Buffalo Creek, Manitoba: An Ecosystem Management Perspective

by

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BUFFALO CREEK, MANITOBA:

AN ECOSYSTEM MANAGEMENT PERSPECTIVE

BY

CALVIN MCLEOD

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

Abstract

The purpose of this research was to determine if there is merit in managing a small component of a larger ecosystem without due consideration of the broader ecosystem. The Buffalo Plains Soil and Water Management Association are a group of landowners who have undertaken an initiative to rehabilitate a small section of an intermittent stream in south central Manitoba. This initiative provided for a case study of small scale local environmental enhancement.

Using an ecosystem approach may be an effective means of developing small scale local resource management initiatives. By applying the principles of an ecosystem approach to the BPS&WMA initiative a model for developing fragmented environmental enhancement initiatives was devised.

As shown through the case study the "Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems" can be used to develop and implement management plans for smaller components of larger watershed ecosystems. The model can also be used to identify, develop, and implement specific resource management projects outlined within any management plan. The Decision-Making Model consists of the following seven steps: Definition and Scope of Initiative; Establish Goals and Objectives; Background Information/Existing Conditions; Site Analysis and Impact Identification; Project Evaluation; Project Implementation;

and New Initiatives.

Managing smaller, or fragmented, components of larger ecosystems has merit in south central Manitoba. To effectively manage these sites, however, requires that an ecosystem approach to management be applied. The "Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems" can be used as a tool to guide organizations who wish to manage these small sections of larger systems on an ecosystem basis.

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I am grateful to the Prairie Farm Rehabilitation Administration and the Buffalo Plains Soil and Water Management Association for hiring the Natural Resources Institute study team to develop the Buffalo Creek Multiple Resource Use Management Plan.

I would like to extend my gratitude to each member of the study team for their contribution to my learning experience at the Natural Resources Institute: thanks to Sherry Danderfield for being the hardest working member of the study team; thanks to Pierre Johnstone for illustrating the difficulties of working in groups; and thanks to Dr. John Sinclair for assisting and developing each member of the study teams practicum from start to finish.

Finally, I would especially like to thank my parents for giving me the moral and financial support to achieve a university education. This practicum is dedicated to them.

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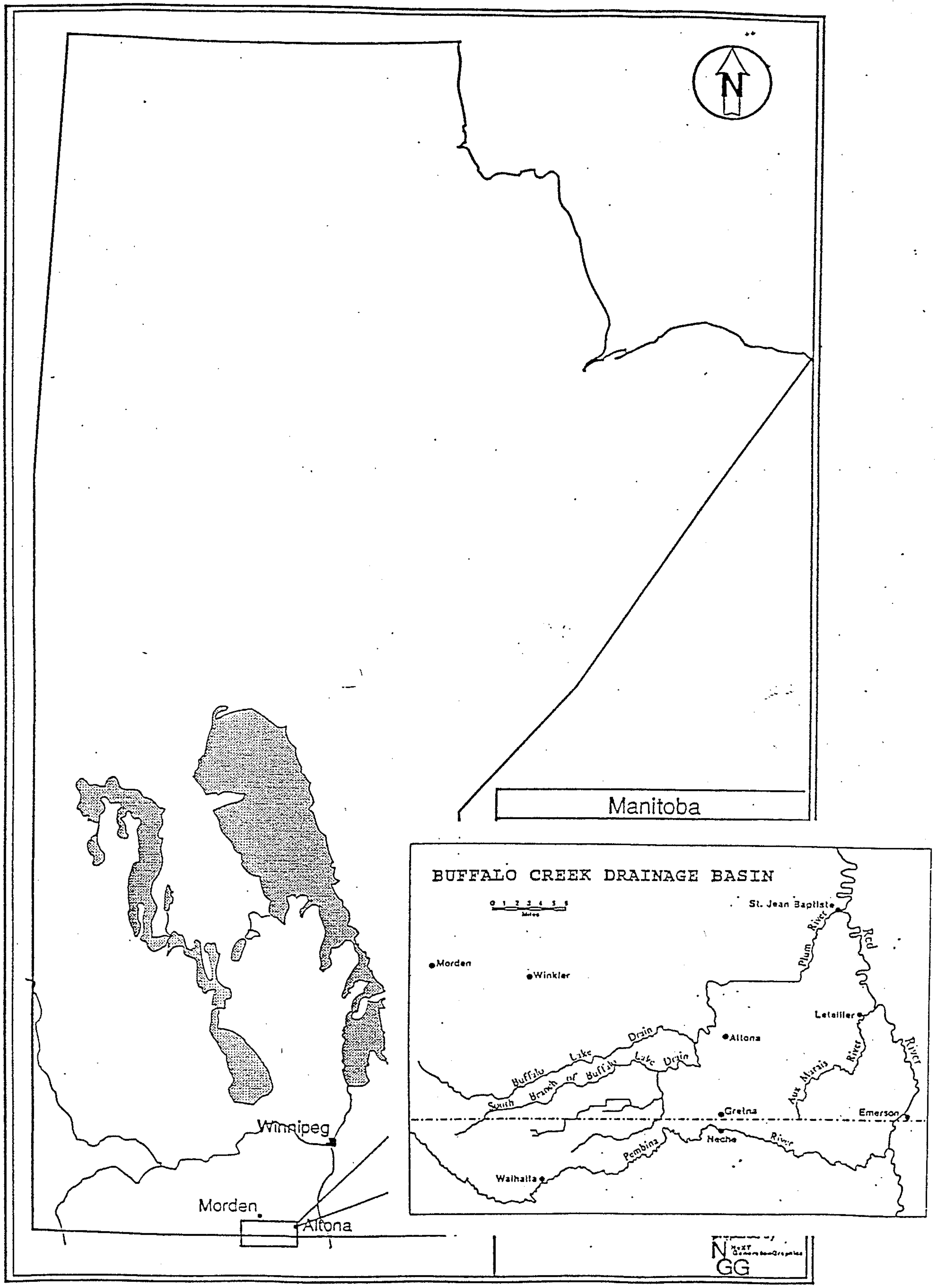
Chapter 1: Introduction

1.0 Background

The desire for local habitat enhancement and reclamation initiatives is increasing and government as well as non-profit agencies are responding to this demand. However, financial assistance for local resource management initiatives usually provides only enough money to study or manage a small section of what is a larger ecosystem. This fragmented approach to resource management initiatives appears to be becoming a trend as the public becomes more concerned with the health of its local environment. There are several questions relating to the merit of this approach to habitat reclamation and preservation. Small-scale, narrowly defined approaches to resource management fall short of the holistic approach that is necessary for management of integrated ecosystems. A watershed ecosystem has an overall effect on the components contained within it. For example, improving wildlife habitat in one section of a watershed may cause animals to migrate from the surrounding region. Given the fact that the larger ecosystem will influence any site specific rehabilitation, conservation, or habitat reclamation initiative, the utility of narrow approaches to the management of interconnected ecosystems becomes questionable.

Buffalo Creek is an intermittent stream located in south central Manitoba near the community of Altona (Figure 1.1). The Creek is part of a larger watershed which drains from the Pembina Escarpment eastward into the Plum River and eventually the Red River. Buffalo

Figure 1.1: Buffalo Creek Drainage Basin in Relation to Manitoba



Creek has two tributaries which feed into it, South Branch Buffalo Drain and North Branch Buffalo Drain. These two tributaries both have several smaller unnamed creeks and drains leading into them, some of which cross the international border.

The south central region of the province has low relief and is prone to flooding during peak run off periods, for example, spring thaw and wet periods of the year. Due to this fact many of the riparian areas have been channelized to promote rapid runoff of water. Channelization has been undertaken to make the region more suitable for agriculture.

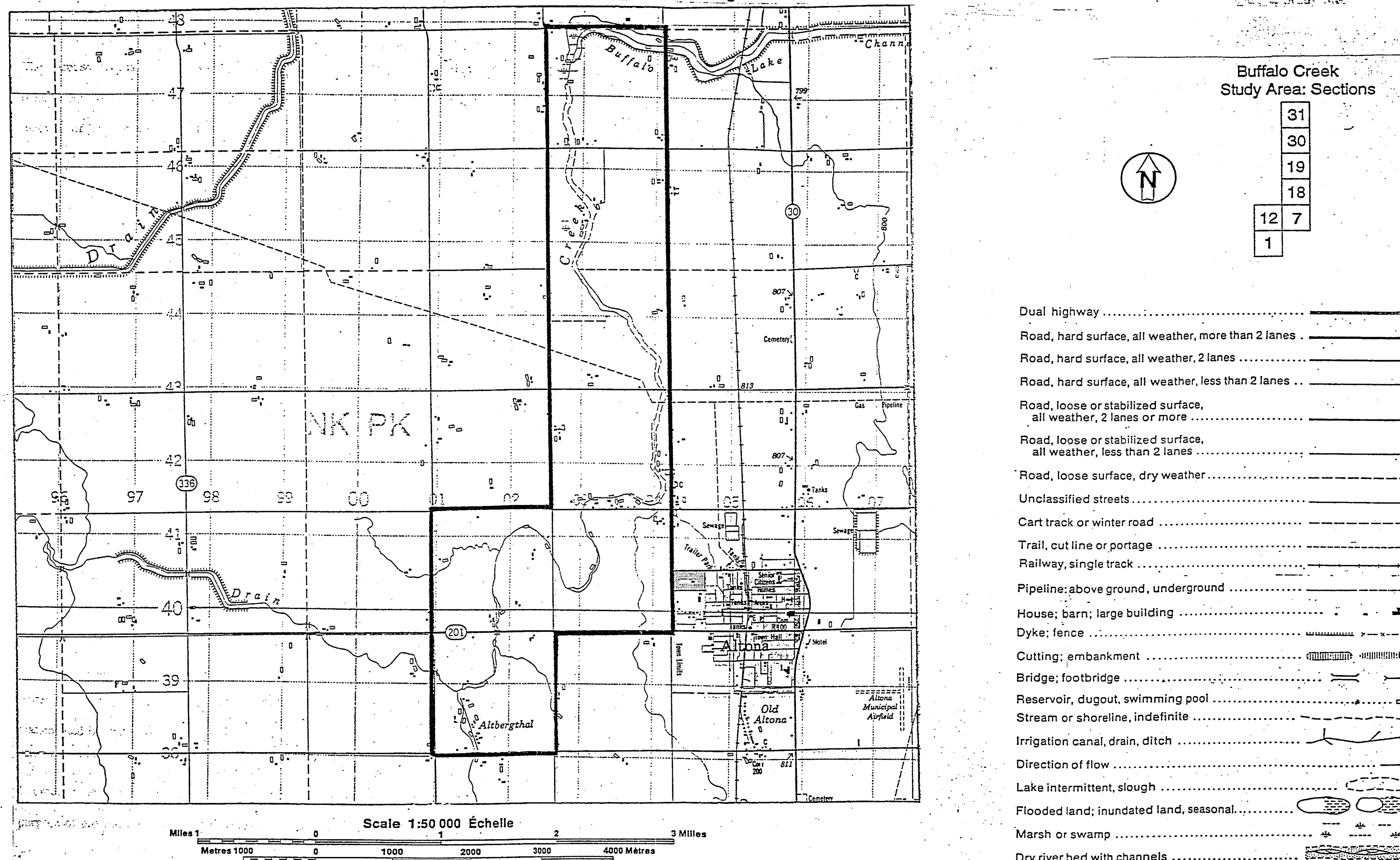
This area of the province is located within the ecological area designated as the grassland region and more specifically the tall grass prairie ecosystem. Dominant soils in the region are chernozemic black, originating from the soil building process associated with the tall grass prairie.

The region is presently used for intensive agriculture. Crops grown in south central Manitoba include potatoes, wheat, canola, soy-beans, sugarbeets, sunflowers, corn, and various specialty crops such as peas and strawberries. Livestock being raised in the region include cattle, hogs and chickens. It should be noted that this area of the province has little if any crown land and "natural" areas are limited to sites that cannot be accessed by farm machinery.

The Buffalo Plains Soil and Water Management Association (BPS&WMA), which has over 180 members in the Rural Municipalities of Rhineland, Montcalm and Stanley, has expressed an interest in reclaiming and enhancing a 16 kilometer stretch of Buffalo Creek near Altona. The study site contains six sections of land, all of which are privately owned (Figure 1.2). This initiative was undertaken because members who live near Buffalo Creek have noticed a decline in the water quality found at the creek. The decline in water quality was highlighted by the occurrence of a fish kill due to oxygen depletion in July of 1991. Residents along the creek have also noticed a decline in the diversity of organisms found at the creek, particularly birds. Members of the BPS&WMA believe that farm practices in the area are significantly impacting the creek.

In response to the current conditions at Buffalo Creek the BPS&WMA initiated a study of the 16 kilometer stretch of creek in an effort to improve and enhance the natural environment found there. In October 1991 three students from the Natural Resources Institute (NRI) began to devise a multiple resource use management plan for the BPS&WMA. The management plan was completed and submitted to the BPS&WMA on March 31, 1992. The plan provides a clear and concise direction for the rehabilitation of lands on either side of a 16 kilometer stretch of Buffalo Creek for fish, wildlife, water and recreation benefits.

Figure 1.2 Buffalo Creek Study Sections in Relation to Altona



In an effort to obtain fish, wildlife, water, and recreation benefits at the study site the BPS&WMA outlined five objectives which were to be addressed in the management plan, including; implement water management strategies, reduce erosion, filter agricultural pollutants, improve wildlife habitat, and provide a public green space.

While devising the management plan the study team looked specifically at characteristics and resource components contained within the study site, while only recognizing the broader ecosystem conceptually. This approach was taken due to limited funding for the initiative and the short time span, approximately 5 months, in which the study was to be completed. As a result the watershed ecosystem was not assessed as to its full impact and future impact on the study site. This lack of information concerning activities in the watershed could influence the implementation of the management plan for the BPS&WMA study site.

The BPS&WMA initiative for developing the Buffalo Creek management plan was funded by the Environmental Sustainability Initiative (ESI). The ESI was a one year joint agreement between the provinces and the federal government. The program was designed to showcase the types of activities which could be implemented under the federal Green Plan. In Manitoba the ESI program was administered by the Prairie Farm Rehabilitation Administration (PFRA) and Manitoba Agriculture (MbAg). The PFRA and MbAg believe that the BPS&WMA

initiative promotes sustainable agriculture practices.

As mentioned earlier the demand for local habitat enhancement and reclamation initiatives is increasing. Representatives of the PFRA have indicated that more initiatives like the Buffalo Creek Multiple Resource Use Management Plan may be undertaken in the future (Olson pers. comm. 1991). The PFRA would like to use the steps taken in the Buffalo Creek study as an example for other multiple resource use initiatives. There is concern therefore about the validity of small scale narrowly defined approaches to environmental enhancement.

1.1 Purpose

The purpose of this research is to determine if there is merit in developing and implementing a multiple resource use management plan for a small section of a larger watershed ecosystem without due consideration of the larger ecosystem. In doing this it was hoped that a procedure for developing and managing small scale or fragmented resource management initiatives would be devised.

1.2 Objectives

1. To identify resource management and policy issues in the Buffalo Creek watershed, which have the potential to influence water quality and quantity at the BPS&WMA study site.

2. To develop a decision-making model for identifying what should

be considered when taking a watershed ecosystem approach to fragmented environmental enhancement initiatives.

3. To apply this model to the BPS&WMA initiative in order to examine the resource management and policy implications of taking a watershed ecosystem approach to natural resources management in south central Manitoba.

4. To comment on the validity of managing a small section of a larger watershed ecosystem.

1.3 Scope and Limitations

This practicum will only identify factors located within the Buffalo Creek watershed or drainage basin that have the potential to influence water quality and quantity at the BPS&WMA site. Water quality and quantity was keyed on in the evaluation because in a watershed ecosystem, and at Buffalo Creek in particular, water is a variable that is of primary concern to residents and wildlife. For the system to remain healthy, water must be supplied at a certain quality and quantity.

Policy and legislative implications of basin or watershed management are not examined extensively. Various levels of government have been identified to illustrate the difficulty in managing integrated inter-jurisdictional resources. From this perspective the policy advantages of smaller scale multiple resource use management initiatives is discussed.

1.4 Organization

This practicum is organized into nine chapters which coincide with several phases of fieldwork and assessment. Following a review of relevant literature (Chapter two), Chapter three discusses the research procedure used to meet the objectives of the research. Chapter four, Study Site Characteristics, documents the watershed location, natural characteristics, and resource uses in the Buffalo Creek Watershed. This initiative was undertaken to give the reader background information before reading Chapter five, Existing Conditions Impacting Water Quality and Quantity at the study site. Chapter six, through an institutional review of the Buffalo Creek Watershed, emphasizes the role various resource management entities play in managing the Watershed's resources. Chapter seven examines several resource management agencies and their methods of planning smaller scale resource management projects. From this research review a "decision-making model" for planning and implementing small scale or fragmented environmental enhancement initiatives was devised. Chapter eight evaluates the management plan prepared by the NRI study team in light of identified concerns regarding watershed impacts and discusses the validity of fragmented environmental enhancement initiatives. Chapter nine provides a summary and recommendations.

Chapter 2: Literature Review

2.0 Overview

This practicum is closely related to the Buffalo Creek Study Site Management Plan: Report Three, April 1992 developed by Sherry Dangerfield, Pierre Johnstone, Calvin McLeod, and Dr. John Sinclair. Much of what follows pertaining to Buffalo Creek is taken from the Natural Resources Institute's study for the Buffalo Plains Soil and Water Management Association (BPS&WMA).

The literature review is broken into six sections; Ecosystems, Agriculture: Impact on the Prairie Environment, Prairie Preservation, Environmental Enhancement, Institutional Implications, and Conservation Districts. Each of these sections examines literature pertinent to the topic and relates it to the Buffalo Creek Study. This was done to give the reader a better understanding of the context in which the practicum research was undertaken.

2.1 Ecosystems

Definitions of Ecosystems

There are variations in the definition of the term, ecosystem, as evidenced by Odum's (1982), Vallentyne's (1988), Holling's (1986), and Christie's (1986) definitions. Odum (1982) states that an ecosystem is a functional term used to describe any selected unit of nature where all living and non-living components can be seen to exchange materials and energy. Spatial proximity and interaction are implied in this definition, with spatial boundaries drawn to encompass the particular set of components and interactions under study (Lee et. al. 1982 p. 505).

Vallentyne (1988) defines ecosystem to mean a subdivision of the biosphere with boundaries which are arbitrarily defined to some particular purpose or purposes at hand. For example, under The Great Lakes Water Quality Agreement (1978) the Great Lakes Basin Ecosystem was defined as: the interacting components of air, land, water, and living organisms, including man, within the drainage basin of the St. Lawrence River at or upstream from the point at which the River becomes the international boundary between Canada and the United States (Vallentyne 1988 p.58).

Holling (1986 p. 297) defines an ecosystem as "communities of organisms in which internal interactions between organisms determine behaviour more than do external biological events". External abiotic events do have a major impact on ecosystems but are mediated through strong biological interactions within the ecosystems.

Christie (1986) defines ecosystems as natural or artificial subdivisions of the biosphere with boundaries arbitrarily defined to suit particular purposes. These subdivisions are composed of interacting communities and non-living things in a specified area.

Odum (1983) states that ecosystems function by the interaction of three components which are; the community, the flow of energy, and the cycling of materials. Some of the component characteristics outlined by Odum (1971) are: energy circuits or flows which transfer solar energy into energy that can be used by organisms, a transfer of energy is accomplished by food chains and webs where stored energy is passed on from organism to organism, and food webs and chains which enable ecosystems to cycle nutrients contained within the system. The Buffalo Creek Watershed can be identified as an ecosystem but one that is greatly influenced from outside of its boundary.

Ecosystems have a natural rhythm of change whose timing is determined by the development of internal processes and structure in a response to past external variables. These rhythms alternate with periods of increasing organization and stasis with periods of re-organization and renewal (Holling 1986 p. 313). Successional seres move ecosystems through periods known in the past as immature, mature, climax, old growth and renewal. Changes are brought about by factors called disturbances or perturbations. The effect that a specific disturbance or perturbation has on an ecosystem is dependent on the stability and resilience of the ecosystem itself. Stability and resilience will be discussed later.

The Ecosystem Concept

From the various definitions of the term ecosystem used by researchers an approach to management of natural resources has been derived. The ecosystem concept provides a theoretical framework for the study and management of natural resources. Under this concept the ecosystem is seen as the basic functional unit of nature composed of organisms and their non-living environment. Once defined, the ecosystem can be seen as connected to the surrounding biosphere by a series of inputs and outputs. Energy and matter such as radiant energy, water, gases, chemicals or organic materials are moved through the ecosystem boundary by meteorological, geological, and or biological processes (Van Dyne 1969 p.50).

Since the ecosystem is seen as the basic functional unit it must be taken into consideration when managing the natural environment. When planning a park for example the entire ecosystem which the park is part of must be examined. Ideally a park would contain the complete ecosystem and the context in which that system operates otherwise it becomes an island of extinction.

A wilderness or natural park area should be large enough to maintain natural disturbance cycles. This is because much of the diversity of natural ecosystems depends on the regular occurrence of disturbance and variance among occurrences. The ecosystem concept requires that natural areas be large enough to perpetuate a full range of disturbances required to maintain the particular ecosystem. When establishing a preserve or natural area Agee and Johnson (1988) also recommend that adjacent ecosystems be considered in preserve design.

Ecosystem Approach

The ecosystem concept has promoted the approach to resource management known as the ecosystem approach. This approach involves looking at resource management issues on a holistic level. There are differing versions of the approach, but usually definitions share at least the following characteristics: a primary ecological focus, with emphasis on inter-connectedness, a perception of the ecosystem as somewhat self-regulating yet ultimately limited in recovery capability, and willingness to adopt both reductionist and holistic techniques in a flexible approach to problems (Lee et. al. 1982 p. 505).

For this practicum Vallentyne's (1988) definition of ecosystem approach will be used. Vallentyne (1988) defines the ecosystem approach as an integrated set of policies and managerial practices that relate people to the ecosystems of which they are part rather than to external resources or environments with which they interact. The identifying characteristics include synthesis (integrated knowledge), a holistic perspective interrelating systems at different levels of integration, and actions that are ecological, anticipatory and ethical in respect of other systems (Vallentyne 1988 p.58).

Under the ecosystem approach when creating a management plan for a small section of a larger ecosystem/drainage basin the entire ecosystem in which the community sits must be examined. For this practicum "watershed ecosystem approach" involved examining the biological and human characteristics of the Buffalo Creek Watershed and their interactions with the BPS&WMA study site. This holistic approach to management was used to specifically identify factors which could influence water quality and quantity at the study site.

A general problem of the Ecosystem Concept/Approach is that a community is a biological unit that is readily distinguishable from the ecosystem. Individual ecologists, however, may see a given landscape as one ecosystem or a set of related ones. The relation of the ecosystem to the community may also vary according to individual definitions making it difficult to define what an ecosystem actually is (Pomeroy and Alberts 1988 pp. 1,2).For example, Borman and Likens (1979 p. 7) see an ecosystem as a population of various communities where the concept of community is defined as a discrete, well defined and integrated unit.

The idea of defining a watershed or drainage basin as an ecosystem is well established in the ecological literature (Vallentyne 1988 p. 58). Water and climate regime to a large extent determine the type of living components that an ecosystem contains. Watersheds are integrated systems that transform precipitation, solar radiation, and other variables into a system that has internal characteristics (Christie 1986 p.4).

Hierarchy Theory of Ecosystems

In an effort to study and understand ecosystems some researchers have suggested that the natural environment can be broken into different levels. Hierarchy theory breaks the ecosystem down into parts and wholes, cells and contexts. Much like the human body the ecosystem can be broken down into cells, tissues, organs and the organism itself. Each cell performs a function that contributes to the healthiness or sickness of the organism as a whole. A sickness at the lower level of one cell does not affect the organism to any great extent. A sickness at the level of a organ composed of a group of cells and tissue however may cause the person to be unable to function.

Hierarchy theorists model nature as smaller fast changing subsystems embedded in larger normally slow changing systems. The smaller systems are constrained by the larger system of which they are part. Much like the cells are a part of a tissue elements of smaller systems affect the larger system only as contributors to trends among their cohorts (Norton 1990 p. 119). For example, the health of the world's forests plays a role in the health of the global biosphere. The forests would be the smaller system (i.e., tissue) and the biosphere would be the larger system (i.e., organ). Many people believe that a trend in the decline of the health of the world's forests will lead, or is leading, to a decline in the health of the earth's biosphere.

Another principle of hierarchy theory is the generation of higher levels of organization from lower levels. Systems organized hierarchically can be divided or decomposed into discrete functional components operating at different scales. Lower level units interact to generate higher level behaviours and higher level units control those lower units which aid in defining ecosystem characteristics (Urban, O'Neill and Shugart 1987 p.121). For example, at the lower level, fire in the prairie ecosystem is seen as a signal (perturbation) coming from outside the system. Every time there is a fire it changes the prairie by removing standing vegetation, controlling woody plant growth, and changing species composition. At the higher level, the prairie includes fire as a working part of the system. Fire at this level is not a signal that changes the prairie but one that is required to keep the prairie at a constant state of health, i.e. elemental cycling (Allen and Hoekstra 1984 p.72).

Components of a hierarchy system are organized into levels according to functional scale. Events at a given level have a characteristic natural frequency and typically, a corresponding spatial scale. In general low level events are small and fast, higher level behaviours are larger and slower (Urban, O'Neill, and Shugart 1987 p.121). For example, at the lower level, periodic fire helps control the growth of woody plants on the prairie. At the higher level fires are important for the soil building process associated with grassland ecosystems.

