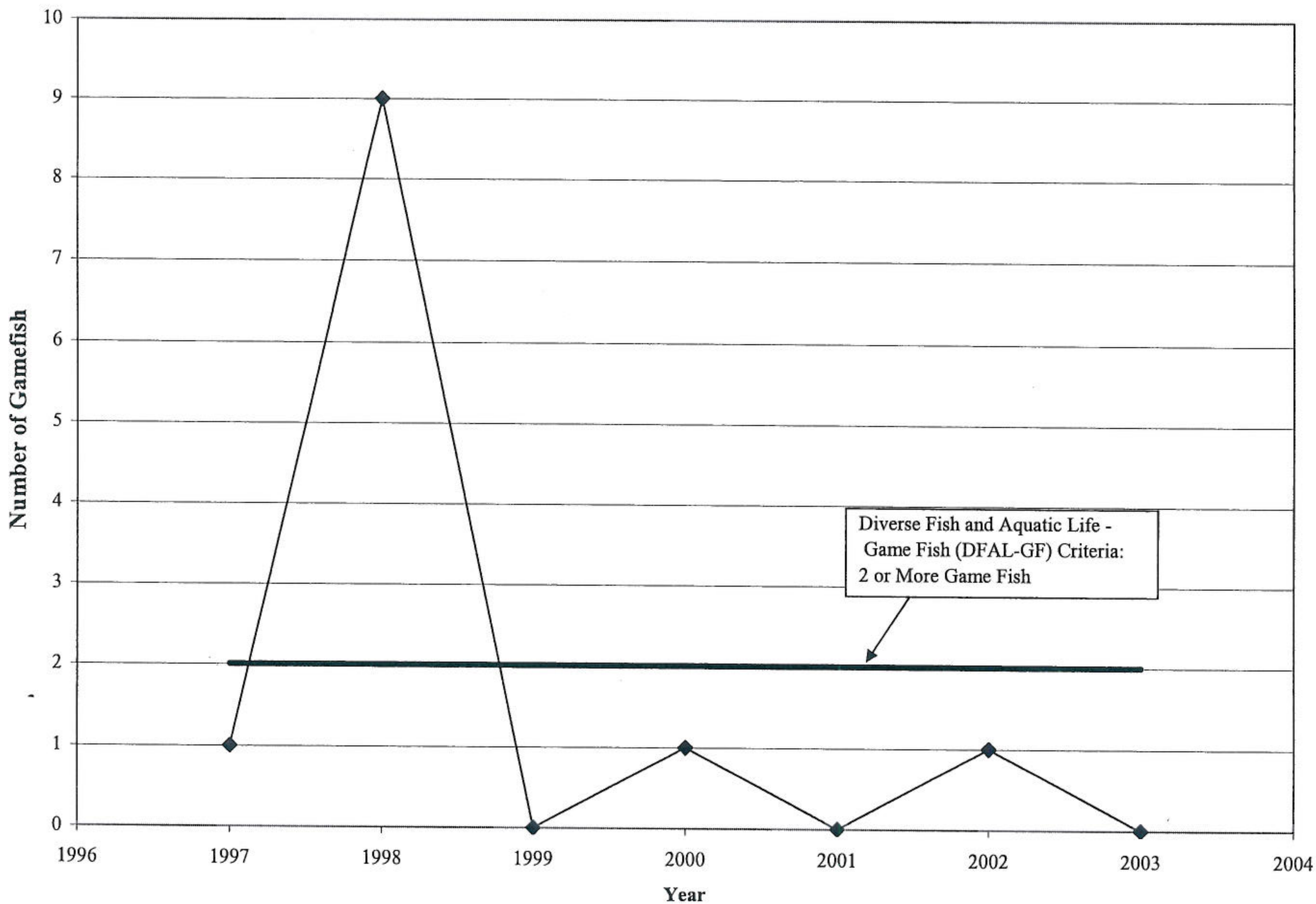
Number of Gamefish

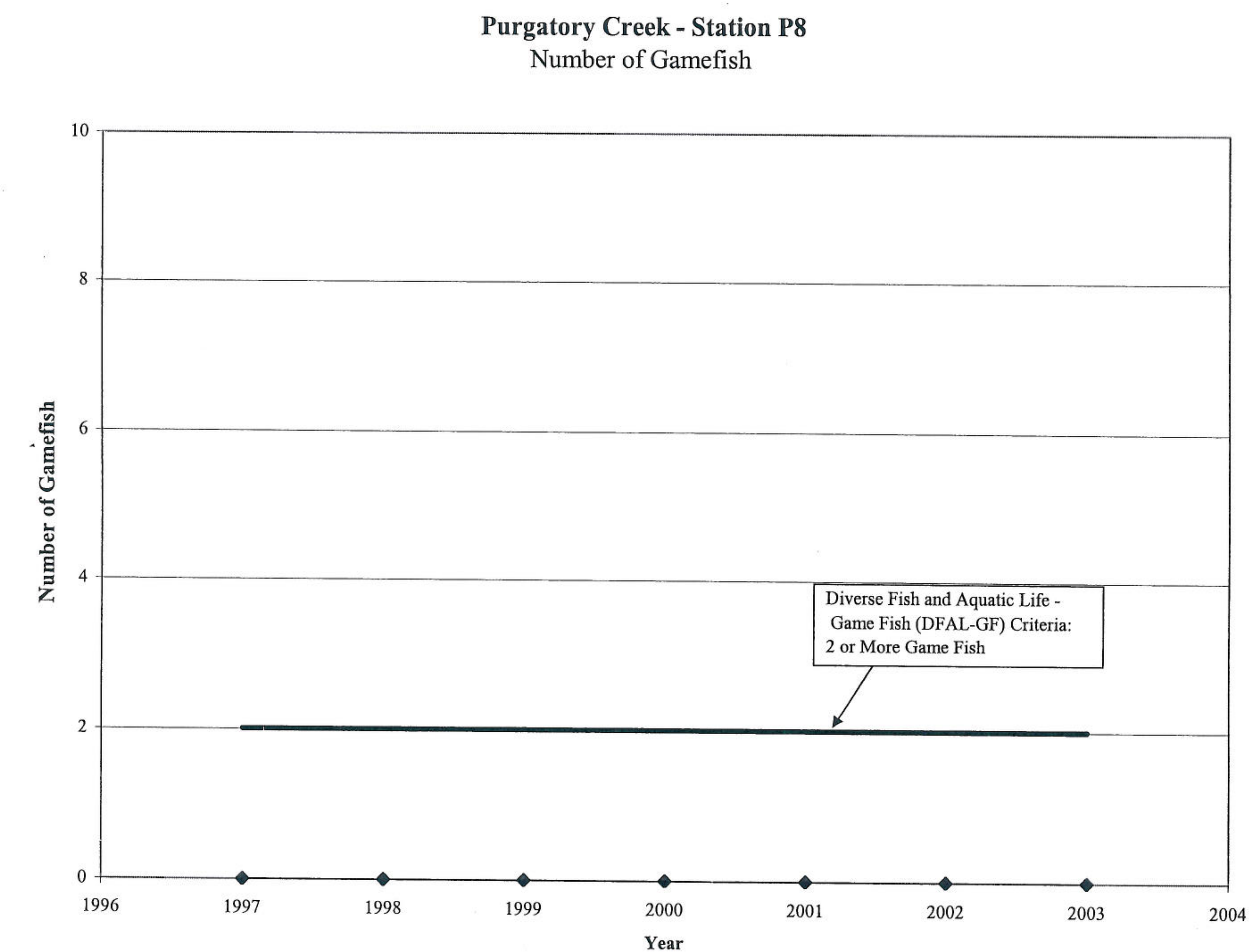


Purgatory Creek - Station P6
Number of Gamefish



Purgatory Creek - Station P7
Number of Gamefish



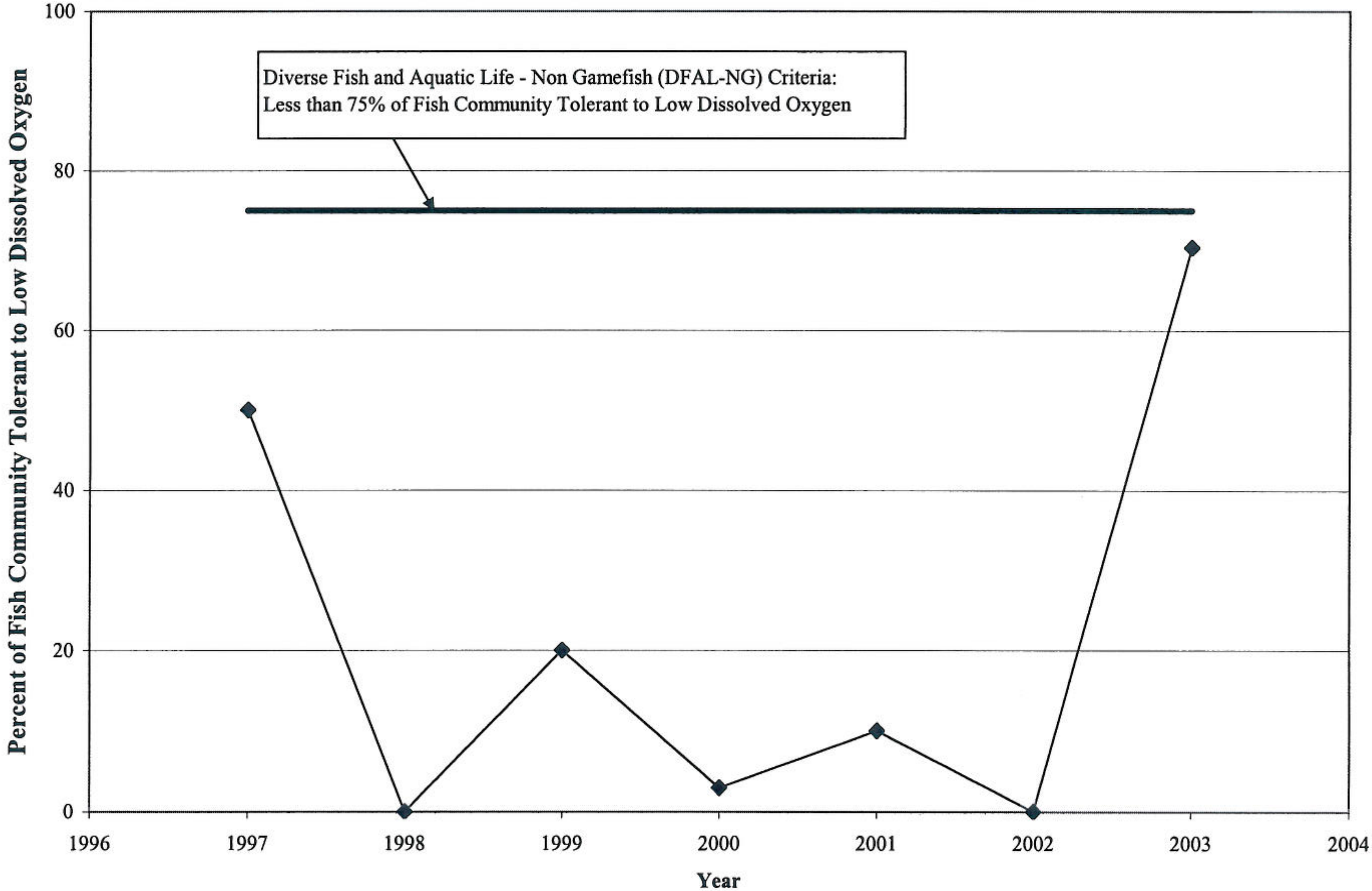

Purgatory Creek - Station P8
Number of Gamefish
Number of Gamefish
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year
Diverse Fish and Aquatic Life - Game Fish (DFAL-GF) Criteria: 2 or More Game Fish

Appendix 3-I-3

Percent of Fish Community Tolerant to Low Dissolved Oxygen

Purgatory Creek - Station P1

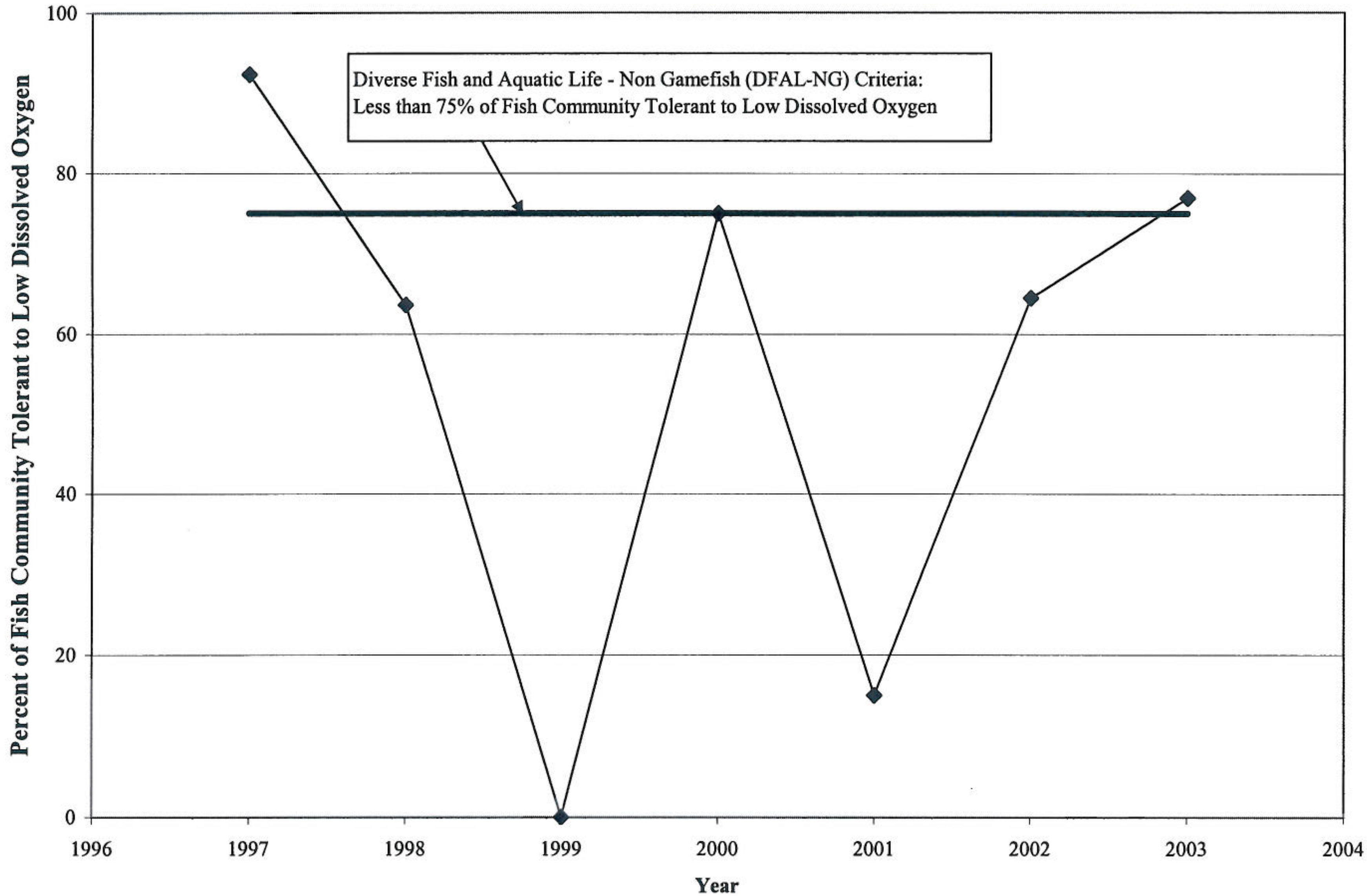
Percent of Fish Community Tolerant to Low Dissolved Oxygen



P:\23\27\053\STREAM\RPBCECU\purg_fish_chartsP1 low DO

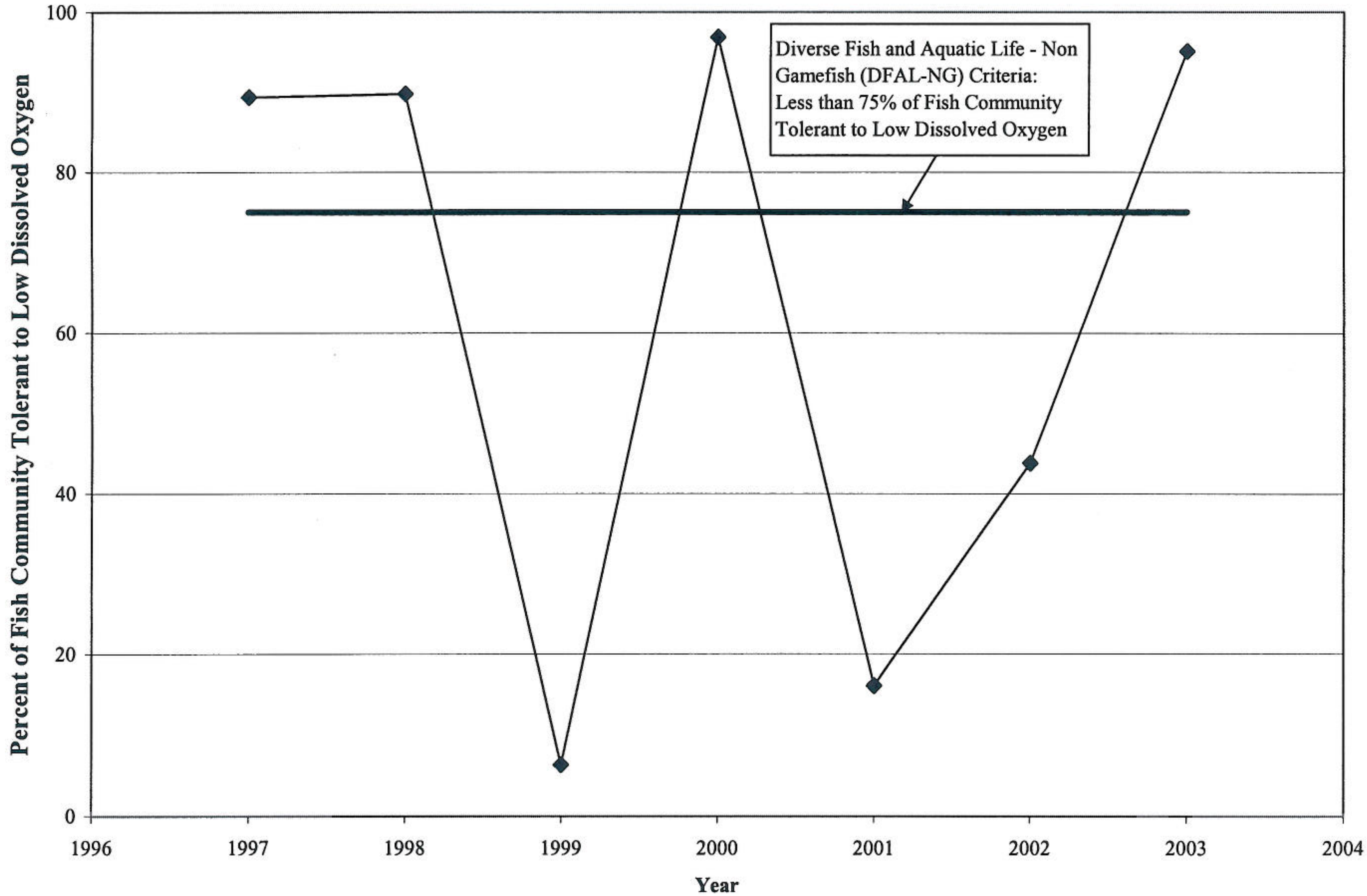
Purgatory Creek - Station P2

Percent of Fish Community Tolerant to Low Dissolved Oxygen

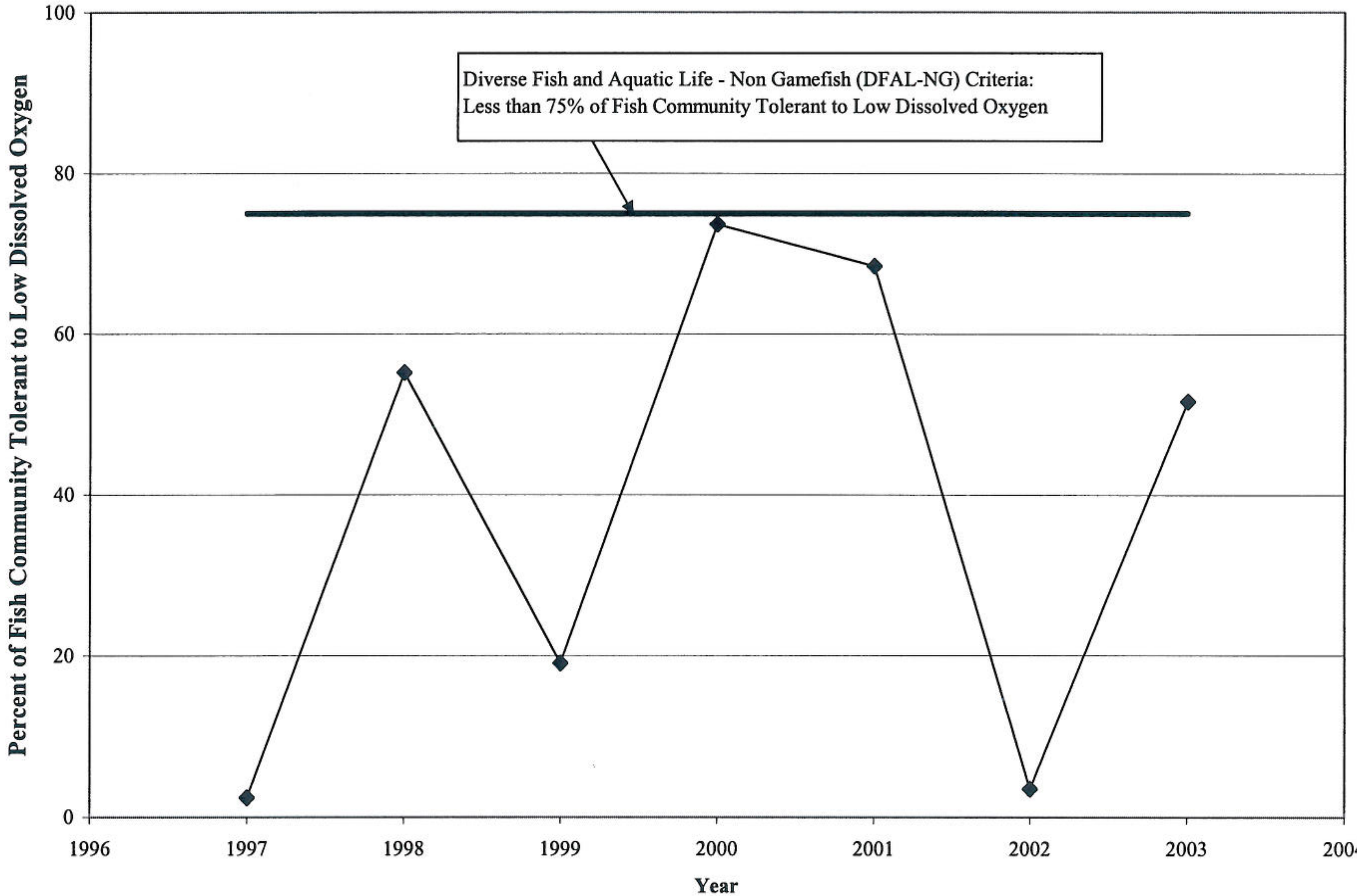


Purgatory Creek - Station P3

Percent of Fish Community Tolerant to Low Dissolved Oxygen



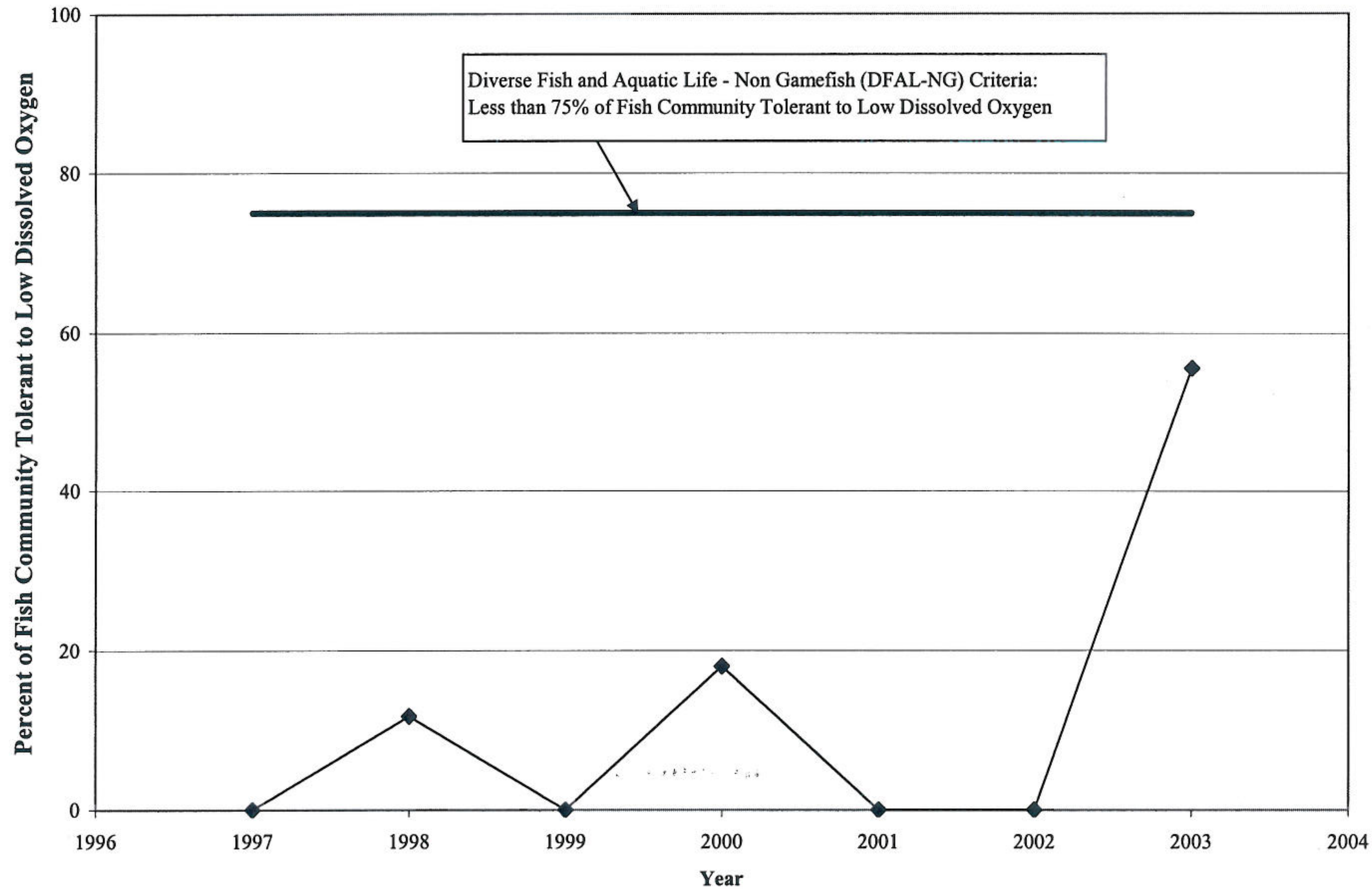
Purgatory Creek - Station P4
Percent of Fish Community Tolerant to Low Dissolved Oxygen



P:\23\27\053\STREAM\RPBCECU\purg_fish_chartsP4 low DO

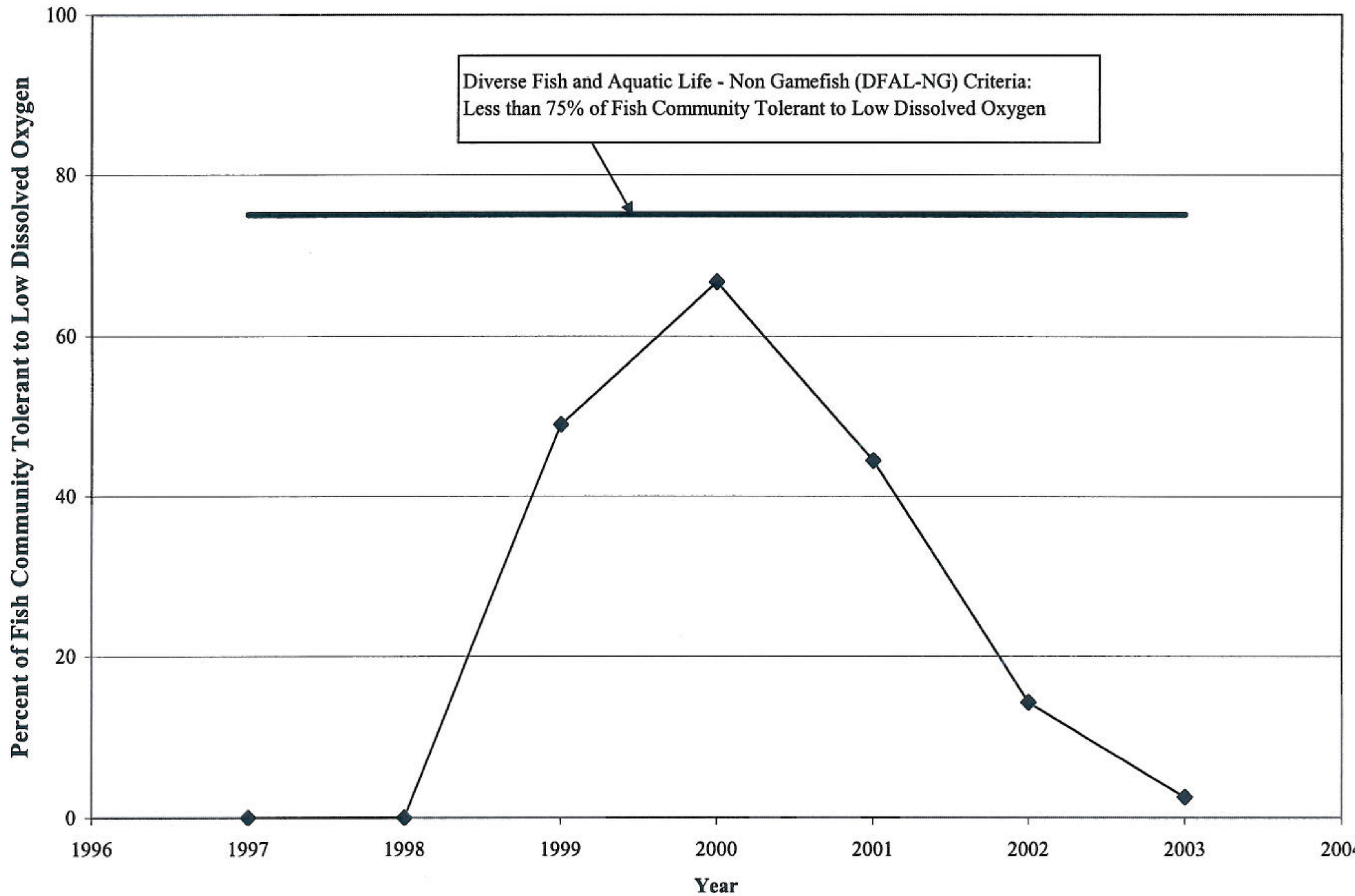
Purgatory Creek - Station P5

Percent of Fish Community Tolerant to Low Dissolved Oxygen



Purgatory Creek - Station P6

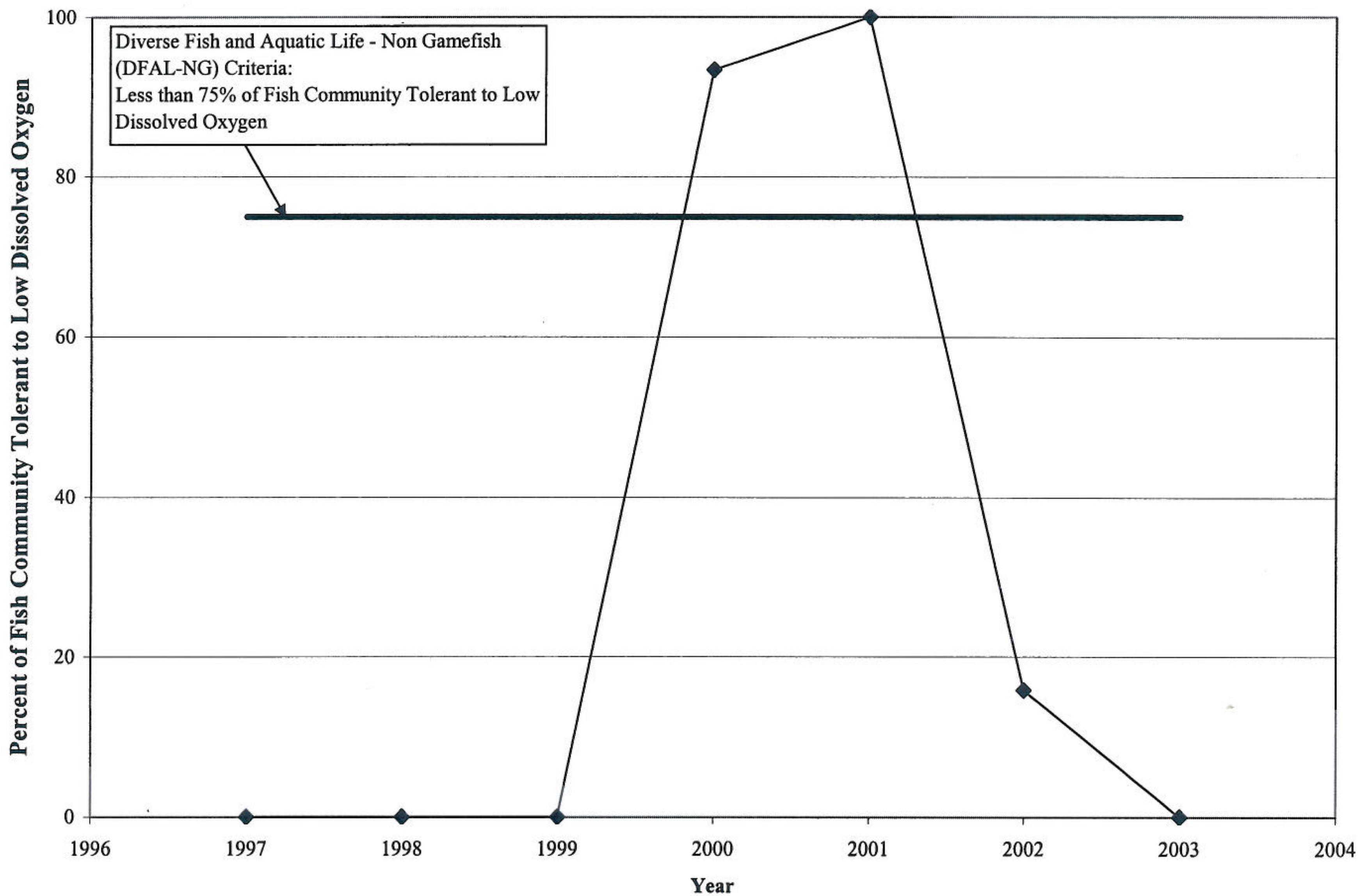
Percent of Fish Community Tolerant to Low Dissolved Oxygen



