# APPENDIX 4.1-2

## POST-MINING WETLANDS DESIGN

The wetlands restoration design is based on a site-specific water balance, which incorporates site precipitation, evaporation, anticipated seepage with annual watershed yields and wetland system classifications to develop long-term wetland land uses on the reclaimed permit area. The design examined existing wetlands at the site and their geographic distribution, incorporated the final post-mining topography and associated geomorphic drainage, and generated a plan which would provide water quality benefits on the permit area, produce diverse habitat, and support ecological richness. Lastly, the goal of the engineering design is to provide an easily quantifiable set of wetlands that may be evaluated during the various phases of bond release.

The basis for the design was based on local precipitation, evaporation, soils, and infiltration water balance data. **Table 4.1-2-1** documents the monthly historic precipitation at the Dickinson Experimental Station in Dickinson, North Dakota. Daily data was collected over a 20-year period from 1990-2010, and mean monthly precipitation was calculated. (Similar data may be reviewed in Table 2.2-2). Monthly lake evaporation rates were determined from the "Hydrology Manual for North Dakota" (USDA-SCS, April 1979) based on estimates of Pan Evaporation and a pan coefficient of 0.71. Seepage was presumed to occur predominantly during the growing season and was derived from an infiltration rate of 0.034 inches per day, which was based on a hydraulic conductivity of $10^{-6}$ feet/day for fine grained clays.

**Table 4.1-2-1: Dickinson, North Dakota Water Balance**

| Month | Precipitation (inches) | Seepage (inches) | Evaporation (inches) | Gain/Loss (inches) | |
|---|---|---|---|---|---|
| January | 0.43 | | 0.27 | 0.16 | |
| February | 0.41 | | 0.35 | 0.06 | |
| March | 0.72 | | 0.84 | -0.12 | |
| April | 1.42 | | 2.13 | -0.71 | |
| May | 2.33 | 1.05 | 3.77 | -2.49 | |
| June | 3.64 | 1.02 | 4.95 | -2.33 | |
| July | 2.2 | 1.05 | 6.78 | -5.63 | |
| August | 1.78 | 1.05 | 7.35 | -6.63 | |
| September | 1.38 | 1.02 | 5.45 | -5.09 | |
| October | 0.99 | 1.05 | 3.12 | -3.19 | |
| November | 0.56 | | 1.09 | -0.53 | |
| December | 0.41 | | 0.37 | 0.04 | |
| | 16.27 | 6.26 | 36.48 | -26.46 | in/yr |

| | | | |
|---|---|---|---|
| Seepage | 0.03401575 | in/day | |
| Water Requirement | | 2.205403 | acre-feet/acre of wetland |
| Water Yield (50% chance) | | 46 | acre-ft/sq mile of drainage |
| | | 0.048 | sq mile of drainage/acre of wetland |
| | | 30.7 | acre of drainage/acre of wetland |

A monthly gain or loss was calculated based on the difference between the gain from precipitation and losses from seepage and evaporation. Precipitation averages 16.27 inches per year, with an annual deficit water balance of 26.46 inches per year near Dickinson, in Stark County, North Dakota. This deficit yields an annual water requirement of 2.205 acre-feet/acre of wetland.

The USDA-SCS (April 1979) evaluated annual watershed yield in the "Hydrology Manual for North Dakota", and predicted the 50% chance of annual yield throughout the state. The 50 percent yield in northwestern Stark County is 46 acre-feet/square mile of watershed. The quotient of the annual water requirement and the 50 percent water yield results in a 50 percent chance that 0.048 sq miles of drainage could support one acre of wetland, or 30.7 acres of contributing watershed could support one acre of wetland.

The contributing watershed associated with individual wetlands were delineated to confirm that there was adequate water yield based on the prior analysis. **Table 4.1-2-2** summarizes the surface area for each wetland, its engineered depth and volume and the contributing subwatershed.