At Buffalo Creek the 16 kilometer rehabilitation site can be seen as one "cell" of many cells which make up the watershed of Buffalo Creek. The sickness or poor health of the environment at the study site is likely an indicator that the ecosystem at Buffalo Creek is being stressed. As previously noted the study team did not examine the other cells that make up the ecosystem found within the watershed. This raises the central research question this practicum discusses. What is the validity of rehabilitating or improving the health of one cell since the cells surrounding the study site will influence it?

Ecosystem Integrity

Ecosystem integrity is an important concept that resource managers need to understand. Integrity relates to the ability of an ecosystem to maintain ecological homeostasis. It specifically refers to the components required to allow an ecosystem to function with minimum extrinsic biophysical processes (Beechy 1989 p.5). It is important to consider this concept when planning to preserve special areas or managing a specified wildlife species. Areas that are not planned with environmental integrity as a rule will require human management to keep the ecosystem functioning in equilibrium.

When managing or preserving a natural area environmental integrity can be broken into two aspects. The first aspect of environmental integrity pertains to the inclusion of critical physical processes that are necessary for maintaining communities and species within an area. Dynamic systems must be considered where dramatic physical processes dictate the structure, composition and succession of constituent communities (Beechy 1989 p.5). In an intermittent stream such as Buffalo Creek flood and drought cycles could be considered dramatic physical processes which need to be considered in a management plan.

The second aspect of environmental integrity to consider when managing or creating natural areas pertains to the surrounding land use, i.e. agriculture. This activity can contribute sediments, chemicals and nutrients to special ecological areas impacting their health. A solution to this problem would be to position the reserve or natural area at a headwater site as compared to a receiving discharge or catchment area. This is contradictory to the location of the BPS&WMA study site as it is positioned in a low lying catchment area known to some as Buffalo Lake.

The integrity of the ecosystem surrounding Buffalo Creek has been reduced due to agriculture. Monoculture crops are grown and livestock are raised in close proximity to the creek. Agricultural land is dependent on human inputs to control or stabilize the ecosystem and natural processes such as prairie fires have been suppressed.

Ecosystem Stability and Resilience

A unique characteristic of ecosystems is their ability to absorb perturbations and or disturbances. The term stability and resilience are used in relation to an ecosystem's capacity to maintain ecological homeostasis. The meaning of ecosystem stability and resilience has changed over the years, and different researchers have used different definitions. Defining stability and resilience is largely determined on how a person conceptualizes the way natural systems behave.

Holling (1986) has defined three distinct viewpoints that have dominated perceptions of ecological causation, behaviour, and management. The first view is the "Equilibrium-Centered" view. Under this view nature is seen to be constant in time, spatial homogeneity, and linear causation. Nature is seen as self fixing so that recovery from disturbances is assured once the disturbance is removed (Holling 1986 p. 294).

The second viewpoint that Holling (1986) defines is one of nature having "Multiple Equilibrium" states. This viewpoint emphasizes the existence of more than one stable state through variability, spatial heterogeneity, and non-linear causation. It emphasizes the qualitative properties of important ecological processes that determine the existence of stable regions and of boundaries separating them. Continuous behaviour is expected over defined periods that end with sharp changes induced by internal dynamics or by exogenous events, the scale of events may be large or small (Holling 1986 p. 295).

The final viewpoint is that of "Organizational Change" where nature is seen as evolving. Under this view nature is composed of a variety of genetic, competitive, and behavioral processes which maintain the values of parameters that define the system. If this natural variability changes the values shift and key variables become more homogenous (Holling 1986 p. 295). For example, spraying pests with DDT allowed those who have a genetic resistance to the chemical to evolve.

Distinction between stability and resilience relies on definitions that recognize the existence of different stability structures, i.e. equilibrium centered, multiple equilibrium, and organizational change. Holling (1986) suggests that there are four points which must be considered when defining stability and resilience. First, there can be more than one stability region or domain, i.e. multiequalibrium structures are possible. Second, the behaviour is discontinuous when variables such as characteristics of an ecosystem move from one domain to another because they become attracted to different equilibrium conditions. The third point is that the precise kind of equilibrium, i.e. steady state or stable oscillation, is less important than the fact of equilibrium. The last point Holling (1986) makes is that parameters of the system that define the existence, shape and size of the stability domain depend on a balance of forces that may shift if variability patterns in space and time change (Holling 1986 p. 296).

From this perspective, Holling (1986) defines stability as the tendency of a system to attain or retain a equilibrium condition of steady state or stable oscillation. It is the achievement of equilibrium, low variability, and resistance to and absorbtion of change. Systems of high stability resist any departure from that condition and if perturbed, return rapidly to it with the least fluctuation (Holling 1986 pp. 296).

Resilience is defined as the ability of a system to maintain its structure and patterns of behaviour in the face of disturbance. The size of the domain, stability domain of residence, the strength of repulsive forces at the boundary, and the resistance of the domain to contraction are all distinct measures of resilience. Resilience emphasizes the boundary of stability domain and events far from equilibrium, high variability and adaption to change (Holling 1986 pp. 296, 297). Holling's definition of stability and resilience will be used for this practicum.

The equilibrium centered view of resilience strongly emphasizes linear interactions and steady state properties. Resilience is treated in the opposite way to above. Resilience is defined as how fast the variables return towards their equilibrium following a perturbation and is measured by the characteristic return times (Holling 1986 p. 247).

In the last century the major factor which has impacted the stability of the prairie ecosystem is agriculture. Odum (1971) recognizes four major distinctions between natural ecosystems and agro-ecosystems resulting from human management. These differences are:

- In addition to solar power, auxiliary energy from human and animal labour, fertilizers, pesticides, irrigation water, and fuel powered machinery are added as energy subsidies to agro-ecosystems.
- Biotic diversity in agro-ecosystems is reduced to maximize economic yields of desired products.
- Artificial selection rather than natural selection produces the dominant plants and animals; and
- Agro-ecosystems are under external goal oriented control rather than internal control mediated by "subsystem feedback" as in natural ecosystems.

These four differences create problems related to an ecosystems ability to sustain a diversity of organisms. Modern agriculture is based on deliberately keeping ecosystems in early stages of succession, where net primary productivity of one or a few plant species is high i.e. corn and wheat. A simplified community or ecosystem is more susceptible to stresses causing it to be less stable than a complex community or ecosystem. This can create problems such as the continual invasion of unwanted pest species like weeds, insects, animals, diseases and viruses (Miller 1988 91,92). To prevent a crop from being wiped out the ecosystem is artificially protected with pesticides, herbicides, and insecticides.

Human management in agro-ecosystems tends to disconnect interacting components and processes. For example, ploughing fields can create several problems. Ploughing is undertaken to aerate the soil, bury fragments of plant residue, and promote decomposition. But ploughing also reduces the abundance of earthworms which perform the same function in a natural ecosystem (Pomeroy and Alberts 1988 p. 151). The process of ploughing also requires that stored energy, i.e. gasoline, be used as opposed to the essentially "free" energy the earthworms would have used. The loss of the earthworms may mean the loss of species which feed on earthworms.

Grassland Ecosystems

The Buffalo Creek Watershed is located in the grassland or prairie biome. Grassland or prairie ecosystems have several characteristics which make them different from other ecosystems, i.e. forest. They are high speed systems where the rates of production, dying off of plants and intake of nutrient elements are higher than those of other ecosystem types (Breymeyer and Van Dyne 1980 p. 746, 747). The annual production of above ground mass in grassland ecosystems exceeds the production of below ground organs, and the rate of elemental cycling in grassland ecosystems is much higher than in forest and desert biomes (probably due to the frequency of fire). What this means is that the system is adapted for change. An example of this adaptability for change is that a large proportion of the prairie plant biomass is located underground which means it is less susceptible to drought conditions and/or frequent fires.

Many characteristics of the grassland biome have been altered by agricultural practices. For example, fire is an important component of the prairie ecosystem which in the past aided in preventing trees from encroaching onto the prairie. Fires likely occurred once a decade, perhaps several times a decade. This is inferred from the rate at which forest invades unburned tall grass prairie (Hulbert 1984 p. 138).

It is interesting to note that prairie preservation sites are generally not large enough to incorporate "natural" prairie fire events into their ecosystem. As a result prescribed burns must be used as a management tool for sustaining prairie on protected sites. At Buffalo Creek, fires have been suppressed due to the proximity of homes and farm structures.

As previously noted, the grassland or prairie biome has been simplified. In general the large mammals that once inhabited the grassland biome have been removed. The large herbivores, such as the bison can no longer free range across the prairie due to the expansion of agriculture and loss of habitat. Associated predator species such as the plains grizzly have also been removed from the grassland biome.

Removal of the large mammals has altered the original characteristics of the grassland biome. For example, large herbivores like the bison played a role in nutrient cycling. Herbivores in a natural, undisturbed grassland community, inhabit and feed on all vegetation levels from roots to the above ground parts. Herbivores recycle plant material in the form of faeces and fresh plant material which falls to the ground while grazing (Breymeyer and Van Dyne 1980 pp. 252, 254).

In short agricultural practices such as increasing monoculture cropping, increasing field mechanization, clearing of forests and hedgerows, drainage of wetland and use of pesticides and fertilizers create disturbances which are superimposed on natural disturbances such as windstorms, flooding, insect infestations and vegetative successions (Moss 1987 p.77). These activities have decreased the habitat of many organisms leading to extinctions and reduced populations of wildlife. It has been noted that the above mentioned practices and associated impacts on wildlife are represented at the BPS&WMA study site. Residents along the creek have noticed a decline in species population and diversity (Dangerfield et. al. 1991 p. 38).

Intermittent Prairie Streams

In the past riparian areas such as intermittent streams supported plant species that required more water than could be found on the open plain. Many of the perennial and intermittent streams supported trees and shrubs. At present in some regions intermittent and perennial streams, are the only areas available for indigenous wildlife species. Intensive agricultural practices in the great plains of North America have meant that these unfarmable regions have become wildlife refuges. Many of the intermittent streams in south central Manitoba have been modified by channelization, removal of riparian vegetation, grazing and construction of head water impoundments. Buffalo Creek and Drain are two prairie water courses that have experienced these modifications. However, as documented in the <u>Existing Conditions: Buffalo Creek Management Plan, December 1991</u> report, Buffalo Creek continues to support a wide variety of wildlife species in the study area.

Riparian zones like the BPS&WMA study site have unique characteristics which make them special and worth preserving or reclaiming. Zale et. al. (1989) suggest riparian areas are critical wildlife habitats for the following reasons:

- Provide a source of water
- Soil moisture is greater than surrounding areas, which usually increases plant biomass -increases structural diversity
- Edge effect between riparian and upland communities, i.e. maximizes wildlife diversity
- Provides a greater diversity in microhabitats, including wildlife breeding and feeding sites.
- Movement and migratory corridors

These factors illustrate some of the reasons why riparian areas are important for indigenous species of wildlife. In south central Manitoba riparian areas are an oasis within a desert of agriculture.

Modification of intermittent streams by channelization, removal of riparian vegetation, grazing, headwater impoundments, siltation, and domestic and industrial effluent are highly deleterious to those sensitive habitats. Information collected by the NRI on the existing conditions of the BPS&WMA study site would support this statement. Residents who live along the creek have noticed a decline in the health of the environment at the creek over the years, i.e. fish kill and reduced numbers of bird species (Dangerfield et. al. 1991 p. 38).

The physiochemical characteristics of intermittent streams are often less stable than those of perennial streams. This instability is due to larger perturbations in ecosystem stability such as seasonal and annual fluctuations in the amount of water flow. At Buffalo Creek there have been years when the flow of the creek was recorded as zero. There have also been years when flow in the creek was sustained over the year. The instability of the habitat available at Buffalo Creek can cause the physiological tolerance limits of organisms to be exceeded at times. An example of this phenomena would be the fish kill which occurred due to oxygen depletion in the creek (July 1991).

The flora of intermittent streams is largely unstudied. However, there is some information on the characteristics important to that ecosystem. Decomposition is slow in the ephemeral headwaters of prairie streams because of the frequent absence of water. Emergent aquatic and invasive terrestrial vegetation is common and abundant. Headwater areas retain detritus and export little organic matter. Decomposition in lower, intermittent reaches exceeds that in the head waters (Zale, et al 1989 p. vi). Conditions found at Buffalo Creek would support the latter statement as several sections of the creek within the study site have dense accumulations of organic matter.

Microalgae are probably the most important primary producers in intermittent streams and along with allochtonous detrital inputs, compose the trophic base of these systems. Macroinvertebrates dominate intermittent streams. Most biological processes of intermittent streams involve or are mediated by microinvertebrates. Insects, crustaceans, annelids, and molluscs are the dominant taxa.

Fish assemblages of intermittent streams are dominated by abundance of a few species which are tolerant to extreme physical conditions. Populations of sport fish are generally low, but some do inhabit temporarily for spawning during periods of high flow. At Buffalo Creek the fisheries resource is dependent on the availability of water. The Department of Natural Resources Fisheries Branch in Brandon, Manitoba has no knowledge of any studies relating to the fishery resource at Buffalo Creek. Officials at the fisheries branch did state that fish migrating from the Red River and Plum River may spawn in Buffalo Creek during the spring when water levels are higher. Spawning fish could become trapped as the spring flood waters receded (Bill Howard pers. comm. October 1991). Residents who live near the creek have identified several species of fish they have seen in the creek at one time or another (Dangerfield et. al. 1991 p. 38).

2.2 Agriculture: Impact on the Prairie Environment

Agricultural development on the prairie has resulted in a great loss of wildlife and habitat, increased soil erosion and sediment load, soil salinity, water and air pollution and general damage to terrestrial and aquatic ecosystems. In south central Manitoba from a water quality and quantity perspective, the main problems are the result of poor land stewardship practices that promote agricultural productivity at the expense of natural ecosystems. These practices include activities such as intensive cropping and livestock grazing, removal of native vegetation, chemical use and creation of artificial drainage networks.

The negative effects of intensive agricultural practices fall into one of three categories which are; loss of soil materials due to wind and water erosion and the oxidation of organic matter, chemical changes within the soil such as the development of salinity or acidity and contamination with heavy metals, and physical changes in the soil, i.e. soil compaction (Coote 1985 p. 229).

It should be noted that negative effects do not accompany all intensive agricultural land use. Farmland can be significantly improved by appropriate land management as well as good agronomic practices, i.e. selecting crops that do not expose or deplete the soil and using zero tillage techniques. Ideally, practices should be directed to the maintenance of a stable system that can persist indefinitely (Coote 1985 p. 229).

Loss of Soil Material

Loss of soil material due to wind and water is a problem that has been compounded by many practices associated with agriculture. There are several factors such as climate and soil texture which determine the susceptibility of a section of land to erosion. Poor land stewardship techniques such as intensive livestock grazing and cropping can enhance the erosion potential of an area.

It is important to understand what makes land susceptible to erosion to understand how agriculture accelerates this natural process. There are three types of water erosion which impact agricultural land. The first type is sheet erosion where runoff water moves as a thin layer over the land surface dislodging and carrying sediments away. The second type, rill erosion, occurs when runoff is concentrated into small visible channels that cut and erode sediment from the land. The last type of water associated erosion is gully erosion which causes large channels to be cut into crop and pasture land.

Coote (1985 p. 231) has identified several factors which determine the rate of soil erosion by water, they are; i) the soils susceptibility to disaggregdation by rain drops or running water, which is a function of particle size distribution, organic matter content, permeability, degree of aggradation and structural stability, ii) intensity of rainfall runoff, iii) degree and length of slope, which determines velocity and concentration of runoff, iv) the presence of frozen layers in the soil profile, and v) the vegetative cover or residue which protects the soil from raindrop impact and retards runoff and soil movement. These factors are influenced by agricultural practices. For example, stubble burning or excessive tillage techniques can reduce vegetative residue on crop land.

In the escarpment area of Manitoba, the western reaches of the Buffalo Creek Watershed, serious water erosion occurs during heavy rainfalls. The rolling sloping lands west of the Red River Valley in southern Manitoba are particularly susceptible as heavy rain storms in this region tend to be localized (Coote 1985 p. 232). The headwater region of the Buffalo Creek Watershed experiences severe erosion which is evident as watercourses have cut large gullies in the landscape.

Wind erosion like water erosion moves the most valuable constituents of the soil first. Once soil movement has been initiated particles bounce along the surface dislodging other particles, which can compound the problem. Coote (1985 p. 233) has identified the following as being the main factors that determine the rate and severity of wind erosion, they are; i) the resistance of soil particles to being moved along the ground by drag of the wind, which is determined by the size of the soil particles and their aggregates, and their moisture content, ii) the velocity of the wind, which depends partly on the shelter provided by wind breaks and crops, iii) the roughness of the soil surface, which determines the drag of the wind itself, and iv) the plant or crop residues on the soil surface which provides shelter from the wind. Once again these factors are influenced by land stewardship practices. For example, lack of hedgerows and shelterbelts can increase the erosion hazard of an area. Agriculture Canada 1981 relative wind erosion risk map categorizes south central Manitoba as suffering from a moderate wind erosion risk (Coote 1985 p. 234). However, some areas have a high erosion risk due to poor soil texture coupled with the planting of low residue crops.

Agricultural Pollutants

Agricultural pollutants can be defined as pollutants that are released into the environment due to various agricultural practices. This type of pollutant can be broken into several categories including sediments, nutrients, pesticides and biocides, and animal or livestock wastes. Sediment is the loose, solid material removed from topsoil by the processes of wind and water erosion. Pesticides and biocides are chemicals used to control unwanted pest species and are applied at various stages of plant growth. Nutrients or fertilizers include materials put on the fields such as fertilizers as well as animal wastes from crop, pasture, and feedlot sources.

Agricultural pollutants can enter riparian zones in several ways. Pollutants can become bound to eroded soil and then be deposited by wind and water erosion. Suspended sediments coming off of agricultural land can contain numerous chemical and biological agents that make water unfit for livestock, irrigation, aquatic organisms and recreational uses. Agents which become bound to soil particles include excess plant nutrients, animal wastes, municipal or household wastes, agricultural chemicals and other materials (McCool and Renard 1990 p. 178). Pollutants can also enter aquatic environments dissolved in solution with runoff water leaving fields.

Agricultural pollution can come from point or non-point sources. Point sources enter the environment from identifiable locations such as farm buildings or solid waste disposal sites. Non-point pollution enters the environment from diffuse sources which may be land based or airborne. Much of the non-point pollution enters a watershed during storm events (Dangerfield et al. 1993 p. 113).

Non-point sources are the major contributors of such materials as sediments, nutrients, pathogenic bacteria, pesticides, acid rain, and in some cases polychlorinated biphenyls. From all sources of non-point pollution sediment compromises the greatest amount by weight of materials transported (Chesters and Schierow 1985 p. 9).

It is interesting to note that the U.S. Clean Water Act and U.S. Soil and Water Resources Act identify agriculture as the single most significant contributor of non-point source pollutants to that nation's waters. In North Dakota more than 75 percent of the state's lakes are seriously affected by non-point source pollution (Duda and Johnson 1985 p. 108).

In general pesticides can be divided into two groups, organochlorides and organophosphates/carbamates. Organochlorides such as endosulfin, dieldrin, and DDT are very toxic to fish and birds and tend to bioaccumulate in the food chain. Organophosphates and carbamates are only moderately persistent in the environment. Most pesticides are broken down by microbial action near the soil surface on cropland.

Biocides include fungicides and herbicides. Fungicides in most cases are toxic to aquatic life, herbicides appear to cause fewer environmental problems. The toxicity of most chemicals applied to land is related to parameters such as inherent properties, quantities used, application method, conditions during application, and sensitivity of area (Dillion 1992 p. 5).

Fortunately modern pesticides tend to be fast acting and degrade rapidly into less toxic products. However, pesticides can constitute a potentially serious threat to surface water quality when application is followed by an intense storm. When this happens runoff can deposit pesticides in waterways resulting in fish kills (Chesters and Schierow 1985 p. 10,12).

Agricultural environments that are regularly exposed to pesticides include corn, soy beans, wheat, alfalfa, potatoes, apples, railroad rights of way and also less intensely managed communities such as pastures, hedgerows, woodlots and wetlands (Moss 1987 p. 80).

Nutrients and fertilizers are added to cropland to enhance plant growth. This may be required if the soil is losing or has lost organic matter and other nutrients. The most common contaminants from cropland and rangeland are the nutrients phosphorous and nitrogen (Chesters and Schierow 1985 p. 12). When washed off agricultural land due to storms phosphorous enters watercourses absorbed in the sediment load of the water, whereas nitrogen tends to remain in solution (Dillon 1992 p. 4,5).

An excess of nutrients and fertilizers can create several water quality problems. Watercourses and catchment areas can experience accelerated eutrophication as aquatic plants take up excess nutrients. This can lower the oxygen content in water bodies reducing fish habitat due to oxygen depletion. Stagnant or semi-stagnant water in shallow areas can also experience algal blooms during warmer periods of the year.

Aside from direct chemical application of phosphorous and nitrogen, livestock manure and human municipal sewage can be a source of fertilizers and other environmental contaminants such as bacteria and other pathogenic micro-organisms (Duda and Johnson p. 109, 110). Livestock waste can enter surface waters from feedlot runoff, pasture areas, and cropland which has had manure spread on it. Contamination can also be delivered in shock loading to streams adjacent to land downhill from barnyards and feedlots (Chesters and Schierow 1985 p .3). Rural landowners and communities may also contribute human sewage to surface waters by discharge in the form of treated effluent, septic field leaks, or improper disposal of raw sewage wastes.

Livestock grazing near watercourses also create several problems similar to those associated with intensive cropping. Livestock grazing can affect the water quality of run off in a watershed by increasing a stream's turbidity and sediment load. Grazing waterways directly affect the riparian environment by changing and reducing vegetation or by channel widening, channel aggradation, or by lowering the water table (Armour 1991 p. 7). More specifically, trampling associated with livestock causes physical bank damage in the form of caving and sloughing that contributes to erosion and sedimentation. Damage to banks reduces aquatic habitat by increasing water temperature, nutrient loading and associated algal blooms.

Artificial Drainage Networks

Constructing a system of artificial channels and drainage networks was one of the first land management strategies employed in southern Manitoba. Creating channels allowed a large area that was seasonal marshland to be brought into agricultural production. However, agricultural drainage networks create several problems concerning water quality and quantity.

Nutrients levels can be higher in watersheds that have artificial drainage when natural vegetation is removed to promote rapid runoff. Wet soil or swamp areas, forested land near streams, and buffer zones associated with natural stream courses tend to trap and assimilate agricultural pollutants (Duda and Johnson 1985 p. 110). Coote (1985 p.420) also suggests that natural vegetation be left in drainage areas like intermittent streams and floodplain swamps to promote the stability of the channel and maintain the potential for filtering sediment and sediment associated nutrients.

Concentrated artificial flow channels can efficiently collect run off and agricultural pollutants and transfer them to other water courses or catchment areas (Duda and Johnson 1985 p. 110). This can create pollution problems in natural ponds downstream impacting aquatic habitat. The BPS&WMA study site is a catchment area as it is one of the few places in the watershed which contain water all year.

Natural stream courses can also help control flooding and erosion. In a natural waterway flows in excess of channel capacity overflow onto floodplains where vegetation and other debris provide a substantial resistance to flow and act as filters for sediment (Debano and Schmidt 1989 p. 45). Channelized areas may or may not have vegetation to slow flows should channel capacity be exceeded. In the Buffalo Creek Watershed most channelized areas have no natural vegetation in the riparian or adjacent zone.

From a water quantity perspective artificial drainage networks can reduce sustainable annual flows. Water is channelled out of a watershed quickly and does not have time to enter the soil mantle. Natural watersheds in satisfactory conditions with native vegetation absorb storm energies, provide regulation of storm flows through the soil mantle, and as a result provide stability to the entire watershed. This in turn can provide more sustained flows necessary for supporting healthy riparian ecosystems (Debano and Schmidt 1989 p. 45). Lack of swamps and backwash area mean there is no available supply of water for flows during drier periods of the year. Channels cut deeply into agricultural land can lower water tables by drawing water from the soil layer at the higher altitude.

Fortunately, the main stems of the North Branch Buffalo Drain, South Branch Buffalo Drain and Buffalo Creek have not been extensively straightened or channellized. However, many of the channels and ditches leading into them have been channelized. It should be noted that, except for Hyde Park Coulee, the lower reaches of watercourses which drain the United States portion of the watershed have been extensively channelized.

Although many land stewardship activities have degraded the prairie environment many farmers are adopting soil and water conservation measures. Contemporary farmers are moving towards more intensive soil and water conservation strategies to maintain the resources of their livelihood. This movement can be attested by the many local soil and water management associations which are promoting government sponsored soil and water conservation programs. In Manitoba there are over 40 soil and/or water management associations. Within the area defined as the Buffalo Creek Watershed there are two local soil and water management associations the BPS&WMA and the Stanley Soil Management Association. The local associations promote farm practices such as mulching and residue management, reduced till and no tillage systems. These practices can result in higher quantities of crop residues remaining on harvested cropland, which in turn helps to reduce soil erosion. Some of these systems, however, require higher application rates of insecticide and herbicides (McCool and Renard 1990 p. 176).