P:\23\27\053\STREAM\RPBCECU\purg_fish_chartsP6 low DO

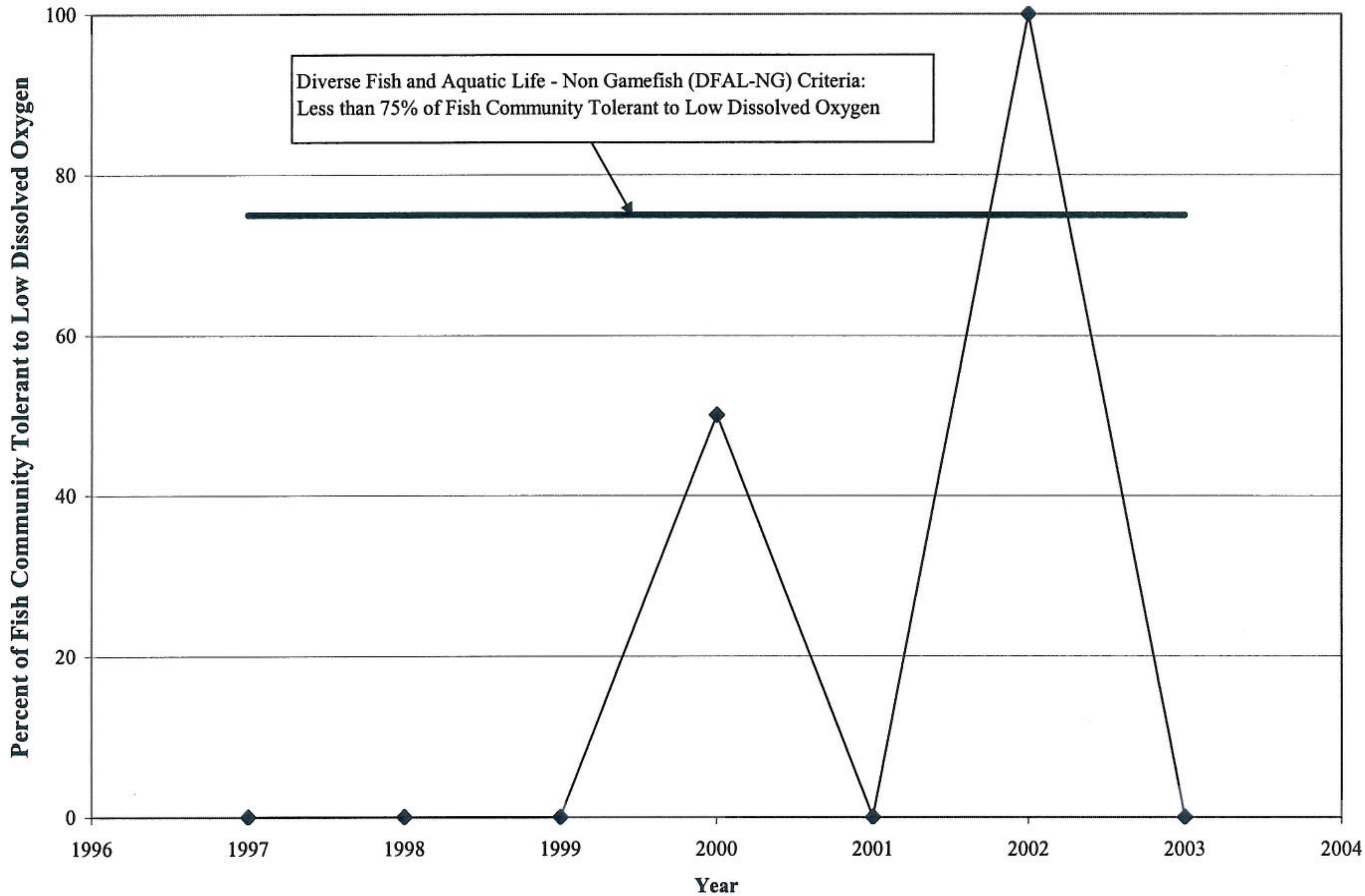
Purgatory Creek - Station P7

Percent of Fish Community Tolerant to Low Dissolved Oxygen



Purgatory Creek - Station P8

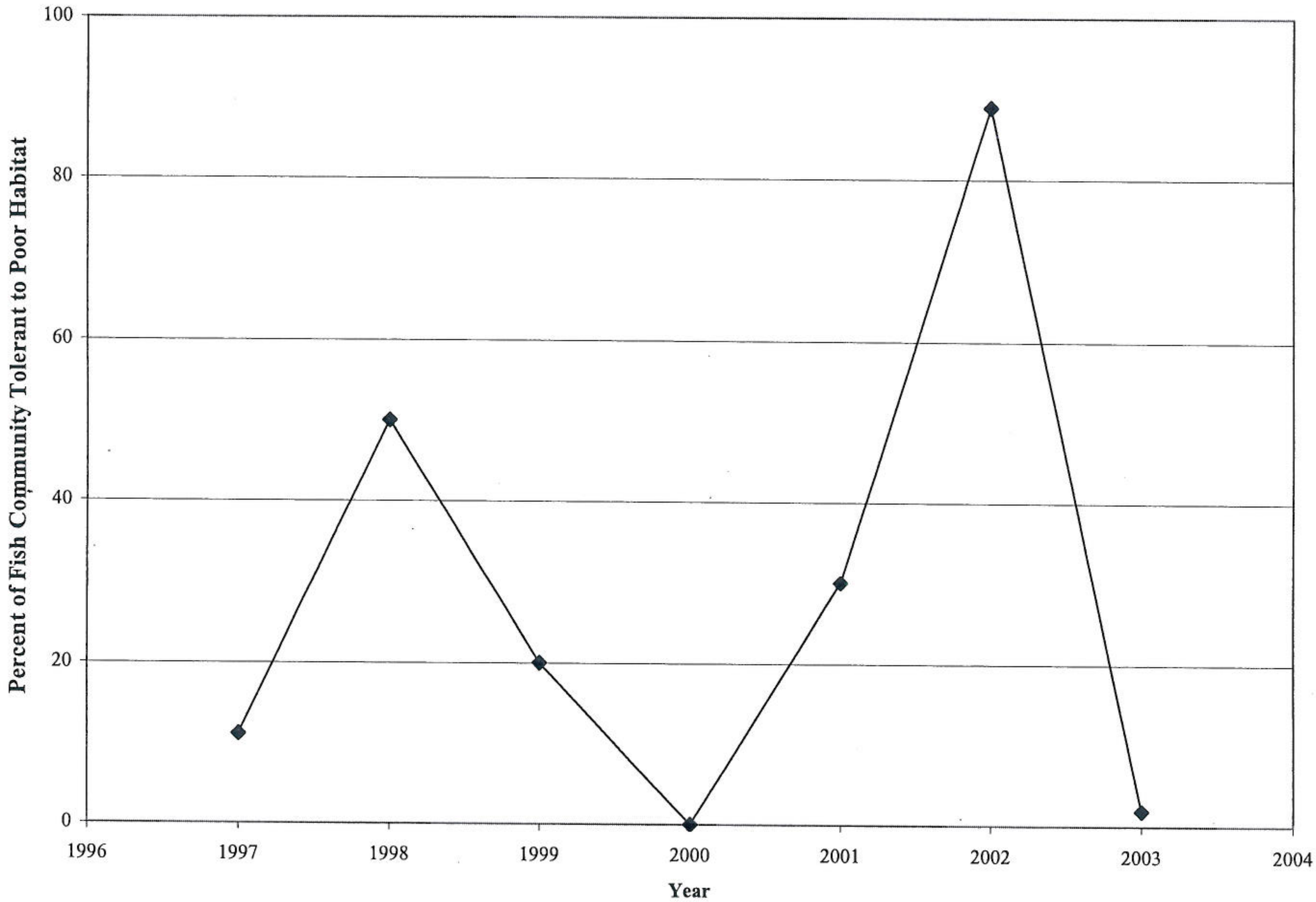
Percent of Fish Community Tolerant to Low Dissolved Oxygen



Appendix 3-I-4

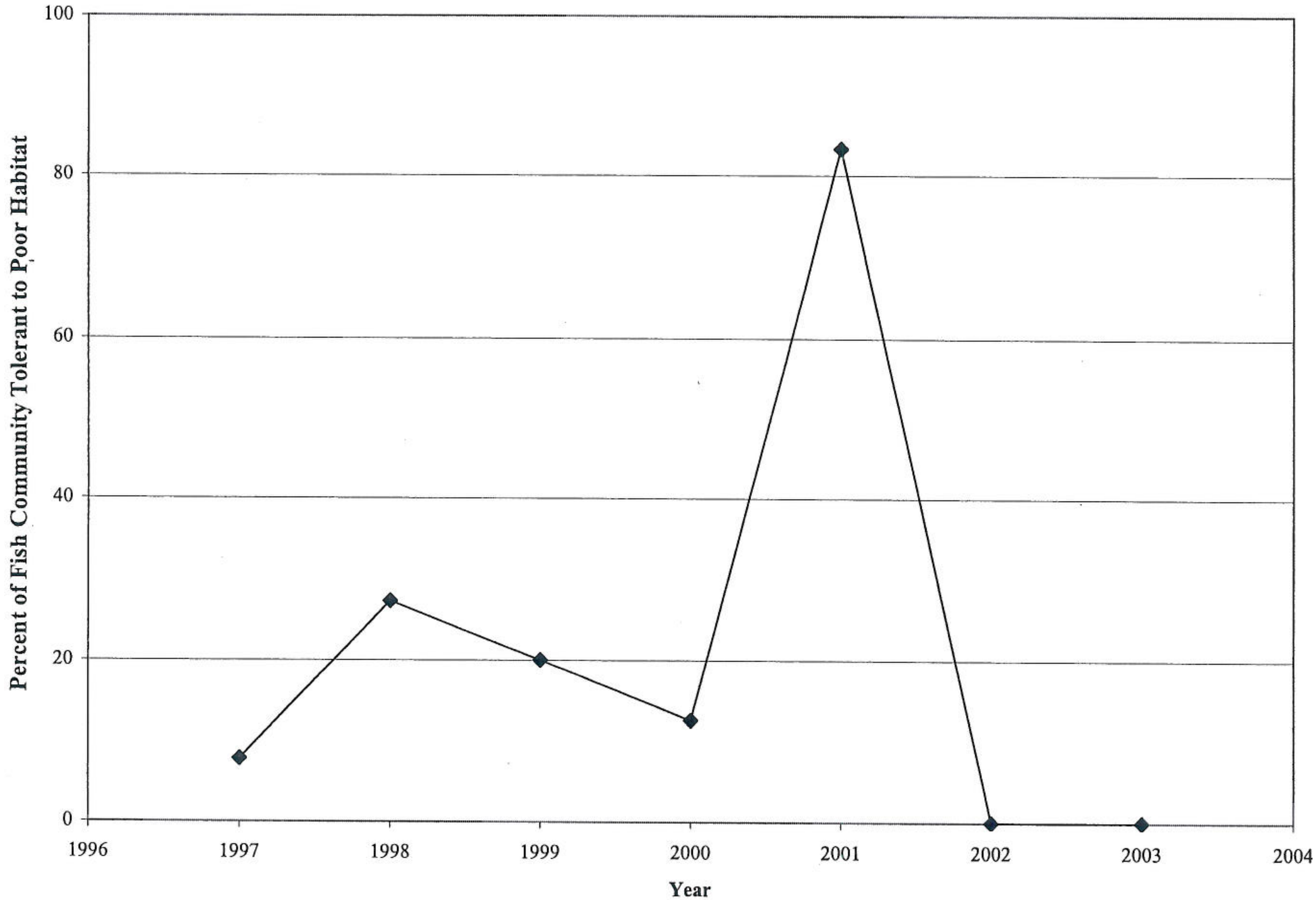
Percent of Fish Community Tolerant to Poor Habitat

Purgatory Creek - Station P1
Percent of Fish Community Tolerant to Poor Habitat



P:\23\27\053\RPBCECU\purg_fish_charts.xlsP1 poor hab

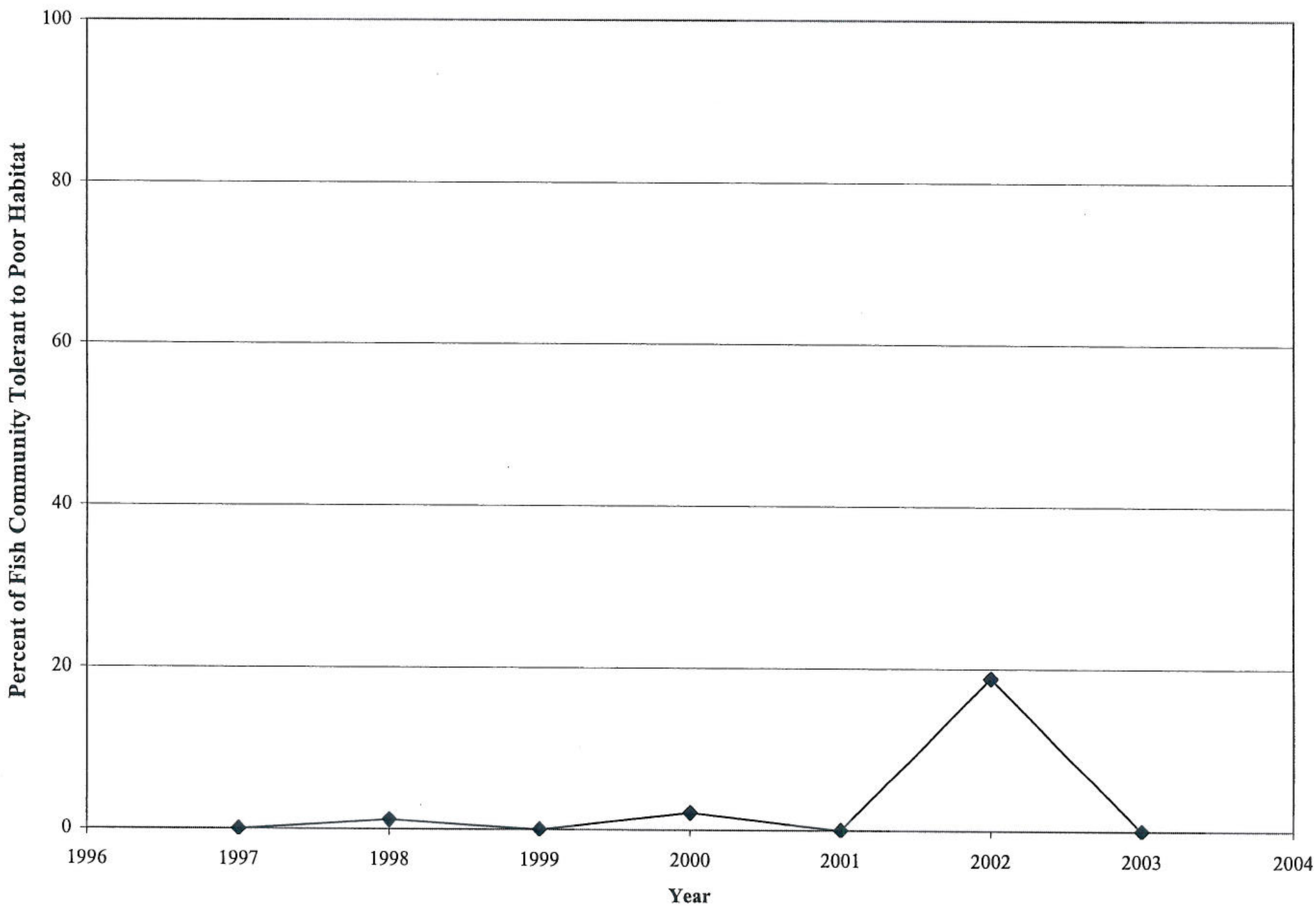
Purgatory Creek - Station P2
Percent of Fish Community Tolerant to Poor Habitat



P:\23\27\053\RPBCECU\purg_fish_charts.xlsP2 poor hab

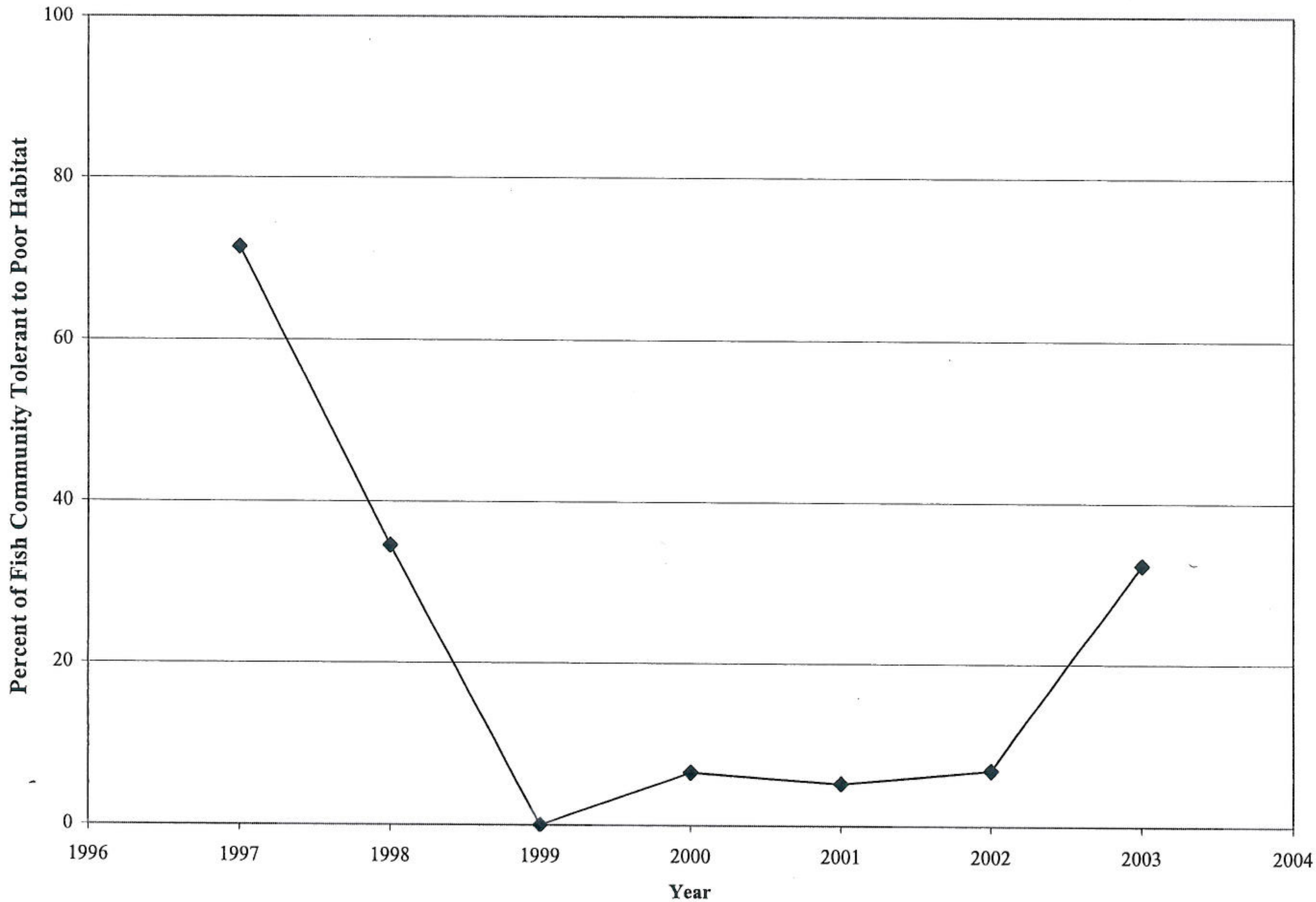
Purgatory Creek - Station P3

Percent of Fish Community Tolerant to Poor Habitat



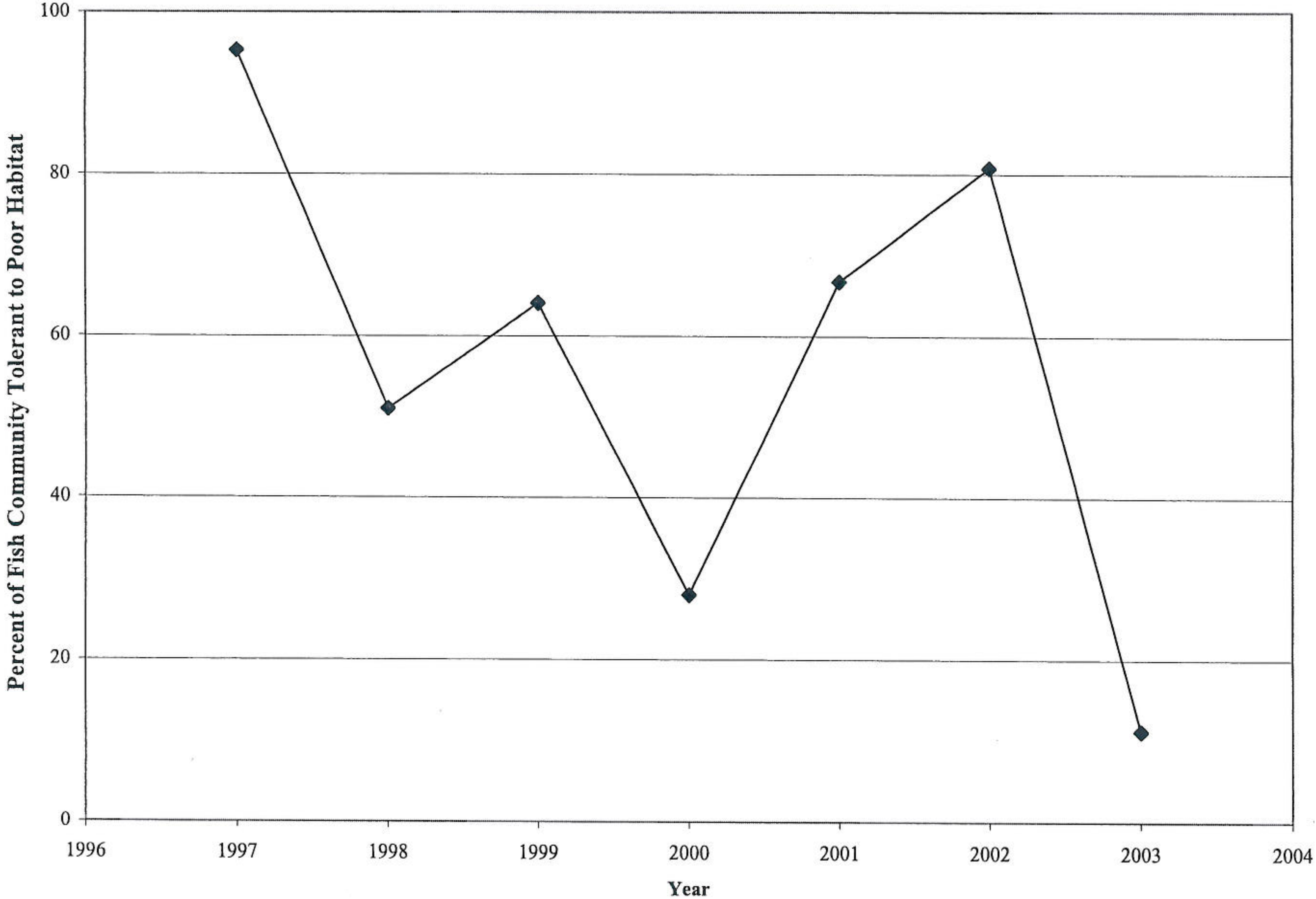
Purgatory Creek - Station P4

Percent of Fish Community Tolerant to Poor Habitat



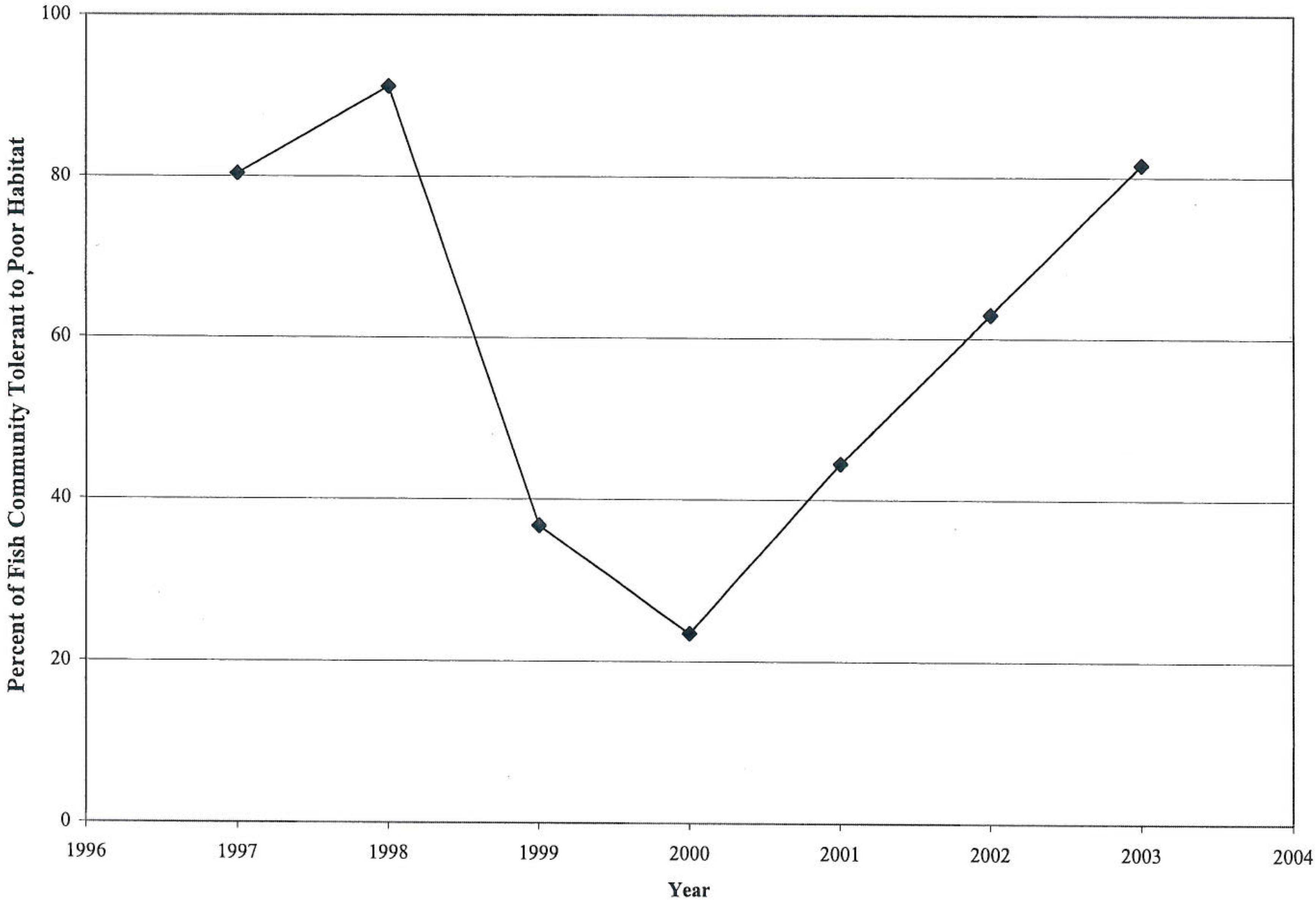
Purgatory Creek - Station P5

Percent of Fish Community Tolerant to Poor Habitat



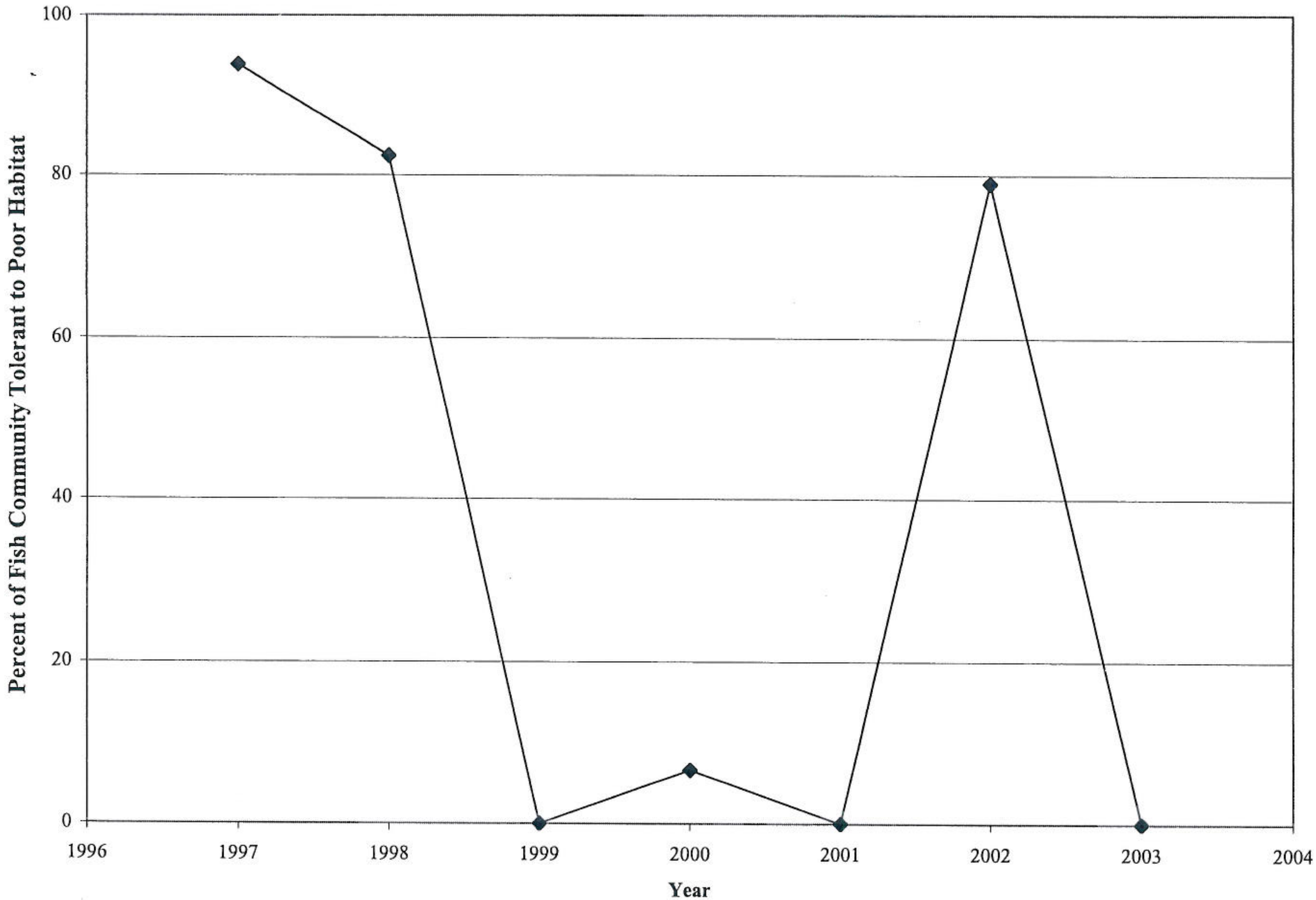
P:\23\27\053\RPBCECU\purg_fish_charts.xlsP5 poor hab

Purgatory Creek - Station P6
Percent of Fish Community Tolerant to Poor Habitat



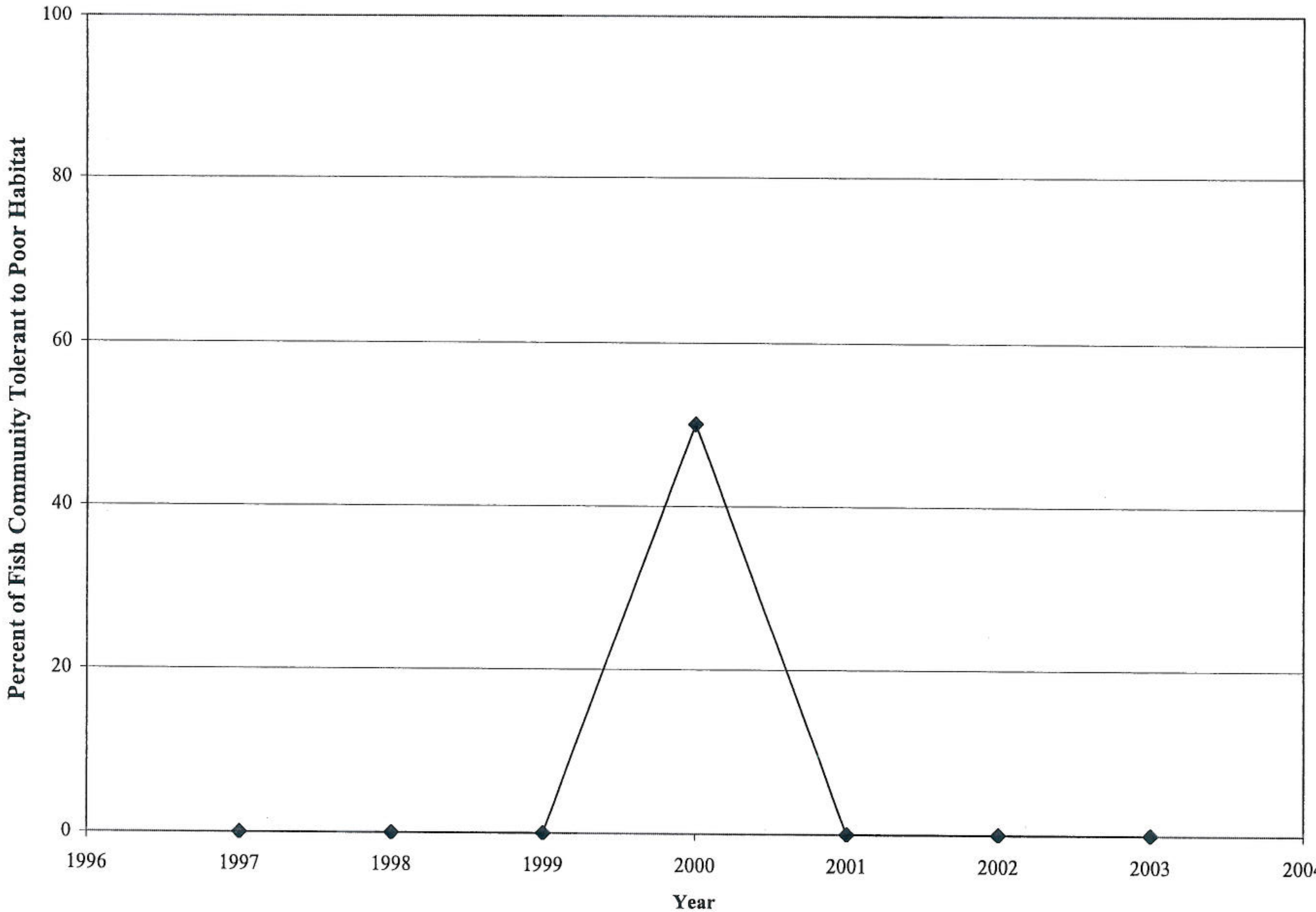
P:\23\27\053\RPBCECU\purg_fish_charts.xlsP6 poor hab