**Table 4.1-2-2: South Heart Lignite Mine Reconstructed Wetland Specifications and Contributing Watersheds**

| Name | Top Area (ac) | Bottom Area (ac) | Depth (ft) | Volume (acft) | Bottom Elev (ft msl) | Top Elev (ft msl) | Subwatershed (ac) |
|---|---|---|---|---|---|---|---|
| 09SE1 | 0.200 | 0.140 | 2 | 0.338 | 2513 | 2515 | 39.427 |
| 15NE1 | 1.511 | 0.976 | 6 | 7.403 | 2482 | 2588 | 177.049 |
| 15SE1 | 1.252 | 0.922 | 4 | 4.331 | 2491 | 2495 | 88.18 |
| 15SW1 | 0.343 | 0.175 | 2 | 0.509 | 2512 | 2514 | 12.762 |
| 15SW2 | 0.164 | 0.037 | 2 | 0.186 | 2508 | 2510 | 5.432 |
| 16NE1 | 1.550 | 1.01 | 3 | 3.811 | 2536.5 | 2539.5 | 96.54 |
| 16NE2 | 1.470 | 1.03 | 3 | 3.730 | 2534 | 2537 | 96.54 |
| 16SE1 | 0.164 | 0.031 | 2 | 0.178 | 2521 | 2523 | 6.212 |
| 16SE2 | 0.203 | 0.032 | 1.5 | 0.158 | 2522 | 2523.5 | 18.839 |
| 16SE3 | 0.111 | 0.034 | 2 | 0.138 | 2514 | 2516 | 47.726 |
| 16SE4 | 0.220 | 0.105 | 2 | 0.318 | 2512 | 2514 | 26.360 |
| 16SW1 | 0.152 | 0.028 | 2 | 0.164 | 2543 | 2545 | 5.643 |
| 16SW2 | 0.315 | 0.154 | 2 | 0.46 | 2540 | 2542 | 99.671 |
| 16SW3 | 0.452 | 0.256 | 4 | 1.398 | 2534.5 | 2538.5 | 816.242 |
| 16SW4 | 0.223 | 0.142 | 1 | 0.181 | 2534 | 2535 | 15.642 |
| 16SW5 | 0.126 | 0.029 | 1.5 | 0.108 | 2531 | 2532.5 | 4.080 |
| 17SE1 | 0.219 | 0.137 | 2 | 0.353 | 2565 | 2567 | 23.349 |
| 17SE2 | 0.139 | 0.046 | 2 | 0.176 | 2560 | 2562 | 4.278 |
| 17SE3 | 0.118 | 0.037 | 2 | 0.147 | 2551 | 2553 | 40.343 |
| 17SE4 | 0.150 | 0.047 | 2 | 0.187 | 2547 | 2549 | 9.889 |
| 17SW1 | 1.625 | 1.272 | 4 | 2.89 | 2583 | 2587 | 59.697 |
| 21SW1 | 1.118 | 0.906 | 3 | 3.03 | 2543.5 | 2546.5 | 94.512 |
| 22NE1 | 5.298 | 4.802 | 3 | 15.144 | 2503 | 2506 | 1587.410 |
| 22NE2 | 2.688 | 2.339 | 3 | 7.534 | 2501 | 2504 | 1603.921 |
| 22SW1 | 0.243 | 0.164 | 2 | 0.404 | 2505 | 2507 | 168.802 |
| 23SW1 | 0.538 | 0.335 | 2 | 0.865 | 2497.5 | 2499.5 | 219.870 |

**Table 4.1-2-2: South Heart Lignite Mine Reconstructed Wetland Specifications and Contributing Watersheds**

| Name | Top Area (ac) | Bottom Area (ac) | Depth (ft) | Volume (acft) | Bottom Elev (ft msl) | Top Elev (ft msl) | Subwatershed (ac) |
|---|---|---|---|---|---|---|---|
| 27NW1 | 0.586 | 0.307 | 2 | 0.878 | 2508 | 2510 | 18.033 |
| 27SE1 | 0.336 | 0.175 | 2 | 0.502 | 2518 | 2520 | 15.505 |
| 27SE2 | 0.343 | 0.175 | 2 | 0.509 | 2523 | 2525 | 106.765 |
| 27SE3 | 0.185 | 0.080 | 2 | 0.258 | 2528 | 2530 | 9.258 |
| 27SW1 | 2.671 | 2.318 | 3 | 7.477 | 2511 | 2514 | 142.587 |
| 28NE1 | 0.193 | 0.045 | 2 | 0.221 | 2512 | 2514 | 7.566 |
| **Total** | **24.906** | | | **63.986** | | | **4082.018** |

Each wetland was individually checked to confirm that there was adequate supporting contributing watershed. On a permit area basis, the 25.36 acres of wetlands would require 55.92 acre feet of annual yield according to the previous water balance analysis, and 65.18 acre feet through the engineered specifications. The available contributing watershed consists of 3909.2 acres, which has a 50 percent chance of generating 127.7 acre feet annually.