2.3 Prairie Preservation

For the most part, agriculture on the great plains of North America has isolated, degraded, or totally removed the natural grassland ecosystem. Tall grass prairie has been particularly decimated in parts of the United States and Canada. In Illinois, for example, approximately 1 square mile of high quality black-soil prairie remains, this was once the predominant community in the so called prairie state (White 1988 p. 100). Of the 1.5 million acres of tall grass prairie that once flourished in the Manitoba Red River Valley only a fraction of 1 percent remains (Latta 1992 p. 14). It is with the realization that this unique ecosystem might be lost that preservation efforts have been undertaken by various wildlife groups. Efforts to preserve tall grass prairie in Manitoba have been undertaken in the last five years under the Tall Grass Prairie Conservation Project.

The remaining tall grass prairie in Manitoba can be found in areas that have been untouched by agriculture during the last century. These areas include pioneer cemeteries, railway rights of way, and the road allowances of some highways. Remnant prairies found at pioneer cemeteries and on railway rights of way have in many cases been isolated from cropland for 100's of years. These remaining tall grass areas have lost most associated animals, i.e. bison, butterflies, etc. but they have not lost the plants. For example, any given 1/100 acre plot in a remnant prairie cemetery is apt to have the same plant species diversity as any given 1/100 acre plot in a larger prairie (White 1988 p. 106). Similar studies of railway rights of way suggest that any given 1/10 acre patch of prairie isolated along a railroad is apt to have roughly the same native vascular plant species composition as any 1/10 acre patch selected in any 100 or 300 acre prairie (White 1984 pp. 172-173).

Remnant prairie sites should and are being preserved for several reasons. First it is necessary to save what is left of the prairie ecosystem or it will be lost forever. Second they are needed to help preserve the diversity of natural areas. Thirdly they are the habitat for rare species that are found only in grassland ecosystems, an example being the grey tiger salamander.

Selecting Sites For Preservation

White (1984) suggests that when selecting an area for prairie preservation (and or rehabilitation/restoration) site quality must be assessed. Sites which are of high quality and relatively undisturbed should take precedence over sites which are degraded even if the latter is larger. This is because there are relatively few high quality undisturbed remnant prairie sites. High quality sites are needed to maintain species diversity and to provide a source of seeds for future restoration projects. Seeds are uniquely adapted to local ecotypes.

It should be noted that stretches of poorer quality prairie need to be maintained for several reasons. First they are refuges for remaining prairie wildlife serving as migratory routes for terrestrial animals. Second, degraded prairies which surround high quality remnants provide a buffer zone between cropland and natural prairie (White 1984 p. 172-173).

In 1987 and 1988 the Tall Grass Prairie Conservation Project undertook a systematic inventory of this unique community in Manitoba. Potential sites examined included farmsteads, abandoned and existing railway lines, cemeteries, undeveloped road allowances, native pasture and hayland, and areas difficult to access with farm machinery, all within the historic range of the true tall grass prairie. Sites were ground truthed and ranked as to their quality according to several criteria ranging from prairie quality to the potential of a site being preserved. The majority of the prairie remnants found in the true prairie zone occurred along railway rights of way, which were broken for construction lines some 100 years ago. The best remnant prairies were found in areas adjacent to the true prairie zone on poorer soils which had never been broken for agriculture. Sites in these azonal areas were found along undeveloped road allowances and pasture on hayland.

The main objectives of the Manitoba Tall Grass Conservation Project were to identify and conserve as much tall grass prairie as possible. The peripheral areas were the areas recommended as holding the greatest potential for future work. Presently in Manitoba, prairie conservation efforts are geared to setting up a preserve in the azonal area for reasons such as having the best potential for the creation of a large prairie preserve (Joyce and Morgan 1989 pp.71-74). This does not lessen the need to secure sites in the true prairie zone for reasons afor mentioned.

White's (1984) and the Tall Grass Prairie Conservation Projects preservation selection criteria have implications for the management plan developed for Buffalo Creek. The study site falls within the historic location of tall grass prairie and tall grass species have been identified at the site (Dangerfield pers. comm. 1992). Buffalo Creek, however, is not a high quality site for tall grass prairie restoration/preservation for reasons such as soils in the Buffalo Creek area were broken for agricultural purposes over 100 years ago and farming in the region is intensive. The BPS&WMA site can be considered an important refuge area for remaining tall grass plant species and associated wildlife.

2.4 Environmental Enhancement

For this practicum, biological restoration, reclamation, and rehabilitation have been grouped under the heading Environmental Enhancement. This heading will be defined as activities which people undertake to improve natural systems they feel are damaged or can be improved.

Environmental enhancement can be broken into two basic divisions or classes. The first class are those initiatives which seek to repair a natural system back to its pre-damaged or pre-disruption state. The second type of initiative are those which seek to create or heal an area so it may support a viable community or ecosystem. The new community in the second circumstance may or may not be similar to the system that existed prior to disruption.

Restoration, reclamation, and rehabilitation are words that have different meanings when it comes to describing the type of project which is to be undertaken. Restoration means that the environment will be brought back to its former state or condition, i.e. a tall grass prairie ecosystem will be restored. Reclamation means that something that has been damaged will be made useful, i.e. a landfill site will be reclaimed to a forested area. Rehabilitation is the enhancement of something that has deteriorated or been damaged. Specifically, the goal of rehabilitation is to restore something to a prior good condition or higher value level. When talking about enhancing the environment the goal of all three should be to heal a system permitting the process of balanced change to begin again, i.e. create a viable ecosystem (Falk 1990 pp. 71,72).

Types of Environmental Enhancement

Environmental enhancement initiatives can be ecosystem oriented, community oriented, or species oriented. Cairns (1988) has broken restoration into three categories including: full restoration which is the restoration of an environment to its pre-damaged condition, partial restoration which is the restoration of selected ecological attributes of a site, and the last category, which is not restoration, is an alternate ecosystem (Cairns Winter 1988 pp. 65-67).

From these categories, Cairns (1988) has suggested a two-tiered approach to environmental restoration. The first approach is alternate systems which includes the categories partial restoration and alternate ecosystem. The end result of this approach may or may not resemble the original system. The main characteristic of this approach is the establishment of a relatively stable ecosystem to keep the need for human management to a minimum. Cairns feels that the goals and objectives for the alternate system approach should be designed to provide benefits that are readily appreciated by the public, i.e. wildlife viewing, walking trails etc. The system should also have the compatibility for further upgrading should new techniques for restoration become available.

Research is not the primary objective for alternate ecosystems, however, the development of an alternate system will require some research and may yield valuable information for the development of truly restored systems (Cairns winter 1988 p. 67). An example of an alternate system would be the reclamation of a hazardous waste site. The main goal here might be to immobilize toxic residue with a buffer strip.

The second type of environmental restoration Cairns has proposed is "true restoration" which is the restoration of natural communities and ecosystems. It is recommended that true restoration be undertaken only at specific experimental sites. The reason Cairns gives is "that if the result of restoration does not bear a close resemblance to the model community, public confidence in the ability of ecologists to restore damaged ecosystems is likely to deteriorate." True restoration initiatives require a coordinated interdisciplinary research effort involving scientists, engineers, economists, lawyers, and regulators among others (Cairns Winter 1988 p.67).

An alternate method of enhancing or restoring the environment is to design a rehabilitation or reclamation plan for a desired species. Initiatives aimed at a particular habitat for a particular species are not unlike general habitat enhancement initiatives except that baseline studies require direct analysis of the target species in addition to habitat studies.

Baird (1989) suggests that the success of any habitat reclamation/enhancement program for a desired species is directly related to the goals and objectives set out by the initiating or funding party. Goals are needed when one is concerned with restoration for a particular species or when the goal is to create a self sustaining ecosystem (Baird 1989 pp. 60-64).

The goal of species habitat enhancement should be to encompass both long and short term objectives. The short term objective would be to provide habitat for the desired species. The long term objective would be to create a framework with in which natural selective forces could operate to create a self sustaining, functioning natural habitat that provides in the long term for the desired species (Baird 1989 p. 61). In essence an area which is capable of long term generation and recovery following disturbances, i.e. an ecosystem.

Another method of environmental enhancement or rehabilitation/reclamation is to target the key species of wildlife for the biome or ecosystem of concern, i.e. coniferous forest, short grass prairie etc.. By improving habitat for key species other components of the wildlife community will benefit even though reclamation will not be aimed specifically at all of the wildlife species that may potentially occupy a site. Due to the pivotal role of key species in structuring and implementing a reclamation plan for wildlife, key species must be selected on a site specific basis. As a general guideline key species should be of socio-economic and ecological importance and should represent the habitat requirements of several other species of wildlife. Key species can also be used to monitor the progress of the reclamation program in creating wildlife habitat (Green, Salter and Fooks 1989 pp. 8-12).

When using the key species approach to rehabilitation/reclamation there are several variables which must be taken into consideration. These considerations are; the uses the land can tolerate, the possibilities for improvement, the care the land will require, and the surrounding land use (Holdgate and Woodman 1976 p. 393). For example, surrounding land use must be considered because when choosing a key species the species must be compatible with the desires of people living around the site. If the area slated for enhancement was located within an agricultural region, the key species should be ones that have minimal effect on farm practices.

Full restoration of Buffalo Creek to a pristine tall grass prairie ecosystem is not an option for environmental enhancement for several reasons. First, it may never be known what type of ecosystem existed at Buffalo Creek prior to channelization and dredging in that area of the province. Second, there may not be an adequate source of seeds to replant tall grass prairie at the creek since seeds are uniquely adapted to local ecotypes. Lastly, it may not be possible to convince current landowners to sell their land or discontinue their current land management practices.

Since the restoration of the pre-agricultural community was not an option for Buffalo Creek the Buffalo Creek Study Site Management Plan: Report Three, April 1992 offers a guide for the creation of an alternate ecosystem or community. The Buffalo Creek Management Plan offers suggestions as to how the environment at the study site can be improved. Options range from building waterfowl nest boxes to establishing better fish habitat with pools and riffles because as Libby and Millar (1989) suggest "if a truly native ecosystem can not be restored then restoration of something biological viable and sustainable is far preferable to complete loss of the system".

The method of establishing habitat for a desired species was not used for the BPS&WMA initiative because members of the community at the public meetings did not identify any specific species they would like to see more of. They only indicated that they would like to see less pest species such as grasshoppers and blackbirds.

2.5 Institutional Implications

Buffalo Creek Watershed is a resource that is transboundary in nature, creating several problems for agencies and groups that wish to manage a portion of that resource. The watershed's tributaries cross an international border as well as the border of several Municipalities. The resources of the creek are used by many individuals and groups who have a wide range of interests. The agencies responsible for managing the resources of the creek are disjunct and do not operate as a single cohesive unit.

Interest Groups and Management Agencies: Buffalo Creek Watershed

The resources of Buffalo Creek are not regulated by any one group or agency. It is used by many individuals and groups who look to several different agencies and levels of government to manage the resources in the watershed. Individuals who use the creek consist of landowners who live directly beside the creek and those who live near the creek. Individuals use the creek for several purposes, ranging from a source of water for irrigation to wildlife viewing.

There are special interest groups who use and wish to manage different sections of Buffalo Creek. The BPS&WMA would like to rehabilitate and manage a 16 kilometer section of the creek near the community of Altona, Manitoba. There is also one hunting and fishing organization and a irrigation association that has expressed an interest in the rehabilitation or management of Buffalo Creek.

There are various non-governmental organizations interested in wildlife who may, in the future, be interested in the management of Buffalo Creek. A wildlife organization could have an interest in a habitat restoration/reclamation project at Buffalo Creek. Prior to investing time and money into a project the organization would want to make sure that activities in the drainage basin do not negatively impact their potential site.

Several government agencies are responsible for the management of the resources at Buffalo Creek. The Manitoba Department of Natural Resources (MbDNR) and the Manitoba Department of the Environment (MbDOE) are two agencies which have administrative jurisdiction over various resources associated with the watershed. Some of these agencies have several branches which deal with specific resources associated with the creek. For example, the MbDNR Water Resources Branch is in charge of maintaining channels associated with Buffalo Creek.

Various federal agencies have an interest in the management of the resources found at Buffalo Creek. The PFRA is one federal agency which seeks solutions to the contemporary problems that farmers face. Problems such as shortages of water and soil erosion would be examples. The PFRA is interested in sustainable agriculture practices and expressed concern when the BPS&WMA speculated that farming practices were impacting Buffalo Creek.

A watershed or ecosystem approach to the management of the resources found at Buffalo Creek would likely require federal government intervention. The headwaters of the creek have several inlets which originate in the United States.

Due to the fact the creek crosses two Rural Municipalities a drainage basin approach to management would require coordination between the two municipal governments. Problems could arise over the distribution of funds when maintaining resources at the creek. For example, one Municipality might feel that erosion control in its jurisdiction is more important than erosion control in the other Municipality and the other Municipality may not agree.

This section has identified some of the various entities that have an interest in the management of Buffalo Creek. This topic will be examined in greater detail in Chapter six. At first glance it becomes apparent that the various interest groups make it difficult for the many regulating bodies to function.

2.6 Conservation Districts

In Manitoba, Conservation Districts are organizations of local people cooperating to manage natural resources and seek solutions to resource management problems unique to their area. These organizations manage resources for multiple resource uses. Programs that a Conservation District may become involved in include water management and conservation, conservation research, wildlife projects and recreational development. Operating costs are financed by provincial grants, Municipal taxes and non-governmental organizations. The Conservation District Authority is an agency established within the Manitoba Department of Natural Resources to assist in coordinating services to the Conservation Districts. Establishing a Conservation District was a recommendation made by the NRI study team for Buffalo Creek Watershed. A Conservation District could help alleviate some of the existing institutional problems. A district board would allow for the coordinated management of the resources within the watershed.

Historical Perspective

An early attempt to take a more integrated approach towards the management of water and related resources was undertaken in the late 1950s by the province of Manitoba. Up until this period water management centered mainly on removing excess surface water. However, problems of soil erosion and floods indicated that a more holistic approach to water and related management was required. In an attempt to integrate water management issues the Watershed Conservation Districts Act was created. The Act provided Municipalities with the opportunity to implement their water management strategies through a district board. Conservation Districts were to be created within areas defined as a watershed. The district board was set up to have complete jurisdiction over all drains in the district eliminating the provincial-municipal and inter-municipal split in jurisdiction (Ogrodnik 1984 p.13).

In 1970 the Watershed Conservation Act was replaced by the Resource Conservation Districts Act. The second Act differed by having an emphasis on multiple use resource management as opposed to water management. Land management activities such as grassing waterways to prevent erosion were to be undertaken. Boundaries of the Resource Conservation Districts were to be municipal boundaries and not the watershed area (Ogrodnik 1984 pp. 13, 14). Even though the two acts seemed like good ideas response to them was poor. The first Conservation District, Whitemud River, was not created until 1972. The Alexander Resource Conservation District was created in 1973 but was disbanded shortly thereafter.

Ogrodnik (1984) offers several reasons why he believes Municipalities were reluctant to form Watershed Conservation Districts. Municipalities may be unwilling or unable to reach agreements on issues among themselves. They may also fear a shift in financial responsibility from the provincial governments back to the Municipalities, even though the province grants a substantial amount of money to the Conservation District to pay for its operations. Lastly, Ogrodnik feels that many Municipal councils may have been wary of the powers the Conservation District Boards would be granted, i.e. expropriation of a land owner to meet the desired end of a project.

In 1976 the Watershed Conservation Act and the Resource Conservation District Act were consolidated into the Conservation Districts Act. This Act combines and represents the resource management objectives of the Watershed Conservation Districts Act introduced in 1959 and the Resource Conservation District Act of 1972. Unlike the two previous Acts the Conservation Districts Act addresses all aspects of soil, water, and related resource problems as they exist in areas defined by the natural boundaries of a watershed or by man made borders such as Municipal boundaries.

The purposes of the Conservation Districts Act are: i) to provide for the conservation control and prudent use of resources through the establishment of conservation districts; and ii) to protect the correlative rights of owners. The purpose of part ii) of the Act is likely an attempt to allay fears that the board would have too much power to dictate to individual landowners (Ogrodnik 1984 p. 14).

In 1978 the Conservation Districts Authority (CDA) was established to aid in operating and managing the Provinces Conservation Districts. The CDA is an independent agency within the Manitoba Department of Natural Resources. The CDA acts as a liaison between the Conservation Districts and government agencies as well as non-governmental organizations. The CDA aids Conservation Districts by providing planning and support for activities such as resource planning, financial management and administration, support for external agency partnerships, distributing information to the public, and assisting in the creation of new Conservation Districts.

At present there are 6 Conservation Districts operating in the province of Manitoba. The six are; the Whitemud Watershed Conservation District, Turtle River Watershed Conservation District, Alonsa Conservation District, Turtle Mountain Conservation District, the Cooks Creek Conservation District, and the Pembina Valley Conservation District.

2.7 Summary

The term ecosystem is a functional term used to describe any selected unit of nature where all living and non-living components can be seen to exchange materials and energy. Vallentyne (1988) also includes human activities in the definition of ecosystem.

Many researchers have suggested that ecosystems cannot be mapped because ecological systems compromise many populations of different species of organisms and the abiotic parts of the environment which they interact with. These systems have no boundaries in space or time and are not discrete identifiable units like organisms (Moss 1988 p. 38). For as Christie (1986) suggests "everything from atoms to galaxies is literally connected" and this sharing and interconnectedness are the reasons why the boundaries of ecosystems overlap (Christie 1986 p.9). This is also why the idea of managing a 16 kilometer stretch of a larger watershed without due consideration of the larger system becomes suspect.

The management concept of ecosystem integrity is another reason that narrow approaches to natural resource management are suspect. Ecosystem integrity relates to the ability of an ecosystem to maintain ecological homeostasis. More specifically it refers to the components required to allow an ecosystem to function with minimum extrinsic biophysical processes, i.e. human input and management. For example, parks planning needs to consider critical physical processes and surrounding land use. The ecosystem concept as a method of examining the environment has given rise to a management tool known as the ecosystem approach. Which can help to plan resource management projects with ecosystem integrity.

Published information would suggest that agriculture has significantly altered the prairie biome. Many characteristics such as fire events and nutrient cycling by large mammals have been removed. Poor land stewardship practices such as creation of artificial drainage networks and other intensive land management practices have enhanced natural processes like wind and water erosion. External energy regimes and chemical inputs have also replaced natural processes which accomplished similar tasks in the past.

Literature on prairie preservation and environmental enhancement would suggest that ecosystem planning is important to these activities. Manitoba's Tall Grass Prairie Conservation project has chosen a larger area in the azonal tall grass prairie zone because sites located there are more complete and healthy ecosystems than those found in the true tall grass prairie zone. All methods of environmental enhancement stressed the importance of striving for a self sustaining natural community (ecosystem) when planning projects.

It was noted that taking an ecosystem or watershed ecosystem approach to management can create institutional problems because these entities are usually interjuristictional resources. In the case of the Buffalo Creek Watershed it has been documented that there are several interest groups and management agencies who manage parts of the watershed. It was also noted that one of the main institutional problems that becomes apparent is a lack of an agency to coordinate activities among interest and management groups.

The fact that resources like the Buffalo Creek Watershed are interjuristictional was recognized by the government of Manitoba in the 1950s. In an attempt to take a more integrated approach to resource management and avoid interjuristictional red tape the Conservation Districts Act was created. The Act makes provisions for the creation of a Conservation Districts Board that allows for the coordinated management of resources within the area defined as the Conservation District. Establishment of Conservation Districts or integrated resource management in Manitoba, however, has been limited to only six districts for various reasons. Ogrodnik (1984) has indicated that not all Rural Municipalities wish to form Conservation Districts or wish to co-manage transboundary resources such as watersheds. This has necessitated the need for a method of managing fragmented components of larger systems.

Chapter 3: Methodology

3.0 Overview

The research procedure used for this practicum included literature reviews, structured informal surveys, policy, legislation and jurisdictional review, and interviews with experts. These methods of data collection were used to gather information during several phases of fieldwork and assessment.

Phase one consisted of establishing the existing conditions found in the Buffalo Creek Watershed and factors that are impacting, or have the potential to impact, on water quality and quantity at the BPS&WMA site. Phase two involved examining the institutional framework associated with resource use and management in south central Manitoba. The third phase of research involved contacting resource management organizations and discussing their methods of planning small scale resource management projects. From this discussion a decision-making model for planning and implementing fragmented environmental enhancement initiatives was devised. The last phase of practicum research involved commenting on the validity of managing a small section of a larger watershed ecosystem.

3.1 Research Procedure

The first phase of practicum research focused on a literature review and the identification of factors which could influence the BPS&WMA study site. More specifically the literature review involved using Ecological Hierarchy Theory to study the Buffalo Creek Watershed Ecosystem. Factors which could influence water quality and quantity at the study site mentioned in the three reports prepared for the BPS&WMA were examined in greater detail. An informal survey was used to identify further impacts as noted by various members of the public who live in the watershed. Conservation groups, government agency representatives, and local soil and water associations participated in the informal survey. A resource inventory was carried out in February 1993 to confirm the findings found during the literature review and informal surveys.

The resource inventory involved driving along the various watercourses associated with the Buffalo Creek Watershed (February 1993). This task was accomplished very easily as roads in the south central region of the province exist in a network of perimeters surrounding one square mile sections of land. Driving these roads allowed a visual survey of over 100 landowners in the Watershed. The visual survey involved looking for evidence of soil erosion and livestock pasture areas near watercourses. The survey also allowed verification of the extent of domestic water use in the watershed.

The factors identified as affecting water quality and quantity assisted in the development of a decision-making model. Developing the model required consulting the literature on decision making-models and canvassing the opinions of various organizations on how to plan and implement small scale resource management projects.

Wildlife habitat organizations, The Association of Ontario Conservation Authorities, Soil and Water Conservation Groups, and Manitoba's Conservation Districts have initiated and sponsored many environmental enhancement projects. Examination of their methods of developing and implementing projects which are fragmented or small scale revealed useful insights for the development of the decision-making model. Informal interviews were the main method of data collection used during this phase. The main premise of this phase of research was to outline the steps that would be required to take an ecosystems approach to managing a small section of a larger ecosystem or watershed.

Prior to creating the model the institutional implications (policy and jurisdictional) of taking an ecosystem approach when developing initiatives like the Buffalo Creek Management Plan are discussed. This involved identifying the various levels of government who have jurisdiction over matters associated with the creek's resources, i.e. federal (International Boarder), provincial/state (Manitoba and North Dakota), and municipal/civic (Rural Municipalities of Rhineland and Stanley). An attempt was made to identify the institutional arrangements which present the greatest stumbling block to managing resources on an ecosystem or watershed basis.

The research procedure for this phase consisted of a literature review, interviews with people knowledgeable in current institutional arrangements, and the use of an informal survey.

Interviews and or surveys were administered to landowners, conservation groups, Conservation Districts, various government representatives and wildlife organizations.

The last phase of research for this practicum involved commenting on the validity of managing a small section of a larger watershed ecosystem without due consideration of the larger ecosystem. This was accomplished by reviewing all information collected and discussions with experts in the field of environmental enhancement as well as a follow up on the Management Plan the NRI submitted to the BPS&WMA and the PFRA.

Chapter 4: Study Site Characteristics

4.0 Overview

Establishing the study site characteristics was undertaken to aid in identifying factors in the Buffalo Creek Watershed which have the potential to influence water quality and quantity at the BPS&WMA site. This involved documenting the watershed location, natural characteristics and resource uses within the watershed unit.

4.1 Background Resource Information on Buffalo Creek Watershed

Hierarchial Site Context

From an ecological hierarchy perspective the Buffalo Creek Watershed is part of the larger Riviere Aux Marais/Plum River Watershed. The Riviere Aux Marais/Plum River Watershed is one of many watersheds which make up the Red River Drainage Basin. On a larger scale the Red River Drainage basin is part of the Hudson Bay Watershed. (See Figure 4.1 Red River Drainage Basin in Relation to Hudson Bay Watershed and Figure 4.2 Buffalo Creek Drainage Basin in Relation to Riviere Aux Marais / Plum River Watershed).

The Hudson Bay Watershed contains a huge area which extends across the prairies and part of the Canadian Shield. In the west it contains the larger tributaries of the Saskatchewan-Nelson River system which drain from continental divide snow and glacial meltwater. Streams rising on prairie grasslands contribute neglibliy to runoff. Waters from the western portion of the

Figure 4.1 Red River Drainage Basin in Relation to Hudson Bay Watershed.