Purgatory Creek - Station P7
Percent of Fish Community Tolerant to Poor Habitat



Purgatory Creek - Station P8

Percent of Fish Community Tolerant to Poor Habitat

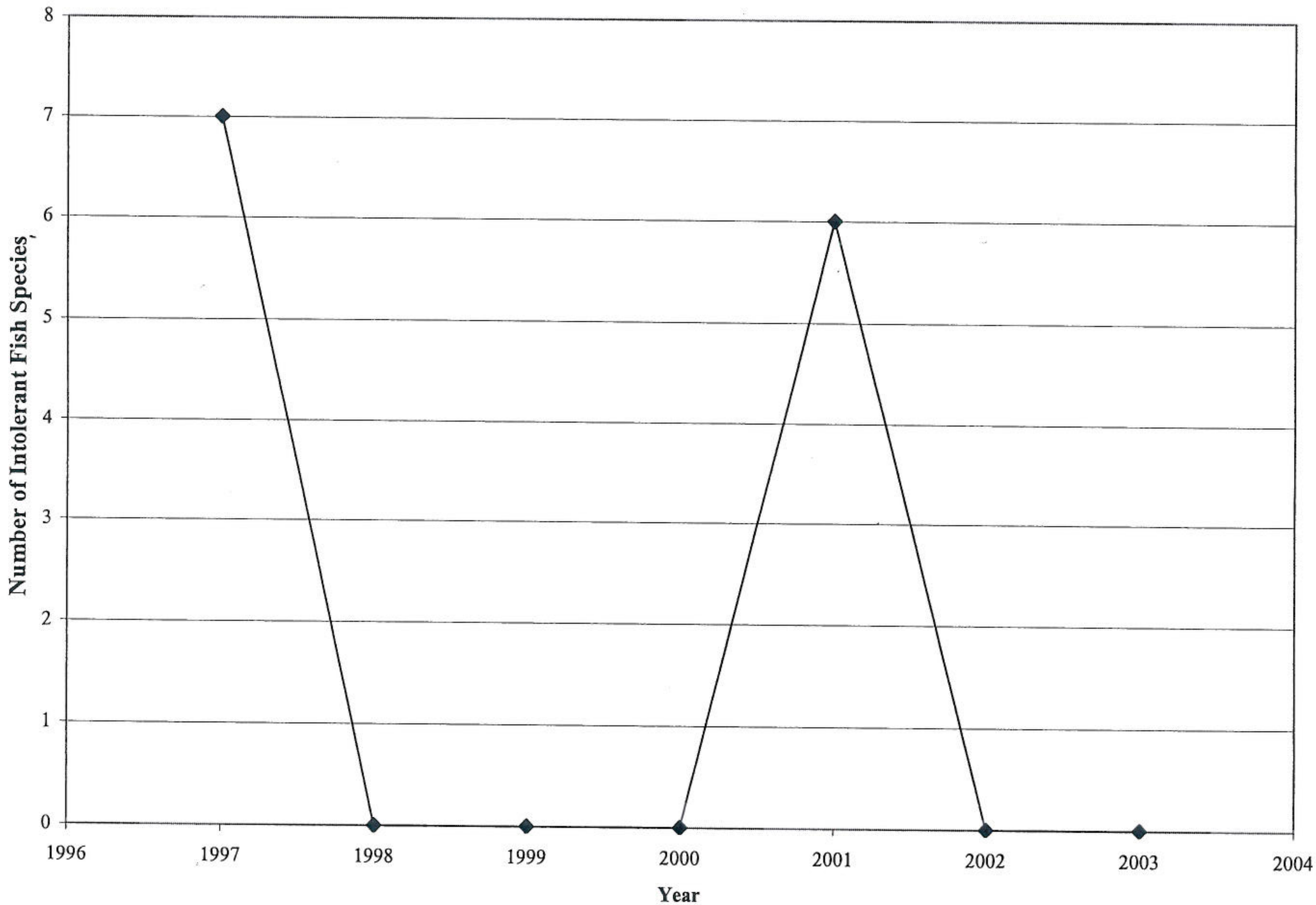


Appendix 3-I-5

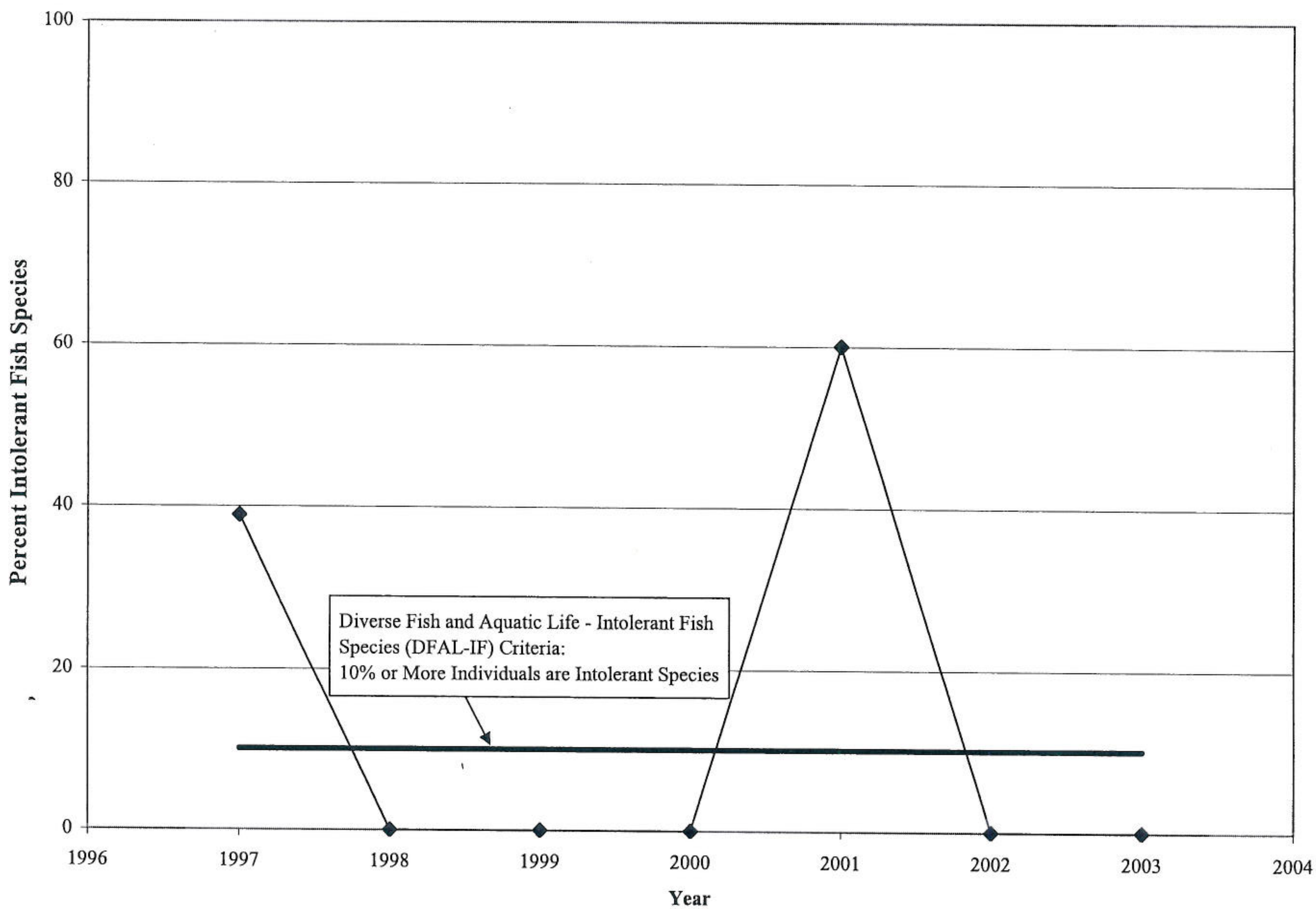
Percent Intolerant Species

Purgatory Creek - Station P1

Number of Intolerant Fish Species



Purgatory Creek - Station P1
Percent Intolerant Fish Species



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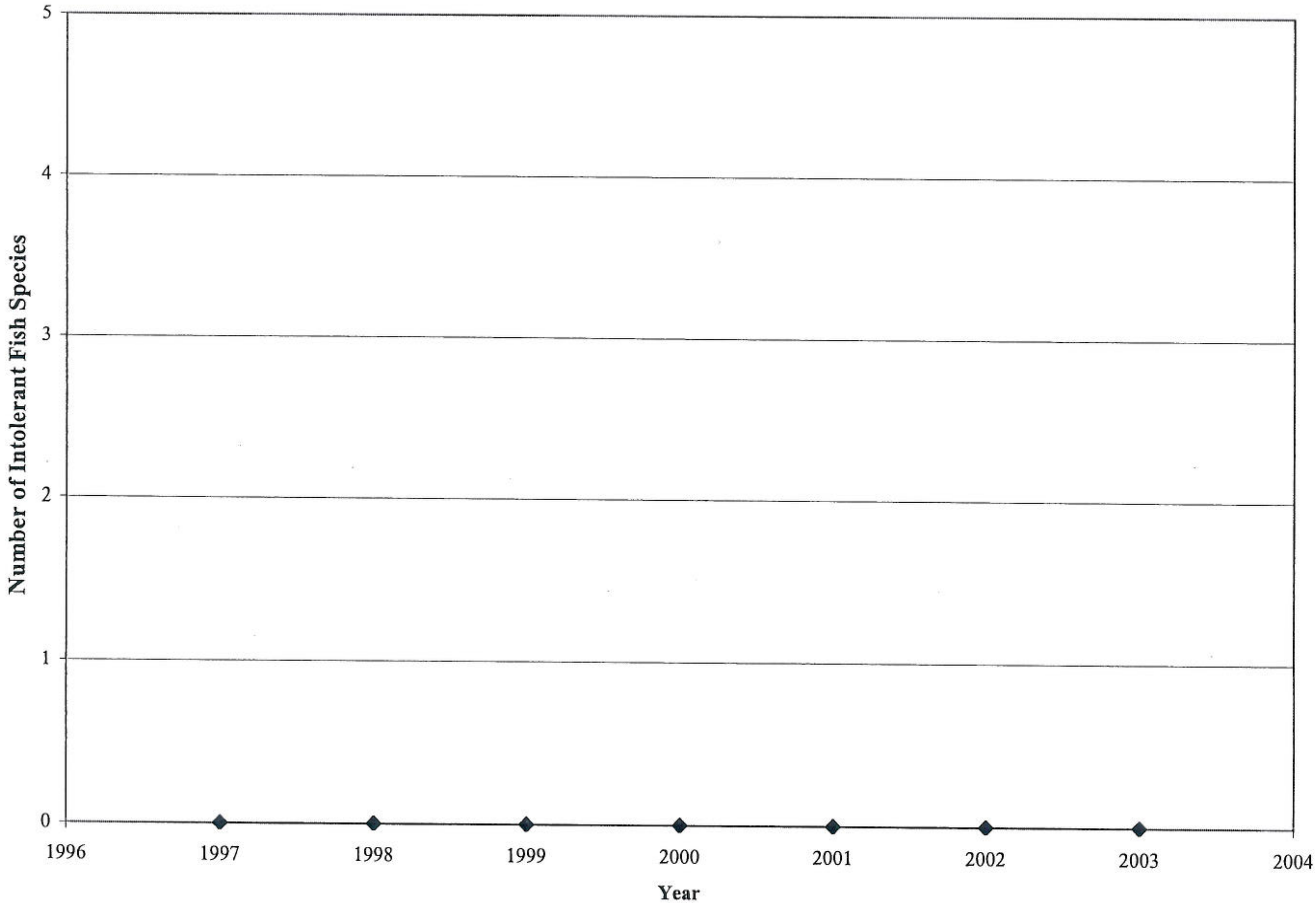
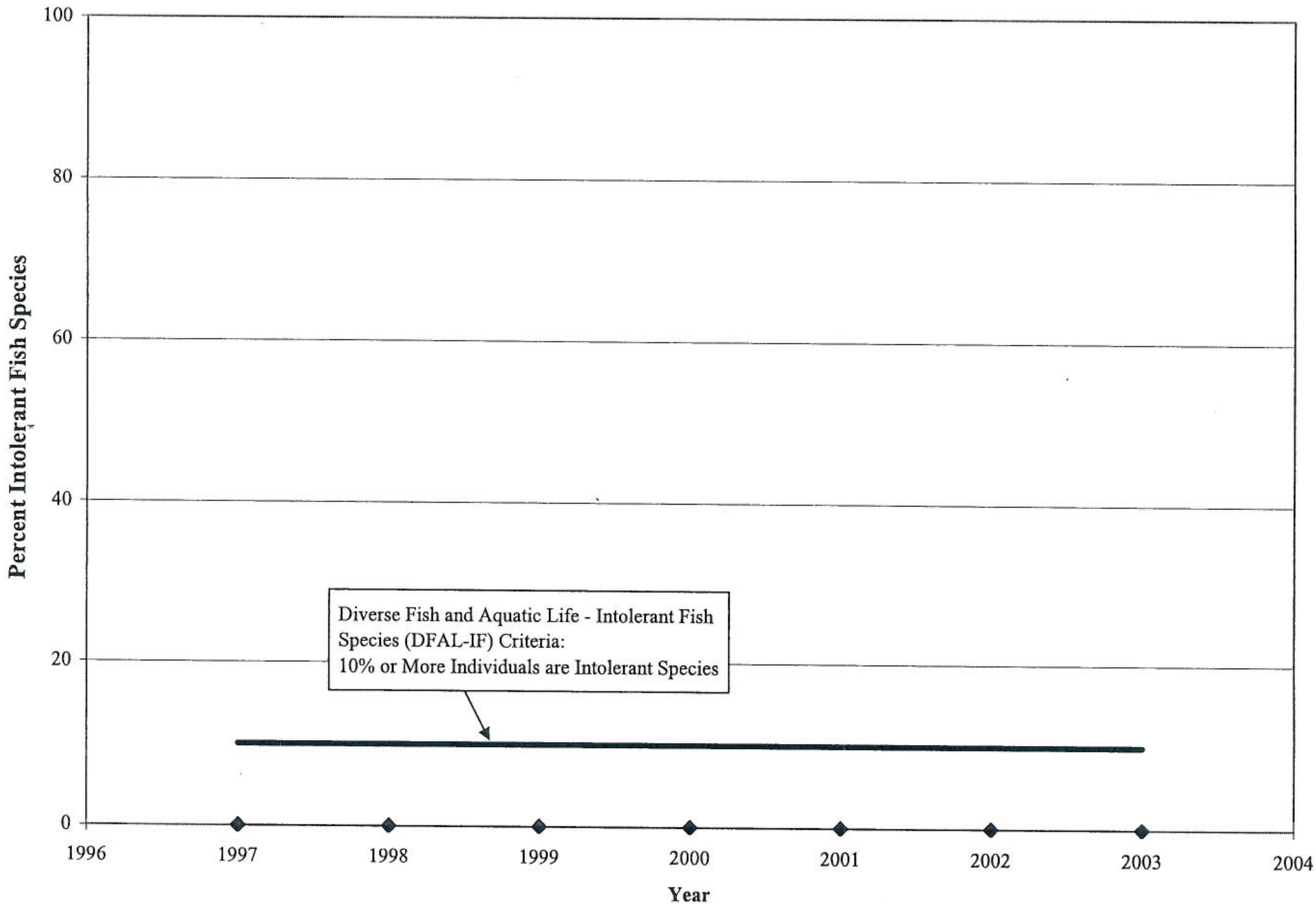
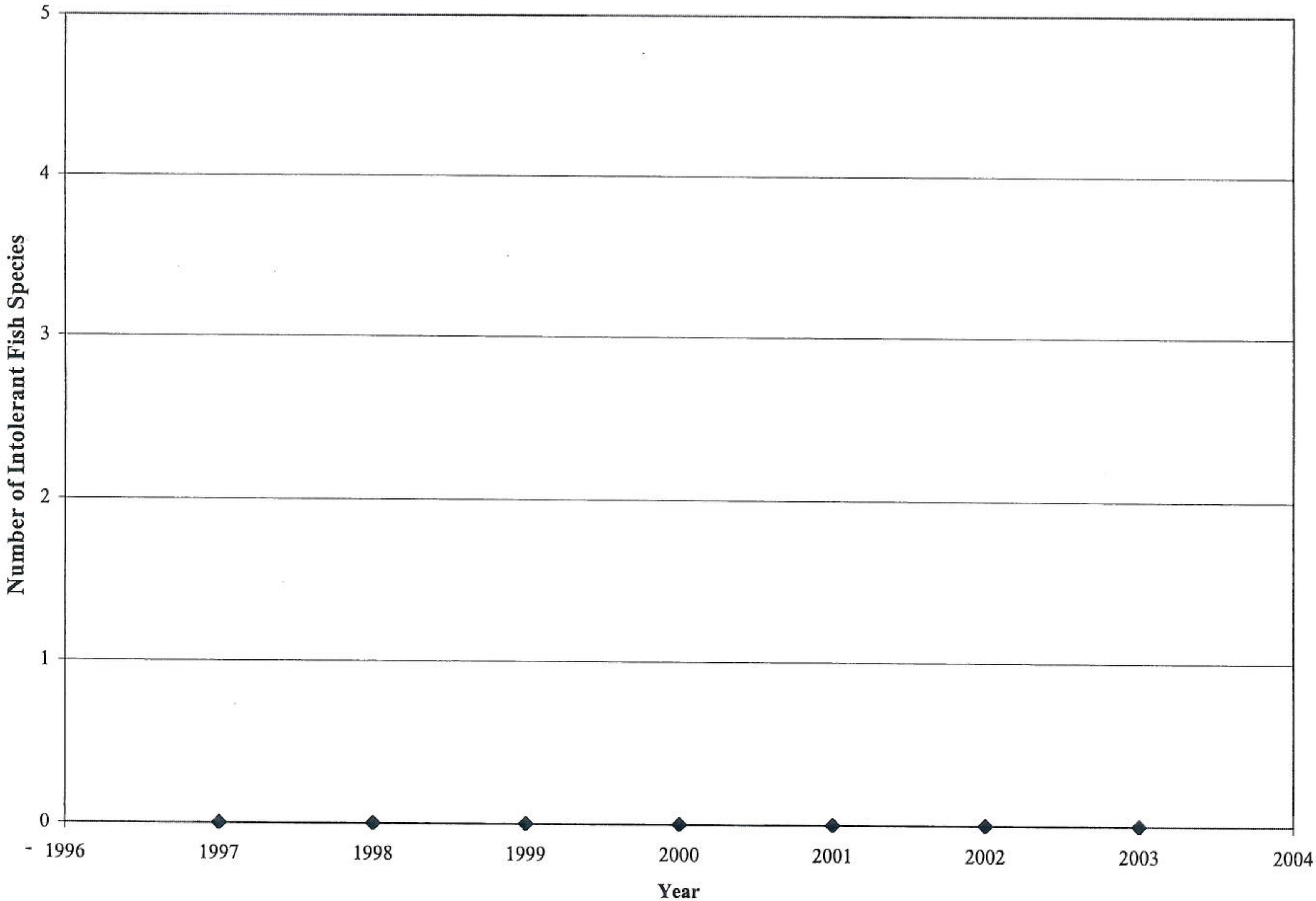
Purgatory Creek - Station P2
Number of Intolerant Fish Species



Purgatory Creek - Station P2
Percent Intolerant Fish Species



Purgatory Creek - Station P3
Number of Intolerant Fish Species



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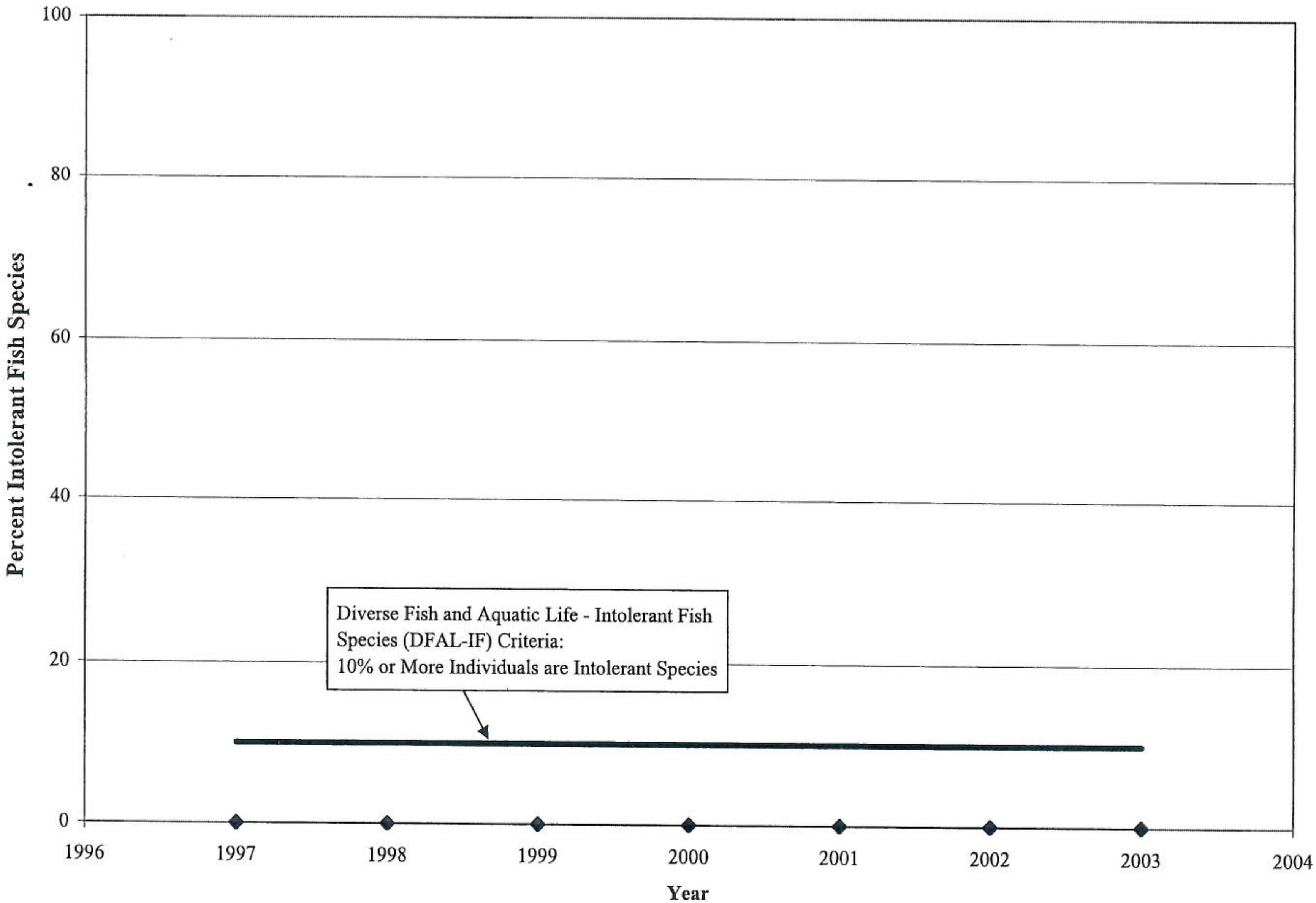
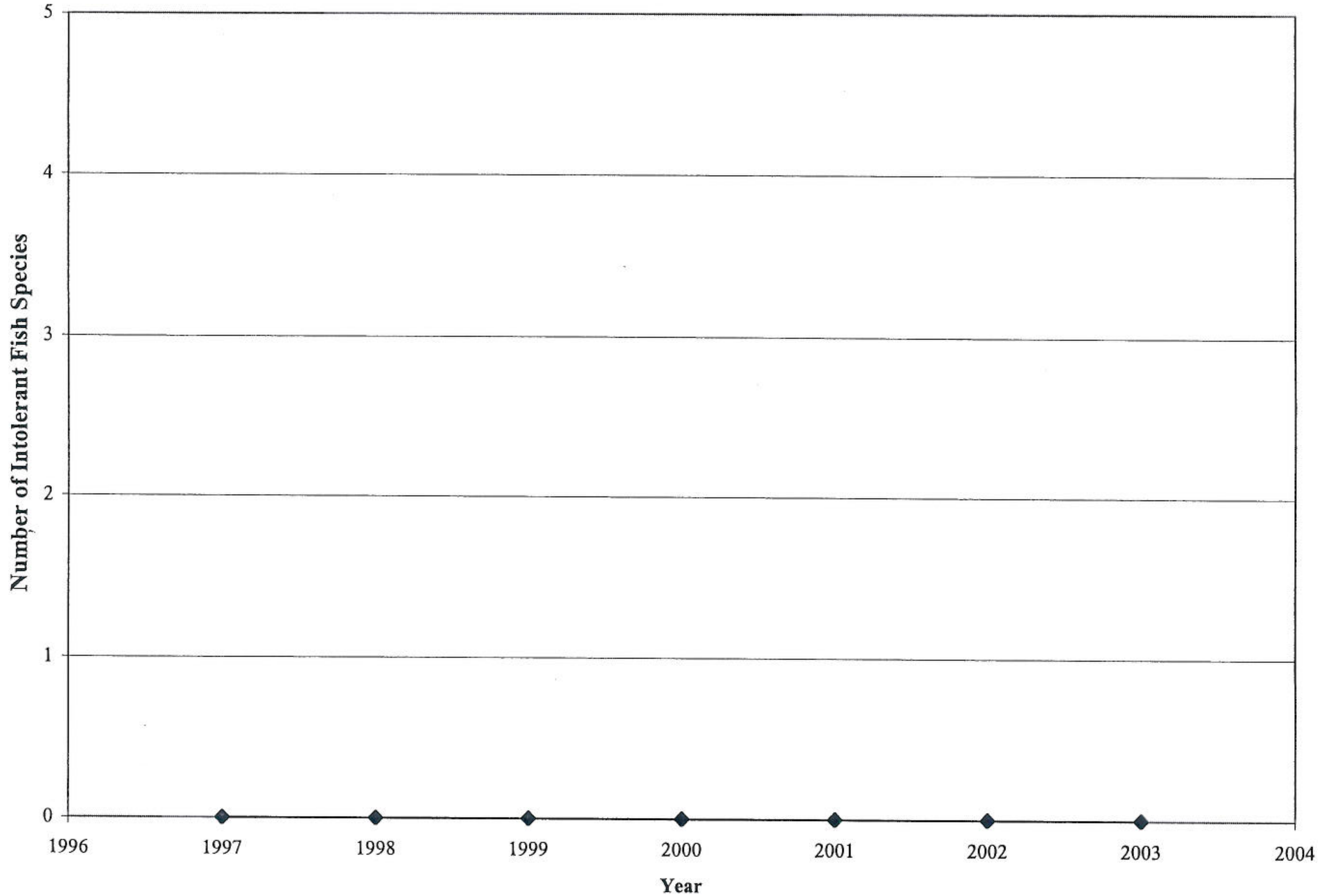
Purgatory Creek - Station P3

Percent Intolerant Fish Species

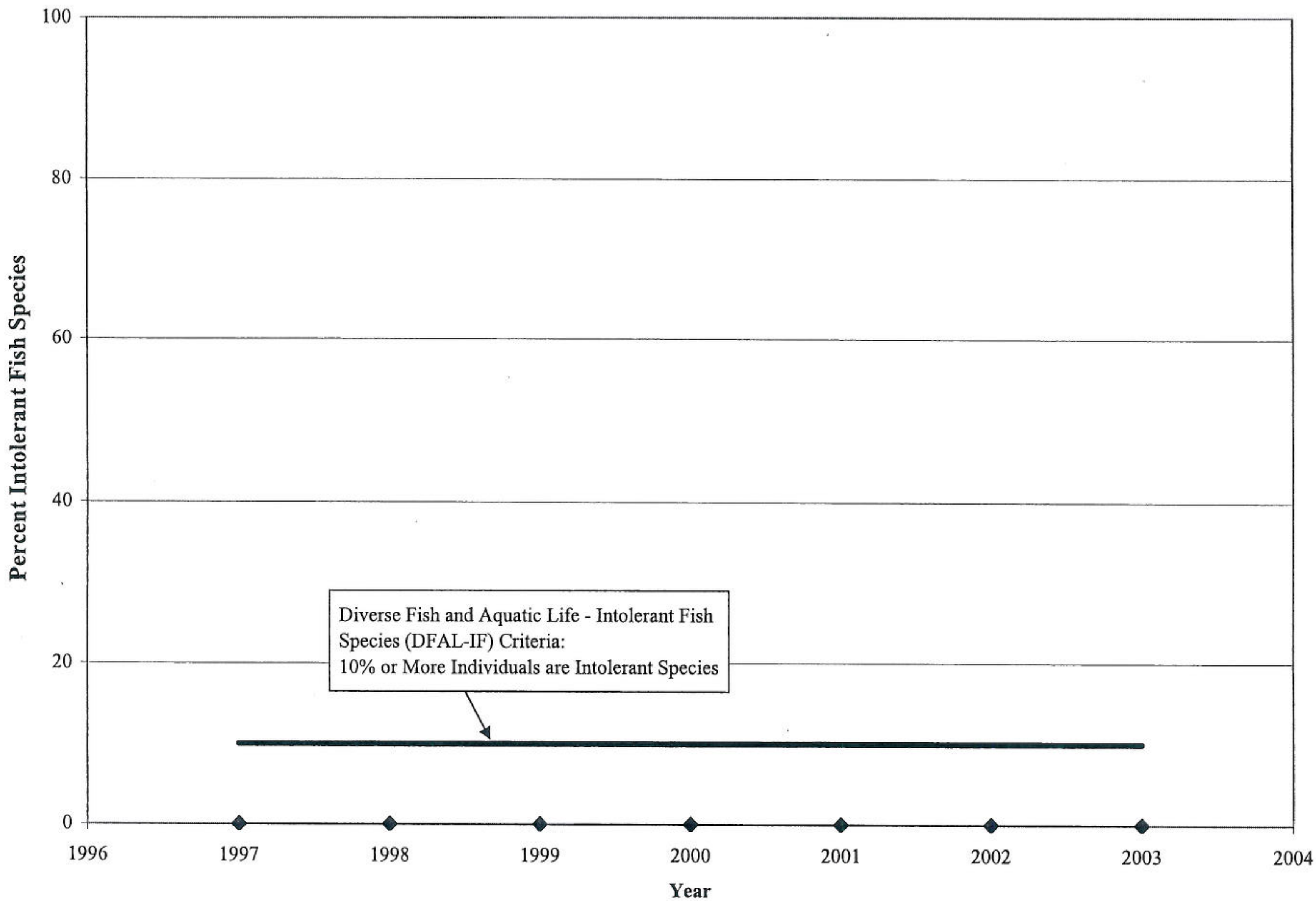


Purgatory Creek - Station P4
Number of Intolerant Fish Species

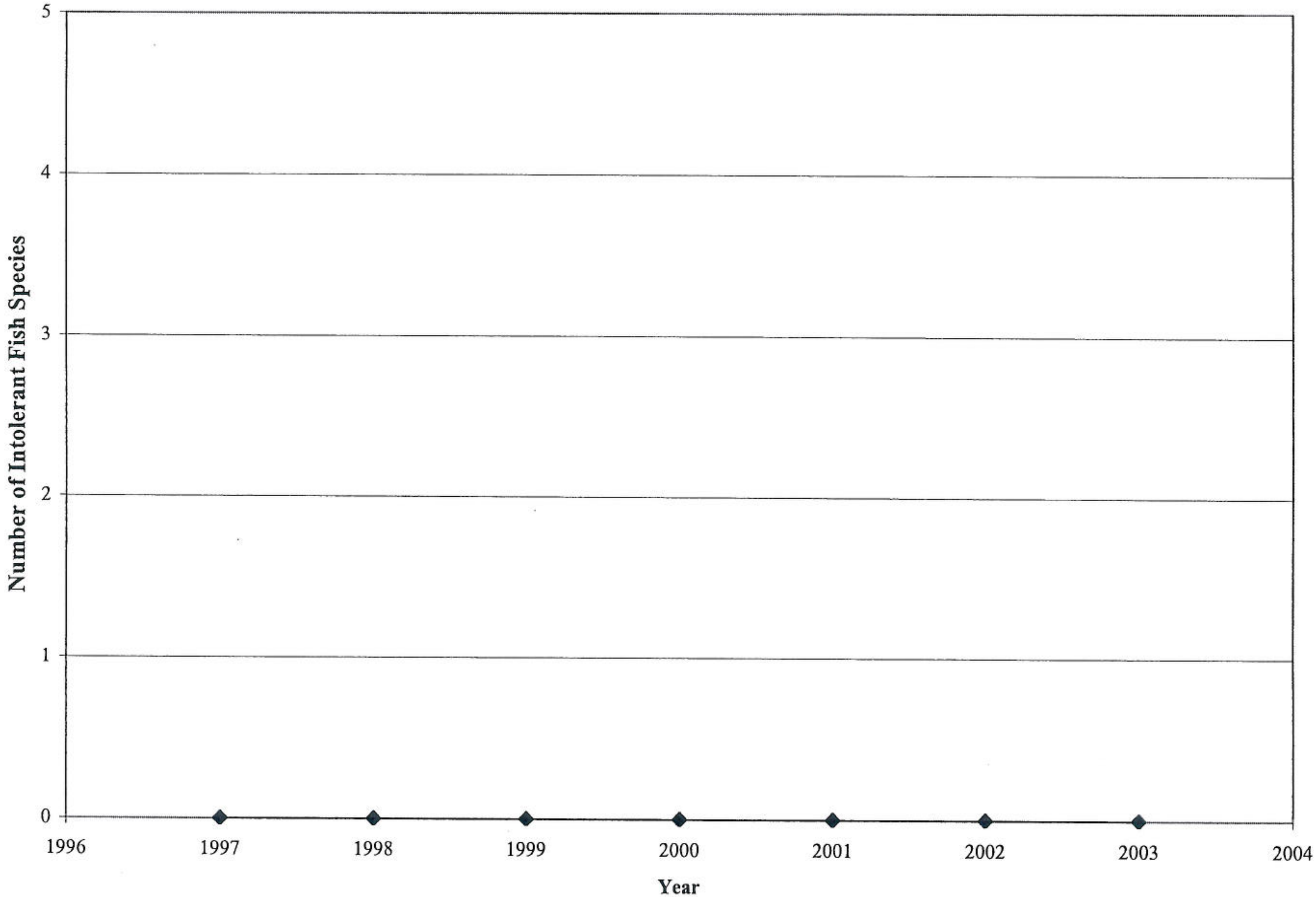


Purgatory Creek - Station P4

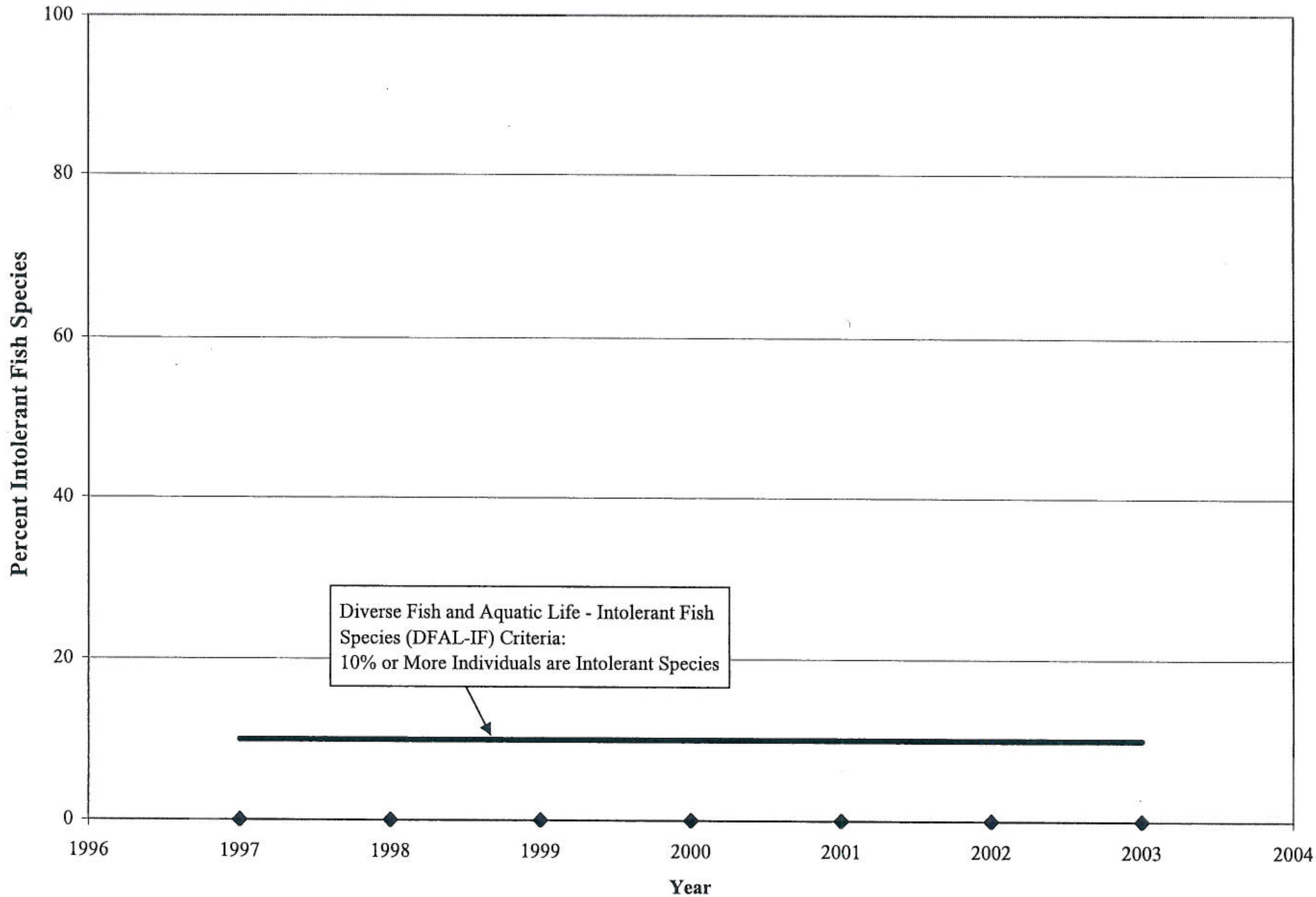
Percent Intolerant Fish Species



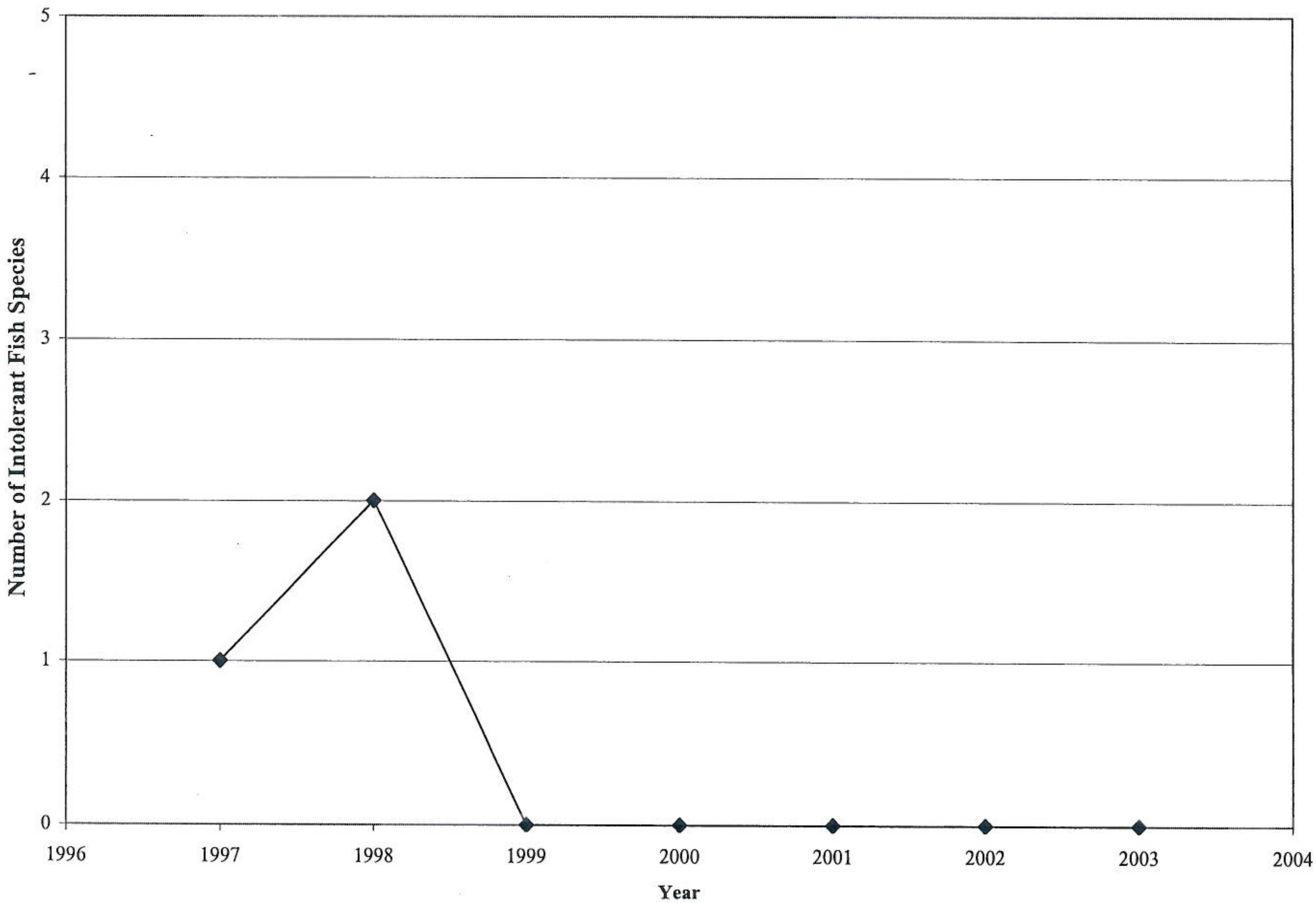
Purgatory Creek - Station P5
Number of Intolerant Fish Species



