9.0 IMPLICATIONS OF WATERSHED CARRYING CAPACITY ANALYSES

Watershed professionals use a variety of resources and methods to assess the health and future condition of a watershed. Topographic, geologic, soils, and meteorological data provide the basis upon which all analyses are performed. Land use and land cover are the dependent variables that change over time, and ultimately affect watershed health.

Most watershed-based models were developed to measure the rate, volume and quality of stormwater runoff as it relates to flooding. These models include HEC-HMS, HEC-RAS, HSPF, SWAT, P8, and others. Other investigators, upon observing the correlation between impervious cover and degraded stream biota, have focused on diagnosing the health of a watershed based on the percentage of impervious cover. Biologists focus on the stream biota as an indicator of watershed health.

Each of these approaches has its own strengths and weaknesses. None of these approaches, in and of themselves, provide a comprehensive assessment of the overall health, vulnerability and restoration potential of a watershed.

In this study, a variety of techniques were used to obtain a deeper, more comprehensive assessment of the watershed with the ultimate goal of developing methods by which watershed health can be preserved, protected, or restored.

9.1 Watershed Characteristic Assessment

Base information indicates that there are two main surficial drainages in the Bonne Femme Watershed that drain from east to west. Gans Creek, Clear Creek and Little Bonne Femme drain the northern portion of the watershed. Turkey, Bass, Smith, Bonne Femme and Fox Hollow branches drain the southern portion of the watershed. This general drainage pattern is complicated by the recharge zones of Devil's Ice Box and Hunters Cave that cross surficial watershed boundaries, and flow through karst features such as sinkholes. Most of the time, all of the flow from the upper portion of Bonne Femme Creek flows underground through the Devil's Icebox Cave Branch into Little Bonne Femme Creek.

Low permeability prairie soils dominate in the upper reaches of the watershed to the east, which is primarily in agricultural land uses. More permeable woodland soils dominate the lower reaches of the watershed, which include wooded areas in steep, rugged areas, and agricultural uses along the floodplains.

Most development within the watershed has occurred at the north end of the watershed along the fringes of Columbia, and to the south along the edge of Ashland.

9.2 Stream Sensitivity Model

The Stream Sensitivity Model uses existing and projected impervious surfaces as modified by field criteria to measure the vulnerability of streams to degradation. This analysis is based on observations that watersheds with less than 10% impervious cover remain healthy; watersheds with 10-25% impervious cover are "impacted" and somewhat degraded; and

watersheds with more than 25% impervious cover are highly degraded and difficult to restore.

This model indicates that subwatersheds around Columbia and Ashland are currently "impacted." This trend is expected to continue during projected build out conditions with downstream subwatersheds degrading further. Subwatersheds contiguous to Columbia and Ashland are restorable with the implementation of new and remedial BMPs discussed in a subsequent section.

9.3 Stream Carrying Capacity Model

The Stream Carrying Capacity Model uses soil permeability, topography and land use to assess existing stormwater runoff and predict future stormwater runoff. In the model, future runoff is based on projected changes in permeability as a result of predicted land use changes. This model indicates that existing runoff in the upper reaches of the watershed has already resulted in the degradation of streams in lower reaches. This concurs with field observations. The model also indicates that stream channels are stable ("acceptable") in the Upper Bonne Femme, Turkey Creek, Turkey/Bass Confluence and Bass Creek subwatersheds. However, observations in the field indicated that these "acceptable" subwatersheds are relatively unstable in the upper reaches due primarily to poor land management practices and loess or sandy soils, and relatively stable in the lower reaches where the creek bed and bank consists of large rock and cobble. The instability in the upper reaches is a concern most notably for the karst recharge areas that comprise most of the Upper Bonne Femme and Bass Creek subwatersheds. If sediment or other material is actively being transported into these conduits, this could be detrimental to sensitive cave ecosystems.

9.4 Landscape Function Model

This model uses ecological communities as defined by National Land Cover Data (NLCD) as a surrogate for how well the landscape functions. This model indicates that landscape function is most degraded around Columbia and Ashland due to development pressure and within the upper reaches of the watershed where the native prairie has been converted to agricultural land uses where poor management practices are employed. Floodplains along the lower reaches of the watershed that have been converted from bottomland forest to agricultural land with poor management practices also are rated poorly. Highest quality landscape functions exist in the remnant woodlands along steep and rugged terrain.

9.5 Watershed Trends and Implications of the Models

1. In the upper reaches of the watershed, the conversion of native prairie to agricultural uses without appropriate BMPs in place has resulted in increased stormwater runoff and decreased soil stability. As a result, streams in the upper reaches are downcut and eroding. Increased flows in the upper reaches also have led to stream degradation in the lowest reaches of the watershed.
2. In the lower reaches of the watershed, the conversion of floodplain bottomland forest to agricultural uses without appropriate BMPs in place has also led to increased runoff and decreased soil stability. Most of the streams in the lower reaches are entrenched, shear, unstable and disconnected from the floodplain during

channel forming (one to two year storm events) storm events. These conditions become exacerbated as flows continue to increase with projected development.

3. Most of the groundwater recharge to Devils Ice Box and Hunters Cave occurs in the upper reaches of the watershed. Streams within the recharge zones occur on highly erosive loess and sandy soils, making the recharge zones highly vulnerable to erosion, streambank degradation, reduced water quality, and sedimentation impacts to sensitive cave systems.
4. Karst topography plays a major role in hydrology of the watershed. The two largest caves are mapped and their recharge areas are fairly well delineated. While the scientific community understands how karst topography affects hydrology, generally more education is needed for the lay public, especially since they have the greatest influence on how land is managed.
5. Channel instability issues appear to be migrating upstream, especially in the Northern Little Bonne Femme subwatershed. This is a common and expected phenomenon in downcutting streams as the stream seeks a flatter, more stable grade.
6. Subwatersheds most vulnerable to degradation based on the impervious cover and field indicators are clustered around Columbia and Ashland. Upper Bonne Femme and subwatersheds downstream from Upper Bonne Femme are the next most vulnerable group of subwatersheds. Most of the recharge for Devils Ice Box occurs in Upper Bonne Femme, a "moderately" vulnerable subwatershed. Most of the recharge for Hunters Cave occurs in the Bass Creek subwatershed, which is ranked as "vulnerable."
7. All subwatersheds are considered restorable, though the greatest restoration challenges will occur, in order of difficulty, in the North Branch Little Bonne Femme, Clear Creek and Bass Creek subwatersheds.
8. When assessed collectively, the three models indicate that there are regions within the watershed that should be prioritized for protection and remediation, namely the urbanizing regions around Columbia and Ashland, and the agricultural headwater region in the eastern portion of the watershed.