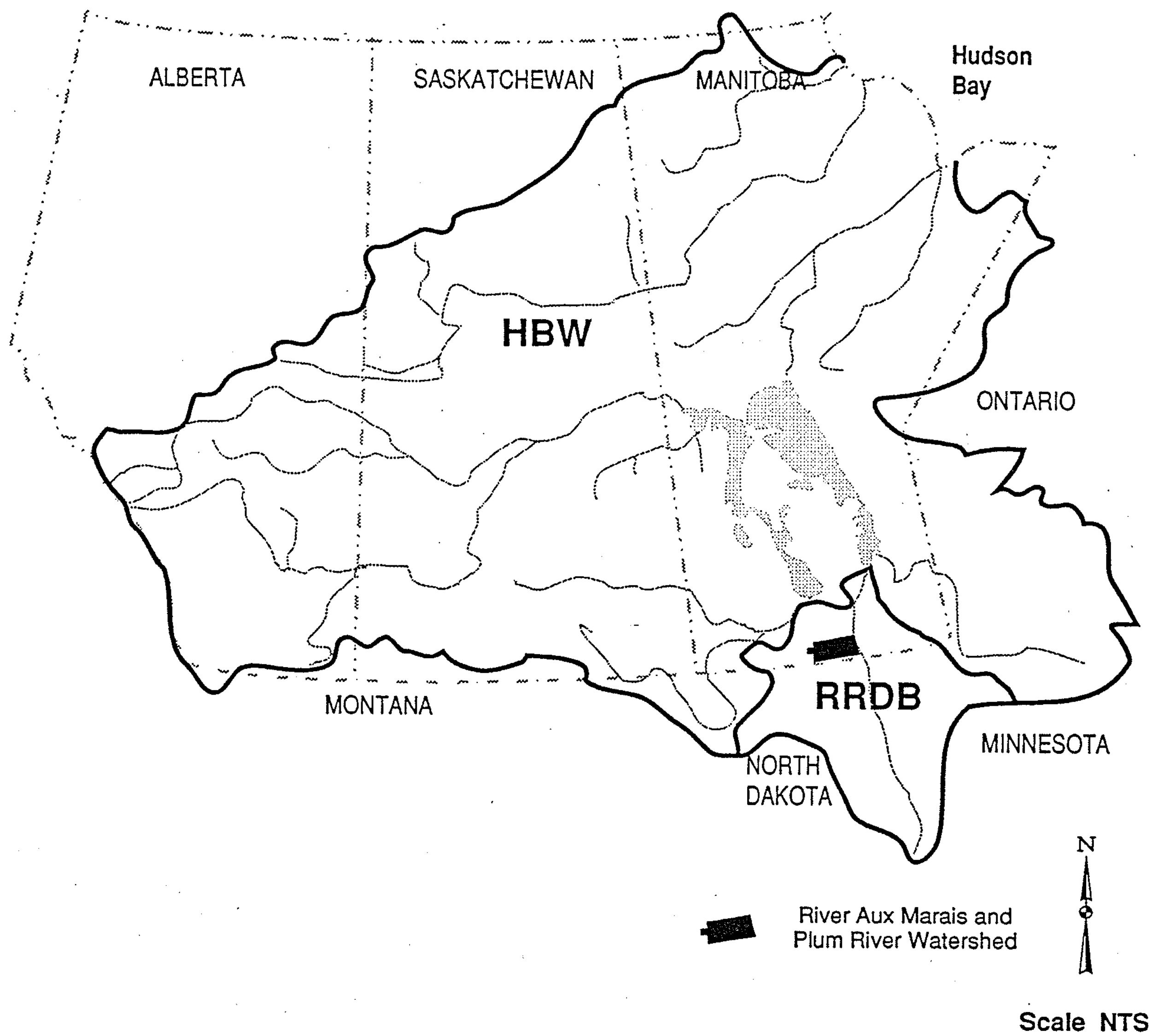
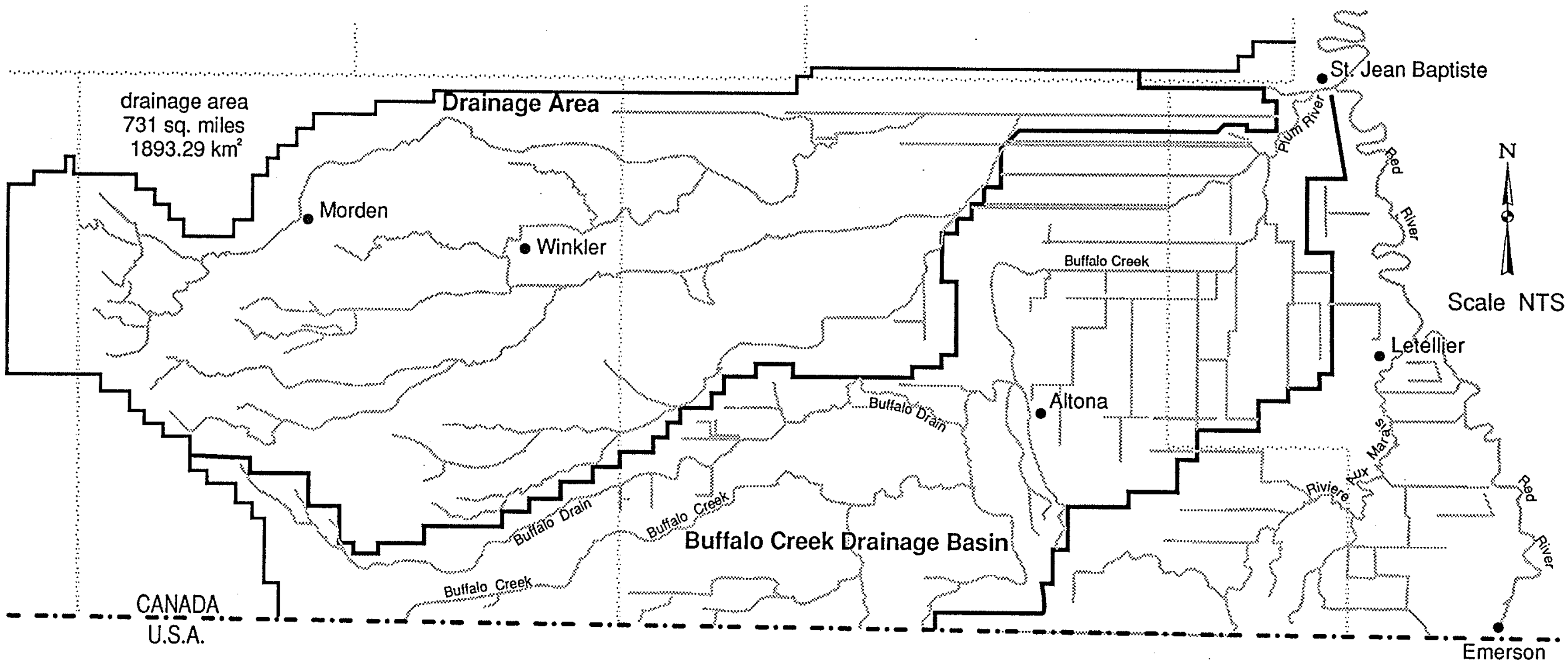


Figure 4.2 Buffalo Creek Drainage Basin in Relation to Riviere Aux Marais / Plum River Watershed.



watershed tend to be highly turbid and hard due to high dissolved soil content.

Northward and eastward drainage to Hudson Bay rises on the Precambrian Shield providing softer and clearer water. Water bodies and courses on the Shield are mostly pristine with a few isolated instances of pollution associated with mining and wood processing. In the western reaches of the watershed, however, problems are emerging as major storage developments release heavy metals like mercury into the Churchill and Nelson Rivers. Chemicals washed from agricultural lands are also being added to waters in the western reaches of the drainage basin (Pearse et. al. 1985 p. 36).

General Site Context

The Buffalo Creek Watershed is located in south central Manitoba along the Canada-United States border. It lies west of the Aux Marais River and directly North of the Pembina River. The watershed is composed of the North Branch Buffalo Drain, South Branch Buffalo Drain, Buffalo Creek and many associated channels and ditches.

Geographically the Buffalo Creek Watershed is located in the prairie biome. More specifically it lies in the ecological area designated as the tall grass prairie ecosystem.

In Manitoba the watershed is located in the Rural Municipalities of Rhineland and Stanley. Portions of the watershed located in the

United States are in the counties of Cavalier and Pembina, North Dakota.

Land Use

Historically the first people to inhabit the south central region of the province were the Plains Indians. These nomadic people left the area along with the bison, and settlers began to colinize the region in the 1800s. In this area of the province the first settlers were Russian Mennonites. Even today there is a strong influence of Mennonite culture on the Canadian side of the watershed. It is an area of Manitoba which has unique cultural characteristics associated with the Mennonite culture. There are several different sects of Mennonites living in the region with varying degrees of acceptance of modern conveniences (Stephens pers. comm. February 1993).

The following communities are located adjacent to streams and channels located within the Buffalo Creek Watershed. In the Rural Municipality of Stanley; Onadenthal. In the Rural Municipality of Rhineland; Reinland, Altbergthal, Old Altona, Altona, and Blumenort. There are no communities located in close proximity to watercourses associated with Buffalo Creek in the United States portion of the watershed.

In the south central region of the province land is used intensively for agriculture. The region contains some of the best soils in the province and due to this fact less than 10 percent of the native vegetation remains (World Wildlife Fund Canada 1989). Within the Buffalo Creek Watershed native vegetation is restricted to areas that can not be accessed by farm machinery or are too wet for livestock to graze, i.e. creek bed, drainage ditches, and any undrained marshland.

Agricultural crops grown on the Canadian side of the watershed include potatoes, canola, soy-beans, sunflowers, sugarbeets, corn, peas, and various specialty crops such as strawberries. Crops grown on the American portion of the watershed consist mainly of cereal grains such as oats, wheat, barley etc. (Samp pers. comm. January 1993). Raising livestock such as cattle, pigs and chickens is also common practice for many landowners on both sides of the watershed. There are several large hog operations located along different sections of the creek on the Canadian side of the watershed (Stephens pers. comm. February 1993).

One of the unique cultural traits of the area is that the majority of landowners on the Canadian side of the watershed raise some form of livestock as well as planted crops. Due to the intensive agricultural practices creekbed, ditches, and channels are used seasonally as grazing areas for these livestock (Stephens pers. comm. February 1993). This practice was confirmed by the informal resource inventory. Most landowners surveyed had a section of the creek fenced off as a grazing area.

Water Use

North Branch Buffalo Drain, South Branch Buffalo Drain and Buffalo Creek are used directly and indirectly as a source of water by several user groups. Water is either removed directly from surface flows and pumped into dugouts or channels leading into the larger watercourses are dammed. At present there are several registered users of water from the Buffalo Creek Watershed and many unregistered water users. Currently MbDNR Water Resources Branch has no hard figures as to the number of unregistered water users and the amounts they withdrawal (Stephenson pers. comm. February 1993).

The first user group are landowners along sections of the creek and drain. Water is removed during the spring runoff and stored in dugouts for use later in the year. Landowners use the water for domestic purposes and are allowed to withdraw 25,000 liters a day without a license. Water is used for general farm purposes, i.e. livestock watering, gardening etc.. This type of non-registered water withdrawal and use occurs throughout the watershed in both the United States and Canada.

Registered users of water in the Buffalo Creek Watershed include the following: (amount diverted is in cubic decameters)

Licensee	Location	Water use	Amount Diverted
W.J & K.L. Hamm	ne 9-1-5w	Irrigation	6.25 dams

L.J. & D.D. Buhler	se 9-1-4w	Irrigation	50.dams
Schmidt Farms	ne 4-1-4w	Irrigation	55 dams
L.J. Buhler	sw 28-1-4w	Irrigation	50 dams

Water is diverted in the spring and stored in large dugouts for use later in the year. Dugout sites range in size from 50 to 120 cubic decameters. The dugout located at ne section 4-1-4w has a capacity of 100 cubic dams. Visually it is about 3 meters deep and is as large as a football field.

The Agassiz Irrigation Association (AIA) is a group of farmers in southern Manitoba who have put forth a proposal to expand the use of Buffalo Creek as a water supply source. Water will be pumped into large dugouts (100-250 cubic dam capacity) during the spring runoff for use later in the year. This is part of a larger initiative to use several intermittent streams in southern Manitoba for irrigation purposes (See Appendix B for present and proposed irrigation reservoir sites). An environmental assessment of the concept of diverting and storing large volumes of water in southern Manitoba has been tentatively scheduled for the summer of 1993 (Mcknotten pers. comm. March 1993). It is interesting to note that some of the proposed dugouts have already been built and contain water (personal observation May 1993).

The last user group within the watershed is the remnant assemblages of the natural flora and fauna found in riparian areas. As mentioned earlier, habitat for indigenous species of wildlife are limited to riparian areas. These ditches, channels, and intermittent stream courses are also the only remaining natural areas people can go to see wildlife in the south central region. Recreation activities such as wildlife viewing, cross country skiing, canoeing, hunting and trapping are some of the activities enjoyed by people in these refuge areas (Dangerfield et. al. 1991 p. 12).

Geology

The headwaters of the watershed lie on the slopes of the physiographic structure called the Pembina Hills Upland. The Pembina Hills Upland is part of a larger physiographic feature known as the Pembina Escarpment. The Pembina Escarpment is composed of a series of hills running from north-central North Dakota to west-central Saskatchewan and includes Riding Mountain, Duck Mountain, the Porcupine Hills, and the Pembina Hills.

The surface geology of the watershed area is the result of Pleistocene glaciation, the deposition of the continental glaciers, and recent erosion by rivers and streams flowing from the Pembina Hills. Coarse till deposits in the upland region are a result of glacial retreats during the Pleistocene. Resulting meltwater from glaciers created Lake Agassiz, sediments which settled out in Lake Agassiz formed a layer which generally becomes finer as you move eastward from the escarpment (Dillon Ltd. 1992 p. 23).

Soils in the watershed generally range from class 1 to class 2 with pockets of class 3 and 4 soils. Class 1 soils being very good-soils composed of fine sandy loam to clay loam, the soils have good water retention capacity, good permeability, low salt content, good drainage, and low general gradient of land surface. Class 2 soils are fine sandy loam to clay loam texture but have some problems with water holding capacity, permeability, depth of material, salt content and topographic factors such as slope, shallow depth to water table and poorer drainage. Class 3 soils are coarse to fine texture. Class 4 soils have drainage problems, impermeable geologic material, salinity, low water holding capacity, and rapid permeability. The poorer soils being found close to the escarpment and soil quality improving as you move eastward (Dillon Ltd. 1992 p.23).

Climate

Worldwide the area is designated as DFb2, subhumid, cool continental; with the temperatures in summer higher and in winter lower than world average for that latitude, due to distance from moderating effect of oceans.

Manitoba designates it as MBt4: Moderately Cool Boreal ecological region. The mean annual temperature is 2.6 degrees to 3.3 degrees Celsius, with 1600 to 1680 degree-days > 5.5 degrees Celsius, 115 to 125 frost free days, average annual precipitation 460-540 mm (Dangerfield et. al. 1991 p. 24).

The Pembina Hills area is known to experience local rainstorms during the summer months. Some of these storms can be very intense, dumping a great deal of precipitation in a relatively short period of time (Coote 1985 p. 232).

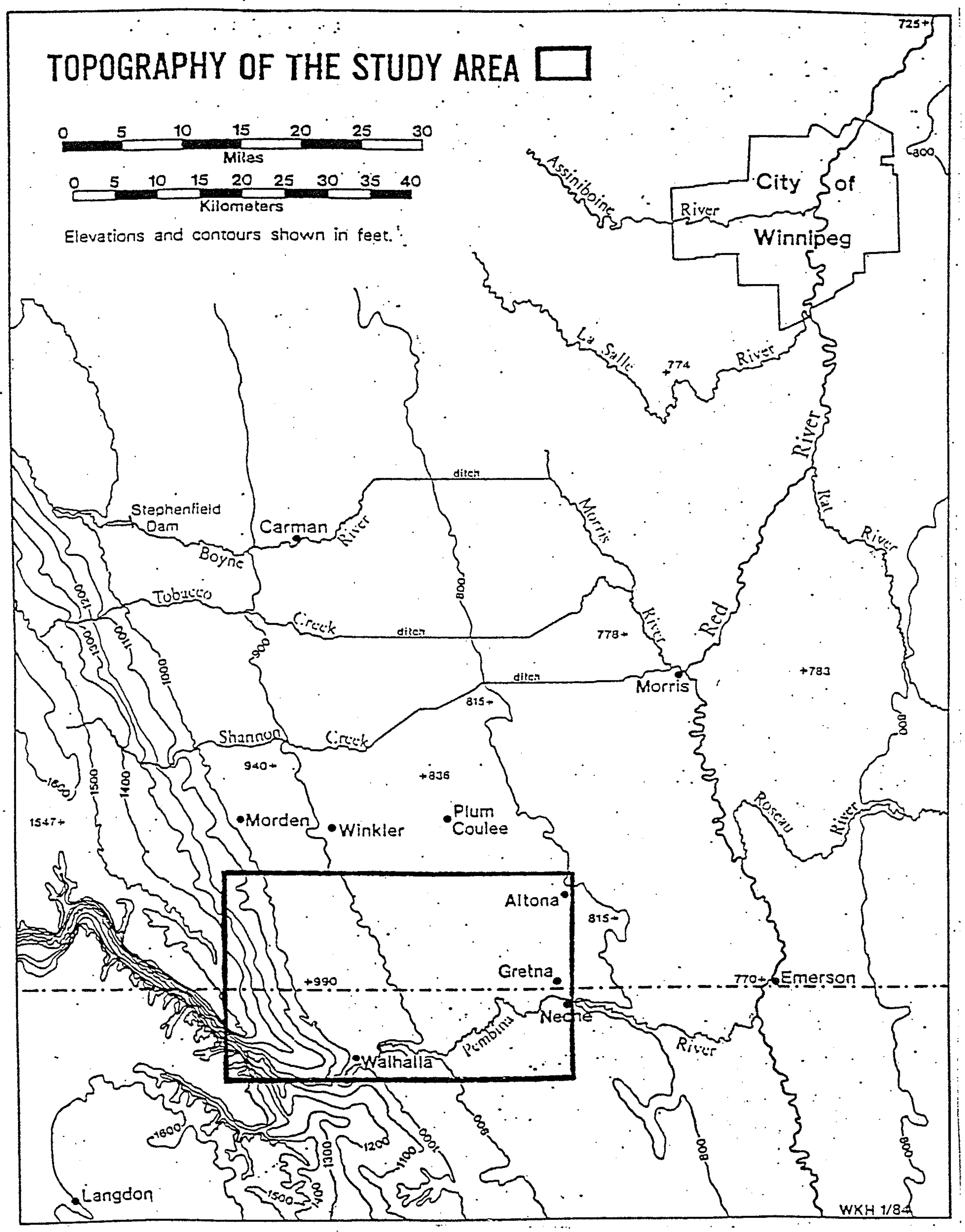
Topography

The topography of the watershed varies from flat at the lower reaches to fairly steep gradient in the western reaches of the watershed. Elevations at the head waters of Buffalo Creek are approximately 435 meters above sea level and drop to 300 meters in less than 16 kilometers as you move eastward. The lower reaches of the watershed can be considered flat. From the base of the Pembina Hills to the BPS&WMA study site elevation drops from approximately 300 meters to 246 meters over a distance of about 32 kilometers. (See Figure 4.3 Topography of the Study Area) On the flatter reaches of the watershed the creek, drains, and associated channels are the only visible relief in the terrain.

It should be noted that the headwater regions of the watershed in the Pembina Hills area were more wooded than the lower reaches. In particular portions of the watershed in the United States, along the escarpment, are very wooded. Sections of the United States portion of the watershed drain land adjacent to the Walhalla State Woodlands and the Pembina Hills State Wildlife Management Area.

Figure 4.3 Topography of Study Area

(Ogrodnik 1984 p. 67)



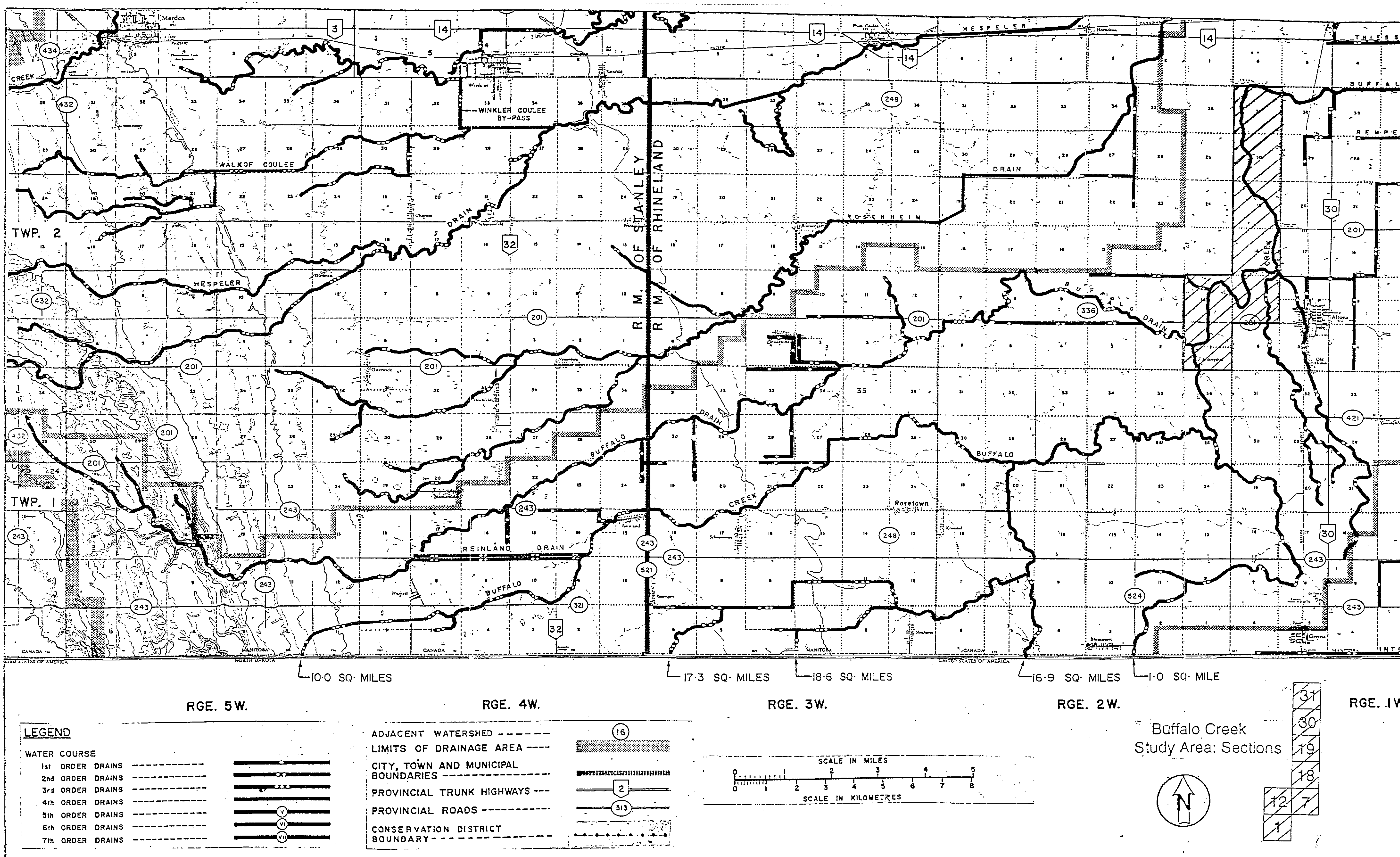
Hydrology

The Buffalo Creek Watershed begins on the Pembina Hills area of the Escarpment approximately 50 kilometers west of the BPS&WMA study site. Water drains off the escarpment and moves in a north easterly direction through the Buffalo Creek drainage system into the Plum River and eventually the Red River. (See Figure 4.4 Drainage Map Buffalo Creek Watershed (Canada)).

The North Branch Buffalo Drain is completely contained in the Canadian portion of the watershed. The main stem of the drain contains its' natural watercourse structure. Tributaries of this drain are mostly channels and ditches which drain agricultural land. The headwaters of the North Branch Buffalo Drain originate in the south western portion of the Rural Municipality of Stanley near the base of the Pembina Hills. The northernmost tributaries of South Branch Buffalo Drain originate on the Canadian side of the escarpment at an elevation of approximately 435 meters. From this point elevation drops 135 meters to 300 meters in the first 16 kilometers of the drain. The remaining stretch of the drain drops approximately 60 meters from that point to the BPS&WMA study site.

Unfortunately, no maps of the entire watershed showing the Canadian and American portions could be found. Maps showing the drainage area of the watershed on the United States side of the watershed could not be reprinted with desired clarity so they were omitted. However, a verbal description of the watershed is provided from

Figure 4.4 Drainage Map Buffalo Creek Watershed (Canada)



analysis of United States 1:100,000 metric topographical maps (1985).

Water draining the United States portion of the watershed enters Canada at five inlets located at section 7 twp. 1 rge. 5, section 6 twp. 1 rge. 3, section 3 twp. 1 rge. 3, section 5 twp. 1 rge. 2, section 2 twp. 1 rge. 2. (See Figure 4.4 Drainage Map Buffalo Creek Watershed (Canada)).

The three most western inlets headwaters originate in the United States in the Pembina Hills area of the Escarpment. Each of the inlets have several intermittent water courses feeding into them on the American side of the watershed. The relief of the tributaries in the United States is steeper than on the Canadian side of the watershed. Drop in relief in the United States headwater area is from approximately 450 meters to 300 meters in approximately 8 kilometers. (See Figure 4.3 Topography of the Study Area).

The most western inlet section 7 twp. 1 rge. 5, has a drainage area of 16 square kilometers and drains mainly off the Pembina Hills and directly into the South Branch Buffalo Drain. The water course is in a natural state, i.e. not channelized.

The inlets at section 6 twp. 1 rge. 3, drainage area 27.68 square kilometers, and section 3 twp. 1 rge. 3, drainage area 29.76 square kilometers, have a larger drainage area and drain areas of the

Escarpment as well as agricultural land before entering Manitoba. The upper reaches of these inlets have not been channelized, however, the areas draining the flat agricultural land before entry into Canada are extremely channelized. The above two inlets feed into a tributary of the South Branch Buffalo Drain on the Canadian side of the Watershed.

The fourth inlet at section 5 twp. 1 rge. 2, has a drainage area of 27.04 square kilometers and has not been channelized. It originates north east of Walhalla, North Dakota. The American name for the watercourse is Hyde Park Coulee. There is a small park located at the headwaters of this watercourse.

The last inlet to Manitoba from North Dakota is at section 2 twp. 1 rge. 2, and has a drainage area of 1.6 square kilometers. This waterway is a small channel located south of Blumenort, Manitoba.