Purgatory Creek - Station P5
Percent Intolerant Fish Species

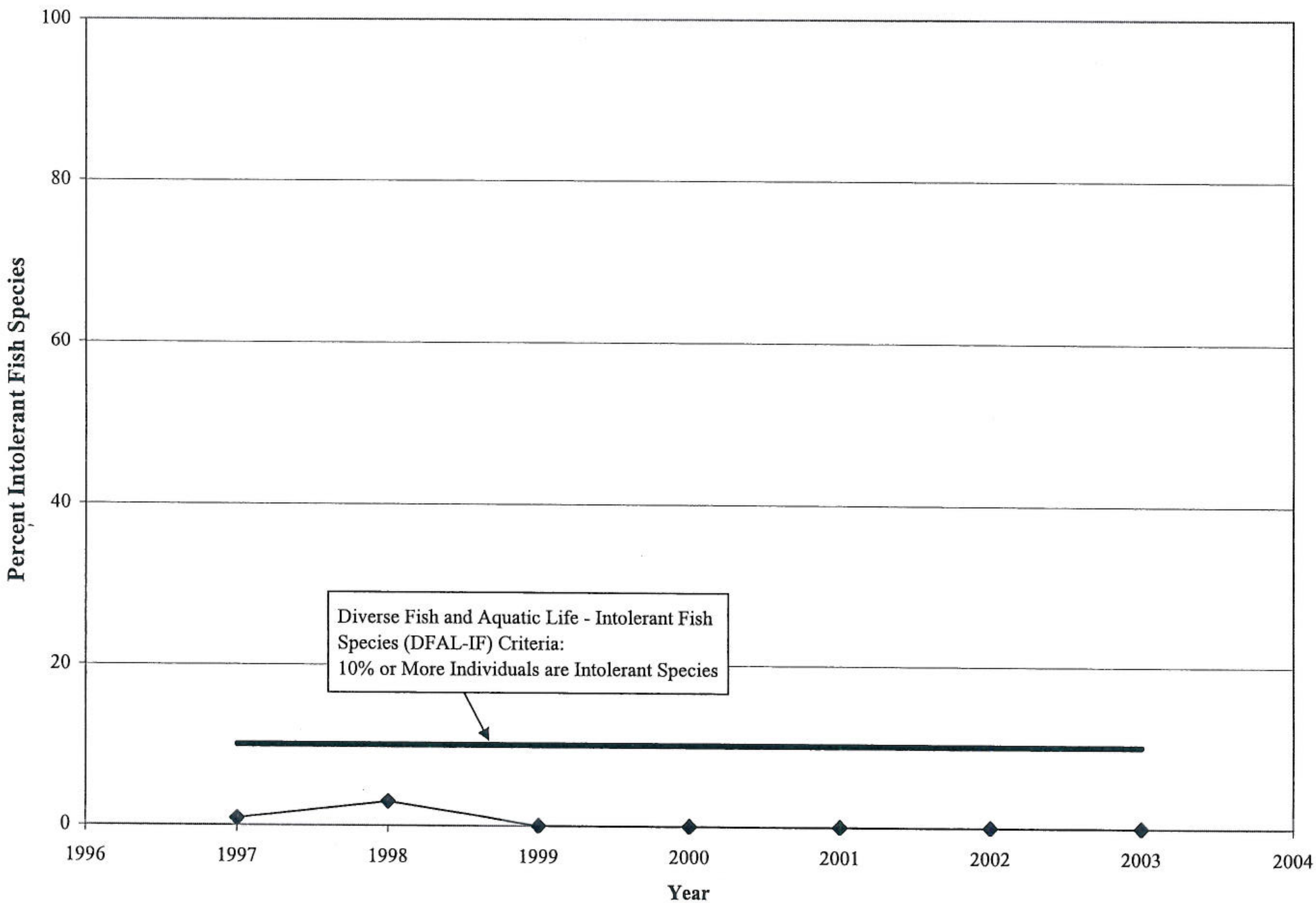


Purgatory Creek - Station P6
Number of Intolerant Fish Species

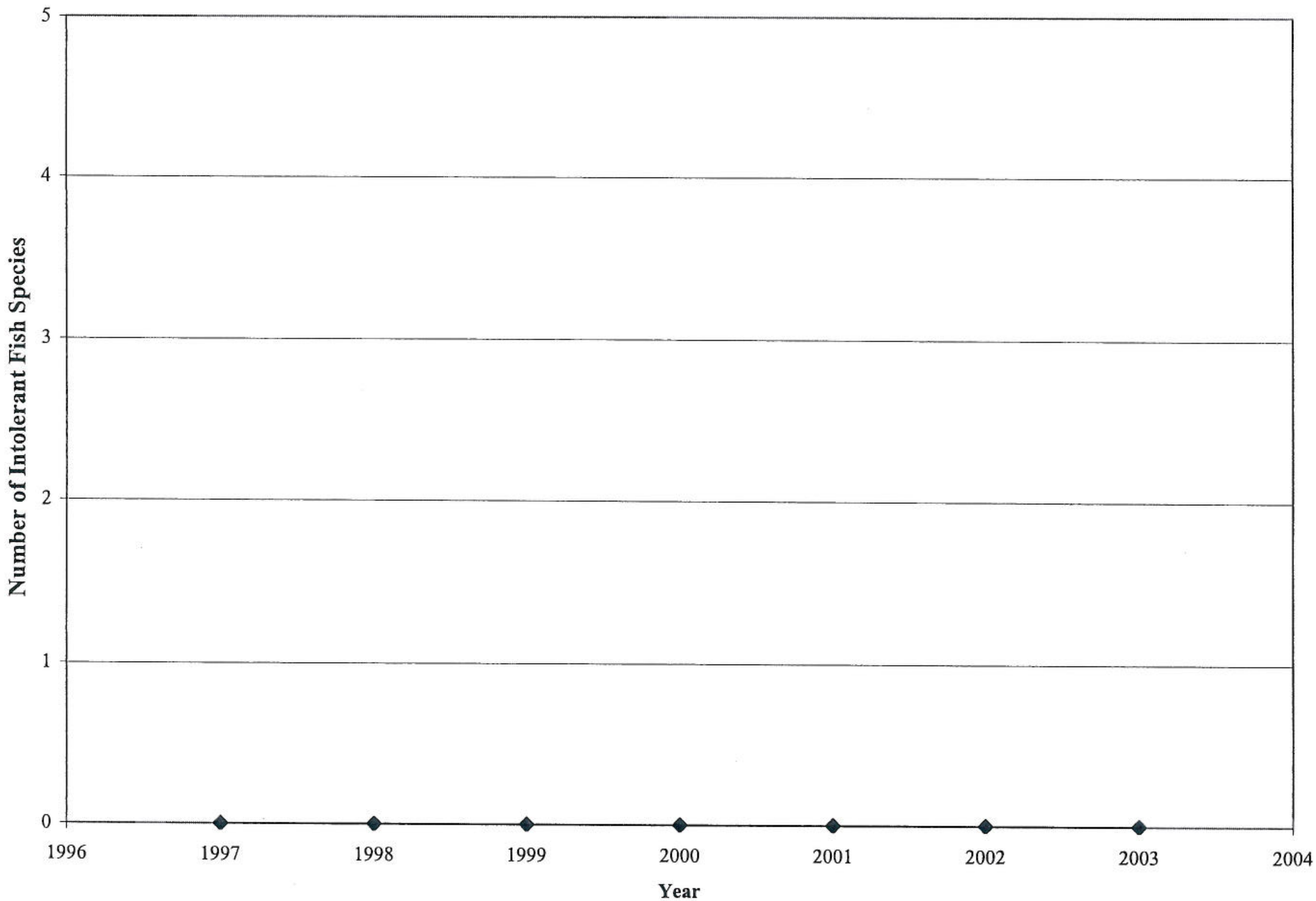


P:\23\27\053\RPBCECU\purg_fish_charts.xlsP6 #intol

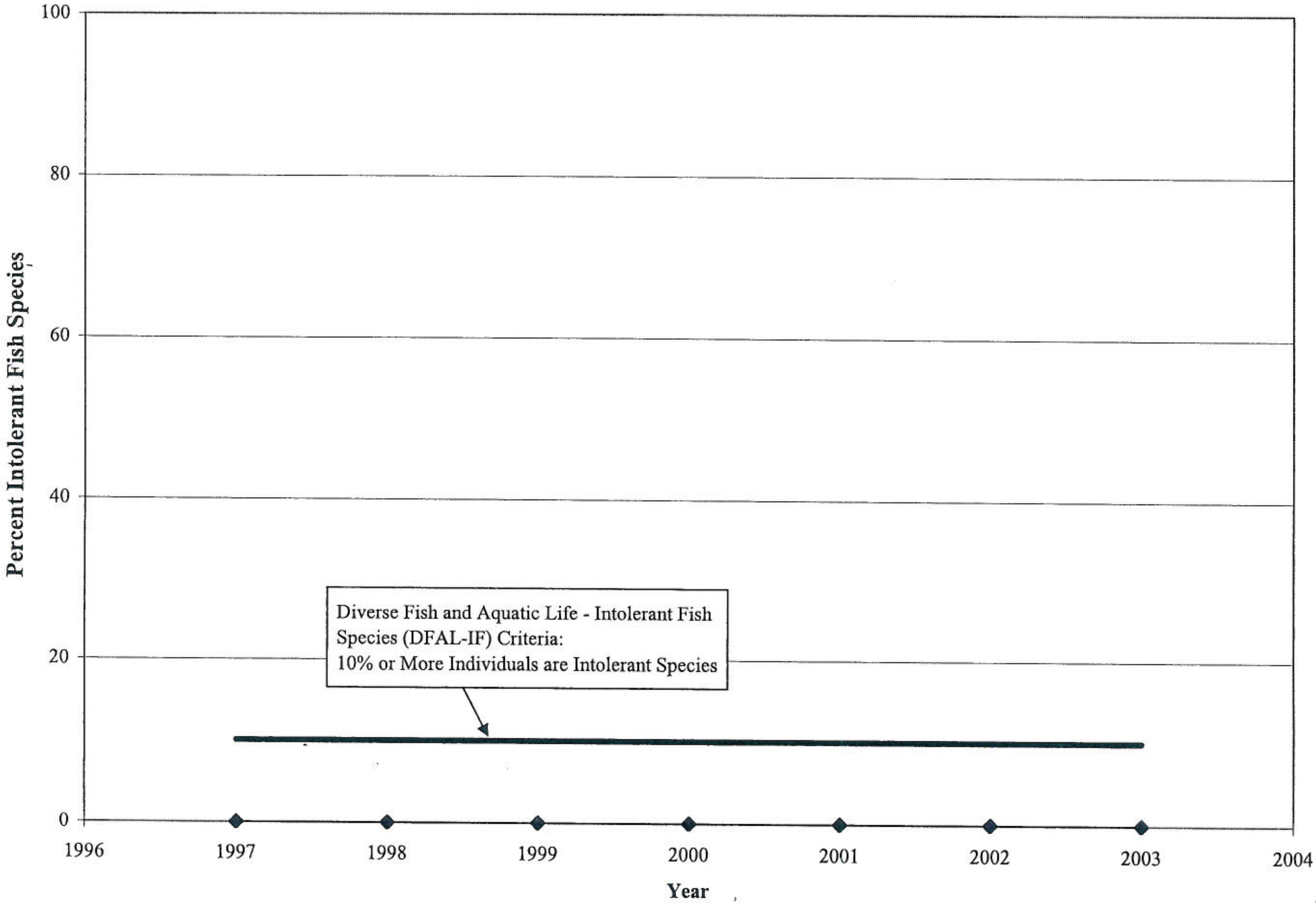
Purgatory Creek - Station P6
Percent Intolerant Fish Species



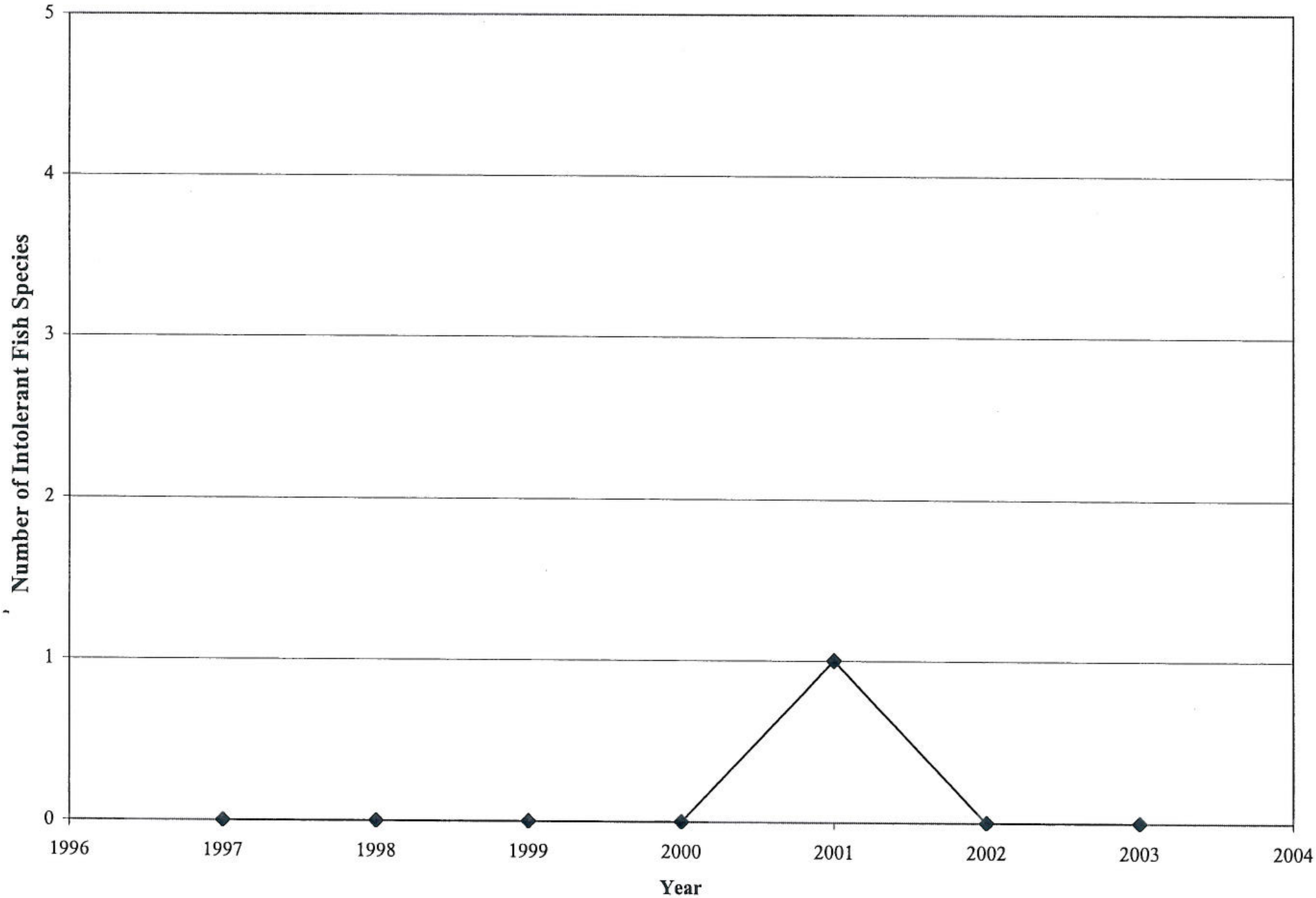
Purgatory Creek - Station P7
Number of Intolerant Fish Species



Purgatory Creek - Station P7
Percent Intolerant Fish Species



Purgatory Creek - Station P8
Number of Intolerant Fish Species



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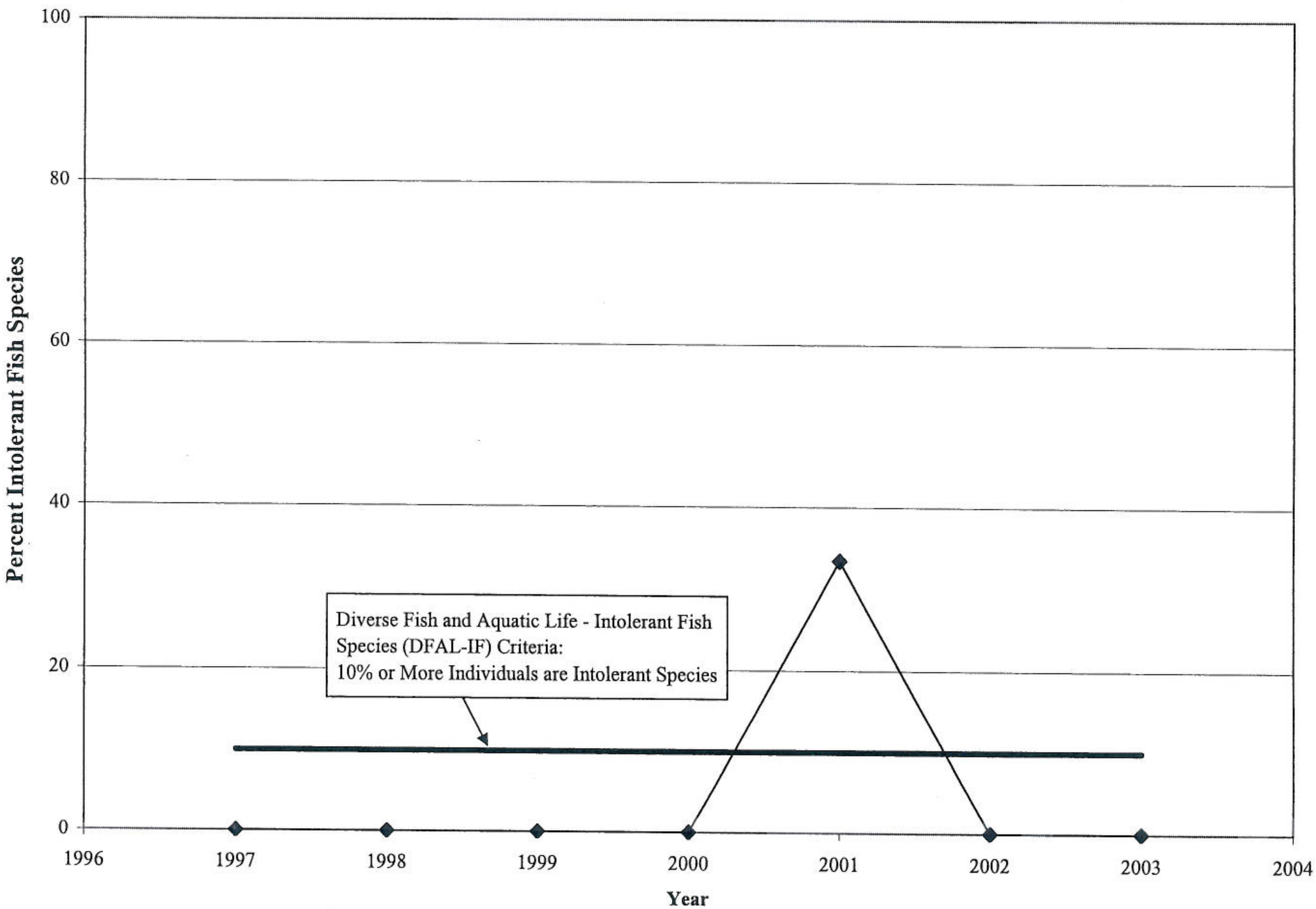
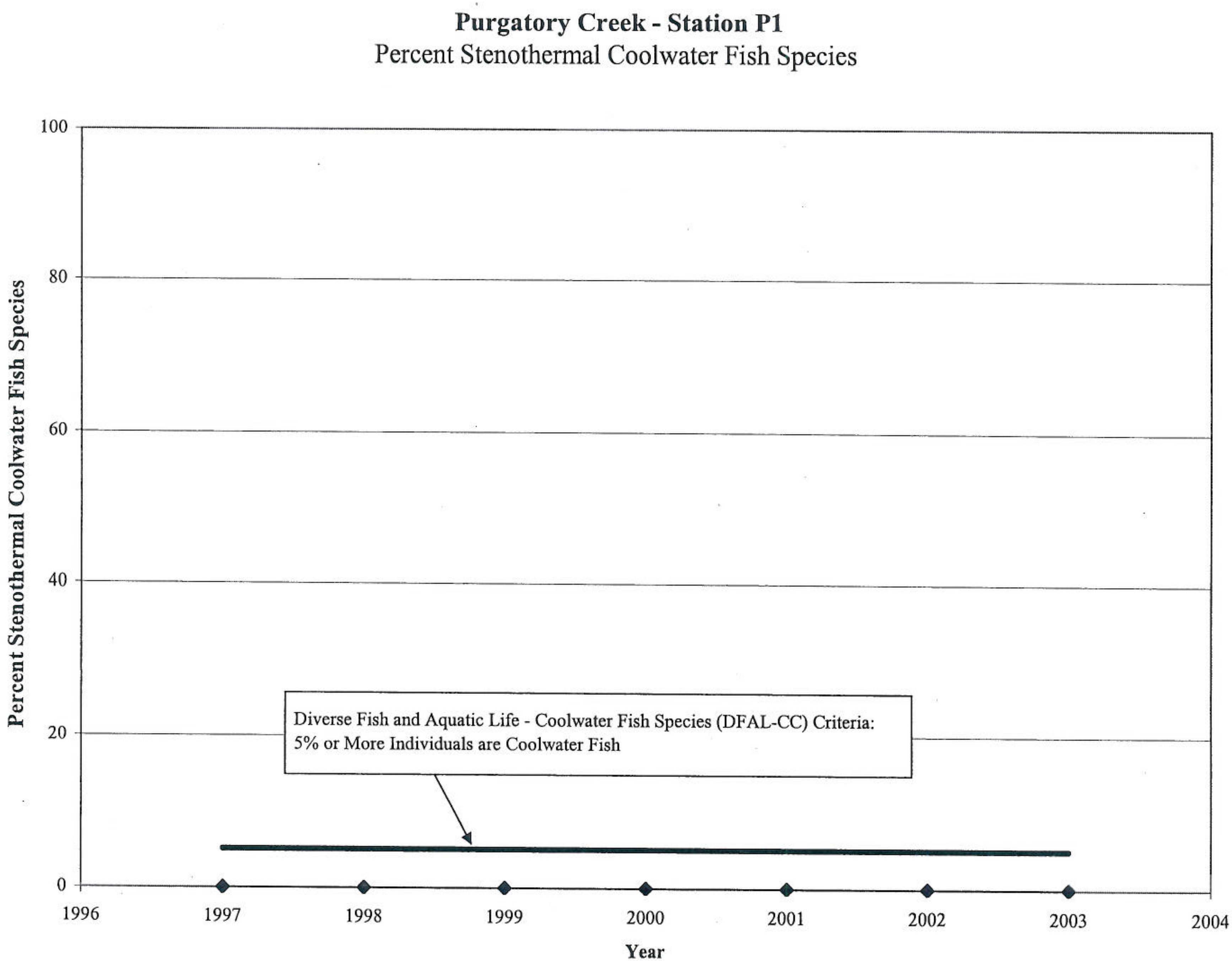
Purgatory Creek - Station P8
Percent Intolerant Fish Species

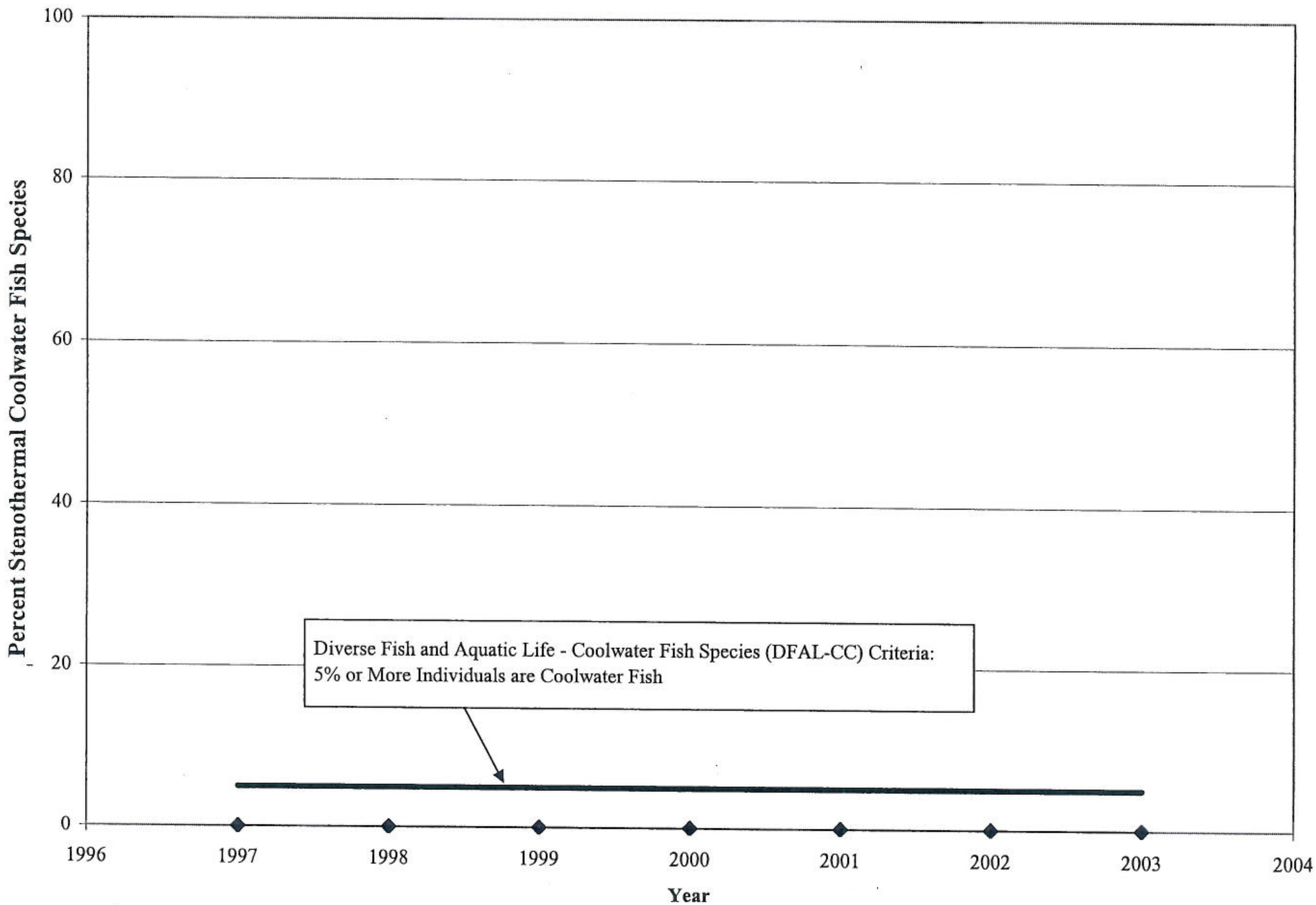


Appendix 3-I-6

Percent Stenothermal Coolwater Fish Species

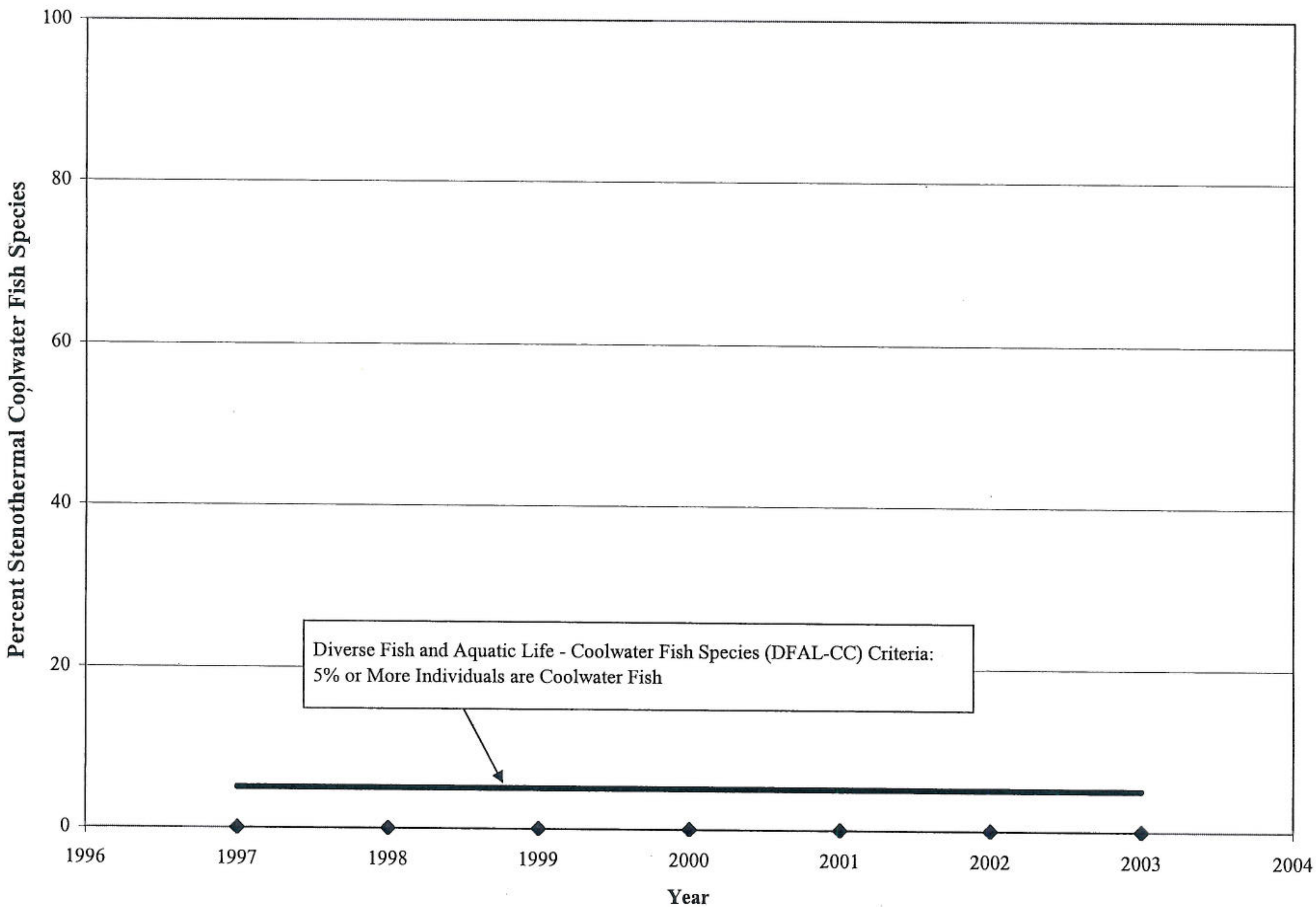

Purgatory Creek - Station P1
Percent Stenothermal Coolwater Fish Species
Percent Stenothermal Coolwater Fish Species
100
80
60
40
20
0
Diverse Fish and Aquatic Life - Coolwater Fish Species (DFAL-CC) Criteria:
5% or More Individuals are Coolwater Fish
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year

