Recovery Potential Metrics Summary Form

Indicator Name: CORRIDOR GROUNDWATER LEVEL

Type: Ecological Capacity

Rationale/Relevance to Recovery Potential: Potentially related in multiple ways to waterbody recovery. Shallower vadose zone depth is likely to be related to the retention of alternating influent and effluent reaches along stream corridors, implying greater likelihood that groundwater/surface water interactions and exchanges are functional rather than isolated and disconnected. Also related to the likelihood of successful reestablishment of riparian vegetation and the greater bank stabilization that is implied.

How Measured: Dependent upon data source; could be based on depth of water table as an average figure over a specific size area.

Data Source: not often available as continuous landscape data

Indicator Status (check one or more)

_______ Developmental concept.
___x__ Plausible relationship to recovery.
_______ Single documentation in literature or practice.
___x__ Multiple documentation in literature or practice.
_______ Quantification.

Supporting Literature (abbrev. citations and points made):

- (Groffman et al., 2003) Stream incision, in combination with reduced infiltration in impervious urban uplands, can reduce riparian groundwater levels (Figures 3 and 4), which can have dramatic effects on soil, plants, and microbial processes. As discussed below, water table level is critical in the control of riparian ecosystem structure and function. It influences soil type, for example the presence of wetland or hydric soils (ie wet, with high levels of organic matter), plant communities (wetland and upland/wetland transition plants) (Gold *et al*. 2001), and the unique fauna (eg salamanders) that depend on the presence of specific soils and plants (Bodie 2001; Groom and Grubb 2002) (317).

- (Groffman et al., 2003) Groundwater level is also a key controller of the ability of riparian zones to prevent the movement of pollutants from uplands into streams, by regulating the interaction of groundwater-borne NO3- with near-surface soils supporting plants and microbial processes that consume this ion (Gold *et al*. 2001; Figure 5). We suggest that riparian "hydrologic drought", caused by lowered water tables, is a general effect of urbanization that probably occurs in many cities. However, further observations are necessary to verify this (318).

- (Flanagan et al. 1999) cold-water fisheries can be found at low elevations in protected headwater streams. These streams are able to support cold-water species because they are primarily fed by ground water, have dense vegetative cover, and have high gradient slopes—all of which contribute to cool water with high dissolved oxygen.

- (Groffman et al., 2003) For example, the lowering of the water table associated with urbanization can create aerobic conditions in soils that have been mapped as hydric. Moreover, dynamic cycles of erosion and deposition in watersheds can alter the normal sequence of horizons (layers) in riparian zone soils (Nakamura *et al*. 2000; Stolt *et al*.

2001). In agricultural watersheds, high levels of erosion and frequent flooding lead to increased sedimentation in the riparian zone, which buries surface organic horizons (318).

- (Pringle 2001) Correspondingly, groundwater depletion and stream dewatering are contributing to loss and alteration of wetland and riparian ecosystems throughout the world (e.g., Gremmen et al. 1990, Stromberg et al. 1996), with particularly strong effects in arid and semiarid regions due to high water demand by burgeoning human populations (990).

- (Pringle 2001) The San Pedro Conservation Area is threatened by external groundwater pumping that vastly exceeds recharge rates. Stromberg et al. (1996) predict that future declines in alluvial groundwater levels will cause desertification of the riparian flora and net loss of local biodiversity (991).

- (Pringle 2001) Drilling for hot water, oil, and gas can disrupt the flow of groundwater or release hydrostatic pressure critical to geyser eruption. Groundwater extraction can also deplete groundwater tables below levels necessary to maintain surface thermal features (NPCA 1993). For example, of the 10 major geyser areas in the world, all but three have been altered in recent years through nearby development (NPCA 1993). A well drilled on Royal Teton Ranch on the park's northern boundary (Fig. 5B) recently disrupted nearby flows to hot springs located just outside the park (991-992).

- (Novotny et al., 2005) The models [for assessing ecological integrity] (functions) link the individual risks and consider their synergy, addictivity, or antagonism. The risks include:
    - (1) Pollutant (chemical) risks, acute and chronic, in the water column
        - Key metrics: Priority (toxic) pollutants, DO, turbidity (suspended sediment), temperature, pH.
    - (2) Pollutant risk (primarily chronic) in sediment
        - Key metrics: Priority pollutants, ammonium, DO in the interstitial layer (anoxic/anaerobic or aerobic), organic and clay content.
    - (3) Habitat degradation risk
        - Key metrics: Texture of the sediment, clay and organic contents, embeddedness, pools and riffle structure, bank stability, riparian zone quality, channelization and other stream modifications.
    - (4) Fragmentation risk
        - Key metrics:
          Longitudinal—presence of dams, drop steps, impassable culverts.
          Lateral—Lining, embankments, loss of riparian habitat (included in the habitat evaluation), reduction or elimination of refugia.
          Vertical—lack of stream-groundwater interchange, bottom scouring by barge traffic, thermal stratification/heated discharges, bottom lined channel (190).