Water Quality and Quantity

Watercourses in the Buffalo Creek Watershed, Buffalo Creek and Drains, are classified by the MbDNR Water Resources Branch as intermittent streams. This means that during periods of the year certain portions of the streambed may contain no water.

The majority of runoff arises in the intermittent streams stemming from the Pembina Escarpment. Runoff is usually limited to spring snowmelt, although periodic intense summer rainfalls may provide short duration flows (P.M. Associates 1992 p.38). In the months November, December, January, and February flows in the watershed have been calculated as zero. These estimates are based on the presumption that the creek freezes completely in some areas causing zero flow. Water flow peaks in March, April, and May during the spring thaw.

Flooding is a problem which occurs seasonally and periodically in the Buffalo Creek Watershed. In general, flooding occurs in the spring when channel capacity is exceeded or when ice jams occur in flowing channels. Extreme rainfall events at other times of the year may also cause channel capacity to be exceeded leading to local flooding. Periodically, during years of high flow on the Pembina River overflows near Walhalla, North Dakota, water flows overland into the Aux Maraias and Plum River Watershed, compounding flooding in the Buffalo Creek drainage basin.

Excessively dry years have caused flows in the watershed to be very low or non-existent some years. For example, in 1939 and 1940 the creek was classified by the PFRA as having zero flow (Dangerfield et. al. 1991 p.16). Dry years have the potential to effect water quality in the watershed, in that nutrients and chemicals washed off agricultural land could become more concentrated. There may also not be enough water to supply all the users of water in the watershed.

The maximum, minimum, and average flow at the BPS&WMA study site for the last 71 years are: maximum-92,618.9 cubic dams (1974), minimum 46.4 cubic dams (1939), and average 12,799.2 cubic dams. These figures come from studies done by the PFRA in the 1980s when the watershed was looked at as a domestic water supply source for Altona (See Appendix C Historic Flow Buffalo Creek Watershed). The community looked at damming Buffalo Creek at section 19 twp.2 rge.1, which is located within the BPS&WMA study site, however, the site was rejected for reasons such as intermittent flow and problems of water turbidity, taste, and odour.

The impact of agricultural practices in the watershed have on water quality has never been analyzed but it is likely an influencing factor. <u>Existing Conditions: Buffalo Creek Management Plan</u> catalogues a fish kill and subsequent water analysis taken at Buffalo Creek in July 1991. The fish kill was attributed to a lack of oxygen which is not uncommon for intermittent prairie streams. A chemical analysis of water samples taken by the Department of the Environment revealed the presence of a large number of chemicals associated with agriculture (Dangerfield et. al, 1991 p. 38). (See Appendix D Chemical Analysis Form).

4.2 Summary

Documenting the hierarchial site context of the Buffalo Creek Watershed helped establish that there is a trend in the decline of health of some of the ecosystems that make up the larger Hudson Bay

Watershed. It has been documented that in the western portion of the watershed problems are emerging as major storage developments are releasing heavy metals like mercury into the Churchill and Nelson Rivers. It was also noted that chemicals washed from agricultural lands are also being added to waters in the western reaches of the drainage basin. This is an important finding to note because on a hierarchial scale problems emerging at the higher level (Hudson Bay Watershed) indicate more severe problems are occurring at the smaller scale such as the Buffalo Creek Watershed.

Examining the land and water use in the Buffalo Creek Watershed helped to establish some of the human activities in the ecosystem which can influence water quality and quantity. It has been documented that in the watershed there are unique cultural characteristics that have the potential to influence environmental health at the study site. For example, it is apparent that most landowners on the Canadian side of the watershed use riparian zones to raise livestock. Examining water use in the watershed identified the various user groups and areas of potential conflict in water management.

Establishing the natural characteristics such as geology, climate, topography, hydrology, etc. of the Buffalo Creek Watershed revealed useful insights for determining the watershed's susceptibility to environmental problems like erosion. Wind and water erosion influence water quality and quantity through sediment and chemical deposition, as discussed in Chapter two. In short, examining the Study Site's characteristics, both human and natural, helps to set the stage for the more in depth analysis of factors affecting water quality and quantity at the BPS&WMA study site presented in Chapter five.

Chapter 5: Existing Conditions Impacting Water Quality and Quantity at the BPS&WMA Study Site

5.0 Overview

There are several factors which have the potential to impact water quality and quantity at the BPS&WMA site. These impacts have the potential to directly influence water characteristics at the study site as well as influence management decisions to reach objectives desired by the BPS&WMA. The factors or impacts range from a lack of information about the Buffalo Creek Watershed to current resource management strategies employed by government agencies.

5.1 Information

One of the first factors that became evident in the research procedure of phase one was a lack of information about the Buffalo Creek Watershed and a centralized data source. Although this does not directly influence water quality and quantity at the BPS&WMA site, it creates problems in establishing the Study Site's biophysical database, which can influence management decisions.

Collecting information on the United States portion of the watershed required contacting several different agencies in different locations of North Dakota and Minnesota which was time consuming and did not provide much information. Organizations such as the Pembina County Water Resources Branch, Cavalier County Soil Conservation Service, and The International Coalition for Land and Water Stewardship in the Red River Basin were contacted.

Data collection on the Canadian side of the watershed was also difficult as there is not a lot of "hard data" on factors influencing water quality and quantity in the watershed. Information that was available was not at a centralized location and was spread out between various government agencies, private organizations, consulting firms and knowledgeable individuals.

Lack of information is a potential impact because to do a watershed ecosystem study an individual or organization would want to access all available information on the given area. A lack of hard data makes the identification of impacts to water quality and quantity more difficult as you are working with an incomplete data base. Having one organization responsible for a definable area, i.e. watershed, could allow for the establishment of a centralized information base.

Other factors which have the potential to influence water quality and quantity at the BPS&WMA site can be divided into several categories. The first category is natural phenomena which includes floods and droughts. The next category is land stewardship practices which can further influence the first category. The last category is current resource management strategies employed by government agencies.

5.2 Natural Phenomena

Natural phenomena such as flooding and droughts can have positive and negative impacts on water quality and quantity. Flooding events that occur seasonally and perennially can have the following positive impacts: spring flooding associated with winter thaw helps recharge groundwater tables and flowing water helps flush sediments from the streambed; flushing of the streambed helps to maintain channel and stream depth as well as cleaning aquatic habitat; excess water helps dilute any agricultural pollutants leaving crops or pasture land with the runoff. Flooding also has negative impacts such as erosion which is compounded when streambanks have little vegetation.

Droughts have little benefit and are usually associated with a decline in water quality. Lack of water means that soil moisture levels will be lower increasing soil susceptibility to erosion. Less water in the catchment areas of watersheds means that there is a potential for agricultural pollutants in runoff waters to be more concentrated. A lower water volume in catchment areas also means these areas will be more susceptible to algal blooms and lower oxygen content of water. In short, the health of the riparian environment is degraded.

5.3 Intensive Agriculture/Land Stewardship

The literature examined and consultation with knowledgeable persons would suggest that past and present land stewardship techniques have and will continue to influence water quality and quantity at the BPS&WMA study site. As noted practices such as channelization, intensive agriculture, chemical use and the removal of riparian vegetation can contribute to problems of soil erosion and chemical contamination.

In the Buffalo Creek Watershed cropping occurs within meters of watercourses and livestock are fenced off in the creek's channels and ditches. These practices create the potential for substantial erosion when conditions are right, i.e. spring thaw. Almost every landowner inspected by the resource survey had some form of livestock pasture area in the watercourse or fenced to the watercourse.

While developing the management plan for the BPS&WMA the NRI study team uncovered the fact that erosion is an issue of concern for residents who live near and along the BPS&WMA study site. Wash out areas after heavy rains and soil drifts have been seen by residents who live in the area surrounding the study site. Landowners along the creek complained at public meetings, held while developing the management plan, that during the spring thaw ice floes on the creek would erode and deposit sediment downstream (Dangerfeild et. al. 1991 p. 24).

Some landowners along the BPS&WMA study site have complained that the creek has become shallower in recent years due to sediment deposition. It is probable that sediments settle out of water when flow resides. However, this cannot be proven as water levels in the creek fluctuate from year to year changing creek depth. The real or perceived shallowing of the creek could be associated with the fact that a flood has not occurred recently and flushed sediments from the creekbed.

Although it is likely that a substantial amount of sediment comes off the land adjacent to the study site many landowners believe its source is farther upstream. There is some evidence to support this claim. The area surrounding the BPS&WMA study site has very low relief indicating that there would be a low water erosion potential. It is likely that the steeper headwater areas near the Pembina Escarpment are a source of sediment.

Dean Hildebrand, president of the Stanley Soil Management Association, indicated that the steeper headwater areas have experienced significant erosion in the past (Hildebrand pers. comm. February 1993). Jake Enns, president of the BPS&WMA, also suggested that areas near the Pembina Hills may be a source of sediments. Mr. Enns indicated that low residue crops such as potatoes and beans are grown in the upper reaches of the watershed which could be contributing to sediment deposition (Enns pers. comm. January 1993).

It should be noted that erosion (associated with water) in the watershed is an event that occurs only at specific times of the year. Three quarters of the watershed's flow occurs in the spring and the remainder occurs periodically throughout the year. Manfred Samp, hydrologist PFRA, (1993) stated that in general erosion in the Buffalo Creek watershed is not a major problem. However, Samp did say that there is the potential for significant erosion due to chance events, i.e. heavy summer rainfall. In the past severe summer storms have eroded substantial amounts of land in the Pembina Hills area. Several years ago a severe rain storm and associated runoff caused substantial soil loss as evidenced by large gullies on crop and pasture land in the Pembina Hills area (Hildebrand pers. comm. January 1993).

Chapter two identified the south central region of the province as being at a moderate wind erosion risk. The recent efforts of Soil and Water management groups in the Buffalo Creek Watershed would support the fact that wind and water erosion is a problem. From the resource survey it was evident that many new shelterbelts have been planted on cropland in the watershed. The resource survey also evidenced that many fields were bare and the effects of soil erosion by wind could be seen, i.e. soil drifts, which may indicate the need for more soil conservation measures.

Chemical contamination of water in the Buffalo Creek watershed is also an issue of concern. Sources of contamination include cropland, feedlot and livestock grazing areas and point sources such as solid waste disposal sites.

Water draining the Buffalo Creek Watershed consists essentially of runoff from the surrounding land which is used for agriculture. The influence that chemicals washed or blown off the land have on the environment depends on several factors: time of application, volume applied, type of product, and climatic conditions.

A chance event could create a problem related to chemical contamination of the creek. If chemicals are applied and a significant rainstorm were to occur a problem may arise. For example, nitrates could be washed off a field due to surface runoff should a heavy rain occur and cause the soil to be oversaturated (Buhler pers. comm. January 1993).

As previously mentioned, besides being a source of erosion livestock grazing areas can be a source of fertilizers and pathogens associated with wastes. This could be a significant problem in the Buffalo Creek Watershed since a cultural characteristic of south central Manitoba is that the majority of landowners raise some sort of livestock, i.e. chickens, hogs, and cattle (Stephens pers. comm. February 1993). The practice of fencing off part of the creek as livestock pasture and watering holes will aggravate problems of soil erosion and agricultural pollutants.

There is the potential for biological wastes from point sources to influence water quality at the study site. There are several large hog operations located within the Buffalo Creek Watershed which could be a source of livestock wastes. It is not known how many hog operations there are because not all operations are registered. These facilities accumulate waste in barns over the winter months in collection pits. This liquid waste could enter the environment through leaks in holding tanks. However, most of the waste enters the environment by direct application disposal methods. Disposal practices include spraying liquid wastes on top of snow in fields with the assumption it will enter the soil during the spring melt (Stephens pers. comm. February 1993). It is unlikely that all of the wastes go directly into the fields and some would be washed into riparian areas.

There is also a small risk that human sewage could enter watercourses in the watershed. There are several small communities located on or near North Branch Buffalo Drain, South Branch Buffalo Drain, and Buffalo Creek. These communities could be contributing biological wastes from outhouses and leaking septic fields.

As documented in <u>Existing Conditions: Buffalo Creek Management Plan</u> sections of Buffalo Creek, North Branch and South Branch Buffalo Drain have been used as solid waste disposal sites. Except for one, these sites are not registered and are ad hoc arrangements on private land. As evidenced in the resource survey these sites contain old cars, trucks, farm machinery, empty chemical containers and probably toxic materials.

The one registered waste disposal site is the Stanley Nuisance Ground which is a Municipal waste disposal area for the Rural Municipality of Stanley. The disposal site is located in a coulee in the headwater section of the South Branch Buffalo Drain at section 16 twp.1 rge.5 in the north east corner. The coulee was approximately 12 meters deep when operations started and garbage has been dumped in and burnt repeatedly. At present the coulee is full and successive layers are being built. There are no clear records as to what types of garbage are in the dump. Chemical leaching is likely occurring as it is probable that there are chemical containers in the dump which have not been rinsed properly (Hildebrand pers. comm. 1993). Mark Stephens, Manitoba Environment, (1993) has stated that the dump will likely be closed in a year as there are concerns over leaching heavy metals.

5.4 Irrigation Impacts

Irrigation is an intensive land management strategy which could be placed under the category Intensive Agriculture. At the Buffalo Creek Watershed, however, irrigation is an impact of relatively unknown significance as it is a new method of farming within the watershed. Due to the fact that its full impacts to the BPS&WMA site are unknown it warranted special attention in this section on impacts to water quality and quantity.

Irrigation operations can have many impacts on the environment depending on the type of irrigation method being used. The type of irrigation method being used in the Buffalo Creek watershed is a relatively new concept. Water is being diverted from intermittent streams and stored in large dugouts for use in drier months of the year (Samp pers. comm. January 1993). Dillon consultants (1992) have identified several impacts for the proposed expansion of irrigation in the Buffalo Creek Watershed. Impacts range from an increase in aquatic habitat at the large dugout sites to a potential increase of agricultural pollutants to areas downstream of irrigation sites.

The environmental scoping exercise carried out by Dillon (1992) consultants for the AIA identified the following potential impacts to areas downstream of irrigation dugouts and water withdrawal sites:

-Impoundments may act as collection basins for surface water runoff reducing the flow to downstream users.

-During construction of the impoundments there may be an increase in erosion and sedimentation to downstream areas.

-Water withdrawals could aggravate a drought situation and suppressed flow regimes in the spring could reduce the scouring action associated with larger volumes of water.

-Irrigation will increase surface runoff, which may carry harmful substances such as fertilizers, and pesticides that are used on potato crops as well as salts that may accumulate through salinization.

-The large dugout sites may enhance the wildlife habitat of the region as it will provide some riparian habitat.

-The report also indicates that withdrawal of water has the potential to help control downstream flooding associated with spring thaw (Dillon 1992 p. 24). However, this is debateable because during a severe flood the dugouts would be full and water would still flood areas downstream (Samp pers. comm. January 1993).

The full impact that the expanded use of the Buffalo Creek Watershed for irrigation purposes may have on the BPS&WMA study site is unknown. It is likely, however, that during drought years any impacts to the study site will be magnified.

5.5 Current Resource Management Strategies

Dean Hildebrand, president of Stanley Soil Management association, and Jake Enns, president of BPS&WMA, both have concerns over the potential for conflict over water allocation. In drought years water supply may be lower than the demand among users.

The main problem with water management in the Buffalo Creek Watershed is that the majority of water users are not registered or licensed. This means that the resource is being managed with an incomplete information base pertaining to water withdrawals. As mentioned earlier the AIA has proposed to expand operations in the Buffalo Creek Watershed and have been given water withdrawal licences. This could complicate matters as the MbDNR Water Resources Branch has allotted water based on data that does not reflect actual water use in the watershed. Fortunately, the licences have a stipulation that they are subject to review with future experience and any changes to accepted licence criteria would be carried out in consultation with the various local interests.

Under the Water Rights Act individuals can withdrawal, without a license up to 25,000 liters of water a day from watercourses for domestic purposes. Research for this practicum and the reports prepared for the BPS&WMA would suggest that a very high percentage of landowners along the creek remove water for domestic purposes. It should be noted that water withdrawal for these domestic uses do not occur at a rate of 25,000 liters per day. Water is only available to some landowners during the spring thaw and, as a result, more than 25,000 liters in one day are pumped into small dugouts.

The Water Resources Branch realizes that there is a potential for conflict at Buffalo Creek among water users. At present the Branch is trying to get a grip on the number of domestic water users at

Buffalo Creek before a drought occurs. Problems in south central Manitoba have historically been associated with excess amounts of water (Stephenson pers. comm. February 1993).

5.6 Summary

Research for this practicum has identified the following activities occurring in the watershed as impacting or having the potential to impact water quality and quantity at the BPS&WMA study site;

-Natural Phenomena such as floods, droughts and localized storm events.

-Intensive cropping of land adjacent to watercourses, in some cases to within less than one meter of South Branch Buffalo Drain, North Branch Buffalo Drain, and Buffalo Creek.

-Intensive livestock grazing near and in watercourses; many of the watercourses in the watershed are fenced to provide livestock watering areas and some watercourses are grazed seasonally during drier periods of the year.

-Tillage practices and crop selection; some farmers use summer fallow, stubble burning, and other soil damaging practices, many farmers also grow low residue crops such as potatoes and beans.

-Chemical contamination of soil and water; chemicals are entering the environment from croplands, feedlot and livestock pasture areas, and other point source areas such as solid waste disposal sites.

-Irrigation, several people contacted felt that the proposed irrigation expansion is an impact because it would influence water quality and quantity during drought years. It may also increase the amount of chemicals and salts delivered to riparian areas.

-Problems associated with resource management agencies, i.e. lack of ability to monitor and collect information on resources that have not experienced environmental problems, and a lack of a reliable data base to manage water withdrawals.

Chapter 6: Policy and Institutional Reveiw

6.0 Overview

Various governing authorities ranging from individual landowners to the federal governments of both the United States and Canada have jurisdiction in the management of resources associated with the Buffalo Creek Watershed. The BPS&WMA, to effectively manage their 16 kilometer section of land, have to take into consideration existing institutional arrangements as they may impact the study site.

Many of the present institutional arrangements make managing the Buffalo Creek Watershed on a watershed ecosystem basis difficult. This chapter will briefly examine some of the existing federal and provincial legislation related to basin, watershed, or ecosystem management. It will also emphasize that it is not only the natural resources that need to be considered but also the existing policy and resource management environment which need to be examined when smaller scale initiatives are developed. Problems of managing the watershed on a holistic basis have been identified to draw support for smaller scale environmental enhancement initiatives.

6.1 Legislative Basis for Basin Management

There are three levels of government which manage the resources found in the area defined as the Buffalo Creek Watershed. The three levels are federal, provincial, and municipal. These various levels of government have policy and management strategies which, in theory, promote the ecosystem approach to resource management. There is legislation which promotes the management of water and related resources on a watershed or basin basis. However, there is no legislation, at any level of government, which states that water and associated resources must be managed on a watershed, ecosystem, or basin basis (Whitney pers. comm. June 1993).

Federal

At the federal level government has recently promoted the concept of integrated resource management through sustainable development initiatives. For example, the Green Plan contains over 100 specific initiatives to help achieve Canada's National Environmental targets and goals. The plan articulates seven key principles which government has adopted as the basis to secure sustainable development. The seven principles are: respect for nature, the economy-environment relationship, shared responsibility, leadership, informed decision-making, and ecosystem approach (Canada's National Report.. 1991 p.108). This is relevant because the Green Plan promotes holistic management of the environment. Managing a basin is holistic resource management applied at a more local level.

There is no federal legislation which states that any resource must be managed on a basin, ecosystem, or watershed basis. However, basin management is promoted or can be implied by many federal Acts which affect our use of the environment. The following are some of the federal statutes which promote or imply basin, ecosystem, or watershed management.

Since 1988, the Canadian Environmental Protection Act has empowered the Federal Minister of the Environment to regulate environmental pollution on a national basis. The Act adopts an ecosystem approach, looking at terrestrial atmospheric, freshwater and marine resources; it applies to all federal lands and can be utilized to help safeguard such lands from various forms of pollution (State of Canada's... 1991 p. 5-16).

The Canadian Environmental Assessment Act (1992), (passed, not yet proclaimed), may imply basin or watershed management. For example, the cumulative effects of activities in a river system/watershed must be documented for an environmental assessment.

The federal government is assigned responsibility for all fisheries in Canada under the Fisheries Act (1985). This Act gives the federal government power to protect and manage fish habitat which involves the federal government in regulating activities that alter either the flow or quality of water in a way which would be harmful to fish (Pearse et. al. 1985 p. 64). This implies basin or watershed management as water is a resource which is best managed on a basin basis.

Under the Canada Water Act (1970) there may be a legislative basis for basin or watershed management at the federal level. Part one and two of this four part Act authorize the federal government to join the provinces in a wide range of activities including planning and implementing projects.

Part one of the Canada Water Act authorizes federal-provincial agreements for conducting research and water inventories, forming comprehensive management plans, and designing and executing projects (Pearse et. al. 1985 p. 72). Initiatives of this nature have not been undertaken for several years (Whitney pers. comm. June 1993).

Part two of the Act, has never been exercised nor have the federal and provincial governments ever seriously considered doing so. It's provisions authorize agreements for designing water quality management areas. An agency would formulate water quality management plans which when approved by the Ministers of the governments involved, would enable significant cooperative activity. If a plan were approved the agency would be empowered to design, construct and operate waste treatment facilities, collect fees for effluent discharges and waste treatment, monitor water quality and perform other water management activities (Pearse et. al. 1985 p. 72).

The Canada Water Act (1970) does not state the area to be managed by an agency must be a defined watershed or basin. However, it is implied given the ineffectiveness of managing water resources on a fragmented basis.

Provincial

The government of Manitoba has developed a land and water strategy as part of a provincial sustainable development initiative. The strategy promotes the concept of integrated resource management which would imply basin or watershed management. The strategy is not legislation, however, some of the ideas presented are being considered for changes to current provincial legislation (Bartow pers. comm. June 1993).

In Manitoba there is a legislative basis for basin or watershed ecosystem management. The Manitoba Conservation Districts Act (1976) addresses all aspects of soil, water, and related resource problems as they exist in areas defined by the natural boundaries of a watershed or human made borders such as Municipal Boundaries. (See section 2.6, Conservation Districts). It should be noted that the Minister of Rural Development can force an unwilling Rural Municipality to enter into a Conservation District (Dugay pers. comm. June 1993).

A brief review of the Manitoba Municipal Planning Act (1987) would suggest that the Manitoba Department of Rural Development could play a role in coordinating inter-municipal watershed projects. A general interpretation of the Act seems to suggest that in theory the department could become involved in development of inter-municipal watershed management plans if two or more Municipalities both agreed to initiate a project. This has never been attempted before as the department is more geared to economic development of Rural Municipalities and would likely only assist at the field level, i.e. the department would help rearrange tax structures and zoning by-laws (Glassen pers. comm. March 1993). Normally when Municipalities wish to manage a watershed or interjuristictional resource they would form a Conservation District.

6.2 Resource Management Authorities

There are various individuals, groups, and government agencies which manage the resources associated with Buffalo Creek. These management authorities can be broken into two categories, promoters and regulators. Landowners, industry, soil and water associations, and special interest groups are promoters and can promote positive and negative resource management strategies. Regulatory agencies, which include all levels of government, manage resources with a legislative basis and are involved in activities such as licensing.

Individuals

Individual landowners have control over the land stewardship practices employed on their land. They are responsible for determining the type of agriculture, i.e. crops, livestock or both, and how these commodities will be produced. Landowners have the right to use their land in the way they want as long as it is within the confines of rules and regulations imposed by various levels of government. The individual landowner may or may not obey these rules and regulations as their enforcement may be difficult or their meaning may be open to interpretation. For example, under The Water Rights Act, individuals have a right to 25,000 liters of water per day from watercourses for domestic use. Does this mean a person can take only 25,000 litres a day or can they take 365 times this amount in one day and store it? Also enforcement of the 25,000 litres per day rule is difficult due to lack of power and a lack of reliable monitoring mechanisms (Stephenson pers. comm. March 1993).

Individual land stewardship practices can be influenced by culture and by market incentives. Culture may determine what types of livestock are raised, how they are raised, and where they are raised. Markets do not directly determine resource use and land stewardship practices but does influence the two. For example, markets can influence the type of crop grown and how that crop is grown. High prices for a particular crop may promote intensive agricultural techniques to produce that crop. In the case of potatoes in south central Manitoba, markets may require farmers to have irrigation capabilities to ensure product quality and quantity. Carnation and McCain's plants who receive potatoes from this area are operating under capacity due to a shortage of raw product. As a result processors are demanding additional irrigation to increase quality and quantity of product (P.M. Associates 1992 p. 2). In fact farmers will not receive contracts with the potato processors unless they have irrigation capabilities (Olson pers. comm. May 1993).

Soil and Water Associations

Soil and water associations also have a role in the management of resources within a specified area. These local associations solicit members and promote positive land stewardship practices, i.e. shelterbelts, conservation tillage, etc.. The associations operate as a vehicle of communication for relaying the concerns of landowners to higher government levels. The local organizations decide what issues are of concern to members. Once an issue or problem has been identified various government and private resource organizations can be contacted for assistance. These organizations offer financial aid, use of special equipment and expert assistance. The following are some of the soil and water conservation programs and there sponsors available to Manitoba farmers; under the Farming for Tomorrow Program (PFRA and Manitoba Agriculture)-residue management, shelterbelt planting, forage planting, small dam construction, gully stabilization, conservation equipment support and rotational grazing systems; under the Manitoba Heritage Corporation-delayed hay cut; and, under Ducks Unlimited-rotational grazing systems.