Purgatory Creek - Station P2
Percent Stenothermal Coolwater Fish Species

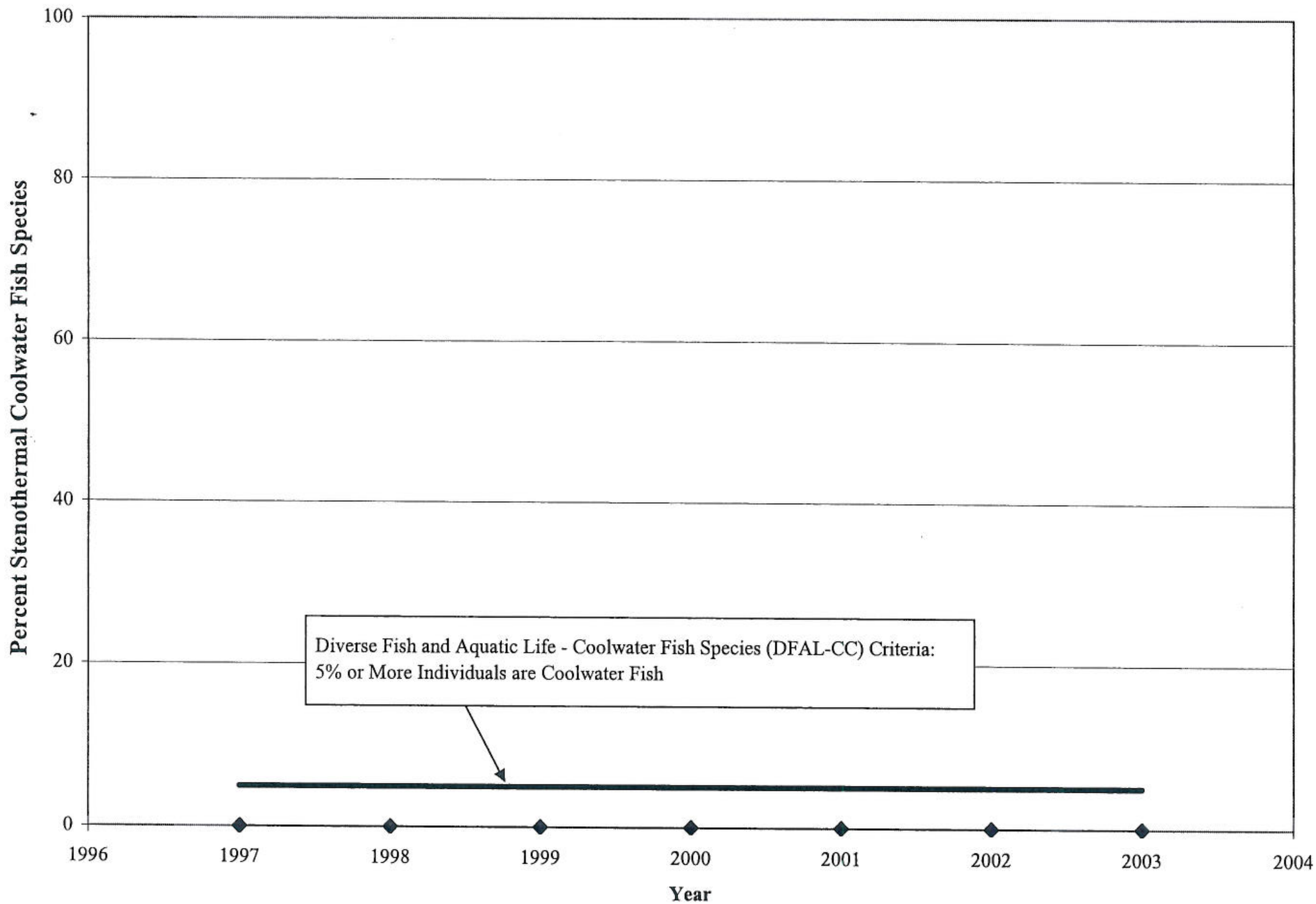


Purgatory Creek - Station P3

Percent Stenothermal Coolwater Fish Species

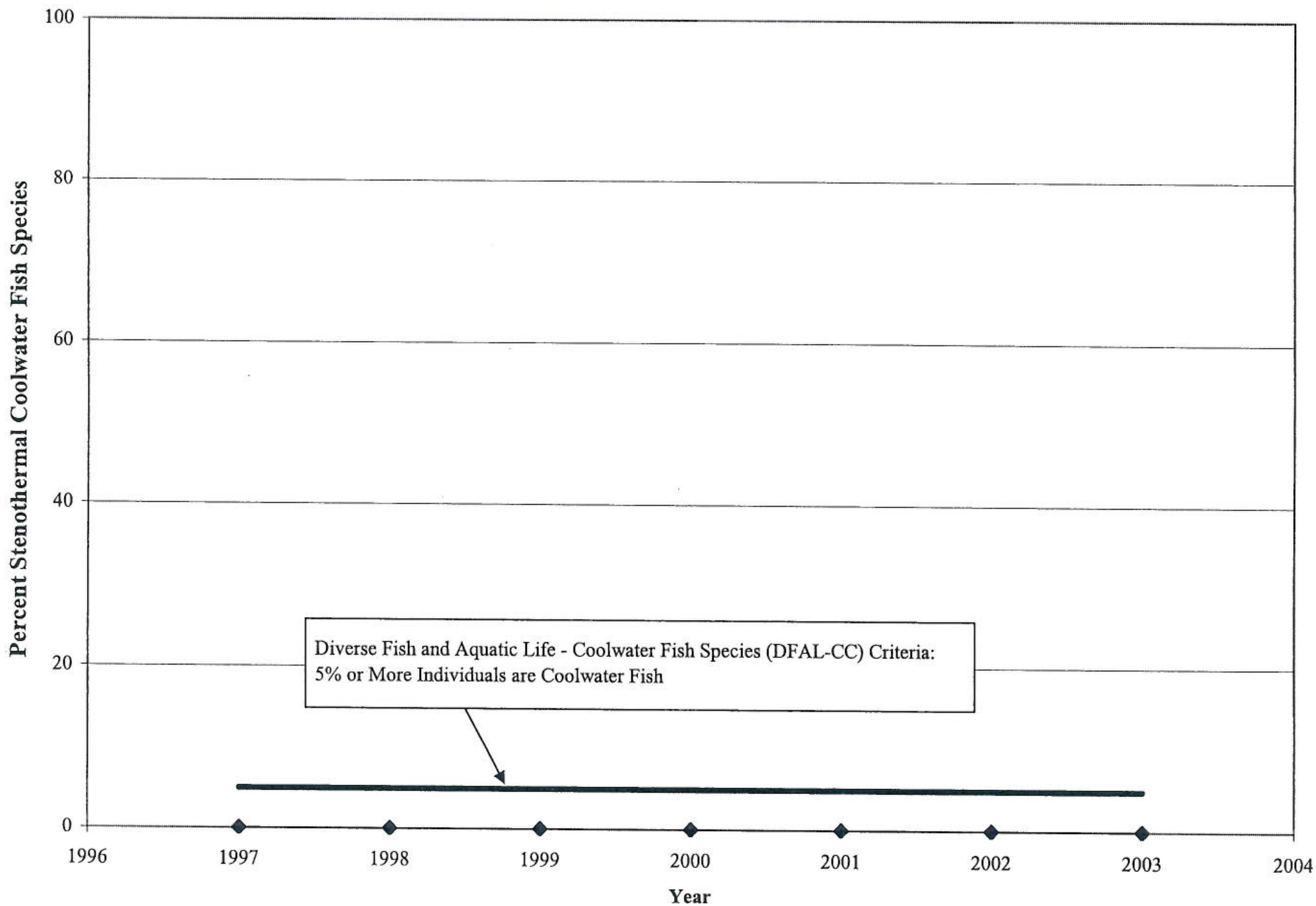


Purgatory Creek - Station P4
Percent Stenothermal Coolwater Fish Species

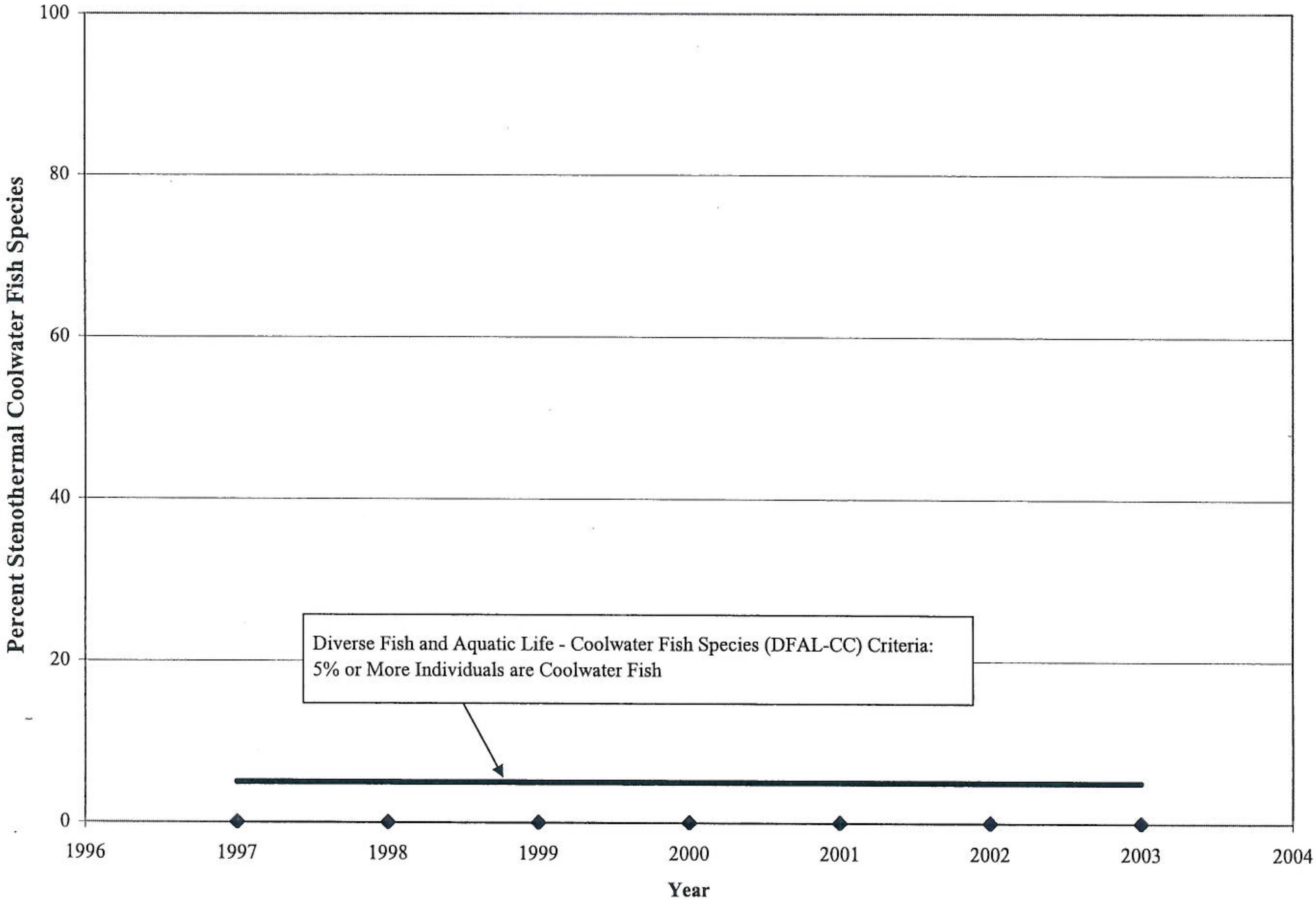


P:\23\27\053\RPBCECU\purg_fish_charts.xlsP4 coolwater

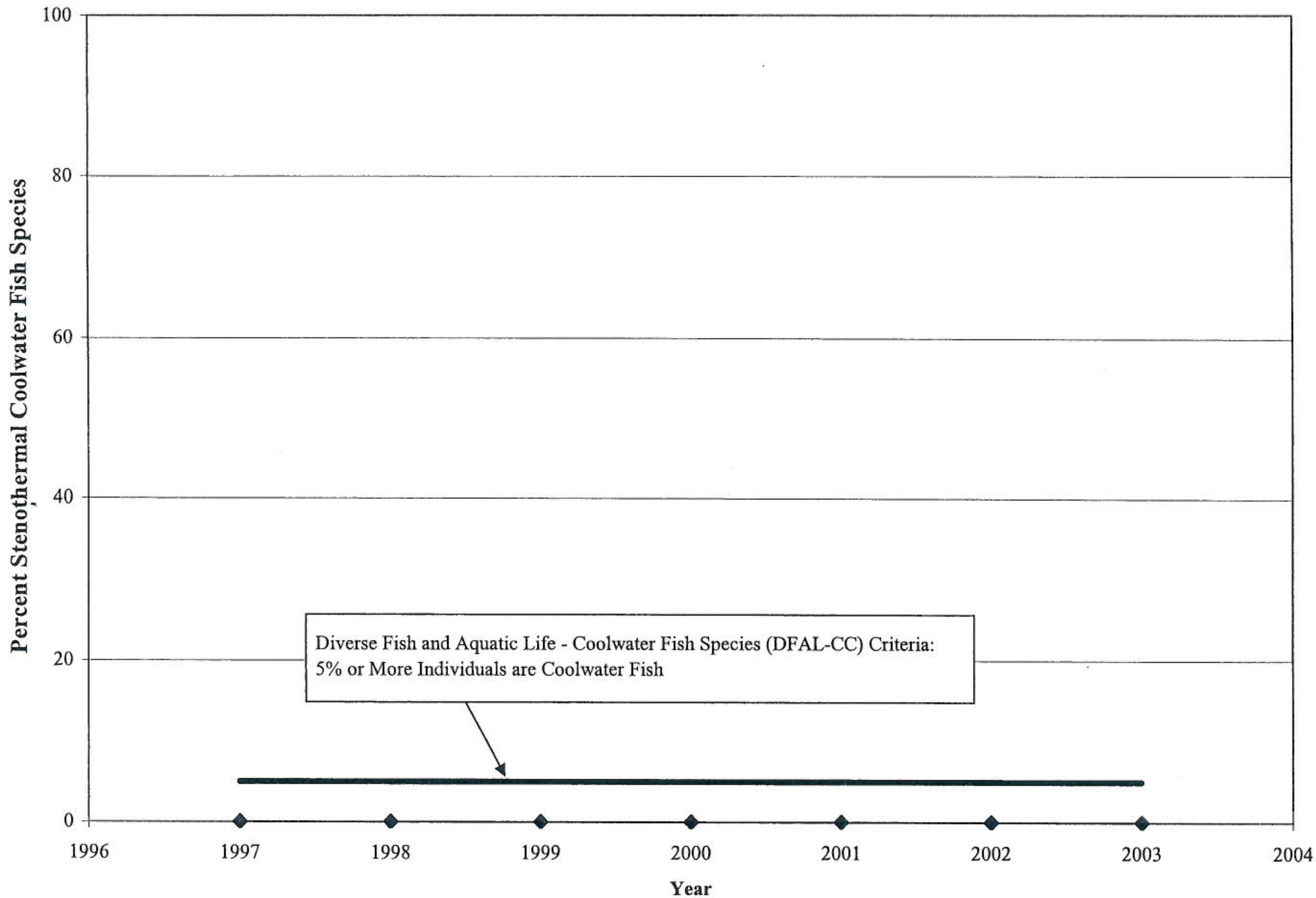
Purgatory Creek - Station P5
Percent Stenothermal Coolwater Fish Species



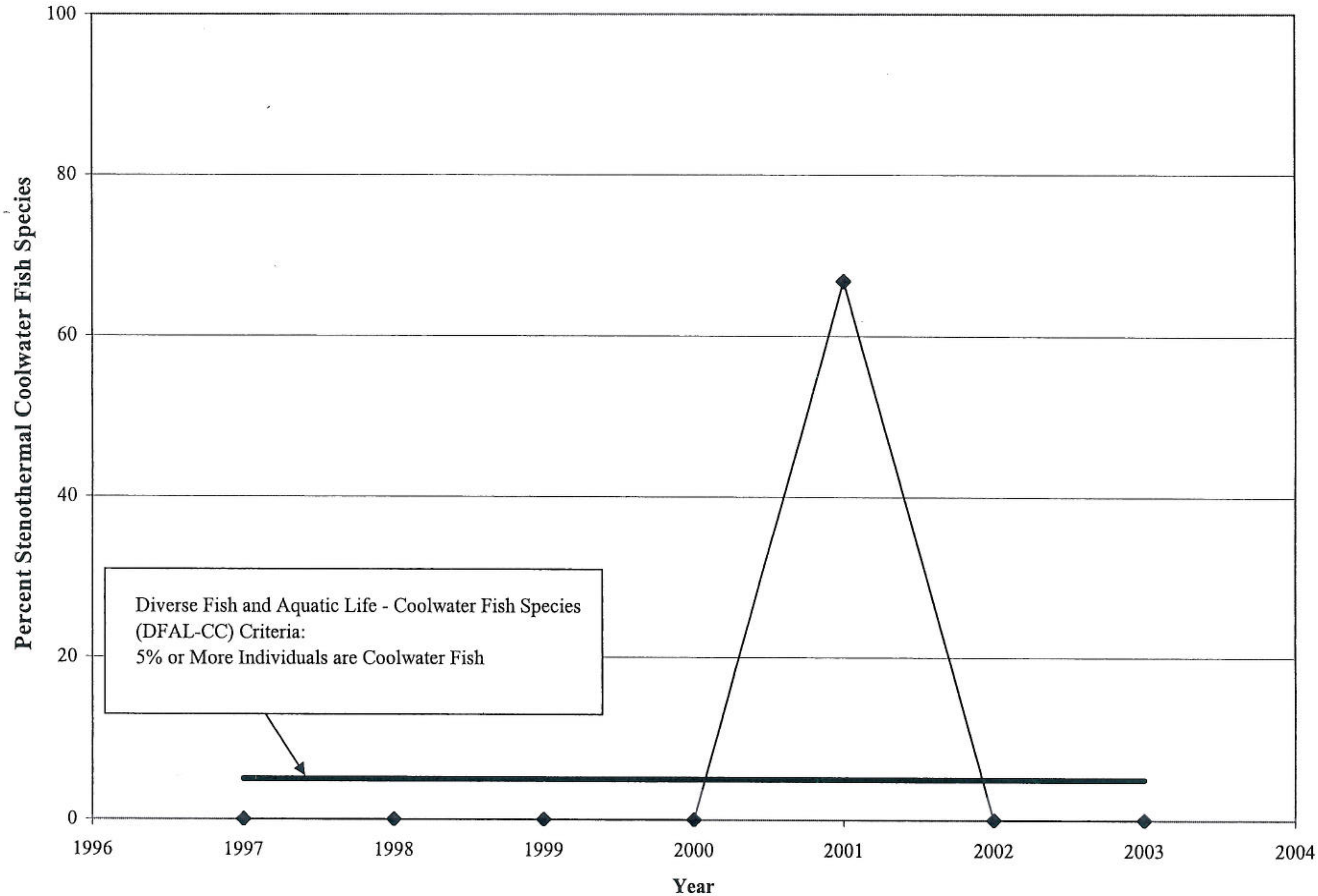
Purgatory Creek - Station P6
Percent Stenothermal Coolwater Fish Species



Purgatory Creek - Station P7
Percent Stenothermal Coolwater Fish Species

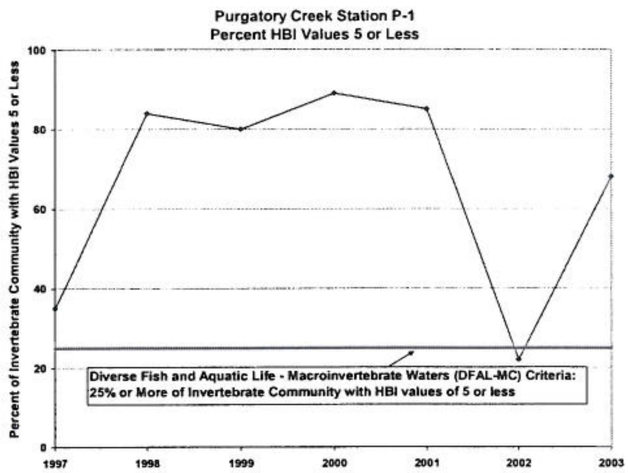


Purgatory Creek - Station P8
Percent Stenothermal Coolwater Fish Species

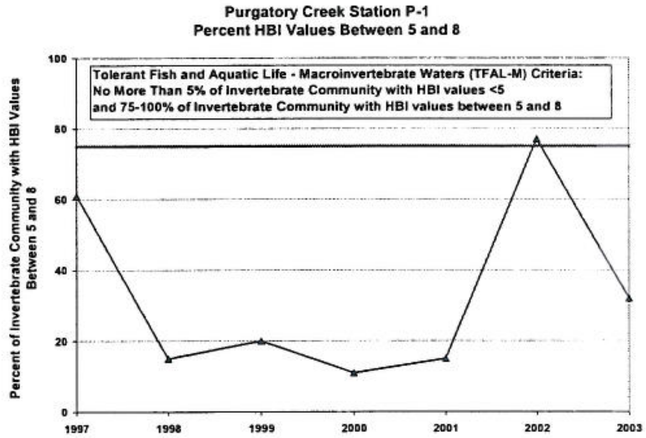


Appendix 3-I-7

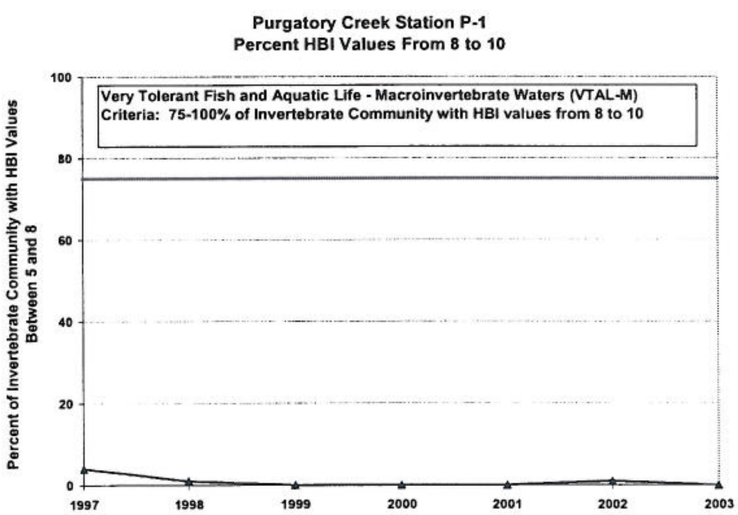
Percent HBI Values by Category: Reach P-1



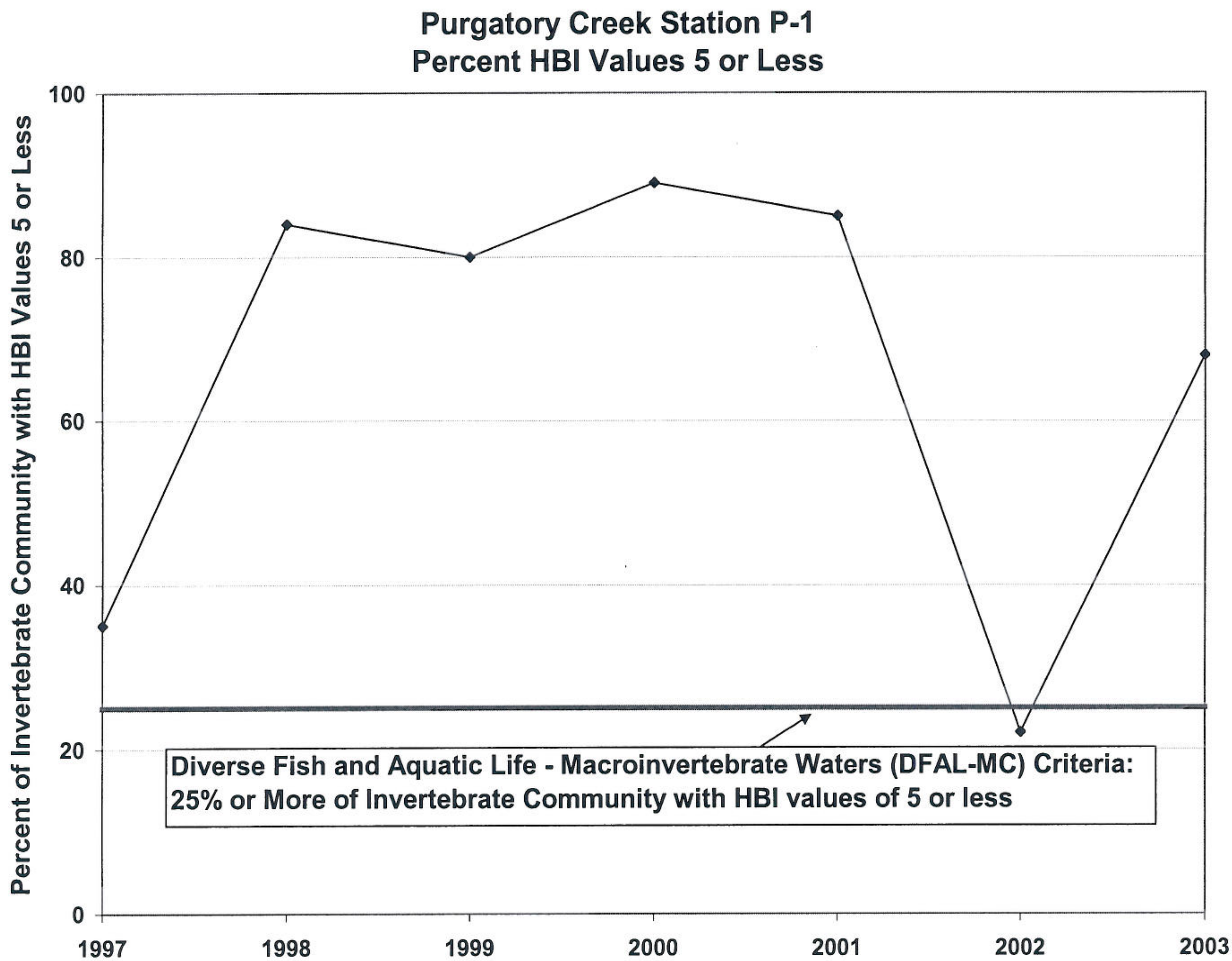
Purgatory Creek Station P-1
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less



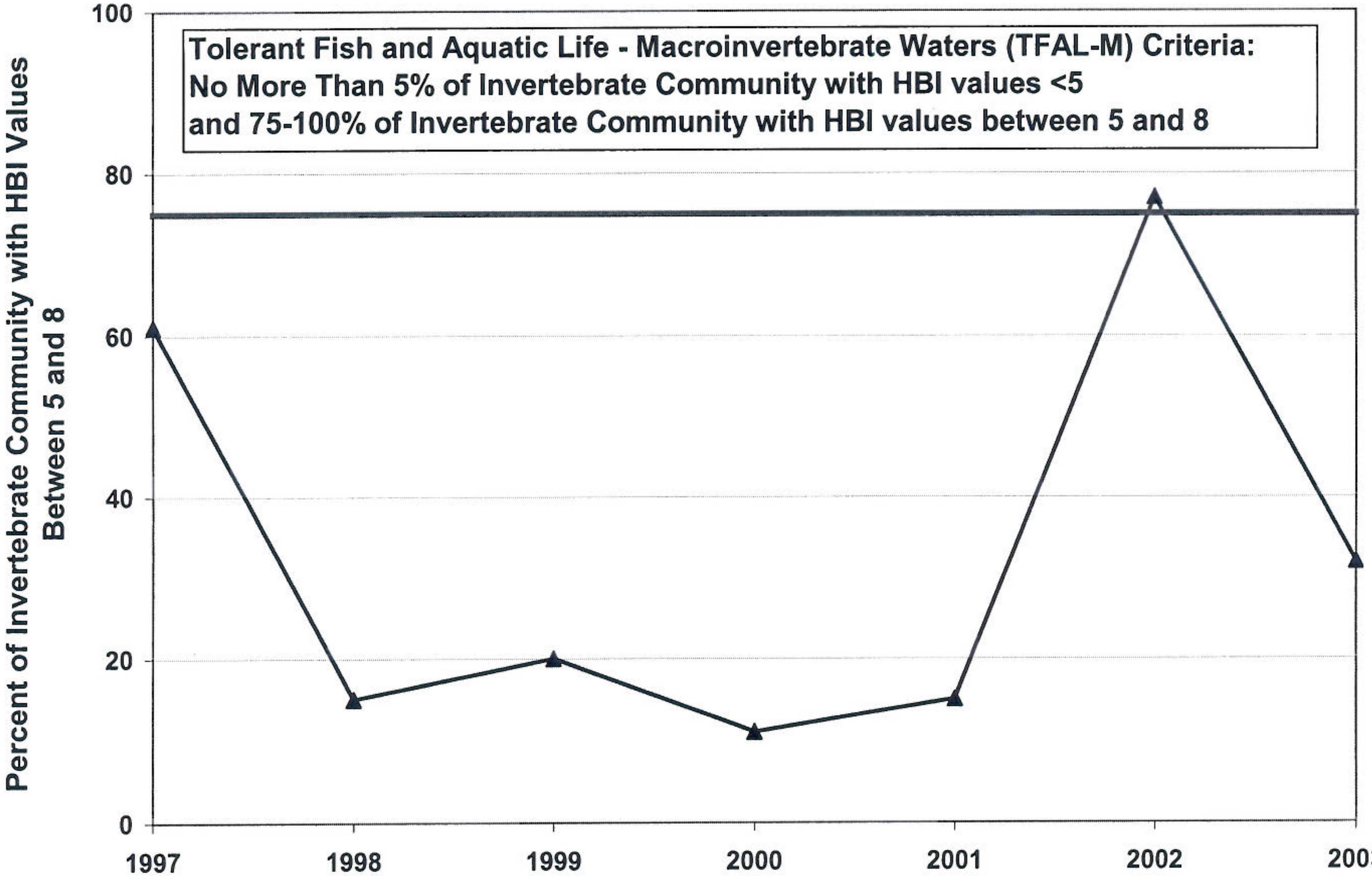
Purgatory Creek Station P-1
Percent HBI Values Between 5 and 8
Percent of Invertebrate Community with HBI Values Between 5 and 8
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (TFAL-M) Criteria:
No More Than 5% of Invertebrate Community with HBI values <5
and 75-100% of Invertebrate Community with HBI values between 5 and 8



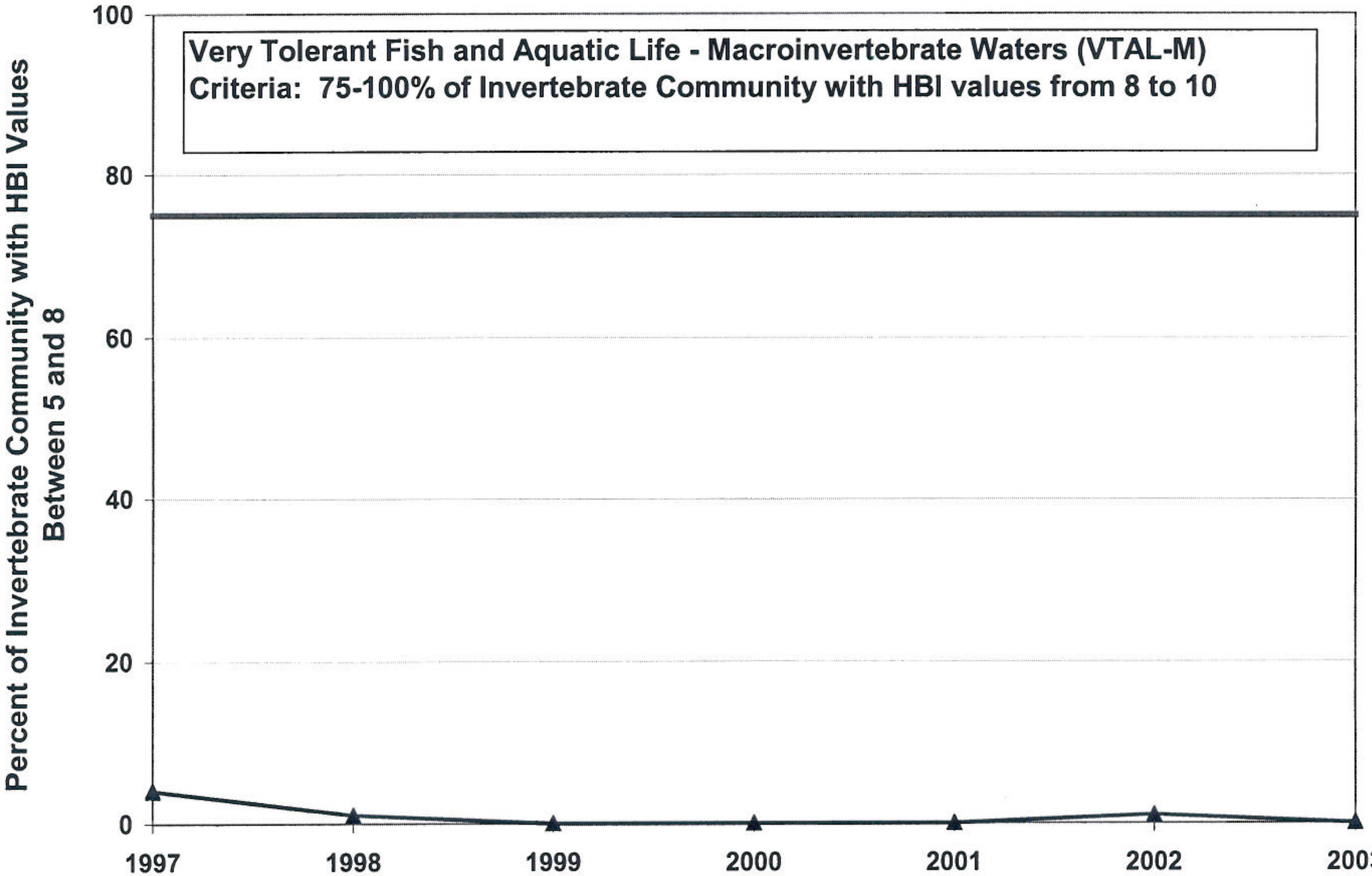
Purgatory Creek Station P-1
Percent HBI Values From 8 to 10
Percent of Invertebrate Community with HBI Values Between 5 and 8
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
Very Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (VTAL-M)
Criteria: 75-100% of Invertebrate Community with HBI values from 8 to 10


Purgatory Creek Station P-1
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less

