3 Conceptual Sensitivity Model

The evaluation of GDE sensitivity requires an explicit conceptual model of the system to be assessed. The GDE sensitivity model developed here first describes the drivers of hydrologic change that may alter GDEs. The drivers may be anthropogenic, natural, or some combination. Secondly, the type of effects that threaten the ecosystems are defined. Different species will be sensitive to different stresses or degrees of change. Finally, a framework of species tolerance is outlined to relate the sensitivities of vegetation species and communities to GDE attributes.

The purpose of the conceptual model is to provide a framework upon which methods to evaluate GDE sensitivity could be defined. Once defined, the methods were evaluated in selected areas and an initial assessment of GDE sensitivity developed. Finally the success of the methodology was considered and suggestions were made for improvement .

3.1 Drivers of Hydrologic Change

GDE extent and health can be affected by alteration of the physical water supply and chemical quality. The hydrologic cycle is complex and changes to one part of the system can impact other parts. For example, changes to recharge in the upper parts of the groundwater flow system will impact discharge to GDEs in downgradient areas. The pressure effects are transmitted rapidly so water level changes will be seen more rapidly than the actual groundwater flow.

Global climate change is of considerable concern because of impacts to groundwater recharge, increased potential evapotranspiration, changes to the magnitude and timing of surface water flow, and increased demands on groundwater resources. This report does not attempt to predict impacts of climate change on specific GDEs, however, inferences can be drawn from the effects of recent drought conditions and ongoing groundwater exploitation.

Drought and below average precipitation will reduce watertable elevations and local infiltration. Reduced surface water availability will further reduce flooding, bank storage, and groundwater recharge from streams. Biota able to use both groundwater and surface water or local infiltration will become more dependent on the availability of direct access to groundwater or groundwater-fed remnant pools.

Conversely, increased precipitation will tend to increase water tables, subjecting some areas to increased waterlogging or inundation. Water quality changes, particularly salinity increases can accompany water table elevation increases.

Increased groundwater extraction can lead to short- or long-term declines in aquifer piezometric head affecting groundwater interconnection between aquifers and between groundwater and surface water.

Stream regulation and other surface water alterations have the potential to affect the health of GDEs. Regulation increases inundation in some areas while potentially reducing surface water provided to other wetlands. Increased surface water head can induce groundwater recharge and pressure effects alter flow in distant parts of the system. Drainage of groundwater-fed wetlands can restrict the ecosystem extent and increase the importance of remaining areas of groundwater discharge. Draining of wetlands can lower head in the groundwater system changing the location and reducing the amount of groundwater discharge. Terrestrial GDEs will be impacted when the water table declines below the root zone. Changes to surface water flow systems may reduce or increase groundwater recharge.

Mine dewatering has the potential to impact the groundwater flow system for a considerable distance around the mine location.

Land use changes can also affect the hydrologic system and the health of GDEs. GDEs may be directly affected by clearing of native vegetation for establishment of pasture, cropland, or tree plantations. In some cases land use changes may be related to climatic factors. For instance, during periods of drought, wetlands can dry out to the point that they become attractive for cropping. Removal of remaining natural vegetation and tillage can impair reestablishment of wetland species if wetter conditions and greater groundwater availability return. Increasing residential density (e.g. 'lifestyle properties') can have a cumulative impact on groundwater resources through unlicensed stock and domestic bores.

3.2 Ecosystem Effects

Decreased availability of groundwater to GDEs can have a number of different negative ecological effects. Systems wholly dependent on groundwater may die completely. In other instances, growth and vigour can be reduced making the system vulnerable to disease or encroachment of other species. Terrestrial species present within the ecosystem, capable of exploiting groundwater, may be forced to compete with other species for remaining soil water resources. The loss of groundwater supplies can also affect seeding and reproduction. For aquatic systems, the loss of groundwater discharge can reduce the availability of remnant pools that form a refuge from dry conditions.

Ecosystems adapt to the available water resource. Long-term declines in the water table reduce the availability but other aspects of the hydrologic cycle may also impact GDEs. Seasonal fluctuations in water table are common in some areas. Seasonal groundwater use for irrigation or other purposes can increase the range of fluctuation so that water is not available for GDEs at critical times, even if there is no long-term groundwater decline. Climate change may also affect the amount and timing of groundwater availability to the ecosystems.

If groundwater declines rapidly, then trees may not be able to extend their roots rapidly enough to respond. This could reduce vigour or kill the trees.

Groundwater discharge to streams, or base flow, is important in extending stream flow after precipitation events. If the water table drops, the stream can recharge the groundwater rather than receiving groundwater discharge, or the stream can become disconnected from the groundwater system. Typically this leads to reduced stream flow, and threatens remnant pools in ephemeral streams.

Lake through-flow can be affected by changes to the groundwater availability. Through-flow is important in maintaining the chemical balance in the surface water, which in turn affects the nature of the ecosystem.

Groundwater level is intimately related to the location and size of saline discharges. Although declining water tables can reduce salinity in discharge areas, dry conditions can lead to sulphide oxidation and the formation of acid sulphate surface water.

Waterlogging or inundation will change change soil chemistry and oxygen availability in ways that affect species to different degrees. The often relatively constant groundwater availability to GDEs means that wetland GDEs can be dominated by species that tolerate or require waterlogging or inundation for significant periods.

3.3 Species Tolerance Framework

The impact of changes to groundwater availability on GDE species is not always well known. Our approach to assessing the GDE sensitivity is to apply a species tolerance model approach. The species tolerance model relates vegetation types and locations to factors presumed to be associated in some instances with groundwater availability. For example groundwater dependent wetlands will have water at the surface (inundation) or waterlogging of the near surface soils for at least parts of the year. The species in wetland areas will necessarily be tolerant of those conditions and conversely will be expected to be sensitive to changes in near-surface or surface water saturation. Similarly, GDEs often will be found at zones of saline water discharge, so species in those locations will be salt tolerant and either sensitive to changes in salinity or potentially subject to increased competition from other species if salinity declines. Thus, as a first approximation, species tolerance is directly related to GDE sensitivity. Specifics of the species tolerance model are discussed in the Methods section, below.