Special Interest Groups

Various government and non-government special interest groups also play a role, or have the potential to play a role, in the use and management of natural resources such as Buffalo Creek. The Manitoba Habitat Heritage Corporation, Wildlife Habitat Canada, Ducks Unlimited, and the Manitoba Naturalist Society are a few of the many organizations which can influence resource management decisions. These organizations can influence landowner participation in special projects by providing education and monetary incentives for the use or disuse of certain land management practices on their land.

Rural Municipalities

Rural municipalities have various regulatory powers which can be placed on resources and resource uses within municipal boundaries. These regulatory measures, or by-laws, are additional restrictions placed on top of provincial and federal regulations. For example, under the Manitoba Municipal Act regulations concerning drainage of land are subject to the Water Resources Administration Act and The Water Rights Act. Each Municipality has jurisdiction over all drains within its boundaries and may pass by-laws under The Water Rights Act for activities such as improving, deepening, and or diverting watercourses. However, in some cases the Rural Municipality can not legally undertake certain activities until the MbDNR Water Resources Branch has given the go ahead for an initiative, i.e. channel widening.

In regard to special areas such as parks Rural Municipalities have regulative authority. For example, special zones can be created within the municipal boundaries and land use in that zone can be regulated. Rural Municipality councils can create tax structures on certain lands. They can also pass by-laws for regulatory purposes such as restricting the keeping of animals or certain types of animals in designated areas. Council could also ban certain species of animals from being kept within a given distance of watercourses, i.e. ban cattle from accessing the creek within the study site. Municipal council could play a key role in the implementation of the Buffalo Creek Multiple Resource Use Management Plan. For example, a restructuring of the tax structure on rehabilitated lands will be required if the current Municipal tax structure is geared towards agricultural production.

Government Departments and Branches

The Manitoba Department of Natural Resources has several branches which have legislated jurisdiction over various resources within the Buffalo Creek Watershed. The Wildlife Branch, Fisheries Branch, and the Water Resources Branch being the main three.

The Water Resources Branch is directly responsible for regulating activities associated with water. Its role is to administer the Water Rights Act on behalf of the Minister of Natural Resources. The Water Rights Act states that "All property in, and rights to, all water in the Province is vested in the Crown". Water belongs to everyone and the provincial government has the responsibility to manage water and allocate it for use on behalf of all people in the province. The Water Resources Branch manages the province's water resources on a watershed basis and regions of the province are classified into watershed and sub-watershed districts. The Water Resources Branch is the licensing authority for surface and ground water withdrawals.

The Wildlife Branch is responsible for managing the various wildlife species found in south central Manitoba. The Branch has various programs designed to enhance, control, and monitor wildlife populations. The Branch works with other federal and provincial organizations as well as non-governmental organizations who are concerned with wildlife and habitat.

The Fisheries Branch is responsible for studies, education, and programs related to aquatic resources, specifically fish habitat. At present there have been no studies of the fishery resources associated with the Buffalo Creek Watershed. However, there is speculation that the lower reaches of the watershed are spawning grounds for fish migrating from the Red River. The Fisheries Branch will likely be looking at the aquatic resources of the Buffalo Creek Watershed in greater detail as part of the environmental assessment process associated with irrigation dugouts.

At present the south central region of the province is experiencing a loss in species diversity due to a loss of habitat. All branches of the Manitoba Department of Natural Resources and many other organizations are working to enhance and preserve existing native species.

The Manitoba Department of the Environment plays a limited role in the management of the natural resources found in the watershed unless environmental problems occur or major developments are proposed. For example, the Department of the Environment would respond to complaints that there had been a fish kill in some part of the watershed. The main goal of the department is to administer the Environment Act which deals with environmental impacts and assures public review of development proposals. The Department of the Environment will play a role during the environmental assessment of dugout sites to be used for storing irrigation water.

Agriculture

Management activities associated with the agricultural resources of the Buffalo Creek Watershed are under the jurisdiction of the PFRA and Manitoba Agriculture. Both these government agencies have different mandates and programs related to agriculture in the watershed. But in regard to factors influencing water quality and quantity this federal and provincial organization work jointly to promote soil and water conservation measures under the Farming for Tomorrow program. This initiative allows programs to be jointly administered under the National Soil and Water Conservation Strategy. The Canadian Constitution permits both federal and provincial governments to legislate with respect to agriculture. In the case of a conflict federal legislation prevails (Pearse et. al. 1985 p. 65).

Federal and International Jurisdiction

Due to the geographic location of the Buffalo Creek Watershed there is the potential for federal intervention in the management of Buffalo Creek. The Constitution makes all dealings with other states a federal responsibility. There are several statutes which enable the federal government to address international responsibilities, i.e. the International Boundary Waters Treaty (1909). Various federal regulatory agencies would become involved if it became apparent that activities on the American side of the watershed were impacting resources on the Canadian side. In the case of impacts to fish the Department of Fisheries and Oceans would become involved.

On the American side of the Watershed the following are some of the agencies responsible for management of resources associated with the Buffalo Creek Watershed; North Dakota State Water Commission, Pembina County Water Management Board, Cavalier County Water Management Board, United States Soil Conservation Service, United States Fish and Wildlife Service, and the United States Army Corps. of Engineers.

6.3 Institutional Implications of Watershed Ecosystem Management

Managing the entire Buffalo Creek Watershed for multiple resource use benefits would be difficult for several reasons: it would require that the majority of landowners in the watershed support the idea; it would also require the coordination of many resource user groups and various levels of government; and it would require the cooperation of the United States and Canadian officials which could be difficult.

Any effort to promote improving the whole watershed would likely be met with resistance. Improving the watershed would require establishing a "buffer zone" of vegetation between cropland and the creek and limiting irrigation. It would also require keeping livestock out of watercourses during certain times of the year. Both these facts mean that landowners would incur economic costs as land would be taken out of production. Most landowners likely believe that things are perfect the way they are.

Another problem is that there would be a lack of a coordinating authority in charge of operations within the watershed. As documented, there are many different organizations responsible for the resources associated with the watershed. These organizations are divided into different groups, i.e. AIA, BPS&WMA, Water Resources Branch, Fisheries, etc.. This creates problems because the agencies are sectoral in nature even though many of the resources they manage interact and influence each other. A management authority would be required to coordinate the activities of interested agencies and resource users. At present, it is not within the BPS&WMA mandate or budget to take on the responsibility of managing the Buffalo Creek Watershed.

As stated previously when Rural Municipalities decide that they wish to control and manage their local resources a Conservation District is formed. This allows the Conservation District's board to coordinate the activities of other resource management agencies for multiple resource use benefits such as recreation, wildlife, education, and soil and water conservation benefits.

Previous flood events in the Plum River/Aux Maraias River Watershed have caused international problems. Problems have occurred when the Pembina River on the United States side has overflown and dumped water into Canada. In the 1970s and 1980s both governments tried to mediate perennial flooding through the Canada-United States Water Resources Committee.

The Committee was composed of the following parties; North Dakota State Water Commission, Manitoba Water Resources Branch, Souris Red-Rainy River Basin Committee member, Canada Department of Environment, Pembina County Water Management Board, Cavalier County Water Management Board, Rural Municipality of Rhineland council member, and a Rural Municipality of Stanley council member. The committee decided that flooding could be controlled by building two dams on the Pembina River, one in Canada and one in the United States. However, the idea never came about due to disputes over project benefits and cost sharing structures between the two governments.

In any event the Canadians went ahead and installed a municipal road along the international border south of Gretna, Manitoba. Officials in the United States feel that this road is effectively a dyke, as culverts in the road are sized only to accommodate runoff and not overflows from the Pembina River. During overflows water is prevented from moving over the natural drainage area.

Canada has recently reviewed the idea of establishing dams on the Pembina River. However, building the dams is not likely because the water would be expensive environmentally. The reservoir would inundate a large area of natural habitat (Samp pers. comm. January 1993).

6.4 Summary

The policy and legislative basis for managing basins, ecosystems and watersheds on a holistic basis is weak. The federal government does not have any legislation which states that resources must be managed on a basin basis. The province of Manitoba does have legislation pertaining to basins or watersheds. This legislation, however, only applies when Rural Municipalities wish to create a Conservation District to manage their resources at a local level.

After a brief review of resource management authorities it becomes apparent that there are many role players in the management of the resources associated with the Buffalo Creek Watershed. To effectively manage the 16 kilometer study site the BPS&WMA needs to identify which agencies can help them to achieve their initiatives's purpose, goals, and objectives. Once this has been done the association can share information and responsibilities with others who have a vested interest in the management of the watershed.

From the perspective of institutional and policy red tape it would appear that smaller fragmented resource initiatives have several benefits. On a smaller scale BPS&WMA is working with people who are directly interested in the multiple resource initiative since it was their idea. Therefore the organization does not have to waste time or money recruiting supporters. Policies related to land use and tax structure can be more easily established within the confines of one Rural Municipality as conflicts over costs and benefits which could occur if two Municipalities were involved are avoided. It would also be easier to coordinate the roles of other interested resource management agencies as the BPS&WMA would be the coordinating authority. In the future the site could also act as a showcase of what could be achieved on a larger watershed scale should interest in the project be raised. Lastly and perhaps more importantly in these times of financial constraint it may be the cheapest method of preserving and enhancing part of a endangered ecosystem.

Chapter 7: Decision-Making Model

7.0 Overview

This chapter examines a procedure for developing and implementing initiatives like the BPS&WMA multiple resource use management plan for Buffalo Creek. There are many resource management organizations who use an ecosystem type approach in their operations. Examination of their methods of planning has revealed useful insights for devising a decision-making model. The "Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems" provides a seven step strategy for taking an ecosystem approach to development and management of fragmented environmental enhancement sites. The model can be used to develop comprehensive management plans and to develop and implement projects identified within a management plan.

7.1 Current Decision-Making Practices

Several resource management agencies were contacted to determine if and how an ecosystem approach was used in their operations. Two of these organizations were also asked how they would approach developing the BPS&WMA initiative. The resource organizations contacted included the Turtle River Watershed Conservation District, Whitemud Watershed Conservation District, as well as a representative from the North American Waterfowl Management Plan, and the Association of Conservation Authorities of Ontario. All of these organizations use an ecosystem type approach to management as specified in their mandates and as evidenced in their day to day operations.

Resource Management Organizations

North American Waterfowl Management Plan

Resource management initiatives under the North American Waterfowl Management Plan (NAWMP) are developed and implemented in a unique way. Operations for the organization are based on the theory of landscape ecology which is similar to the theory of hierarchy and ecosystems (Chapter two). Under the auspices of the NAWMP North America is broken into many landscape units, i.e. duck breeding and rearing areas. Each of the landscape units are different and are composed of different habitat variables. Under the theory of landscape ecology each of these landscape units interact and influence each other.

Planning for programs under the NAWMP are developed by the use of a computer planning tool patented by Ducks Unlimited. The computer tool is derived from a software program of a mallard production model. The model can predict how many mallard ducks an area with given characteristics will produce. Background information (existing conditions) such as amount of land cultivated, percent cover, and water bodies for a given area would be collected and entered into the computer tool. The tool then develops an image of the land unit and sends out information on the type of management the area should receive.

The recommended management goals, or objectives, may include intensive management strategies such as developing dense nesting cover, idle hay and pasture areas, and building of nesting structures. Extensive management practices such as marginal land conversion to habitat, promotion of delayed haying, green manuring and conservation farming may also be recommended (Prairie Habitat Joint Venture 1990 p.17). The computer tool develops a mix of these management practices and identifies where they could be applied in a given unit area.

The land unit area entered into the computer tool is usually quite large, (i.e. 100 square kilometers), so it is broken into smaller units, (i.e. 25 square kilometers), and a ground crew would then apply the management recommendations at the smaller local level. In short the model identifies where and what types of activities should be undertaken given the existing conditions entered in the computer tool. The ground crew then makes it happen. Implementation of the recommended management practices depends greatly on the extent that landowners are willing to cooperate with organizations associated with the NAWMP (Baydack pers. comm. February 1993).

It should be reiterated that the model used for planning is based on one species, i.e. mallards. There are, however, spin off benefits for other species that inhabit the same ecological niche. At present the NAWMP is evaluating these benefits as many resource agencies are concerned about other species associated with the prairie biome (Baydack pers. comm, February 1993).

Conservation Districts Manitoba

In Manitoba, Conservation Districts are based on watershed and Rural Municipality boundaries. Activities undertaken within Conservation Districts are implemented and managed on a watershed basis. Smaller projects, undertaken within a Conservation District, that are site oriented have some similarities with the BPS&WMA initiative. For example, smaller projects such as bridge building require the analysis of the upstream watershed and associated drainage area. Background information such as flood frequencies and aquatic habitat would have to be considered before a bridge is built (Boychuk pers. comm. February 1993).

The BPS&WMA initiative is similar because, before projects identified within the management plan can be implemented, an overview of the watershed may be required. For example, if sections of Buffalo Creek were to be dammed for water storage water use in the watershed would need to be examined.

The Turtle River Watershed Conservation District (TRWCD) does not have a detailed model or plan for developing and implementing small projects on a watershed basis. In general, however, projects do follow a certain method or progression. All water related projects require that the drainage area of a project site be examined. Background resource information such as land use, wildlife habitat, and environmental problems up and downstream of a project site need to be examined. Factors which could influence a project are then examined and mitigation measures are determined. For example, a bridge may have to have culverts sized to accommodate flash flood events. During the process of project proposal, background information collection, and project implementation, the TRWCD encourages public participation (Boychuk pers. comm. February 1993).

Wayne Hildebrand (1993), Whitemud Watershed Conservation District (WWCD), also stated that there is no model that the WWCD uses to manage smaller sections of land on a watershed basis. He noted further that the concept of riparian resource management is new to Manitoba and there would be little information on procedure for implementing small scale resource management initiatives.

There are many smaller scale projects which have been undertaken within the WWCD. In general, these projects require that background information on a site's watershed characteristics be collected. This information is then analyzed to determine if a project's proposed purpose and objectives are attainable (Hildebrand pers. comm. January 1993).

Conservation Authorities Ontario

In Ontario Conservation Authorities are, in most cases, based on a defined watershed area. Activities undertaken within a watershed area are planned for in much the same way as activities in Manitoba's Conservation Districts. In Ontario, however, the watershed planning unit has been broken into smaller sub-watershed units for some Conservation Authorities.

Sub-watershed planning takes watershed planning principles and applies them to a tributary or smaller watershed area to produce a sub-watershed plan. Watershed and sub-watershed plans are used in Ontario to help achieve a balance between the natural environment and land use changes associated with urban development. These plans identify the natural resources and development opportunities (potential projects) within a defined catchment area. This procedure helps to integrate resource management and land use planning concerns. Once a plan has been developed, it will identify the goals and objectives of the sub-watershed area and identify where development can and cannot occur while achieving stated objectives (Association of Conservation Authorities Ontario May 1992).

Projects similar to those identified in The Buffalo Creek Study Site Management Plan: Report Three have been undertaken in many Conservation Authorities in Ontario. Watershed and sub-watershed planning has made these types of projects easier to implement. Background resource information such as land use, natural resources, and environmental hazard areas in the watershed or sub-watershed have already been documented. This makes it easier to determine how a project will be influenced by the surrounding watershed ecosystem (McColl pers. comm. February 1993).

Conservation Authorities in Ontario have several programs to enhance environmentally degraded sites within defined catchment and watershed areas. For example, CURB (Clean Up Rural Beaches) is an initiative to clean up degraded waterfront environments. The CURB program is administered jointly by various Conservation Authorities and the Ontario Ministry of the Environment. The program is designed to address rural non-point and point sources of pollution. Implementation of this initiative has been aimed at rural septic and agricultural management practices. Activities undertaken through this program include restricting cattle access to waterbodies, monitoring manure treatment facilities, and treating milk waste water (Rideau Valley Conservation Authority July 1992).

Common Approaches

From examination of these resource management organizations it is apparent that an ecosystem or watershed approach to operations is used. All the organizations recognized the need to consider the external environment of projects which are implemented at a local level. Although there was no clear model as how to develop a management plan for smaller fragmented resource management initiatives, several common characteristics emerged. First, it is apparent that the purpose and objectives for any plan or project within a plan must be tailored to fit the ecosystem it is to be implemented in. To successfully meet this end background resource information on the ecosystem or watershed is required. This data must be analyzed to ensure that the purpose, goals and objectives of the initiative can be achieved within the context of the larger system, or at the very least to ensure measures can be taken to mitigate any impacts on or from the larger system.

It should be noted that each of the resource agencies depend greatly on public assistance. Public input is required for outlining a management plan's or project's need or purpose, developing goals and objectives and generating background information on the watershed. Public input also helps to ensure that there is communication among user groups.

7.2 A Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems

The previous section on Current Decision-Making practices and examination of data collected in Chapters two, four, five, and six has lead to the development of a procedure for implementing fragmented resource management initiatives. The following decision-making model identifies the steps which need to be taken to incorporate an ecosystem approach into the planning and management of small scale conservation oriented resource management initiatives - simply, how to develop and implement a plan to manage a small section of a larger watershed ecosystem.

To effectively undertake a small scale fragmented conservation oriented resource management initiative a management plan must be devised. The management plan will establish the relationship of the study area to the surrounding ecosystems. The plan will also identify projects which may be undertaken to meet the goals and objectives outlined in the management plan. The decision-making model, (Figure 7.1), can be followed when developing a management plan and within any plan for assessing specific projects prior to their implementation. For example, the NRI developed a management plan for the BPS&WMA and outlined specific projects within the plan, i.e. establish a buffer strip, to which the model can be applied.

There are several considerations which should be kept in mind when using the model for developing a management plan as opposed to assessing a project prior its' to implementation. When applying the model to a management plan, collection of background information should be limited to available data and not involve primary research. This is recommended to limit the cost of collecting information, prevent the collection of too much information, and to expedite the planning process. Once projects are prioritized within the broader plan the collection of information for each project may involve detailed field investigations as well as analysis of existing information. Once this is completed for each project the overall database on which to judge future decisions within the plan will have been supplemented.

Figure 7.1 A Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems

Input	Step
Public Input	**Step 1) Definition & Scope of Initiative** -purpose and scope defined. -need for a management plan and projects discussed -public comment/conflict identification and resolution.
Public Input	**Step 2) Establish Objectives & Goals** -goals and objectives identified. -actions to meet objectives.
Public Assistance	**Step 3) Background Information / Existing Conditions** -scoping of issues -on fragmented site and watershed/ ecosystem, ie. institutional, land use, resource characteristics etc.. -project identification/orientation.
Resource User and Management	**Step 4) Site Analysis & Impact Identification** -factors which could influence the fragmented study site identified; natural and human. -determine what can be achieved given outside impacts to study site.
Resource User and Management	**Step 5) Plan/Project Evaluation** -does this project fit into existing conditions of watershed and site. -is mitigation possible yes/no ? -actions and objectives discussed with public. -modify goals and objectives to fit plan/project. -if plan/project cannot be modified project may need to be cancelled.
	Step 6) Project Implementation -plan/project is ready for implementation. -monitoring and evaluation criteria established.
Resource Management Input	**Step 7) New Initiatives** -new issues/problems emerging.

Public input from residents outside of the fragmented study site is very important when developing a management plan. From a planning perspective it is important to identify other resource users and determine their impact on the fragmented site, as evidenced in Chapters four and five. Input from the local public, i.e. landowners, in the study site area will also be critical to any project analysis. At the project level local public input will be critical to acceptance of any proposed activity.

Discussion of the Model

As shown in "The Decision-Making Model for Management of Fragmented Sites Within Larger Watershed Ecosystems" (Figure 7.1) has seven major components as detailed below:

Step 1) Definition and Scope of Initiative

Step one is an education and information gathering step. This step is designed to educate the public of the need to address an issue or problem, collect information on a procedure for addressing the issue/problem (how the problem will be solved), and to identify potential conflicts which could arise in the solution of the problem or issue and how they might be resolved. In step one the purpose and scope of the initiative which is to be undertaken is developed.

Step 2) Establish Objectives and Goals

To successfully achieve the desired purpose of a management plan or project within a plan objectives need to be established. In either plans or projects this will involve the establishment of a specific list of objectives and goals that provide the incremental steps to achieving the established purpose of the plan or project.

Step 3) Background Information/Existing Conditions

The next step in the model is to gather information on the fragmented study site and the broader watershed ecosystem it is part of. Background information helps in determining how the natural and human characteristics interact within the study site. This is important data to know when developing management plans and projects to ensure that actions to meet objectives are clearly thought out.

Collection of background information also has an important secondary component; it helps to establish lines of communication with other resource user and management organizations in a given watershed ecosystem.

In general, background information for a management plan should contain data on watershed ecosystem description, previous inventories, and data on existing and historical conditions. Information collected for plans may include data on the drainage area of the watershed, location of proposed developments, natural features, land uses, institutional arrangements, resource health, environmental hazards, etc.. It has been noted that specific projects identified in a management plan will likely require information from sources other than existing data banks, i.e. resource management organizations, field survey and analysis etc..

While background information is being collected the organization should be generating ideas (projects) of how to achieve their goals and objectives. When devising a plan, projects which may be undertaken within a plan should be identified. When developing projects background information needs to be reviewed to determine project orientation.

To limit the amount of data for management plans, or specific projects, scoping exercises can be undertaken. Scoping of issues or ideas allows the agency in charge of an initiative to determine exactly what types of data need to be collected to create a plan or implement a project.

Establishing the existing conditions was very important in the development of The Buffalo Creek Study Site Management Plan: Report Three, as it allowed the NRI team to develop the management plan while conceptualizing the broader watershed ecosystem.

Step 4) Site Analysis and Impact Identification

This step in management plan or project development is designed to identify past, present, and future factors which could influence the purpose and objectives of an initiative. In short, this step highlights what needs to be considered when developing and implementing a fragmented environmental enhancement initiative. Review of data collected in step three and examining conflicts identified in step one will aid in determining factors which have the potential to influence a management plan or specific project. (See Chapter five, factors which have the potential to impact water quality and quantity at the BPS&WMA study site). The ultimate goal of step four is to identify factors which need to be considered for developing a plan or implementing a project.

Step 5) Plan/Project Evaluation

Organizations who are developing a management plan or project within a plan need to determine if what they are proposing can be accomplished given identified impacts, i.e. can the purpose and objectives of an initiative be achieved in the sub-watershed unit?; can the impacts be mitigated?

It is at this step in the model that a management plan or a project may require re-evaluation and modification. If it becomes apparent that the management plan, or project, purpose and objectives cannot be achieved within the context of the watershed or study site mitigation or modification may be required. Mitigation would involve trying to resolve an identified impact. For example, land stewardship practices outside the BPS&WMA study site may be impacting the health of the environment found at the study site. A mitigation measure might be to prepare an information package giving an outline of the BPS&WMA initiative and practical soil and water conservation measures. Modification of the plan or project may mean those using the model have to go back to step two and develop new goals and objectives. If impacts cannot be mitigated or the plan or project cannot be modified it should probably be cancelled.

Step 6) Plan/Project Implementation

When an initiative has reached step six actions to achieve the objectives for a management plan or specific project will have been developed and should be in the process of implementation. Projects implemented at step six should be monitored and an evaluation program should be put in place to determine how effectively established goals and objectives are being met.

Step 7) New Initiatives

When an initiative has reached step seven the purpose and objectives of the management plan will have been achieved. The monitoring and evaluation of past projects will reveal insights for other fragmented conservation resource management initiatives.

When a management organization has reached this step in the model it may wish to create a new management plan or undertake new projects. The organization would identify new issues and problems occurring within the fragmented site they are managing. Once this was done the organization would move back to step one in the model and repeat the process discussed.

Application of the Model

The following section will examine how the decision-making model could have applied to the BPS&WMA multiple resource use plan and projects identified within the plan.

Plan

Step 1) Definition and Scope of Initiative

The BPS&WMA developed its' own purpose and scope (section 1.0, p.5) for initiating a strategy to deal with the environmental issues and problems associated with a 16 kilometer stretch of Buffalo Creek. The lack of public input in step one meant that the public was not educated as to why the multiple resource use plan was being developed and conflict identification and resolution were not discussed.

Step 2) Establish Objectives and Goals

The BPS&WMA also established objectives and goals for their multiple resource use plan. Once again, this was done without public input. The Association also established preliminary actions to meet their objectives without public consultation.

Lack of public input in steps one and two may be the reason why the BPS&WMA is experiencing some resistance to the implementation of <u>The Buffalo Creek Study Site Management Plan: Report Three.</u>

Step 3) Background Information/Existing Conditions

It was at this step that the NRI study team became involved with the BPS&WMA multiple resource use plan. The NRI team began collecting data on the fragmented study site but did not take a detailed look at activities and data available on the broader watershed ecosystem. Due to this narrow approach some of the potential impacts to the study site from the larger watershed were not assessed as to their full impact. For example, the potential for conflict among water users in the Buffalo Creek Drainage Basin is greater than the study team thought. (See Chapter five).

To aid in assessing potential impacts from the broader watershed ecosystem to the study site the study team could have used a scoping exercise recommended in step three of the model. The study team could have scoped all the potential impacts on a preliminary level and determined the most significant impact. Once this was done the most significant impact could have been more thoroughly investigated.

Step 4) Site Analysis and Impact Identification

The Site Analysis and Impact Identification Step in the model allows plans, and projects within plans, to be developed with a greater degrees of certainty. The model allows an organization to develop a plan or a project within the existing conditions of the watershed ecosystem. Site analysis and impact identification allows an organization to determine if the objectives of a plan can be met and what types of projects can be implemented. In short, step four determines what can be achieved given outside impacts to a study site.