The post-mining wetlands are a combination of artificial stream scars in the floodplains of the reconstructed drainages, ponds within low lying depressions and in channel wetlands along the reclaimed streams. Their geomorphic class was derived from their locations within the reclaimed topography and along channels, their proximity to established drainages, the contributing watershed, and probable water supply. The Wetland Classification was based on Stewart and Kantrud's (1971) classification which relies partially on the geomorphic class. The classification system takes into consideration the hydrologic characteristics of the wetland, including its permanence, depth, chemistry and land use. This influences the vegetation community and assemblage of species, including the life forms, species composition and species dominance. Briefly, the seven wetland classes are:

Class I Ephemeral ponds; the deepest part of the pond basin supports low-prairie vegetation

Class II Temporary ponds; the deepest part of the pond basin supports wet-meadow vegetation

Class III Seasonal ponds and lakes; the deepest part of the pond basin supports shallow-marsh hydrophytes, often with peripheral wet meadow and low prairie zones

Class IV Semi-permanent ponds and lakes; the deepest part of the pond basin supports deep-marsh hydrophytes, often with peripheral shallow marsh, wet-meadow and low prairie zones;

Class V Permanent ponds and lakes; permanent open water zone of submergent hydrophytes, often with peripheral deep-marsh, shallow marsh, wet-meadow and low prairie zones;

Class VI Alkali ponds and lakes; intermittent shallow saline water alternating with salt flats in the central zone, often with peripheral shallow-marsh, wet-meadow, and low-prairie zones; and

Class VII Fen (alkaline bog) ponds; central zone represented by fen vegetation, often with peripheral wet meadow and low-prairie zones.

**Table 4.1-2-3** summarizes the anticipated wetland classifications for post-mining wetlands.

**Table 4.1-2-3: Post-Mining Wetland Locations, Classifications and Flow Status**

| Name | Geomorphic Class | Wetland Classification[1] | Flow Status |
|---|---|---|---|
| 09SE1R4EMAh | Seasonal | III | Lotic |
| 15NE1R4Ch | Temporary | II | Lentic |
| 15SE1R2OWFh | Semi-Permanent | IV | Lentic |
| 15SW1R2EMC | Seasonal | III | Lentic |
| 15SW2R2EMC | Seasonal | III | Lentic |
| 16NE1DEMA (PI) | Temporary | II | Lentic |
| 16NE2R4EMB | Saturated | V | Lentic |
| 16SE1R2EMC | Seasonal | III | Lentic |
| 16SE2R2EMC | Seasonal | III | Lentic |
| 16SE3R2EMC | Seasonal | III | Lentic |
| 16SE4R2EMC | Seasonal | III | Lentic |
| 16SW1REMC | Seasonal | III | Lentic |
| 16SW2REMC | Seasonal | III | Lentic |
| 16SW3 ROWFx | Semi-Permanent | IV | Lotic |
| 16SW4REMC | Seasonal | III | Lentic |
| 16SW5REMC | Seasonal | III | Lentic |
| 17SE1DEMA | Temporary | II | Lentic |
| 17SE2DEMA | Temporary | II | Lentic |
| 17SE3DEMA | Temporary | II | Lentic |
| 17SE4DEMA | Temporary | II | Lentic |
| 17SW1 DEMCx | Seasonal | III | Lentic |
| 21SW1R4Ax | Temporary | II | Lentic |
| 22NE1R2EMB | Saturated | V | Lotic |
| 22NE2R2OWFh | Semi-Permanent | IV | Lotic |
| 22SW1R4OWFx | Semi-Permanent | IV | Lentic |
| 23SW1DEMA(PI) | Temporary | II | Lentic |
| 27NW1 R4EMA (PI) | Temporary | II | Lentic |
| 27SE1DEMA | Temporary | II | Lentic |
| 27SE2DEMA | Temporary | II | Lentic |

| Table 4.1-2-3: Post-Mining Wetland Locations, Classifications and Flow Status | | | |
|---|---|---|---|
| **Name** | **Geomorphic Class** | **Wetland Classification[1]** | **Flow Status** |
| 27SE3DEMA | Temporary | II | Lentic |
| 27SW1DEMC (PI) | Seasonal | III | Lentic |
| 28NE1R4EMA (PI) | Temporary | II | Lentic |

[1] Stewart and Kantrud (1971)

**REFERENCES:**

Stewart, Robert E., and Harold A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/wetlands/pondlake/index.htm (Version 16APR1998).

USDA-SCS (1979) "Hydrology Manual for North Dakota."