Purgatory Creek Station P-1
Percent HBI Values Between 5 and 8

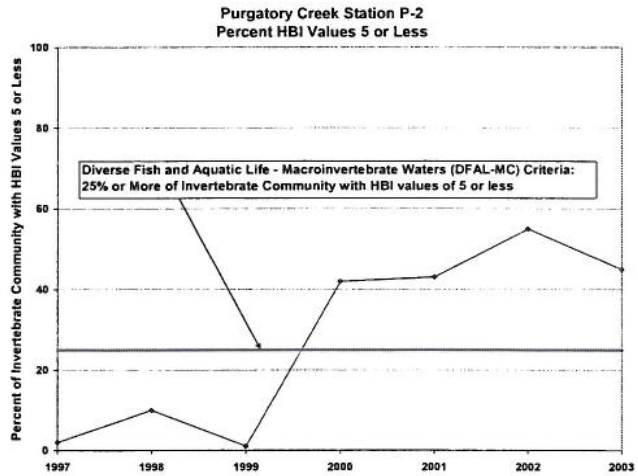


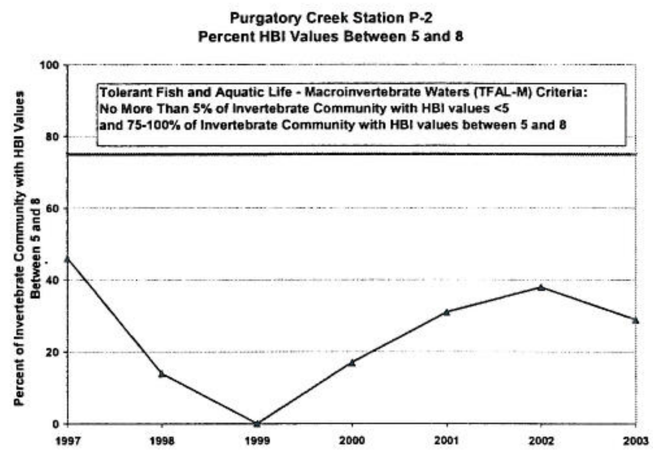
Purgatory Creek Station P-1
Percent HBI Values From 8 to 10

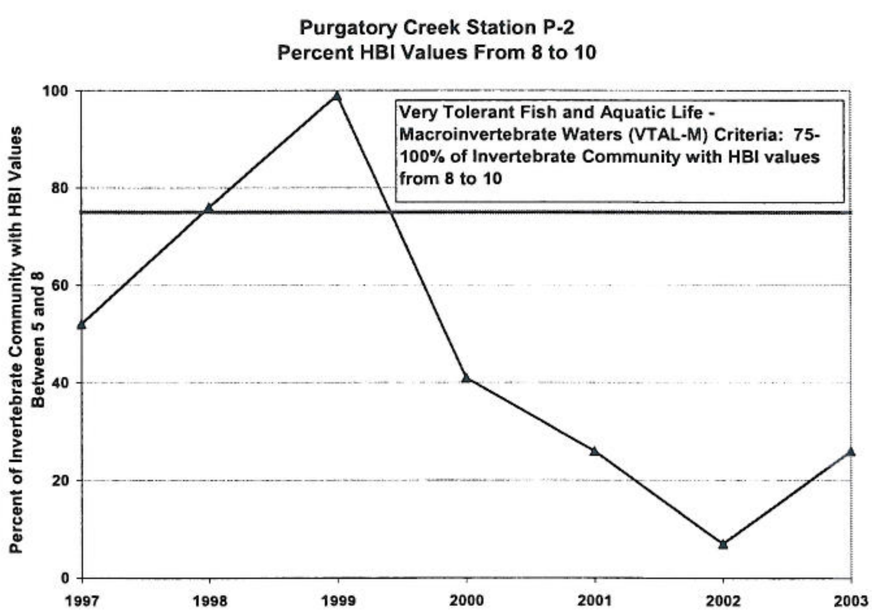


Appendix 3-I-8

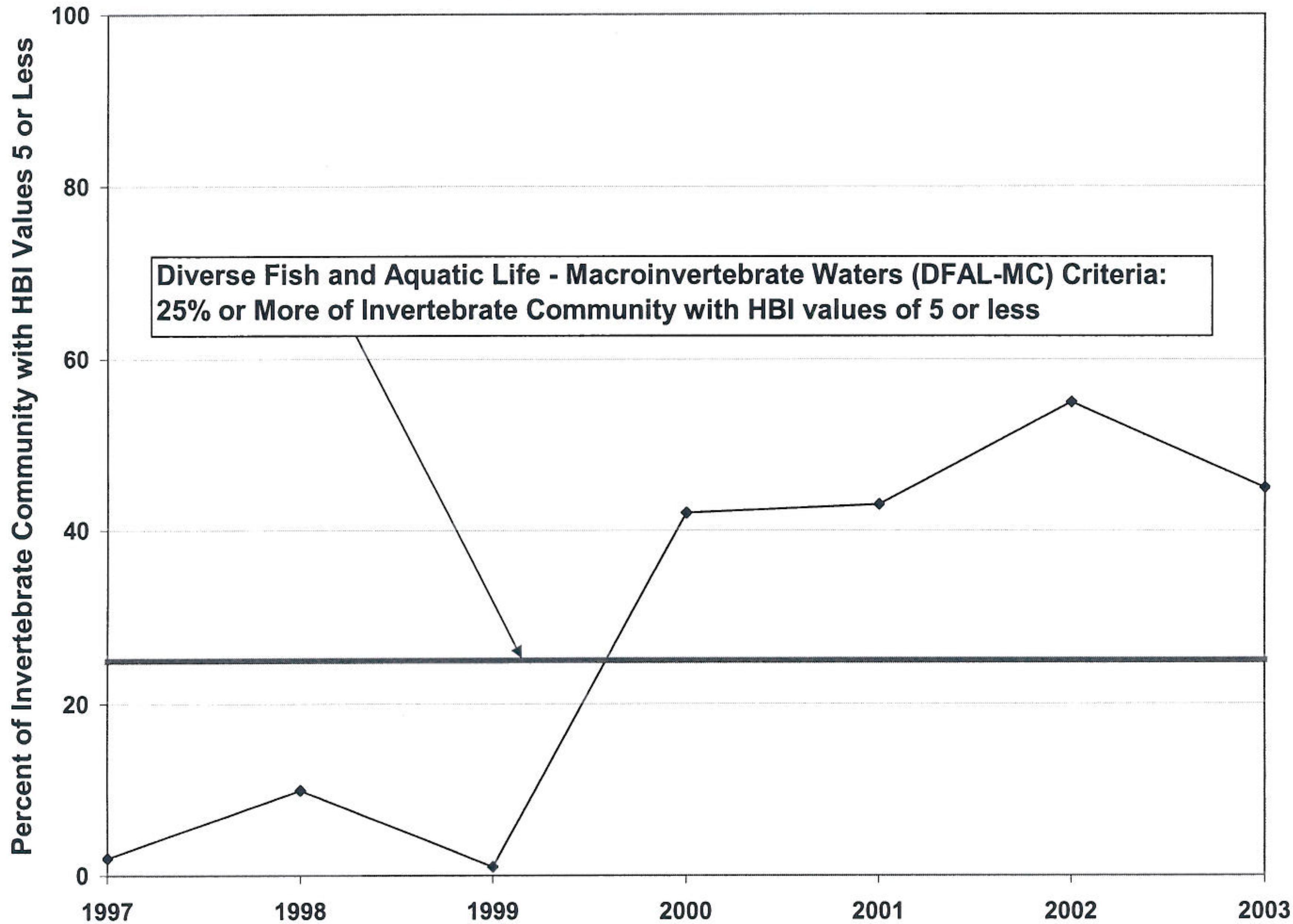
Percent HBI Values by Category: Reach P-2


Purgatory Creek Station P-2
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003

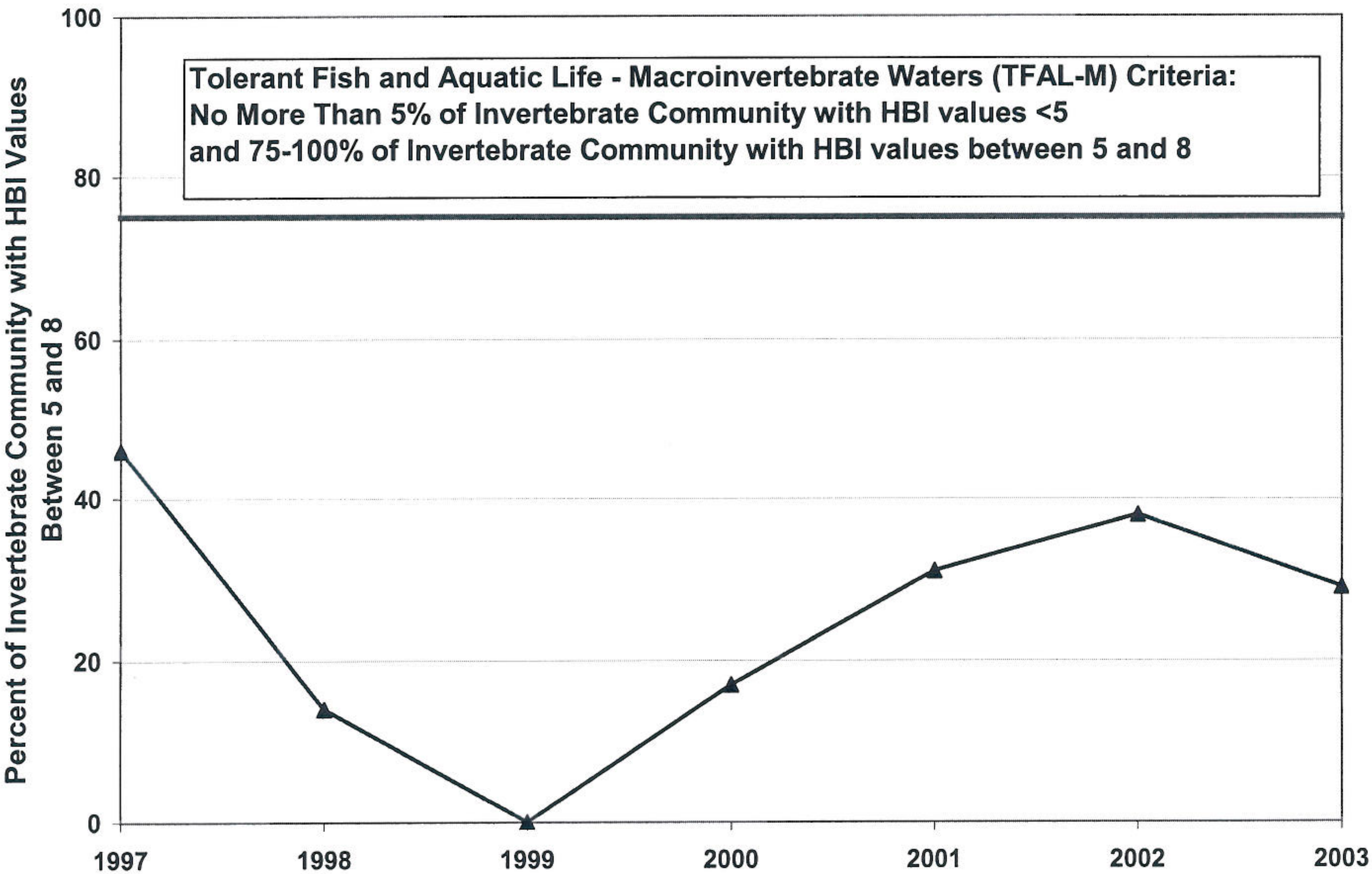

Purgatory Creek Station P-2
Percent HBI Values Between 5 and 8
Percent of Invertebrate Community with HBI Values Between 5 and 8
Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (TFAL-M) Criteria:
No More Than 5% of Invertebrate Community with HBI values <5
and 75-100% of Invertebrate Community with HBI values between 5 and 8
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003

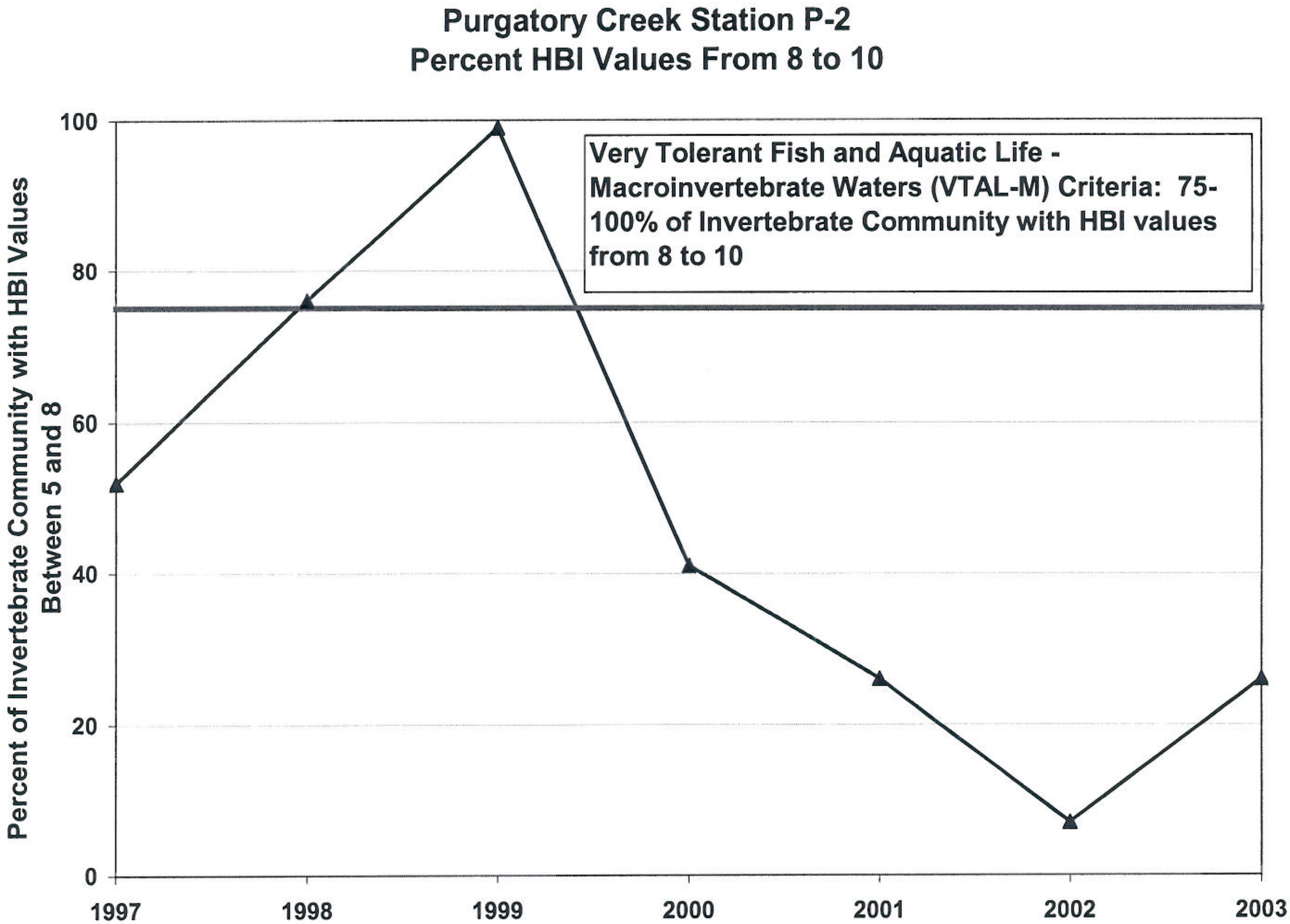

Purgatory Creek Station P-2
Percent HBI Values From 8 to 10
Percent of Invertebrate Community with HBI Values Between 5 and 8
Very Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (VTAL-M) Criteria: 75-100% of Invertebrate Community with HBI values from 8 to 10
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003

Purgatory Creek Station P-2
Percent HBI Values 5 or Less



Purgatory Creek Station P-2
Percent HBI Values Between 5 and 8

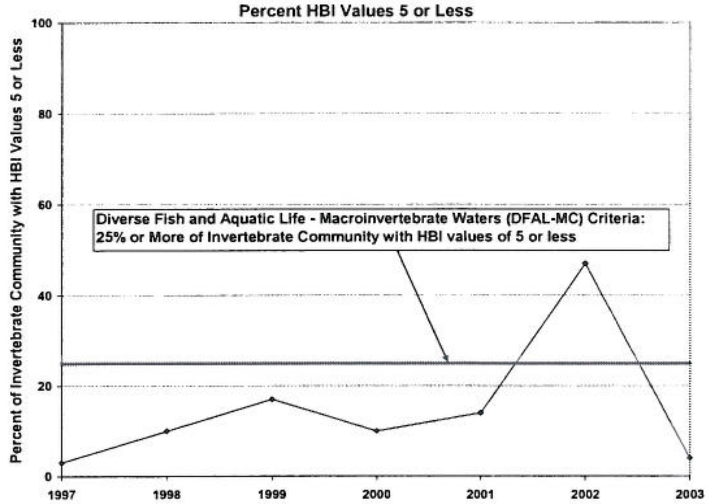



Purgatory Creek Station P-2
Percent HBI Values From 8 to 10
Very Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (VTAL-M) Criteria: 75-100% of Invertebrate Community with HBI values from 8 to 10
Percent of Invertebrate Community with HBI Values Between 5 and 8
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003

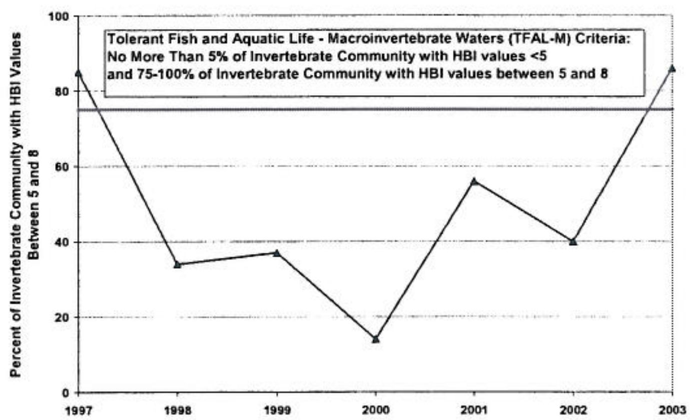
Appendix 3-I-9

Percent HBI Values by Category: Reach P-3

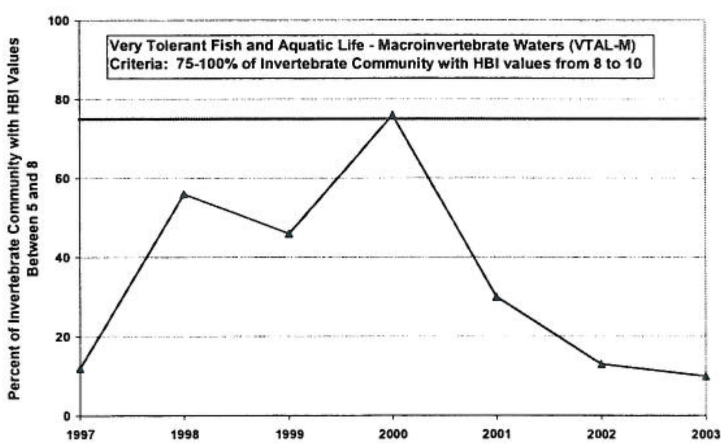
Purgatory Creek Station P-3
Percent HBI Values 5 or Less

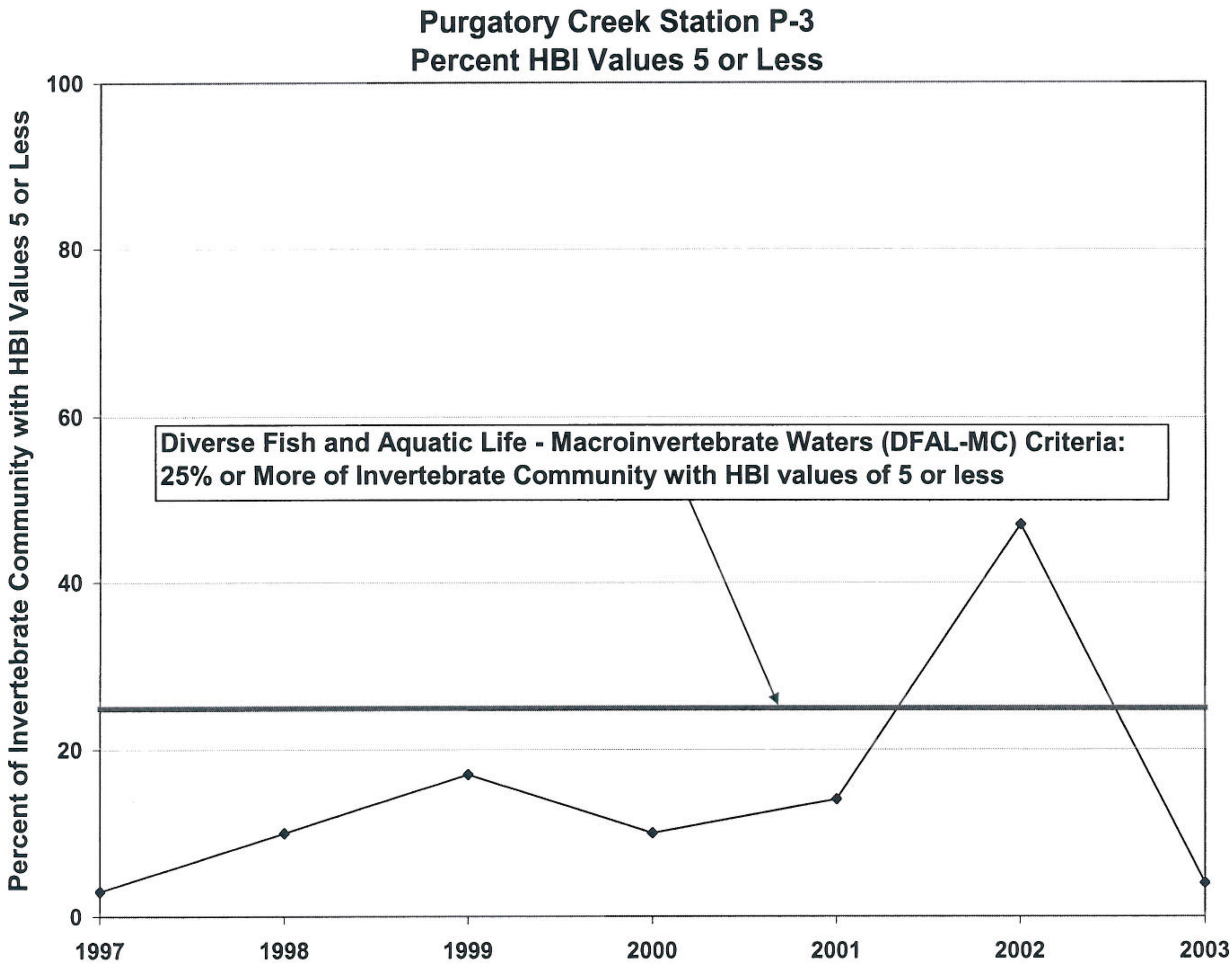


Purgatory Creek Station P-3
Percent HBI Values Between 5 and 8

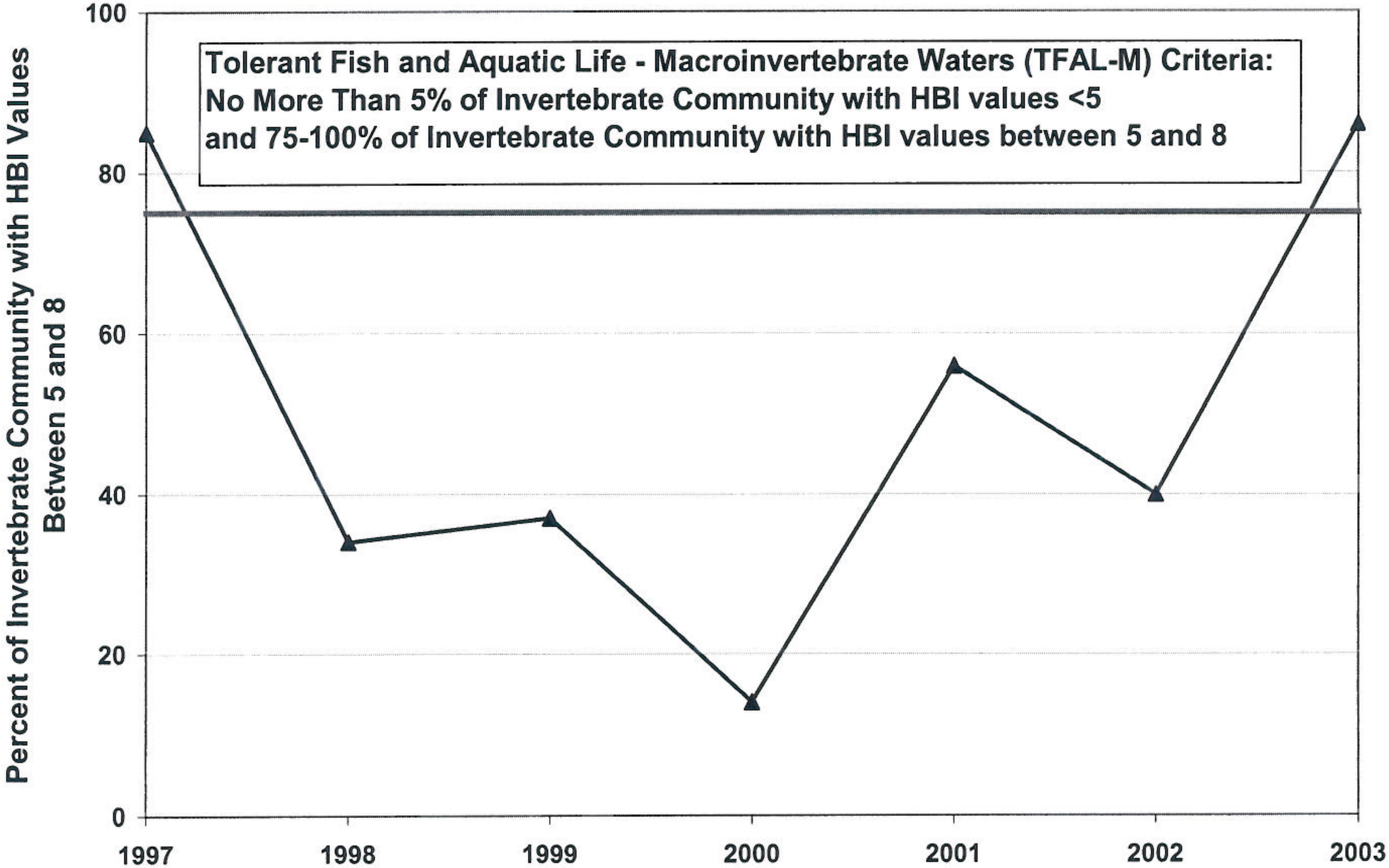


Purgatory Creek Station P-3
Percent HBI Values From 8 to 10

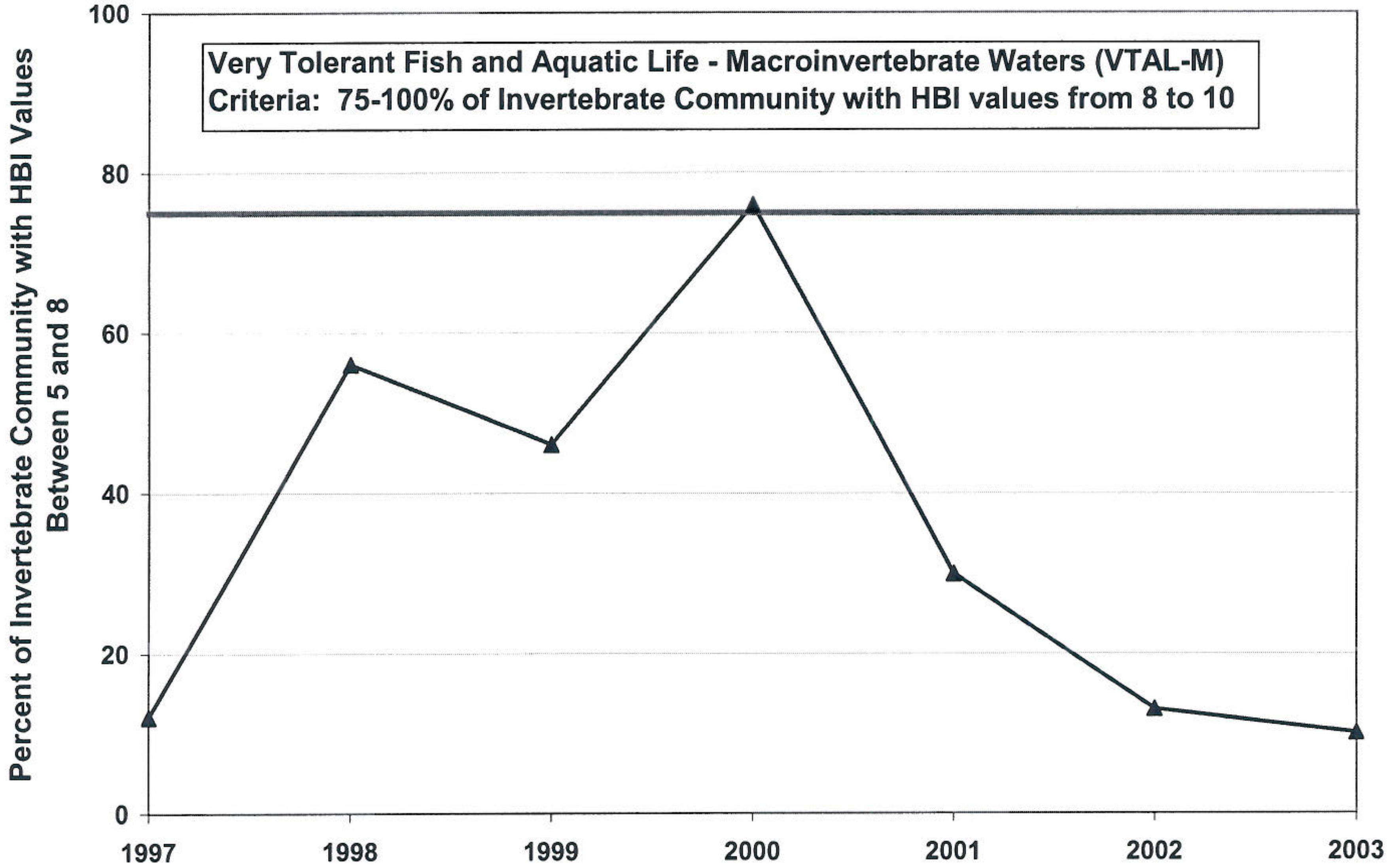



Purgatory Creek Station P-3
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
100
80
60
40
20
0
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less
1997
1998
1999
2000
2001
2002
2003

Purgatory Creek Station P-3
Percent HBI Values Between 5 and 8



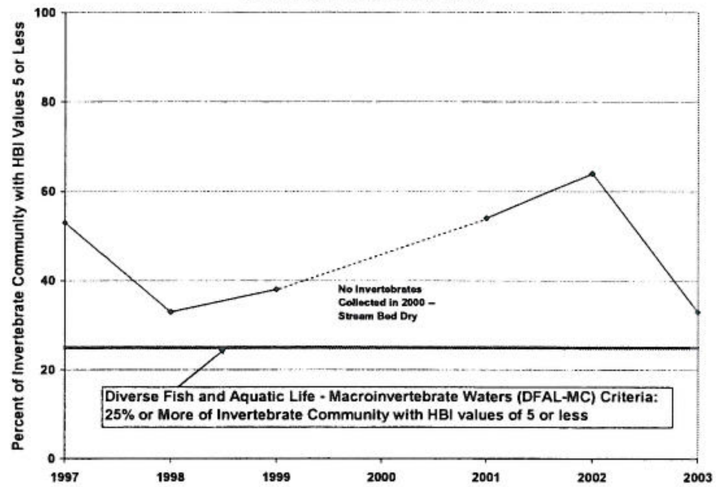
Purgatory Creek Station P-3
Percent HBI Values From 8 to 10



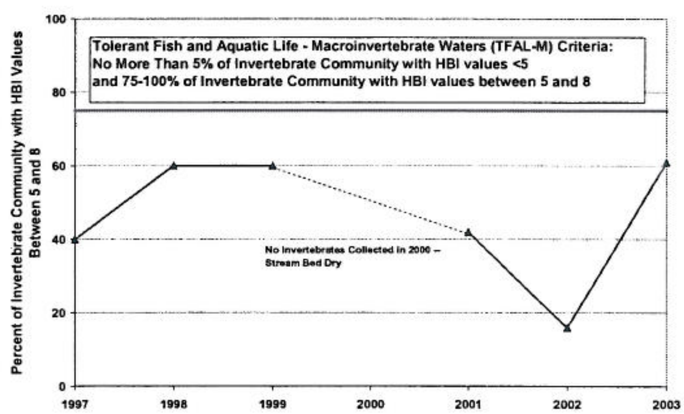
Appendix 3-I-10

Percent HBI Values by Category: Reach P-4

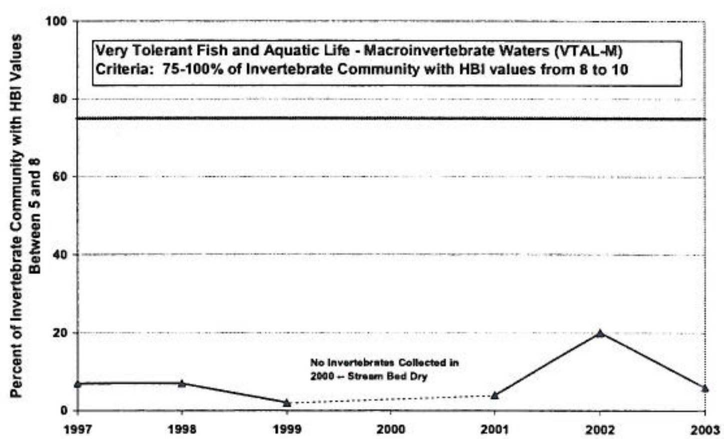
Purgatory Creek Station P-4
Percent HBI Values 5 or Less