Some of the projects recommended within the management plan developed by the NRI for the BPS&WMA were recommended with varying degrees of certainty. Projects mentioned in the management plan such as establishing pool and riffle sites depend greatly on the activities of upstream and downstream water users. The NRI management plan did not detail issues concerning water use outside the study site therefore this project is recommended with some degree of uncertainty. It should be noted that the NRI management plan did state that some projects identified within the plan would require more data from the broader watershed ecosystem before they could be implemented.

The development of <u>The Buffalo Creek Study Site Management Plan: Report Three</u> generally follows the remaining procedures outlined in steps five and six of the model. The objectives of the management plan and projects to achieve the objectives were identified and discussed with the public. The goals and objectives did not have to be modified to fit the plan. Currently the BPS&WMA plan is at step six and projects are being implemented, but no process for monitoring and evaluation has been established.

It must be highlighted that two of the procedures in step five of the model were not followed when the NRI prepared the management plan for the BPS&WMA. Mitigation measures are not discussed in the management plan due to the fact that impacts from the broader watershed ecosystem were not completely identified. Lack of data on impacts would also make it difficult to determine if the current plan fits into the existing conditions of the watershed ecosystem and fragmented site.

Step Seven is not applicable to The Buffalo Creek Study Site Management Plan: Report Three. The NRI plan takes the BPS&WMA initiative from year one to infinity. The decision-making model creates a process for developing new plans once an initiative's purpose, goals and objectives have been met. The model could develop a plan from year one to infinity, however, it is more likely management plans would be devised in blocks of several years or decades. Management plans developed with shorter time frames could have advantages such as an increased degree of certainty for projects, ability to deal with contemporary issues, and ability to reflect economic situations.

Projects

The decision-making model can also be applied to projects identified within a management plan. The management plan will identify and prioritize projects which could be undertaken to meet desired objectives. The model would aid in developing a strategy for implementing these projects on a ecosystem approach basis. For example, a project suggested in <u>The Buffalo Creek Study Site Management Plan: Report Three</u> was the implementation of a buffer strip between Buffalo Creek and agricultural land. The buffer strip was suggested to meet BPS&WMA objective; filter sediment and agricultural pollutants.

The following example will discuss preliminary considerations for implementing a buffer strip project, as established through application of the decision-making model.

Step 1) Definition of Scope and Initiative

The purpose of the buffer strip would be to filter sediment and agricultural pollutants draining agricultural land. The scope of the project might be a 10 meter wide buffer strip of vegetation on either side of Buffalo Creek for the entire 16 kilometer study site. The need for the project could be established by educating landowners within the 16 kilometer stretch about environmental problems associated with the creek.

Step 2) Establish Goals and Objectives

The main objective might be to establish a continuous strip of vegetation on either side of Buffalo Creek for 16 kilometers. Goals for the project might include buying land as it becomes available, designing voluntary agreed upon buffer strip and mandatory buffer strip areas, reducing 15 % of the agricultural pollutants reaching the creek, etc..

Public input in steps one and two is critical to project development. Activities pertaining to a project may have direct impact on members of the public, i.e. landowners, at or near a project site. Therefore, it is very important that the public be included in the decision-making process. Activities such as conflict identification and resolution, in step one, are important to ensure successful implementation of a project.

Step 3) Background Information/Existing Conditions

An organizations first action in step three would be to consult the management plan for background information on existing conditions to aid in project orientation. The organization would then scope the issues pertaining to the particular project to determine what other types of background information are required. The buffer strip project may require data on site specific characteristics such as soil type, which would be attained through field testing. Other resource management organizations may also need to be consulted to determine things such as the best type of grass to plant for a buffer strip.

Step 4) Site Analysis and Impact Identification

At this step factors which have the potential to influence buffer strip implementation need to be identified. Impacts to the buffer strip could range from floods, drought, and policy issues to more specific impacts within the study site such as willingness of landowners to participate in or sell land for the buffer strip. It is also important to consider the impact that a project may have on the study site and broader watershed. For example, a buffer strip could improve habitat for agricultural pest species such as grasshoppers and blackbirds.

Step 5) Project Evaluation

At this step in project development the BPS&WMA would determine if establishing a buffer strip was possible given the existing conditions of the watershed and study site. In particular it must be determined if identified impacts are significant or if mitigation is possible. For example, a mitigation measure for agricultural pests in a buffer zone might include prescribed burns or chemical spraying.

When examining factors raised in step four it may be decided that a continuous buffer strip for 16 kilometers is not possible, however, a fragmented buffer strip is possible. The fragmented strip will still meet the purpose of the project, i.e. filtering sediments and agricultural pollutants. The goals and objectives would then be modified to fit the existing conditions of the project site. For example, the objective of the project may be changed to establish a buffer zone along the Creek when land becomes available through purchase or landowner participation.

Step 6) Project Implementation

At step six the project is being implemented, i.e. the buffer strip is being developed at various sites throughout the 16 kilometer study area. Prior to project implementation a criteria to monitor and measure the project success in meeting goals and objectives should be established.

Step 7) New Initiatives

Step seven of the model allows for new projects such as establishing water retention structures to be developed.

7.3 Summary

The decision-making model has components which can aid in the planning and development of small scale conservation oriented resource management initiatives. The BPS&WMA should use the model to develop and implement projects identified in The Buffalo Creek Study Site Management Plan: Report Three. The model requires a coordinating authority, background information, public input, and communication among user groups.

Watershed size will likely play a role in the effectiveness of using the model. A large watershed may make it difficult or time consuming to collect background resource information. It might also be difficult to incorporate the public and user groups into the planning process. However, scoping of the issues which need to be addressed to meet plan or project objectives may work when dealing with a larger watershed. In any event the decision-making model would be effective in planning small scale fragmented resource management initiatives within small watershed or sub-watershed areas.

Chapter 8: Merits of Fragmented Approaches to Natural Resources Management

8.0 Overview

The last phase of practicum research involved evaluating the management plan prepared by the NRI study team in light of the identified concerns regarding watershed impacts and discussing the validity of fragmented environmental enhancement initiatives. Evaluation of the BPS&WMA management plan involved examining the Buffalo Creek Study Site Management Plan: Report Three and discussing the utility of the document with the BPS&WMA president. A current status report of the initiative is also provided. The discussion on the validity of managing small sections of larger watersheds/ecosystems involved commenting on the ecosystem approach to management, examining the management of fragmented systems, and looking at the issue of environmental integrity. Chapter eight concludes by outlining some of the direct benefits of managing a small section of the Buffalo Creek Watershed.

8.1 Evaluation of the Buffalo Creek Study Site Management Plan: Report Three

Upon review of the Buffalo Creek Study Site Management Plan: Report Three it is obvious that the job done by the NRI was successful from a planning perspective. By conceptually identifying impacts to the BPS&WMA study site the NRI study team was able to effectively develop the management plan.

The more in depth examination of potential impacts to water quality and quantity undertaken for this practicum revealed new information concerning impacts. For example, the Stanley nuisance ground is a potential impact that was not identified when developing the management plan for the study site. The extent of the riparian zone being used for livestock benefits and the potential for conflict over water allocation were two impacts mentioned in the management plan that are more serious than was originally thought.

Actions recommended by the study team in the management plan to meet the desired objectives would have mitigated for any lack of information on impacts. For example, actions recommended to the BPS&WMA in the first year of project development were designed to take a more holistic, or watershed approach, to managing the study site. Implementing action 5.1.1. "Distribute the management plan to the public and any other parties who may have interest", and action 5.1.4., "Contact groups and individuals who use the resources of Buffalo Creek upstream of the study site," would have revealed information on the potential for water allocation conflicts. The fact that there is a municipal dump in a headwater tributary of the creek would have likely also been discovered.

Chapter six of the Buffalo Creek Study Site Management Plan: Report Three, "Considerations for Implementing the Management Plan," offers recommendations for implementing actions such as establishing a buffer strip of native vegetation. This chapter also puts into context the degree of effectiveness actions implemented would have in meeting the BPS&WMA objectives. For example, the section on water management mentioned that various measures undertaken to improve water quality would have limited success due to the fact there are negative influences from outside the study site.

Follow up to the Buffalo Creek Management Plan

Jake Enns, president BPS&WMA, (April 1993) has indicated that the initiative is now at stage one of implementation. The plan was not implemented in the spring of 1992 because the management plan completion date coincided with spring seeding. As a result members of the BPS&WMA were to busy to review the management plan in detail. In the fall of 1992 the BPS&WMA passed the duties of implementing the management plan on to the newly created Buffalo Creek Management Board. The Board is composed of one member of the BPS&WMA executive, one councillor from the community of Altona, and three landowners who live along Buffalo Creek. The BPS&WMA had requested that a representative from the R.M. (Rural Municipality) of Rhineland be on the board, however this request has been denied.

One member of the Buffalo Creek Management Board has offered speculative reasons as to why the representative from the R.M. of Rhineland declined to be on the board. Traditionally representatives from the Municipality have been involved in ditching and drainage activities and the Municipality may be apprehensive about breaking with tradition. In the past representatives from the Municipality have recommended the removal of vegetation in Buffalo Creek to prevent ice jams and associated flooding (Dangerfield et. al. 1991 p.38). Enhancing the natural vegetation at Buffalo Creek has generated fear of the unknown for some individuals in the Municipality. Questions have been raised as to the impact this plan will have on agriculture surrounding the site. For example, will the buffer strip project enhance habitat for agricultural pest species. Members of the R.M. of Rhineland council likely do not want to support the plan because benefits, and more importantly any negative impacts, are unknown.

To date the following actions have been implemented: action 5.1.1. "Distribute the management plan to the public and any other parties which might be interested", copies of the management plan have been placed in the Altona public library and are available at the BPS&WMA office; action 5.1.2. "Establish a management group", the Buffalo Creek Management Board has been established with the sole mandate of implementing the management plan; action 5.1.3. "Apply for outside assistance", the management board has received funding from lotteries; and action 5.1.4. "Contact groups and individuals who use the resources of Buffalo Creek upstream of the study site", the Agassiz Irrigation Association has been contacted to identify the BPS&WMA as an area which could be impacted by the expansion of irrigation in the Buffalo Creek Watershed. Several waterways within the study site that were experiencing erosion were also grassed in the summer of 1992 by the BPS&WMA.

Current activities planned for 1993 include designing and implementing a Voluntary Agreement Buffer Strip (VABS), solicitation of funding from various sources for land purchase, and developing an education program to increase public support and awareness for the initiative. Jake Enns (April 1993) has stated that so far the management plan has been useful for developing the initiative.

8.2 Validity of Small Scale/Fragmented Approaches to Resource Management:

In regard to small scale multiple resource use management/environmental enhancement, most would agree there is little merit in managing a small section of a larger ecosystem unless the ecosystem's interaction with the smaller component is first examined. From a watershed ecosystem viewpoint areas upstream of a study site will influence water quality and quantity found at the site. In the case of the BPS&WMA study site it has been established that land stewardship practices upstream are influencing, or have the potential to impact, environmental conditions found there. Regardless of this fact, however, there is merit in managing a small section of the Buffalo Creek Watershed if planning is done properly. The decision-making model discussed in Chapter seven is an ecosystem oriented process which can be used as a tool to plan and manage smaller components of larger systems.

To help ensure that a smaller scale project or initiative succeeds the ecosystem approach can be used as a tool in project development and implementation. Using the ecosystem approach allows a site to be planned while taking into consideration the issue of environmental integrity. In south central Manitoba there is the potential to apply the ecosystem approach to manage fragmented natural areas. This could help to maintain and enhance the biodiversity of the region.

Literature examined and consultation with experts in the field of habitat preservation, conservation, and enhancement indicated that small patches of natural biota provide many benefits and are worth preserving. Benefits would include the fact that these areas provide habitat for native wildlife species, provide recreation opportunities, and help to assimilate agricultural pollutants. From an institutional standpoint smaller approaches to resource management allow local residents to address issues which concern them. The BPS&WMA initiative has the potential to advance the field of riparian resource management in the province of Manitoba.

Ecosystem Approach:

To give merit or validate the management of a smaller section of a larger watershed ecosystem, the ecosystem concept or ecosystem approach can be used in planning and development. Under the ecosystem approach the ecosystem is seen as the basic functional planning unit and therefore must be taken into consideration when making decisions. Once defined, the ecosystem can be seen as connected to the biosphere by a series of inputs and outputs. Energy and matter such as radiant energy, water, gases, chemicals or organic material are moved through the ecosystem boundary by meteorological, geological, and or biophysical processes. The living and non-living components of the ecosystem are linked by food webs and chains promoting the flow of energy. Also included in the input/output equation are the human aspects of ecosystems such as land use, environmental policy, and resource management agencies.

Literature examined for this practicum on the topic of environmental enhancement identified that the use of the ecosystem concept in planning and management of natural areas is important. Cairns (1988) has suggested that any type of environmental enhancement must be planned at the ecosystem concept level. This is required to ensure initiative success as factors which have the potential to influence a site must be examined. Holgate and Woodman (1976) also have several recommendations that are required when planning rehabilitation, restoration, and/or reclamation for key species. One of these recommendations is that land use surrounding a site be examined for potential impacts to the environmental enhancement site.

Saunders (1991) states that emphasis in the literature has been on the design of nature reserves, but we are usually to late to do anything except try to maintain the remnants left following fragmentation. This fact creates several problems when trying to manage a natural area. In particular, the switch from predominantly internally driven to predominantly externally driven dynamics is a key factor in fragmented systems. The fragmented system is part of a larger system which may have different biological characteristics. The impact of these external characteristics must be taken into consideration when managing a fragmented site and the ecosystem approach allows this to be done.

As previously noted the south central region of Manitoba is a unique area because most of the former native grassland ecosystem has been converted to an agricultural ecosystem. The region has less than 10 % of the native vegetation remaining, which is restricted to areas which cannot be accessed by farm machinery or livestock. Due to this fact, management of fragmented systems found there has merit.

Saunders (1991) suggests that management of fragmented systems has two basic components; i) management of the natural system, or internal dynamics of remnant areas, and ii) management of the external influences on the natural system. For large remnant areas, the emphasis should be on managing the internal dynamics, including for instance the disturbance regime and population dynamics of key organisms. For small remnants on the other hand, management should be directed primarily at controlling the external influences. This is not to say that external influences are not important for larger remnants. The BPS&WMA site can be considered a small remnant of the former tall grass prairie ecosystem. External influences to this remnant area are documented throughout this practicum and in the Buffalo Creek Study Site Management Plan: Report Three.

All of the resource management agencies surveyed for development of the decision-making model used an ecosystem or watershed approach in their operations. For example, Manitoba's Conservation Districts and Conservation Authorities in Ontario plan smaller projects within the context of larger ecosystems or watersheds by using an ecosystem/watershed approach. The approach used by the various agencies range from identifying a broad number of ecosystem characteristics to more refined study of certain ecosystem characteristics. Several common characteristics of the approaches include; knowledge, a holistic perspective interrelating systems at different levels of integration, and promotion of policies and managerial practices that relate people to the ecosystems they are part of. Projects as simple as building bridges require assessment of watershed characteristics to ensure that it can handle natural events such as storm surges or floods.

In the decision-making model the ecosystem approach to planning is recommended at all steps of plan or project development. The model strives to bring the human and natural components of the ecosystem together. Steps one and two look at human desires or management needs of a given area. In step three of the model, background information is collected which is important for examining the environmental integrity of a plan or project site. Step four and five involve examining the plan or project in the context of the ecosystem it is part of. Step seven of the model allows future plans and projects to be developed using an ecosystem type approach.

The major component of the ecosystem approach is baseline data. Information on natural and human characteristics such as climate, geology, land use, and institutional and policy arrangements is essential for several reasons. First it allows the planning agency to have a better understanding of the site and the ecosystem's or watershed's relationship. This allows the agency to make more informed decisions on how to achieve the goals and objectives of a plan or project. In short it allows you to determine what you can and cannot accomplish at the smaller site. The process of collecting information also helps to establish communication links with other resource user groups and management agencies in the watershed ecosystem area. This allows for a human component to the ecosystem approach.

Ecosystem Integrity:

One argument that opponents of fragmented or small scale resource management initiatives may have is the issue of environmental or ecosystem integrity. This relates to the ability of a natural system to function as a self regulating unit. Areas that are not planned for with environmental integrity will require human management to keep the system functioning in equilibrium.

The BPS&WMA site is not large enough to contain the full range of variables/perturbations to keep the natural system functioning without human intervention. Prescribed burns will be required maintenance should a tall grass prairie be established at the site. If wildlife species begin to create problems at the site human intervention will be needed, i.e. if the population of beavers at the site becomes to high, trapping and removal may be necessitated. Ensuring that an adequate amount of water is supplied to the site will require the BPS&WMA establish communication networks with other user and management groups in the watershed.

The definition of small scale or fragmented given to the BPS&WMA site is arbitrary. The entire watershed could be considered small or a fragmented in relation to the prairie biome or grassland ecosystem as various factors will influence the environmental conditions found at the Buffalo Creek Watershed. For example, periodically during years of high precipitation water from the Pembina River Watershed escapes into the Buffalo Creek Watershed. Management of fragmented areas or sections of a larger systems have merit as long as impacts to a site are identified or conceptualized so initiatives can be planned around the external influences.

To address the issue of ecosystem integrity the decision-making model and the Buffalo Creek Study Site Management Plan: Report Three have measures to meet the two aspects Beechy (1989) has stated as required for planning natural areas with environmental integrity. The first aspect pertains to the inclusion of critical processes that are necessary for maintaining communities and species within an area. Dynamic systems must be considered where dramatic physical processes dictate the structure, composition and succession of constituent communities. For example, it has been noted that seasonal and periodic flood events may be required to flush sediments from catchment areas within the BPS&WMA study site. This natural event helps to maintain fish habitat by removing sediments from spawning grounds. The Buffalo Creek Study Site Management Plan: Report Three also noted that human maintenance will be required to establish and maintain native tall grass prairie species planted at the site.

The second aspect proposed by Beechy (1989) pertains to land use surrounding a preserve site, i.e. agriculture is an activity which can contribute sediments, chemicals and nutrients to special ecological areas impacting their health. The decision-making model takes into consideration factors from outside a fragmented site that have the potential to influence a desired project. It also takes into consideration the impact that activities at a site may have on the larger ecosystem, i.e. in step five does-model fit into existing conditions. This aspect is also considered in the Buffalo

Creek Study Site Management Plan: Report Three as the success of reaching several of the proposed objectives is noted as being limited by land uses upstream of the project site.

Direct Benefits of Small Scale or Fragmented Projects:

While devising the management plan and collecting research for this practicum, it has become apparent that small scale fragmented environmental enhancement initiatives have several benefits. These benefits include: maintaining and enhancing the biodiversity of organisms; potential for research into riparian resource management; easier to get public interest groups involved (more local "free" hands); and several policy and regulation advantages.

Diversity

From a wildlife diversity perspective management of smaller sections of natural habitat like the BPS&WMA site are very important. All of the wildlife habitat organizations contacted stated that in south central Manitoba it is valid to manage fragmented patches of natural area and try and protect what is not being impacted by the larger agricultural system. In this region of the province patches of the grassland ecosystem are all that remain to support native wildlife species. Maintaining these refuges will play an important role in maintaining the biodiversity of the region. The wildlife organizations contacted indicated that riparian zones provide terrestrial and aquatic habitat making them very productive natural systems (Jones pers. comm. April 1993).

In the past riparian areas in south central Manitoba have been viewed as a forgotten resource and these areas have been ditched and drained. There has been little attempt to manage any remaining natural areas (Jones pers. comm. April 1993). The lack of attempt to manage these regions exemplifies a larger problem in the prairie provinces which is that the most endangered areas are privately owned. To add to this problem most wildlife and habitat organizations have not thought of effective ways of co-managing these areas with landowners. In general, wildlife habitat organizations tend to back off when the land is privately owned (Barber pers. comm. April 1993).

However, landowners are beginning to realize that riparian areas in a natural state are refuges for native wildlife species, have capabilities to assimilate agricultural pollutants, and are recreational areas. As a result, there has been a movement in the prairie provinces to try and manage these areas. The trend can be evidenced by the BPS&WMA initiative and the fact that the PFRA wanted to use the Buffalo Creek Study Site Management Plan: Report Three as an example for other multiple resource use management plans. The BPS&WMA initiative shows that some landowners are willing to manage these areas provided that local interests are represented.

Research

Since the concept of riparian resource management is new to

Manitoba there are unique opportunities to advance this field of resource management.

One advantage that smaller scale initiatives have is that they are not as threatening as larger scale developments. While developing the Buffalo Creek Study Site Management Plan: Report Three it was apparent that local residents were concerned about pests such as grasshoppers and blackbirds. By improving habitat at the BPS&WMA site they felt there would be improved habitat for agricultural pest species. This example illustrates a larger problem mentioned earlier, namely, what will be the impact of the BPS&WMA initiative be on the larger agricultural ecosystem it is part of? By targeting a small scale site an idea or new concept can be tested. In the case of the BPS&WMA initiative it would be a showcase of the benefits and problems associated with riparian resource management in southern Manitoba. From a monetary standpoint it would also be less expensive to target smaller areas. If a small scale initiative were to fail less money would be lost.

From a scientific or hard data research perspective the BPS&WMA site offers opportunities for further research into riparian resource management that would add to a data base. The effectiveness of a buffer strip of natural vegetation to filter agricultural pollutants coming from adjacent cropland could be monitored. There is also an opportunity to monitor the pollution filtering capacity of the BPS&WMA study site. The quality of water entering and exiting the site could be sampled and compared.

An added bonus of examining natural systems in the grassland biome is that they are high speed systems. The rates of biomass production, dying off of plants, and intake of nutrient elements are higher than those of other ecosystem types. This has implications because results of activities such as rehabilitation of natural vegetation will show up faster as compared to slower evolving systems such as a coniferous forest.

Policy

As mentioned in Chapter five, managing the Buffalo Creek Watershed would be difficult for several reasons. The main reasons being i) current jurisdictional boundaries do not coincide with watershed or ecosystem boundaries, and ii) resource management agencies do not function in sync as a cohesive management unit.

The Watershed is located in two different countries and falls within the boundaries of two Rural Municipalities in Manitoba. This means to manage the watershed on a ecosystem/watershed basis co-ordination between various levels of government would be required. This could be a time consuming and expensive proposition.

To further complicate matters there are several resource management groups and agencies responsible for the managing the resources in the Buffalo Creek Watershed. The PFRA, MbDNR Fisheries, Wildlife, and Water Resources Branches, Manitoba Agriculture, and local soil and water organizations are just a few of many entities who manage resources in the watershed. At present outside of a conservation district there is no mechanism for coordinating activities of these groups on a watershed ecosystem basis.

Management of smaller sections of larger watersheds/ecosystems have several benefits from a policy or institutional perspective. When the site to be managed falls within the jurisdiction of one Rural Municipality resource management policy and regulation for the site can be more effectively established. Rural Municipalities have special powers to place restrictions on land use in addition to existing federal and provincial regulations. For example, Rural Municipalities can pass by-laws regulating what types of activities are permitted or prohibited in certain areas. Having one Rural Municipality responsible for managing an area avoids conflicts which could occur when sites are interjurisdictional, i.e. one Rural Municipality may want to prohibit a particular land use the other may not.

From the perspective of a coordinating authority smaller scale initiatives have benefits. The BPS&WMA has the ability to co-ordinate and interact with resource groups and agencies to reflect local interests. Once their sphere of jurisdiction, i.e. site has been defined they can coordinate the activities of resource management groups who have special interests in the study site. The coordinating authority also has the ability to address concerns of other creek user groups as well as expressing their own concerns.

An added bonus of smaller local management is that local concerns can be effectively addressed by locals. It is not the government telling them what is to be done it is their friends and neighbours. Also a smaller site means that there are fewer landowners to deal with for implementing specific projects. This has advantages in the BPS&WMA initiative as the plan does not have unanimous support by local residents.

8.3 Summary

The documents provided to the BPS&WMA have been useful in developing their fragmented environmental enhancement initiative. However, The Buffalo Creek Study Site Management Plan: Report Three would have been a stronger document had the study team used the decision-making model identified in Chapter seven. If the model had been used, more public support for the initiative might have been generated (Steps one and two of the model). Potential impacts to the BPS&WMA study site would have also been more thoroughly investigated.

The decision-making model uses an ecosystem approach for developing small scale initiatives. The model helps to plan local initiatives while considering the issue of environmental integrity. Literature on the topic of environmental enhancement has suggested that initiatives of this type must be planned at the ecosystem concept level.

In south central Manitoba, managing smaller components of larger systems has merit for many reasons. Two of these reasons are it helps to maintain biodiversity and it offers opportunities for research in the area of riparian resource management. Fragmented approaches to small scale resource management initiatives should, however, follow the decision-making model for greatest success.

Chapter 9: Summary and Recommendations

9.0 Overview

The research for this practicum fulfils the study objectives outlined in Chapter one. Factors located within the Buffalo Creek Watershed that have the potential to influence water quality and quantity at the BPS&WMA site have been identified. A "Decision-Making Model" for identifying what should be considered when taking a watershed ecosystem approach to fragmented environmental enhancement initiatives was developed. The policy implications of taking a watershed ecosystem approach to natural resources management in south central Manitoba has been examined on a preliminary level. The validity of managing a small section of a larger watershed ecosystem has also been discussed. Each of the objectives was met through data collection and analysis during several phases of practicum research

9.1 Summary

Phase one of the research involved examining the existing conditions of the Buffalo Creek Watershed to determine factors which could influence water quality and quantity at the BPS&WMA site. From examination of the human and natural characteristics of the watershed, the following were identified as having the potential to influence water quality and quantity: lack of information; natural phenomena; land stewardship practices; irrigation; and current resource management strategies.

Of the impacts to water quality and quantity at the site irrigation and current resource management strategies are the most significant. Irrigation has the potential to alter existing flow regimes and concentrate chemicals draining off of irrigated land. Current resource management strategies also present the potential for conflict should a drought occur. Water has been allocated on an incomplete database and the Water Rights Act is unclear as to amounts of water which can be withdrawn from the creek for domestic purposes.

Phase two involved examining the policy and legislative implications of taking a watershed ecosystem approach to natural resources management in south central Manitoba. This involved examining federal and provincial policy and legislation related to basin management and identifying the various entities which have promoter and regulative roles over resources within the watershed. These groups include; landowners, local soil and water associations, various levels of government, and special interest groups. The institutional or policy implications of taking a watershed ecosystem approach to managing the Buffalo Creek Watershed was also discussed on a preliminary level.

In general there are two main institutional stumbling blocks that would make the management of Buffalo Creek on a watershed ecosystem basis difficult. These stumbling blocks are; i) current jurisdictional boundaries do not coincide with watershed or ecosystem boundaries, and ii) resource management groups in the watershed do not function in sync as a cohesive unit.

Phase three involved the development of a decision-making model. Development of the model involved looking at several resource management organizations who use ecosystem approaches to management. Planning for initiatives by each of the organizations usually includes the following procedure; i) collection of background information on study site and the ecosystem or watershed it is part of, ii) data is then analyzed to ensure that the purpose, goals, and objectives of an initiative can be met within the context of the larger system, iii) mitigation of any external influences to a study site are discussed iv) followed by plan or project implementation.

From the examination of the various resource management organizations a seven step model was devised for developing fragmented environmental enhancement initiatives. The seven steps are: Definition and Scope of Initiative; Establish Goals and Objectives; Background Information/Existing Conditions; Site Analysis and Impact Identification; Plan/Project Evaluation; Project Implementation; and New Initiatives. To use the decision-making model the following components are required; a coordinating authority, background resource information, public input, and communication among user groups. It was noted that the models effectiveness in planning and managing a smaller site may decrease as the area defined as an ecosystem or watershed increases.

The last phase of practicum research involved commenting on the validity of managing a small section of a larger watershed ecosystem. This involved commenting on the utility of the Buffalo Creek Study Site Management Plan: Report Three presented to the BPS&WMA. It also involved examining literature and soliciting expert opinion on the validity of managing small sections of larger ecosystems.

Concerning the first issue, utility of the management plan, the BPS&WMA has found the documents provided to them useful in initiating their multiple resource use management plan. The Association has been following the stages and actions in the order they are presented in the Management Plan. At present, duties of implementing the multiple resource use plan have been passed on to the newly created Buffalo Creek Management Board.

Commenting on the validity of managing a small section of a larger watershed revealed the following conclusions. From the examination of institutional problems associated with watershed management several benefits of small scale initiatives were presented. One of the advantages being that the local initiatives could be managed more easily especially when the study site is located in one Municipality. In south central Manitoba, fragmented sections of natural habitat are all that remains of the natural ecosystem and these areas are worth preserving because they provide wildlife habitat, recreation opportunities, and help to assimilate agricultural pollutants. The direct benefits of the BPS&WMA initiative to the province of Manitoba was also noted. The benefits mentioned include opportunities for further research into riparian resource management and local control over local resources. It must be highlighted that to ensure fragmented environmental enhancement initiatives are successful the ecosystem approach developed in the decision-making model should be used.

9.2 Recommendations

1. That the decision-making model be used for planning small scale fragmented environmental enhancement initiatives within the context of a larger watershed or ecosystem throughout Manitoba.

2. That the Manitoba Department of Natural Resources and other government agencies share duties in the management of the BPS&WMA study site. The Buffalo Creek Management Board should coordinate implementation of the management plan and the governments of Canada and Manitoba should provide monetary and expert assistance for the initiative.

3. That the BPS&WMA become involved in the environmental assessment process associated with the Agassiz Irrigation Associations proposed expansion. The Manitoba Department of

the Environment and the Manitoba Department of Natural Resources should also be contacted by the BPS&WMA to determine/define their role in the management of the BPS&WMA portion of the Buffalo Creek Watershed.

4. That an education program be developed by the PFRA and Manitoba Agriculture that highlights the importance of maintaining natural riparian areas in south central Manitoba for multiple resource benefits such as maintaining biodiversity, recreation, and agricultural pollution filtering capacities. The program should also highlight the importance of using an ecosystem model in decision making.

5. That Canadian Federal Agencies willingly play a more active role in watershed and basin resource management, particularly when the watershed or basin is interprovincial and or international.

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Appendix A

Abbreviations

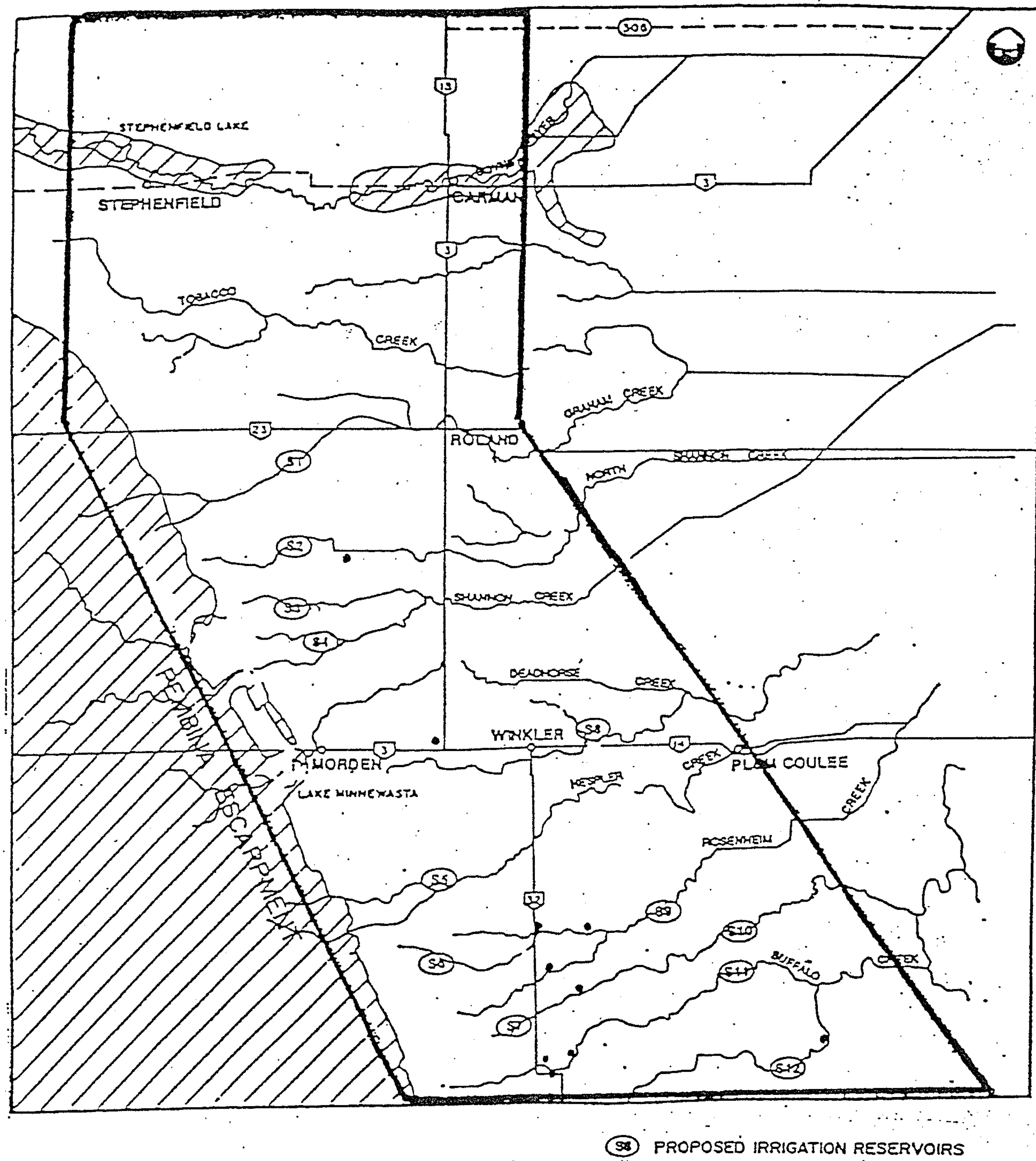
BPS&WMA-	Buffalo Plains Soil and Water Management Association
NRI-	Natural Resources Institute
AIA-	Agassiz Irrigation Association
PFRA-	Prairie Farm Rehabilitation Administration
MbDNR-	Manitoba Department of Natural Resources
CDA-	Conservation Districts Authority
TRWCD-	Turtle River Watershed Conservation District
WWCD-	Whitemud Watershed Conservation District
CURB-	Clean Up Rural Beaches
NAWMP-	North American Waterfowl Management Plan
R.M.-	Rural Municipality
VABS-	Voluntary Agreed Upon Buffer Strip

Appendix B

Existing and Proposed Irrigation Reservoir Sites AIA

Existing and Proposed Irrigation Reservoir Sites (AIA)

(P.M. Associates 1992 p. 43).



• Existing Irrigation Reservoirs

Appendix C

Historic Flow Buffalo Creek Watershed

Historic Flow Buffalo Creek Watershed

(Thomlinson 1984).

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	%	CUBIC-DAMS
1911	0.00	0.00	0.53	0.93	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.15	36	4632.6
1912	0.00	0.00	0.00	0.22	0.15	0.10	0.05	0.02	0.11	0.05	0.00	0.00	0.06	14	1831.4
1913	0.00	0.00	0.00	8.16	0.46	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.72	178	22815.6
1914	0.00	0.00	0.07	0.81	0.19	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.10	24	3045.7
1915	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	107.5
1916	0.00	0.00	3.76	3.35	0.39	0.15	0.02	0.00	0.00	0.00	0.00	0.00	0.64	158	20277.0
1917	0.00	0.00	0.11	9.10	0.01	0.15	0.02	0.00	0.00	0.00	0.00	0.00	0.77	190	24365.3
1918	0.00	0.00	0.18	2.79	0.81	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.33	82	10534.5
1919	0.00	0.00	0.68	3.70	0.33	0.11	0.00	0.00	0.00	0.01	0.00	0.00	0.40	99	12602.4
1920	0.00	0.00	0.00	0.32	0.20	0.10	0.00	0.00	0.00	0.03	0.00	0.00	0.05	13	1711.2
1921	0.00	0.00	0.00	1.26	0.15	0.06	0.03	0.00	0.00	0.02	0.00	0.00	0.13	31	3947.4
1922	0.00	0.00	0.05	1.74	0.21	0.09	0.00	0.00	0.00	0.01	0.00	0.00	0.17	43	5445.9
1923	0.00	0.00	0.00	5.38	0.98	0.21	0.00	0.02	0.04	0.02	0.00	0.00	0.55	136	17339.8
1924	0.00	0.00	0.00	0.54	0.14	0.07	0.00	0.00	0.00	0.04	0.00	0.00	0.06	16	2039.7
1925	0.00	0.00	1.11	1.59	0.17	0.17	0.03	0.00	0.00	0.03	0.00	0.00	0.26	64	8171.1
1926	0.00	0.00	0.10	0.15	0.09	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.03	8	1079.7
1927	0.00	0.00	0.79	4.86	1.00	0.38	0.24	0.07	0.19	0.06	0.00	0.00	0.63	156	19902.6
1928	0.00	0.00	0.92	1.26	0.18	0.12	0.07	0.01	0.01	0.03	0.00	0.00	0.22	53	6840.4
1929	0.00	0.00	0.49	0.54	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.10	24	3094.6
1930	0.00	0.00	0.00	4.25	0.40	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.40	97	12451.8
1931	0.00	0.00	0.05	1.81	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.16	40	5128.3
1932	0.00	0.00	0.00	1.67	0.16	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.15	37	4727.1
1933	0.00	0.00	0.00	3.16	0.48	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.32	78	10034.9
1934	0.00	0.00	0.15	1.19	0.13	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.13	31	3955.1
1935	0.00	0.00	0.00	0.14	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	6	707.5
1936	0.00	0.00	0.01	2.95	0.37	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.28	70	8999.8
1937	0.00	0.00	0.00	0.00	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2	287.3
1938	0.00	0.00	0.47	0.03	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.05	12	1514.9
1939	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	45.4
1940	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	93.7
1941	0.00	0.00	0.00	4.61	0.33	0.12	0.00	0.00	0.07	0.03	0.00	0.00	0.42	105	13376.1
1942	0.00	0.00	0.06	5.34	0.85	0.24	0.05	0.03	0.01	0.00	0.00	0.00	0.87	215	27490.5
1943	0.00	0.00	0.40	2.07	0.26	0.21	0.16	0.08	0.11	0.03	0.00	0.00	0.27	67	8519.5
1944	0.00	0.00	0.00	0.82	0.18	0.17	0.53	0.35	0.37	0.05	0.00	0.00	0.21	51	6514.9
1945	0.00	0.00	2.22	5.05	0.66	0.29	0.19	0.05	0.03	0.01	0.00	0.00	0.71	174	22295.4
1946	0.00	0.00	1.68	2.92	0.25	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.41	101	12954.7
1947	0.00	0.00	0.00	2.57	0.25	0.13	0.00	0.04	0.00	0.00	0.00	0.00	0.25	61	7806.8
1948	0.00	0.00	0.00	4.25	0.77	0.28	0.25	0.07	0.05	0.01	0.00	0.00	0.47	116	14818.5
1949	0.00	0.00	0.00	12.12	1.36	0.44	0.21	0.05	0.01	0.00	0.00	0.00	1.17	288	36882.8
1950	0.02	0.00	0.00	8.64	2.49	0.81	0.57	0.17	0.15	0.04	0.00	0.00	1.08	267	34150.6
1951	0.00	0.00	0.04	3.81	0.44	0.18	0.04	0.01	0.00	0.00	0.00	0.00	0.37	92	11755.0
1952	0.00	0.00	0.00	0.87	0.18	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.09	23	2951.4
1953	0.00	0.00	0.00	0.00	0.04	0.11	0.00	0.01	0.00	0.00	0.00	0.00	0.01	3	424.5
1954	0.00	0.00	0.00	0.00	0.07	0.26	0.67	0.16	0.13	0.03	0.00	0.00	0.11	28	3526.3
1955	0.00	0.00	0.00	7.31	0.74	0.39	0.24	0.03	0.00	0.00	0.00	0.00	0.72	177	22658.1
1956	0.00	0.00	0.00	5.57	1.96	0.59	0.32	0.07	0.07	0.02	0.00	0.00	0.71	175	22477.4
1957	0.00	0.00	0.29	0.83	0.17	0.09	0.00	0.02	0.05	0.04	0.00	0.00	0.12	31	3915.7
1958	0.00	0.00	0.07	0.46	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.05	12	1561.4
1959	0.00	0.00	0.00	2.02	0.14	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.19	46	5850.6
1960	0.00	0.00	0.04	8.02	0.17	0.08	0.00	0.03	0.00	0.00	0.00	0.00	0.68	169	21614.8
1961	0.00	0.00	0.15	0.16	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	7	956.3
1962	0.00	0.00	0.01	3.63	1.46	0.60	0.00	0.02	0.04	0.00	0.00	0.00	0.48	119	15162.2
1963	0.00	0.00	0.04	0.04	0.05	1.83	0.00	0.04	0.01	0.00	0.00	0.00	0.16	41	5199.9
1964	0.00	0.00	0.05	1.71	0.07	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.16	39	4995.2
1965	0.00	0.00	0.01	3.78	0.76	0.16	0.00	0.02	0.03	0.01	0.00	0.00	0.40	98	12523.9
1966	0.00	0.00	0.49	18.84	1.44	0.02	0.00	0.03	0.00	0.00	0.00	0.00	1.72	423	54151.6
1967	0.00	0.00	0.05	6.79	0.53	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.61	151	19371.8
1968	0.00	0.00	0.83	0.36	0.17	0.02	0.01	1.16	0.97	0.04	0.00	0.00	0.30	74	9433.8
1969	0.00	0.00	0.00	7.25	0.22	0.32	0.82	0.01	0.00	0.00	0.00	0.00	0.76	188	24026.8
1970	0.00	0.00	0.00	6.89	2.61	2.54	1.17	0.16	0.00	0.01	0.00	0.00	1.28	314	40220.5
1971	0.00	0.00	0.00	12.07	0.09	0.17	0.04	0.00	0.00	0.00	0.00	0.00	1.01	250	31974.4
1972	0.00	0.00	0.85	1.96	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.25	61	7765.9
1973	0.00	0.00	0.31	0.02	0.00	0.08	0.00	0.00	0.15	0.02	0.00	0.00	0.05	12	1542.5
1974	0.00	0.00	0.00	26.23	9.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	2.94	724	92618.9
1975	0.00	0.00	0.00	1.24	0.28	0.13	0.09	0.00	0.00	0.00	0.00	0.00	0.14	36	4543.1
1976	0.00	0.00	0.00	5.54	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.46	114	14681.6
1977	0.00	0.00	0.02	0.16	0.01	0.05	0.01	0.00	0.07	0.04	0.00	0.00	0.03	7	954.3
1978	0.00	0.00	0.07	1.36	0.28	0.44	0.12	0.00	0.03	0.00	0.00	0.00	0.19	46	5888.2
1979	0.01	0.00	0.00	22.26	1.80	0.47	0.14	0.02	0.01	0.00	0.00	0.00	2.03	502	64166.0
1980	0.00	0.00	0.05	0.52	0.02	0.00	0.02	0.02	0.02	0.01	0.00	0.00	0.05	13	1714.5
1981	0.00	0.00	0.39	0.06	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04	11	1385.3
1982	0.00	0.00	0.17	2.81	0.11	0.18	0.01	0.00	0.00	0.18	0.00	0.00	0.29	70	8995.8
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	46.4
MAX	0.00	0.00	3.76	26.23	9.00	2.54	1.17	1.16	0.97	0.18	0.00	0.00	2.94	724	92618.9
MEAN	0.00	0.00	0.25	3.74	0.53	0.21	0.09	0.04	0.04	0.01	0.00	0.00	0.41	100	12799.2

ESTIMATED NATURAL INFLOW TO BUFFALO LAKE DRAIN RES. (SITE #3) WB211BS3
THIS ARRAY = WB21-1C16 * ((49525.75/116913.94)*(586.2/453.0)) FOR 1911
TO 1978 1979-82 TRANS FROM 05CC025 VIA EDA RATIO (1.2940397). EDA FOR
SITE #3 = 586.2 SQ KM. BRIAN BELL NOV. 29 1983

Appendix D

Chemical Analysis Form

mical Analysis Form IV

Manitoba Environment and W.M. Ward Technical Services Laboratory
745 Logan Avenue
Winnipeg, Manitoba
R3E 1M8
(204) 945-3989

SUBMITTER: ROB CARLSON

LOCATION: IFF

REPORT TO: (1) G.J. WOJCIKOWSKI, (2) DON. LAROSSIERE, FOC.

FILE: ER-1

SAMPLE — Y: 91 Sequent: 1086

L – Less than
G – Greater than

GROUP I-IV: Date Extracted	Y	M	D	Group V: Date Extracted	Y	M	D	Date Sampled	Y	M	D	Date Received	Y	M
	91	07	30						91	07	22		91	07

GROUP I — ORGANOCHLORINE PESTICIDES

Parameter	L/G	Value	Units
ALDRIN	L	.01	ug/l
BHC-alpha	L	.02	ug/l
BHC-beta	L	.03	ug/l
BHC-gamma	L	.02	ug/l
BHC-delta	L	.01	ug/l
CHLORDANE-cis	L	.01	ug/l
CHLORDANE-trans	L	.01	ug/l
DDD-p,p'	L	.03	ug/l
DDE-o,p'		N/A	ug/l
DDE-p,p'	L	.01	ug/l
DDT-p,p'	L	.03	ug/l
DICLOFOP-methyl	L	.09	ug/l
DIELDRIN	L	.02	ug/l
ENDOSULFAN I	L	.01	ug/l
ENDRIN	L	.02	ug/l
HEPTACHLOR	L	.02	ug/l
HEPTACHLOR EPOXIDE	L	.01	ug/l
METHOXYCHLOR	L	.04	ug/l
MIREX	L	.02	ug/l
PCB AS:			
TOTAL PCB	L	.05	ug/l

GROUP II — ORGANOPHOSPHORUS PESTICIDES

Parameter	L/G	Value	Units
AZINPHOS-methyl	L	1.5	ug/l
CHLORPYRIFOS	L	.80	ug/l
DIAZINON	L	.50	ug/l
DIMETHOATE	L	1.0	ug/l
MALATHION	L	.90	ug/l
PARATHION-ethyl	L	.90	ug/l
PARATHION-methyl	L	.60	ug/l
TERBUFOS	L	.70	ug/l

GROUP III — ORGANONITROGEN PESTICIDES

Parameter	L/G	Value	Units
ATRAZINE	L	.50	ug/l
BROMACIL	L	1.0	ug/l
METRIBUZIN	L	1.0	ug/l
PROPANIL	L	2.0	ug/l
SIMAZINE	L	.50	ug/l
TRIALLATE	L	1.0	ug/l
TRIFLURALIN	L	.03	ug/l
PROPACHLOR	L	2.0	
ALACHLOR	L	2.0	

GROUP IV — N-METHYL CARBAMATES

Parameter	L/G	Value	Units
CARBOFURAN	L	2.0	ug/l
PROPOXUR	L	2.0	ug/l

GROUP V — PHENOXY-ACID HERBICIDES

Parameter	L/G	Value	Units
2,4-D	L	.10	ug/l
2,4,5-T	L	.02	ug/l
BROMOXYNIL	L	.92	ug/l
DICAMBA	L	.04	ug/l
DINOSEB	L	.10	ug/l
MCPA	L	2.0	ug/l
2,4-DP	L	.20	
2,4-DB	L	.40	
TRICLOPYR	L	.04	
SILVEX	L	.02	
MCPP	L	4.0	
MCPB	L	20.	

COMMENTS:

MG-14969 Chemist Signature ________ Date July 21/9

Environment and W.M. Ward Technical Services Laboratory
Winnipeg, Manitoba R3E 1M8 (204) 945-3989

SAMPLE —

Y	Sequent
91	1086

BMITTER: ROB CARLSON
OCATION:
EPORT TO(1) G.J. WOJCIKOWSKI,
DON. LABOSSIERE, FOC.
FILE: ER-1

Less than / Greater than	GROUP I-IV: Date Extracted	Y	M	D	Group V: Date Extracted	Y	M	D	Date Sampled	Y	M	D	Date Received	Y	M
		91	07	30						91	07	22		91	07

OUP I — ORGANOCHLORINE PESTICIDES

Parameter	L/G	Value	Units
DRIN	L	.01	ug/l
C-alpha	L	.02	ug/l
C-beta	L	.03	ug/l
C-gamma	L	.02	ug/l
C-delta	L	.01	ug/l
LORDANE-cis	L	.01	ug/l
LORDANE-trans	L	.01	ug/l
D-p,p'	L	.03	ug/l
E-o,p'		N/A	ug/l
E-p,p'	L	.01	ug/l
T-p,p'	L	.03	ug/l
LOFOP-methyl	L	.09	ug/l
LDRIN	L	.02	ug/l
OSULFAN I	L	.01	ug/l
RIN	L	.02	ug/l
PTACHLOR	L	.02	ug/l
PTACHLOR EPOXIDE	L	.01	ug/l
THOXYCHLOR	L	.04	ug/l
EX	L	.02	ug/l
PCB AS:			
TOTAL PCB	L	.05	ug/l

OUP II — ORGANOPHOSPHORUS PESTICIDES

Parameter	L/G	Value	Units
NPHOS-methyl	L	1.5	ug/l
ORPYRIFOS	L	.80	ug/l
ZINON	L	.50	ug/l
ETHOATE	L	1.0	ug/l
ATHION	L	.90	ug/l
ATHION-ethyl	L	.90	ug/l
ATHION-methyl	L	.60	ug/l
BUFOS	L	.70	ug/l

GROUP III — ORGANONITROGEN PESTICIDES

Parameter	L/G	Value	Units
ATRAZINE	L	.50	ug/l
BROMACIL	L	1.0	ug/l
METRIBUZIN	L	1.0	ug/l
PROPANIL	L	2.0	ug/l
SIMAZINE	L	.50	ug/l
TRIALLATE	L	1.0	ug/l
TRIFLURALIN	L	.03	ug/l
PROPACHLOR	L	2.0	↓
ALACHLOR	L	2.0	

GROUP IV — N-METHYL CARBAMATES

Parameter	L/G	Value	Units
CARBOFURAN	L	2.0	ug/l
PROPOXUR	L	2.0	ug/l

GROUP V — PHENOXY-ACID HERBICIDES

Parameter	L/G	Value	Units
2,4-D	L	.10	ug/l
2,4,5-T	L	.02	ug/l
BROMOXYNIL	L	.02	ug/l
DICAMBA	L	.04	ug/l
DINOSEB	L	.10	ug/l
MCPA	L	2.0	ug/l
2,4-DP	L	.20	↓
2,4-DB	L	.40	
TRICLOPYR	L	.04	
SILVEX	L	.02	
MCPP	L	4.0	
MCPB	L	20.	

COMMENTS:

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Chemist Signature ________ Date July 21/9