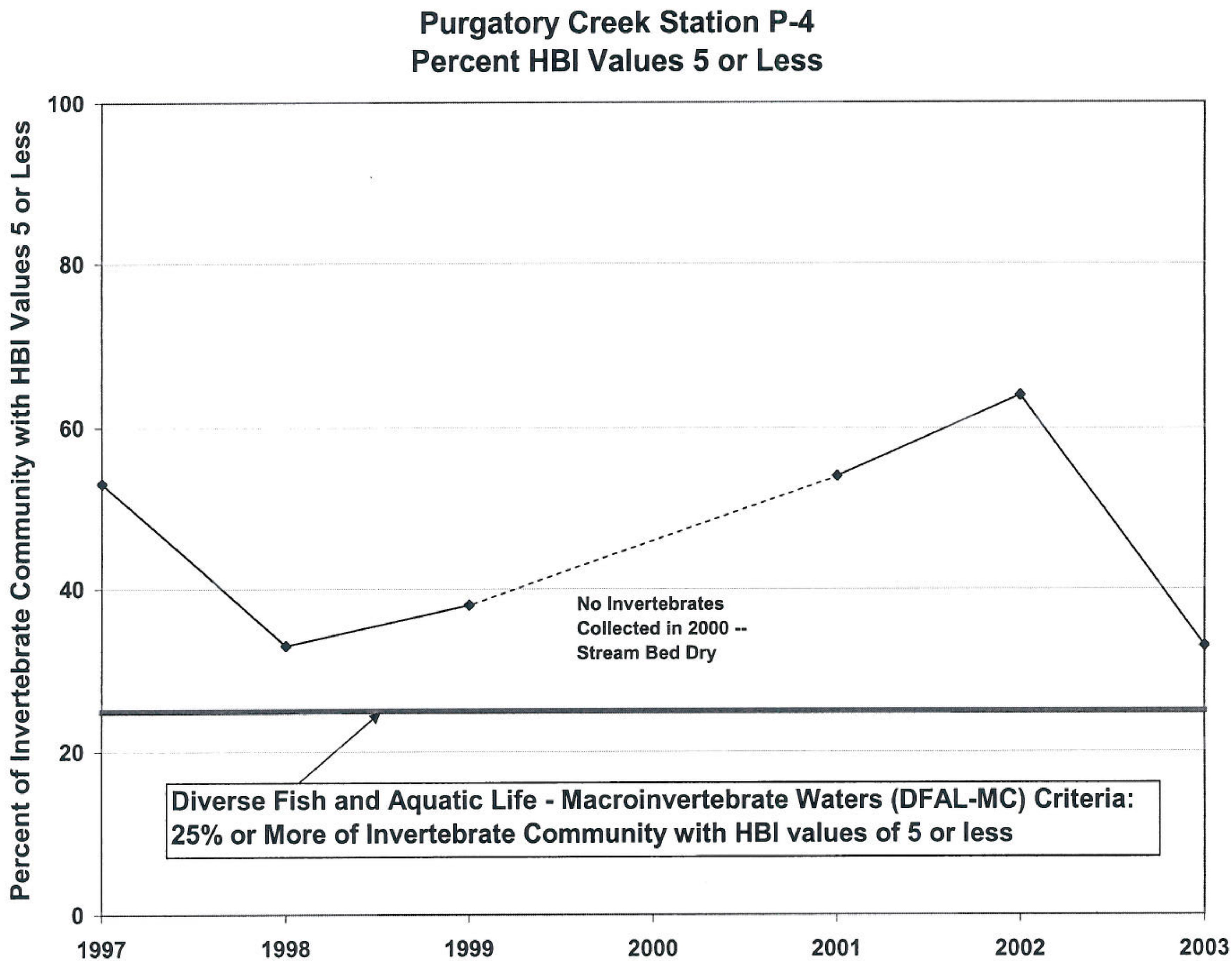


Purgatory Creek Station P-4
Percent HBI Values Between 5 and 8

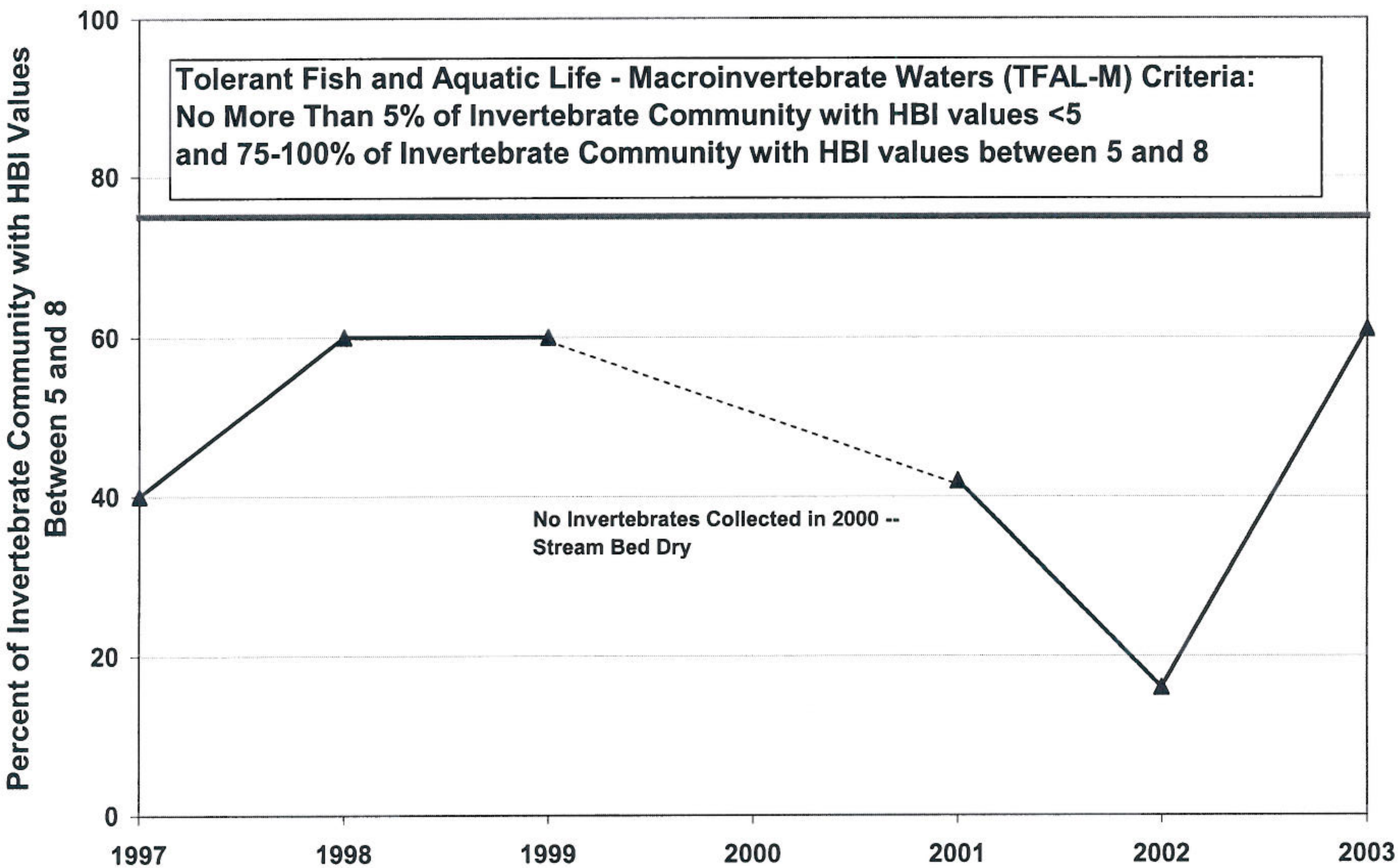


Purgatory Creek Station P-4
Percent HBI Values From 8 to 10

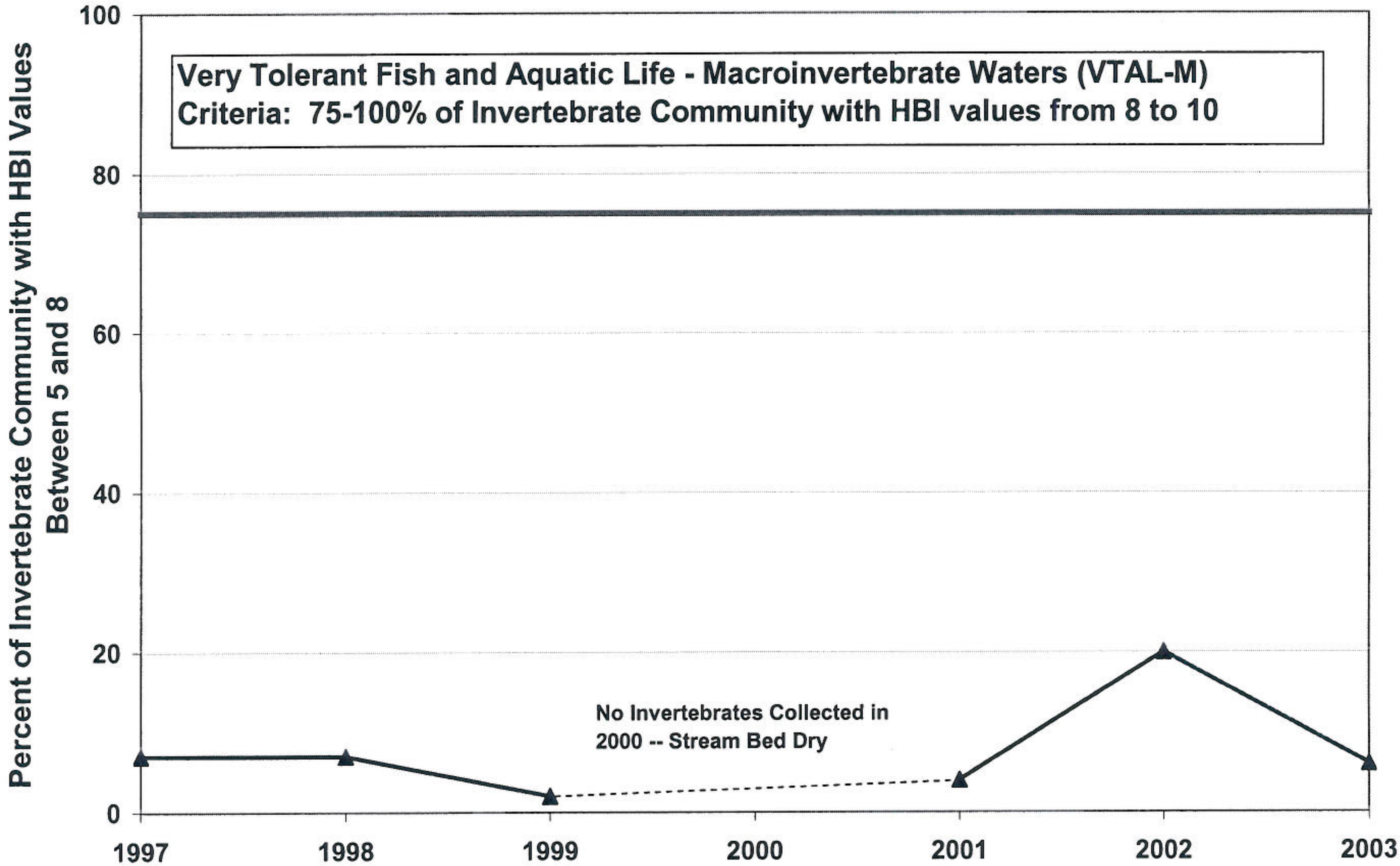



Purgatory Creek Station P-4
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
No Invertebrates
Collected in 2000 --
Stream Bed Dry
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less

Purgatory Creek Station P-4
Percent HBI Values Between 5 and 8

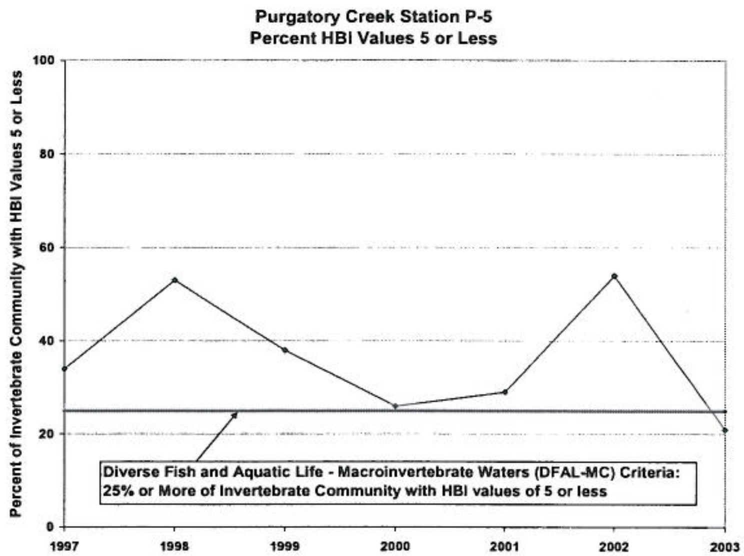


Purgatory Creek Station P-4
Percent HBI Values From 8 to 10

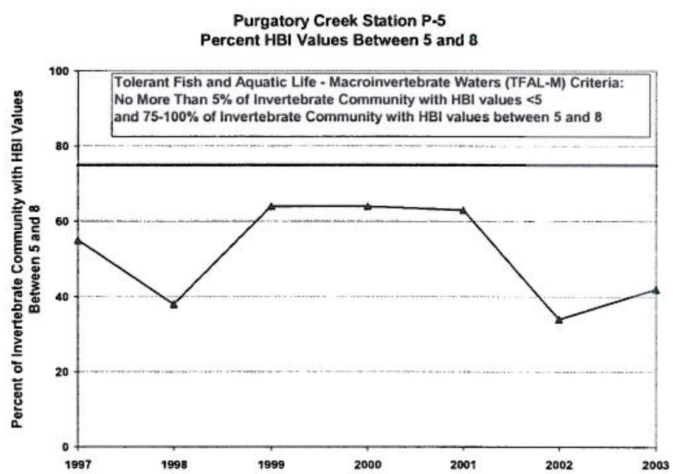


Appendix 3-I-11

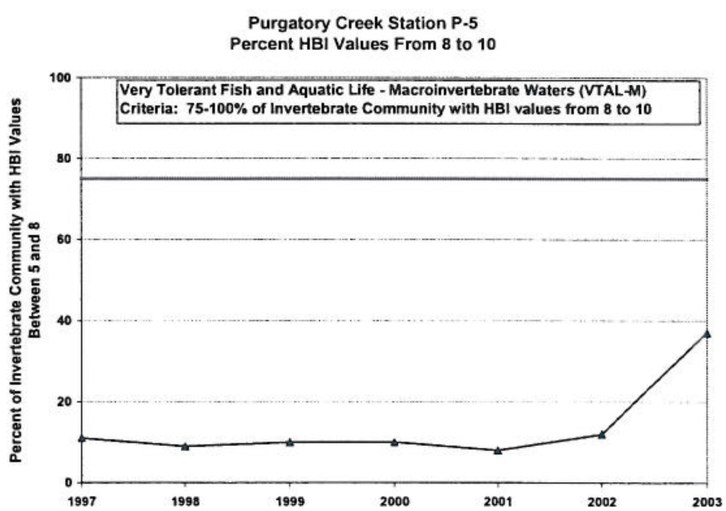
Percent HBI Values by Category: Reach P-5



Purgatory Creek Station P-5
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003

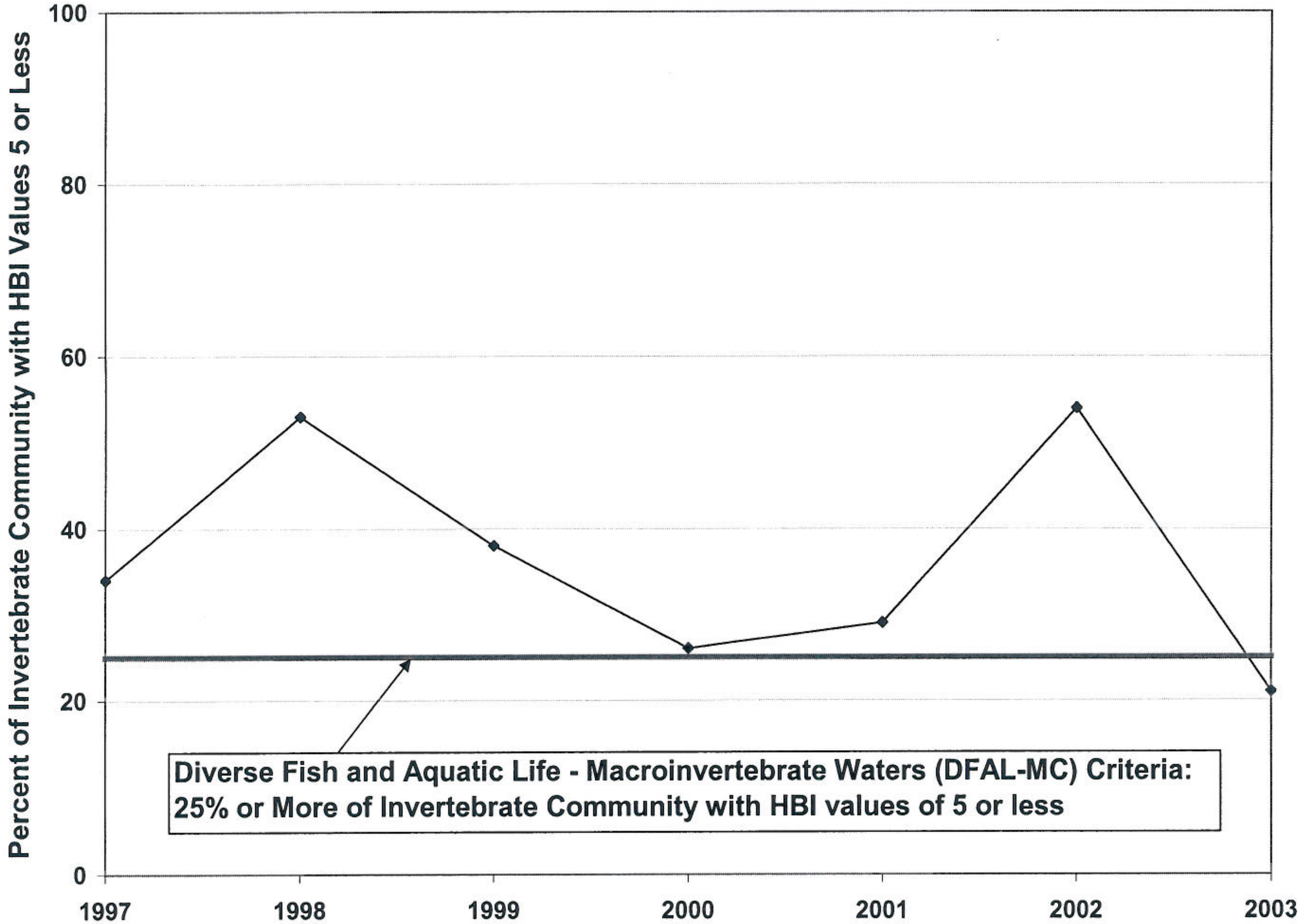


Purgatory Creek Station P-5
Percent HBI Values Between 5 and 8
Percent of Invertebrate Community with HBI Values Between 5 and 8
Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (TFAL-M) Criteria:
No More Than 5% of Invertebrate Community with HBI values <5
and 75-100% of Invertebrate Community with HBI values between 5 and 8
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003

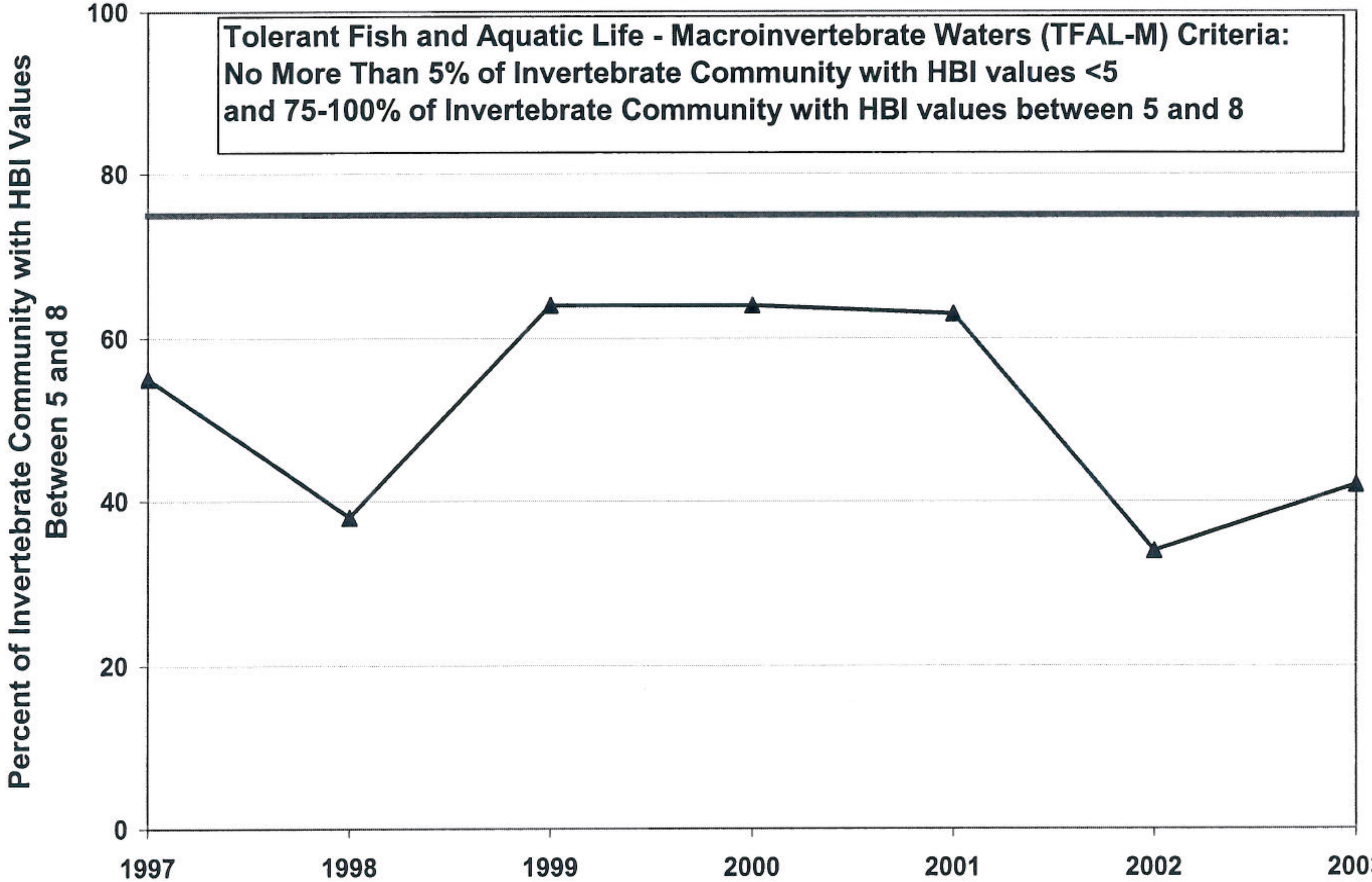


Purgatory Creek Station P-5
Percent HBI Values From 8 to 10
Percent of Invertebrate Community with HBI Values Between 5 and 8
Very Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (VTAL-M)
Criteria: 75-100% of Invertebrate Community with HBI values from 8 to 10
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003

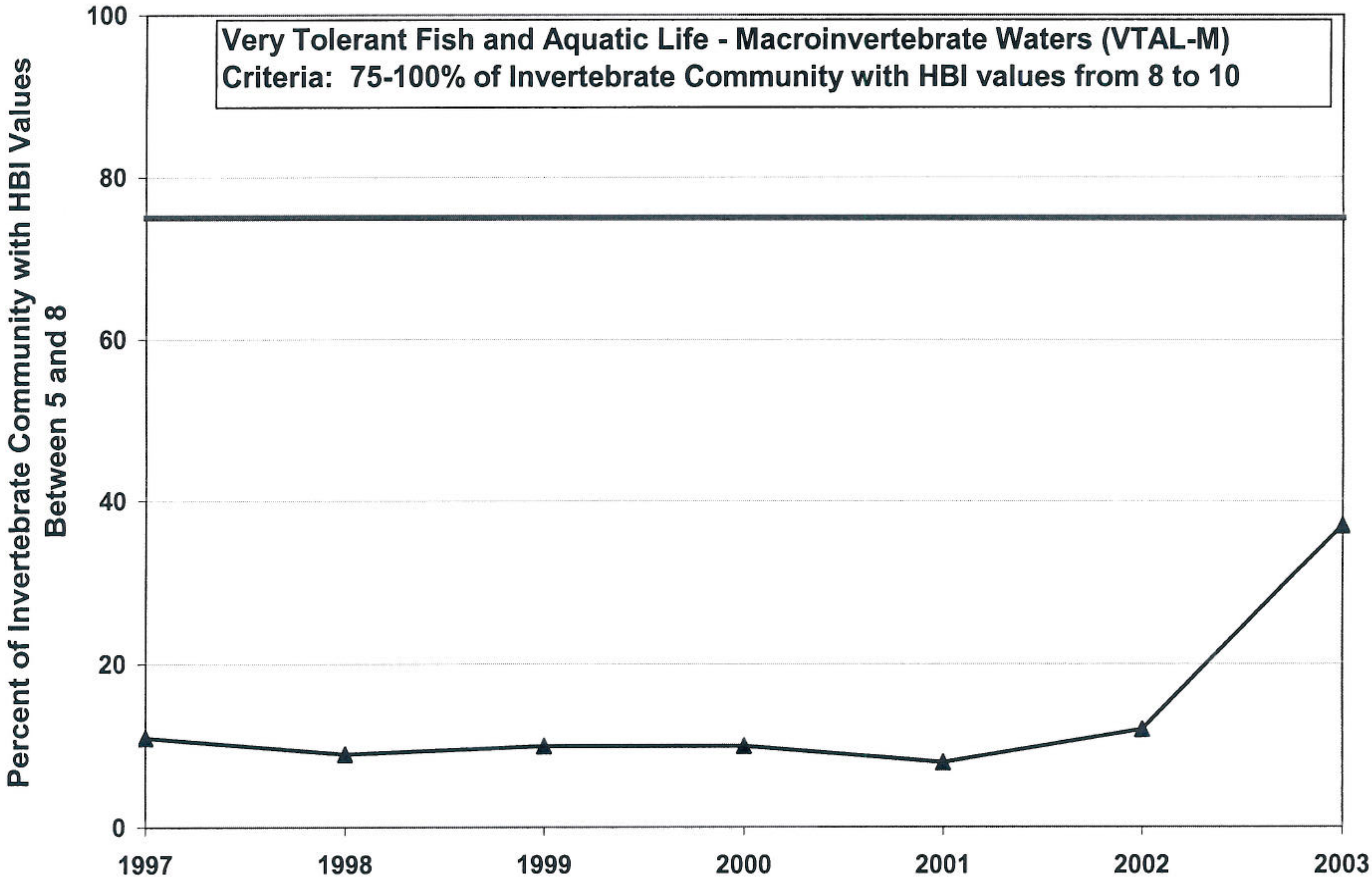
Purgatory Creek Station P-5
Percent HBI Values 5 or Less



Purgatory Creek Station P-5
Percent HBI Values Between 5 and 8



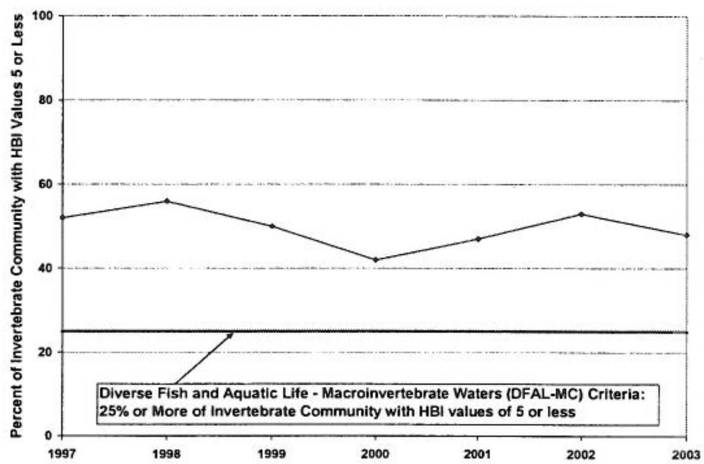
Purgatory Creek Station P-5
Percent HBI Values From 8 to 10



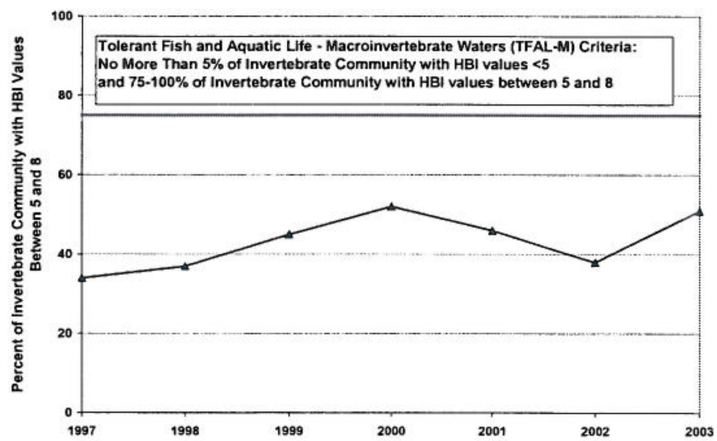
Appendix 3-I-12

Percent HBI Values by Category: Reach P-6

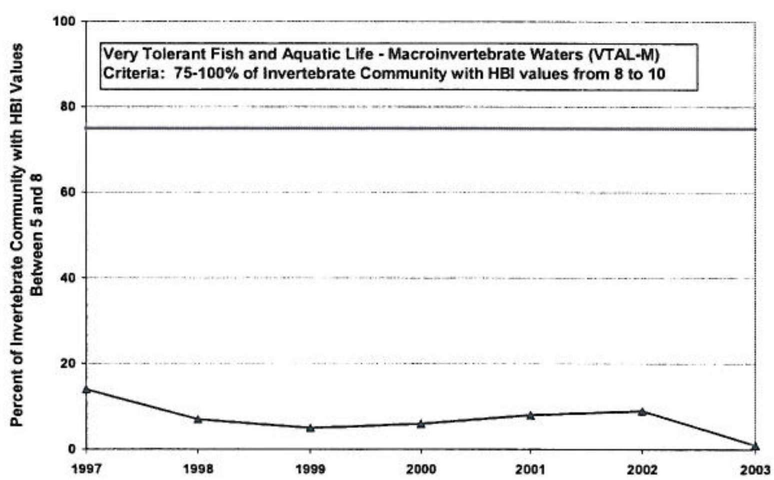
Purgatory Creek Station P-6
Percent HBI Values 5 or Less



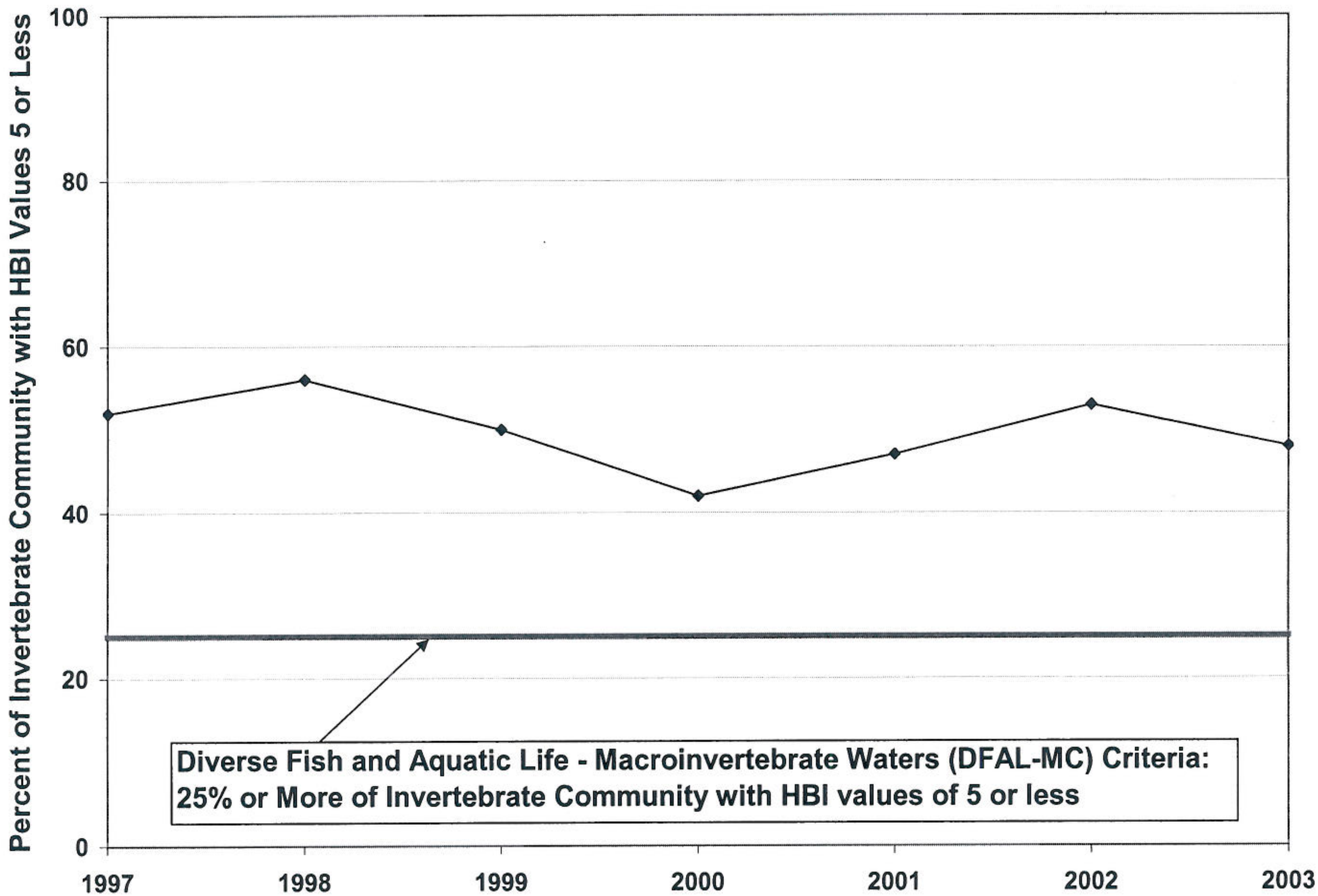
Purgatory Creek Station P-6
Percent HBI Values Between 5 and 8



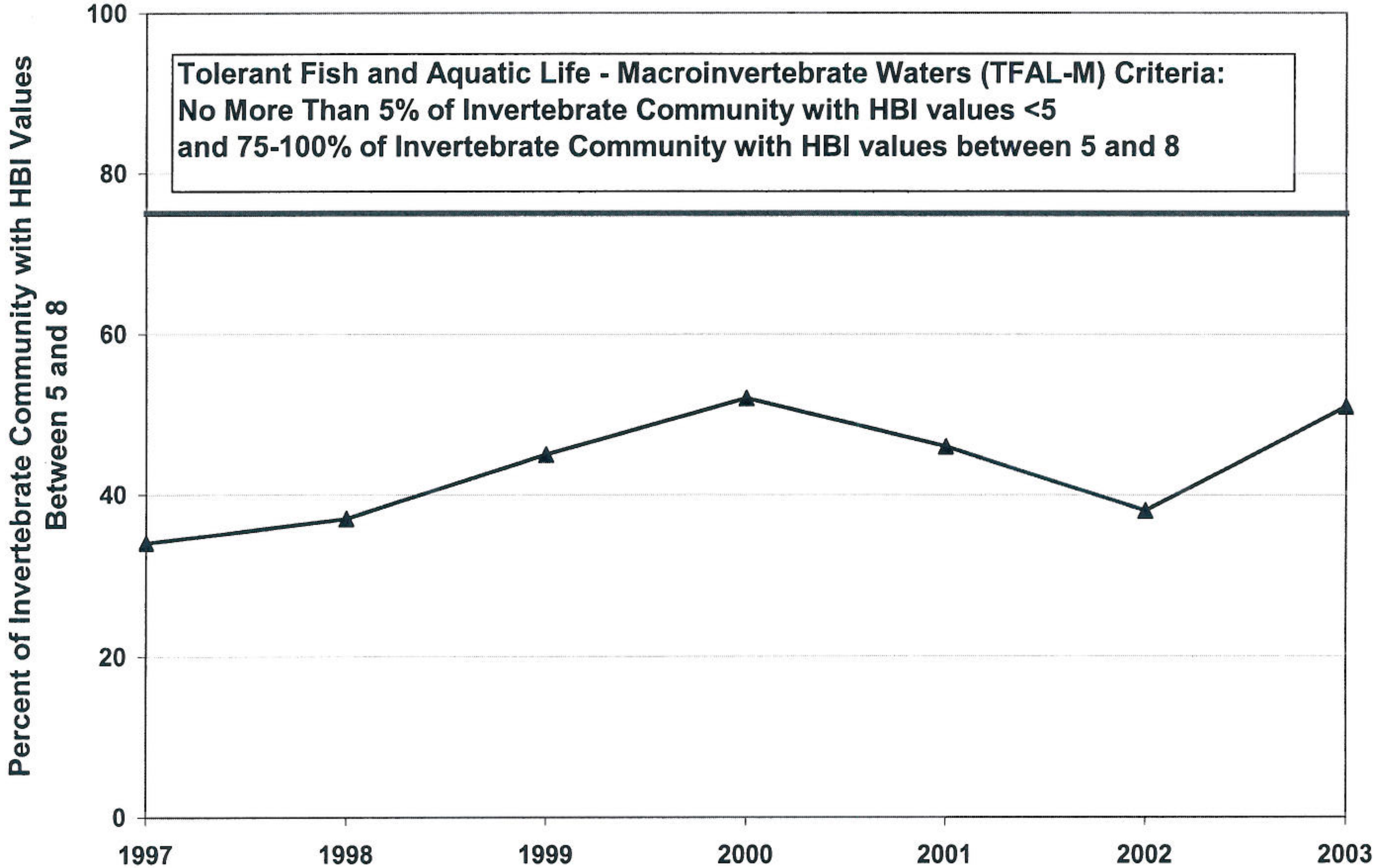
Purgatory Creek Station P-6
Percent HBI Values From 8 to 10



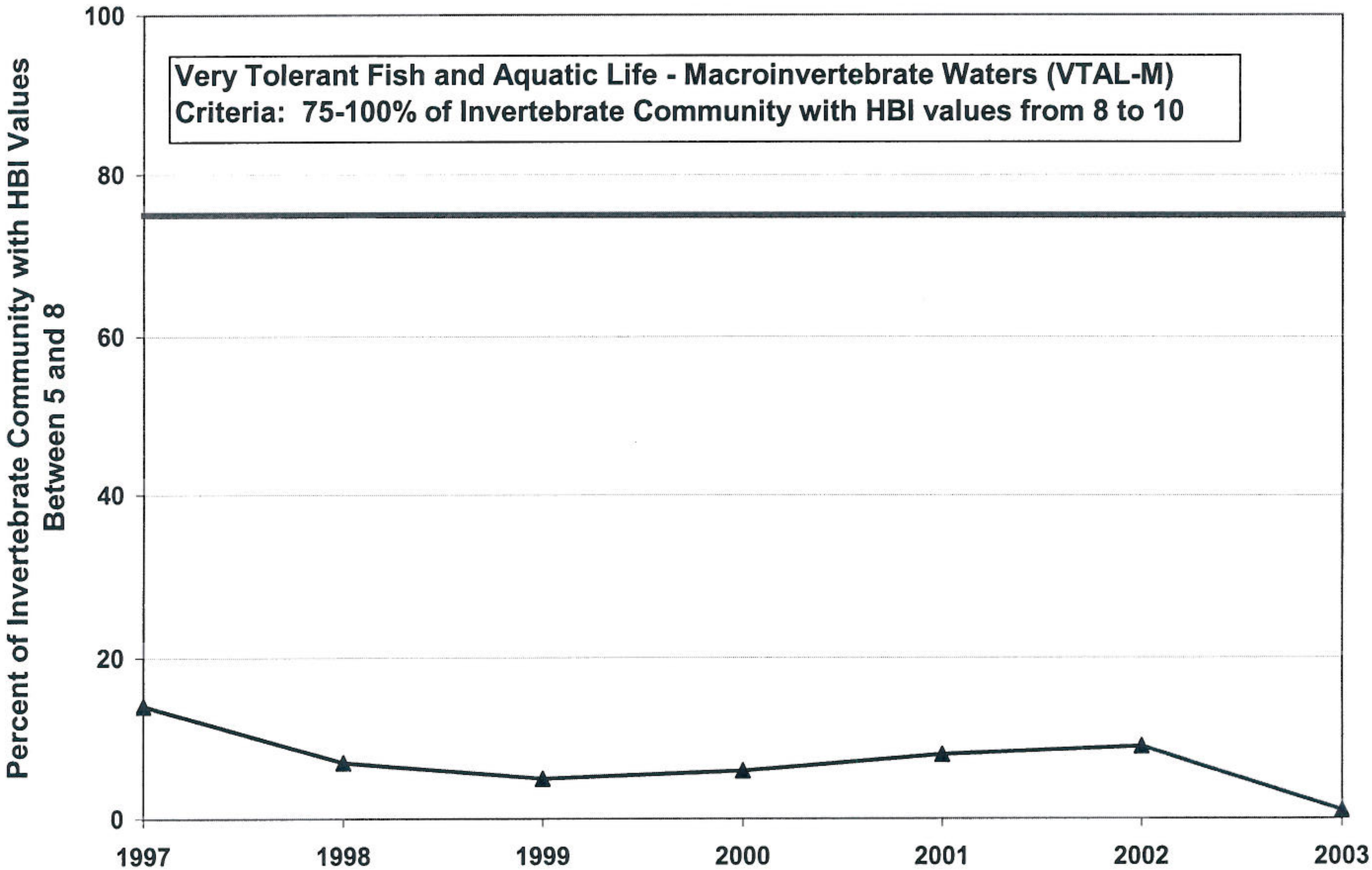
Purgatory Creek Station P-6
Percent HBI Values 5 or Less



Purgatory Creek Station P-6
Percent HBI Values Between 5 and 8

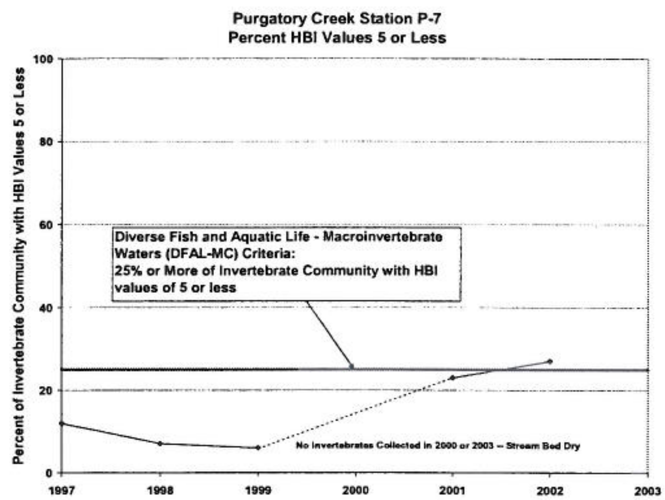


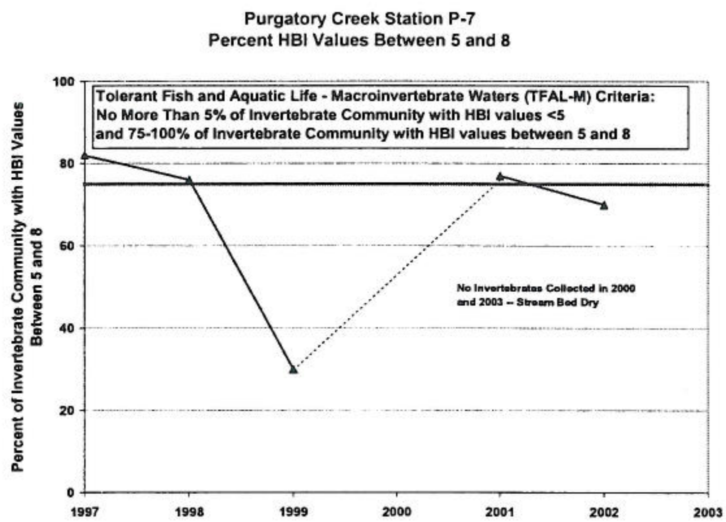
Purgatory Creek Station P-6
Percent HBI Values From 8 to 10

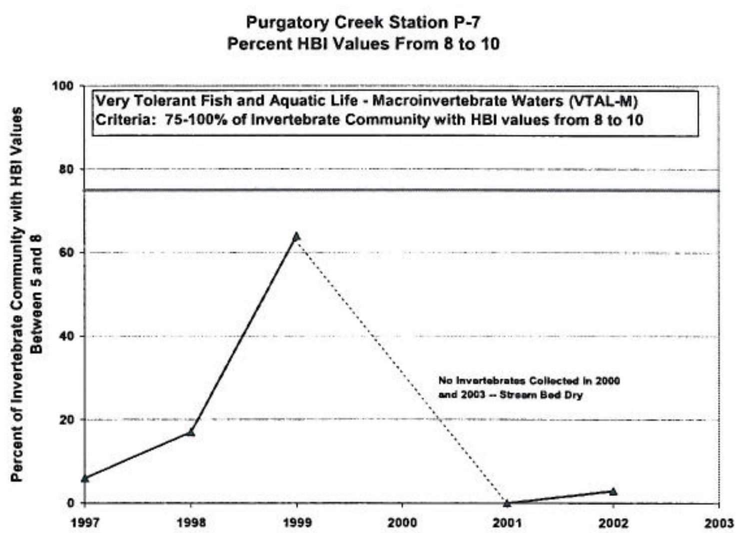


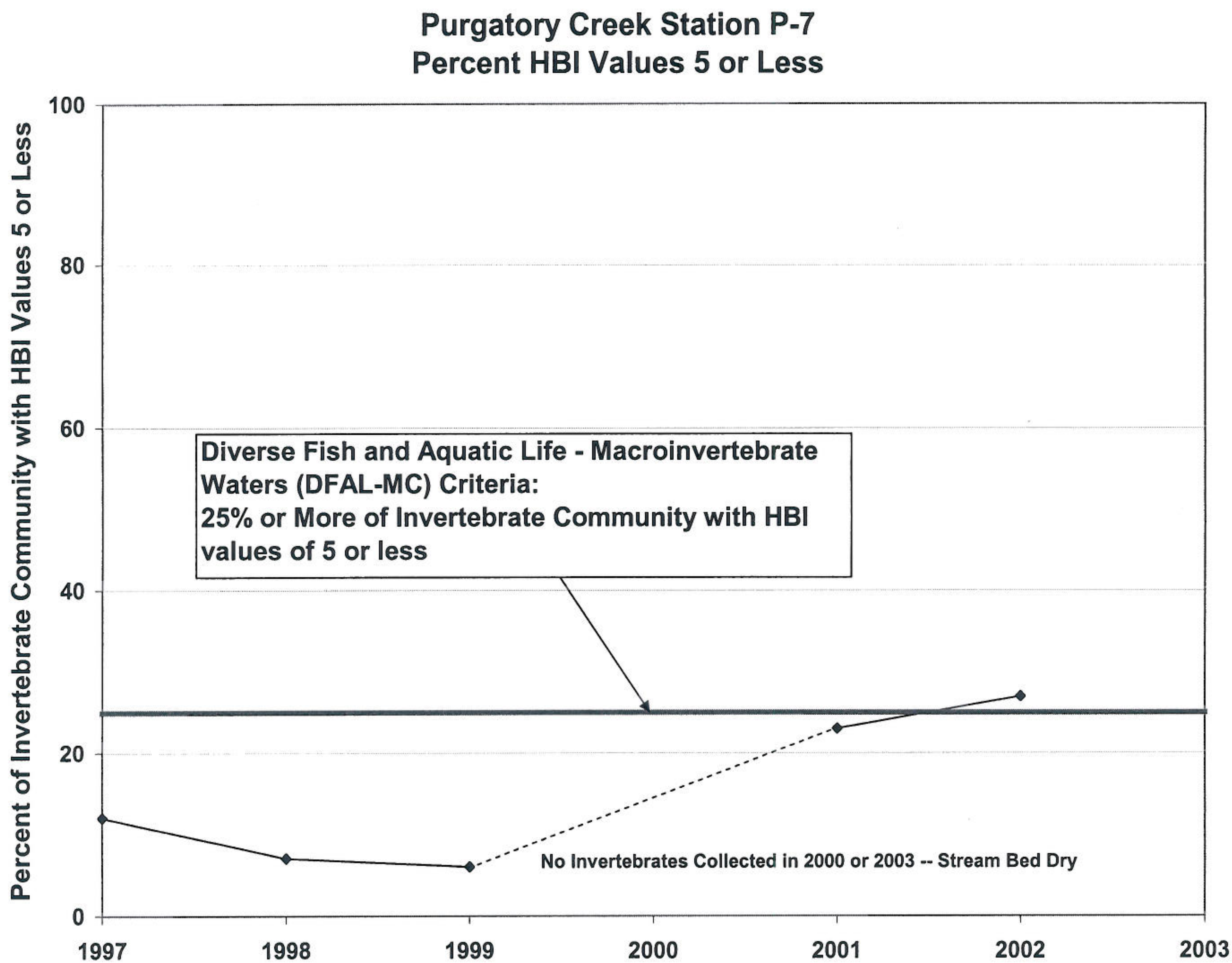
Appendix 3-I-13

Percent HBI Values by Category: Reach P-7

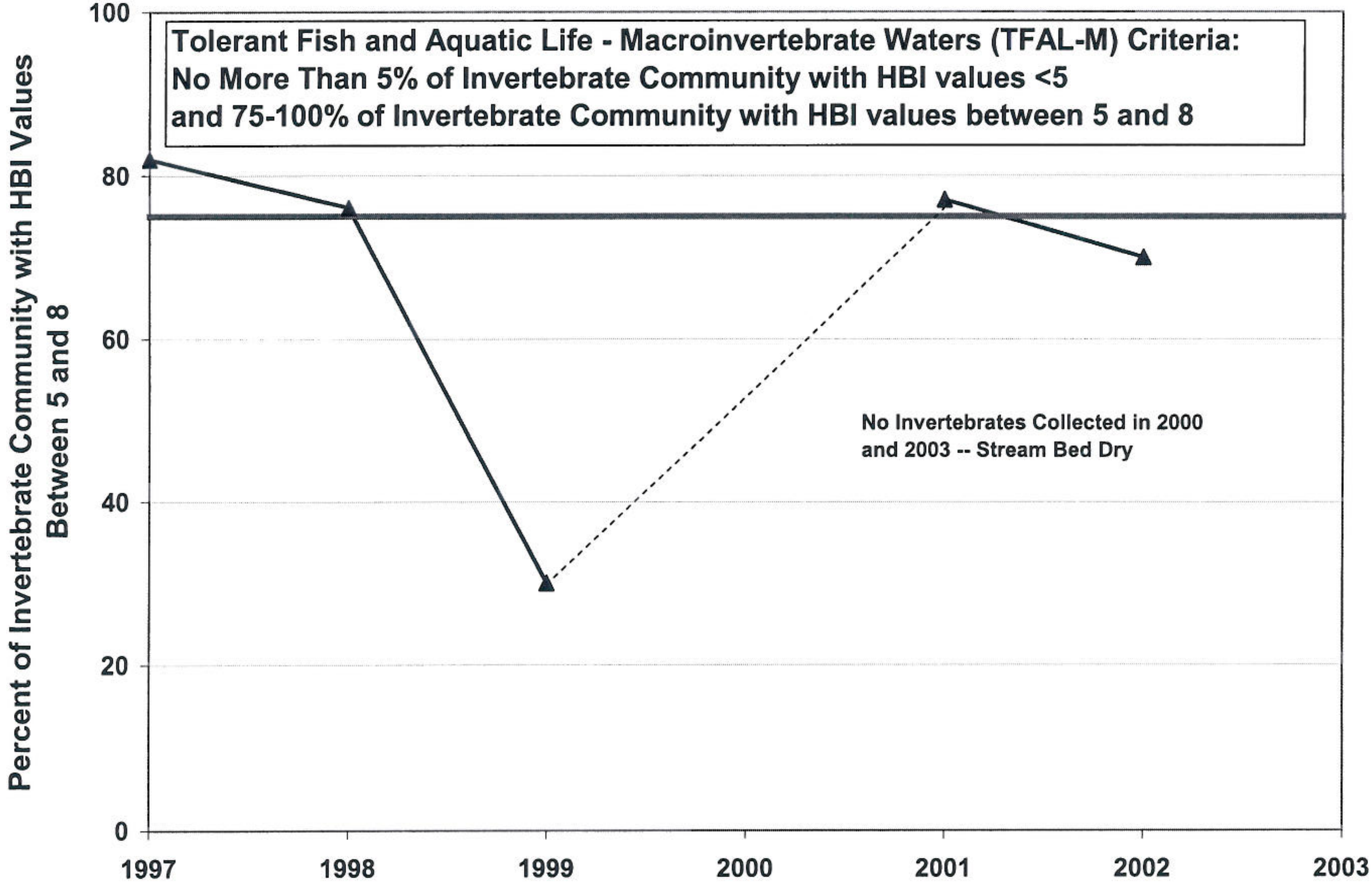

Purgatory Creek Station P-7
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less
No Invertebrates Collected in 2000 or 2003 -- Stream Bed Dry
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003


Purgatory Creek Station P-7
Percent HBI Values Between 5 and 8
Percent of Invertebrate Community with HBI Values Between 5 and 8
Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (TFAL-M) Criteria:
No More Than 5% of Invertebrate Community with HBI values <5
and 75-100% of Invertebrate Community with HBI values between 5 and 8
No Invertebrates Collected in 2000 and 2003 -- Stream Bed Dry
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003

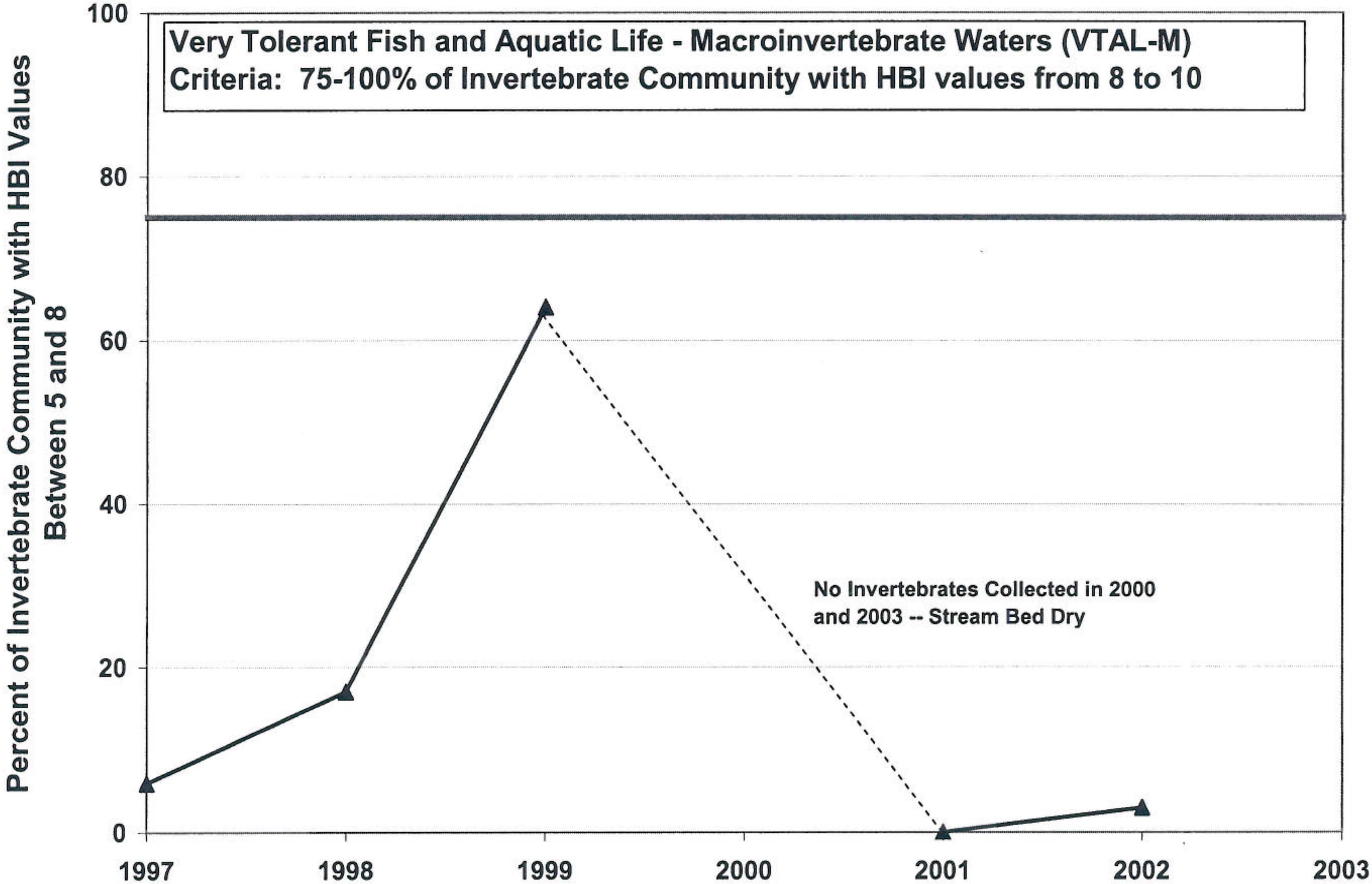

Purgatory Creek Station P-7
Percent HBI Values From 8 to 10
Percent of Invertebrate Community with HBI Values Between 5 and 8
Very Tolerant Fish and Aquatic Life - Macroinvertebrate Waters (VTAL-M)
Criteria: 75-100% of Invertebrate Community with HBI values from 8 to 10
No Invertebrates Collected in 2000 and 2003 -- Stream Bed Dry
0
20
40
60
80
100
1997
1998
1999
2000
2001
2002
2003


Purgatory Creek Station P-7
Percent HBI Values 5 or Less
Percent of Invertebrate Community with HBI Values 5 or Less
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
Diverse Fish and Aquatic Life - Macroinvertebrate Waters (DFAL-MC) Criteria:
25% or More of Invertebrate Community with HBI values of 5 or less
No Invertebrates Collected in 2000 or 2003 -- Stream Bed Dry

Purgatory Creek Station P-7
Percent HBI Values Between 5 and 8



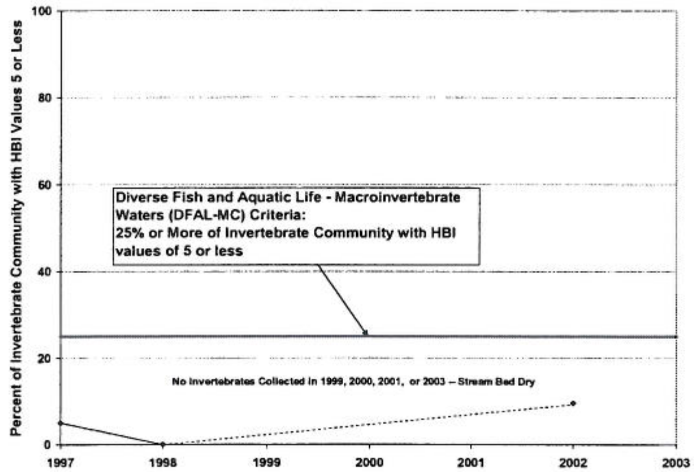
Purgatory Creek Station P-7
Percent HBI Values From 8 to 10



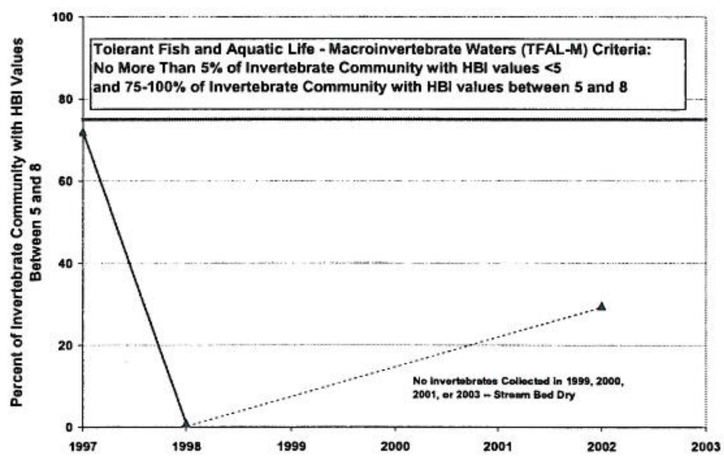
Appendix 3-I-14

Percent HBI Values by Category: Reach P-8

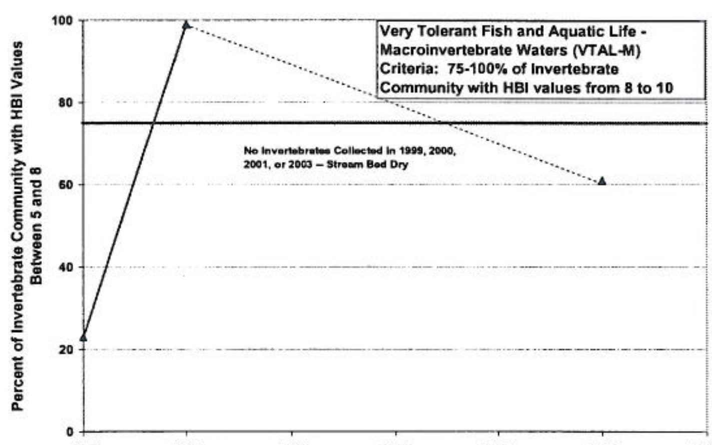
Purgatory Creek Station P-8
Percent HBI Values 5 or Less



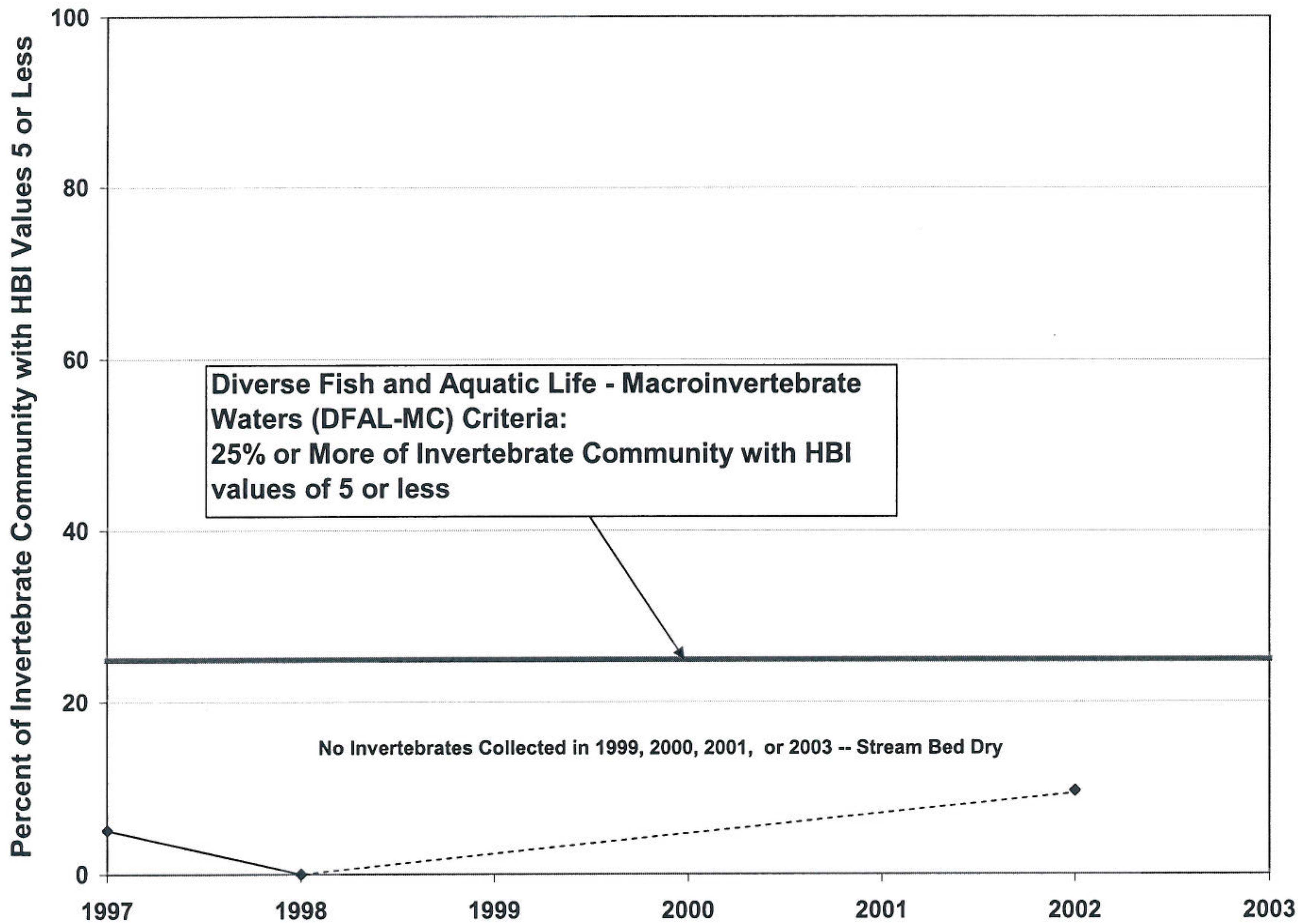
Purgatory Creek Station P-8
Percent HBI Values Between 5 and 8



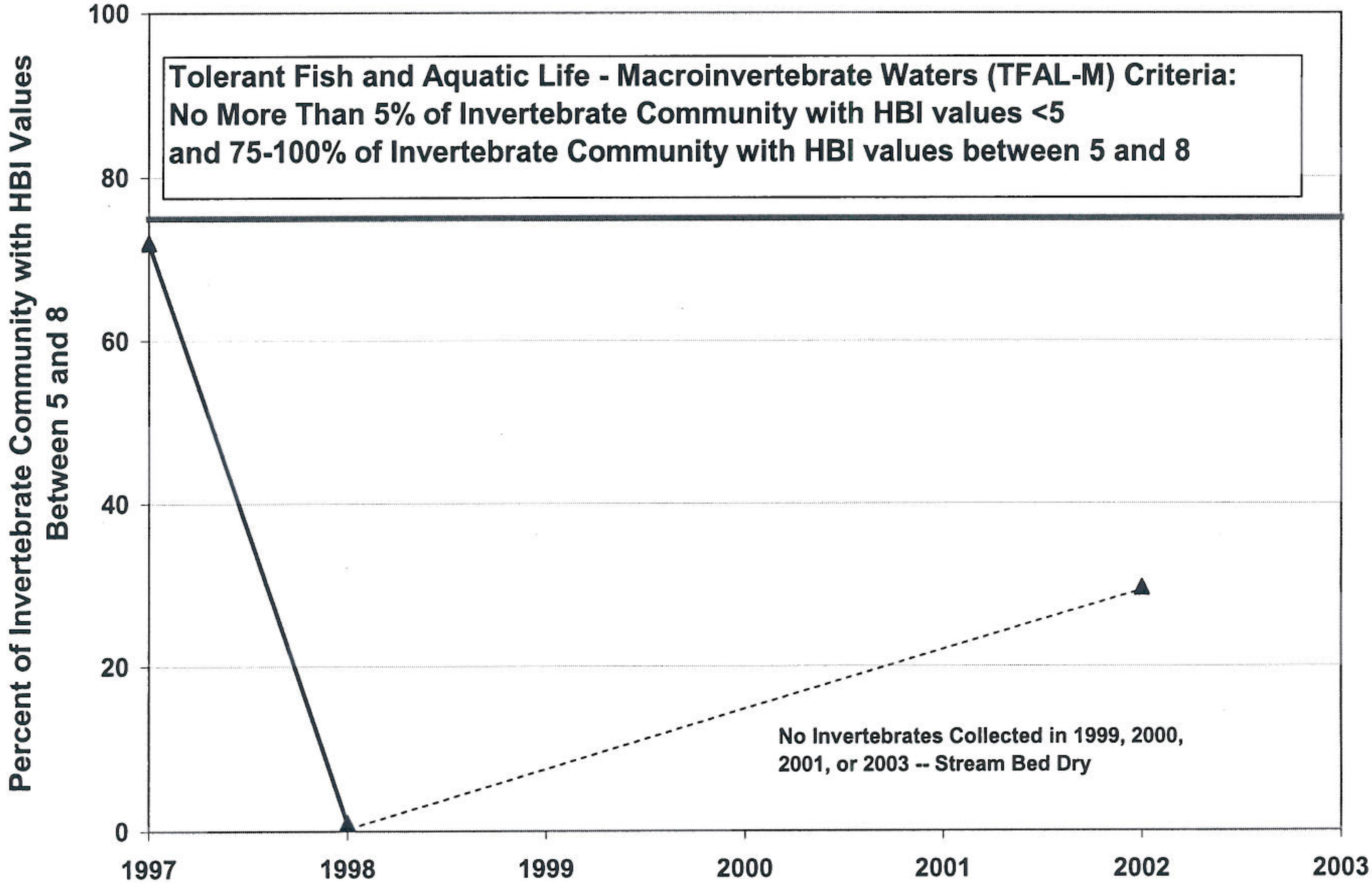
Purgatory Creek Station P-8
Percent HBI Values From 8 to 10

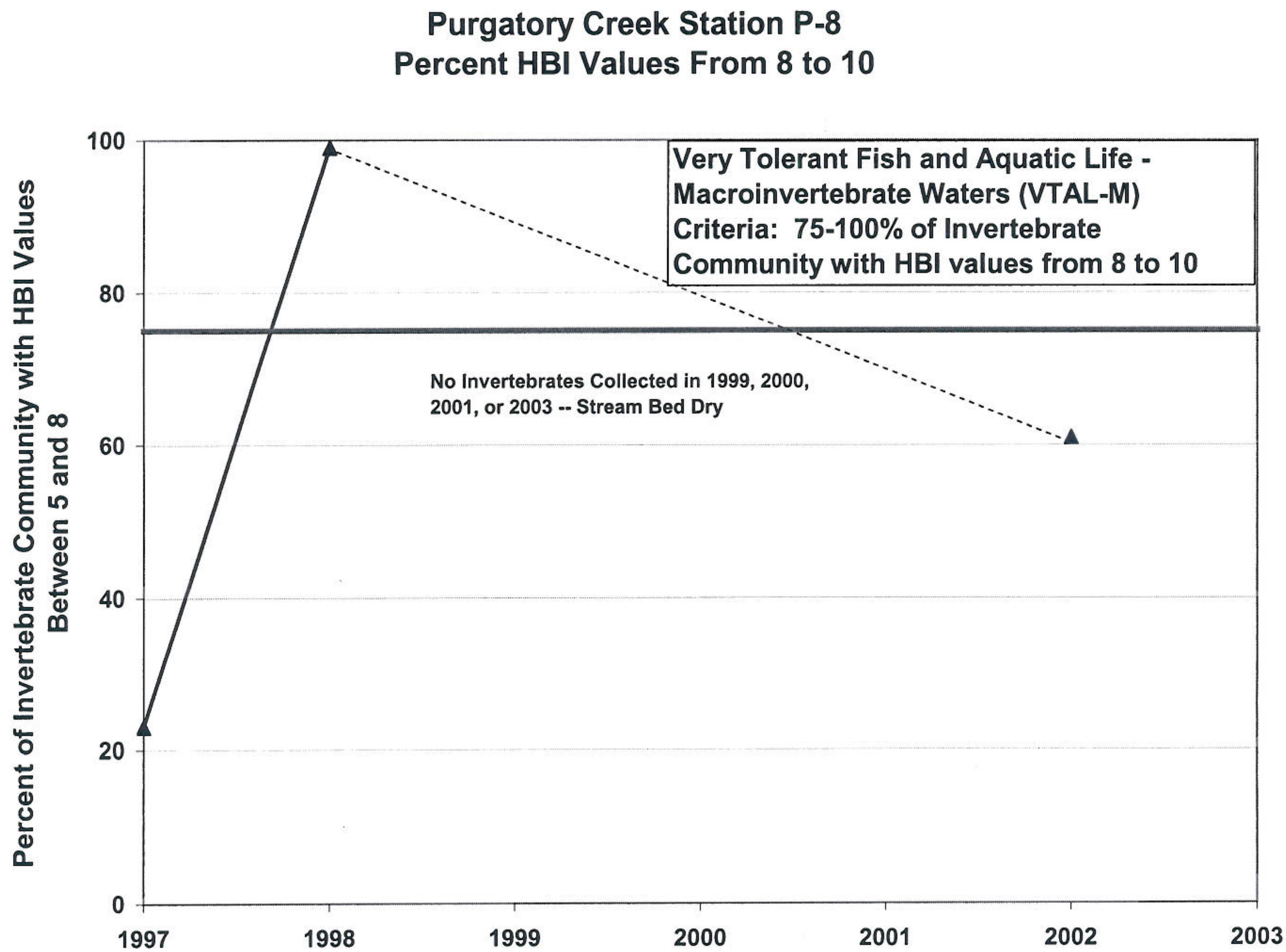


Purgatory Creek Station P-8
Percent HBI Values 5 or Less



Purgatory Creek Station P-8
Percent HBI Values Between 5 and 8





1/1/2005 5:05 PM
P:\23\27\053\STREAM\PURGATORY CREEK UAA\Ecological Use Classification\HBI from 8 to 10Station P-8