ANGLOGOLD H-PIT MITIGATION WETLANDS: ESTABLISHMENT & SUCCESSIONAL DEVELOPMENT ON A XERIC BORROW AREA[1]

by

L. Gionet[2], W. R. Erickson and S. R. Viert

Abstract: Gold mining occasionally impacts natural wetlands. Mining permits must consider the degree and extent of wetland impact. State and federal agencies typically require mitigation for disturbed wetlands in the form of replacement acreage at a predetermined ratio. AngloGold (Jerritt Canyon) Corp. manages the Jerritt Canyon Joint Venture project, located 50 miles north of Elko, Nevada, where natural wetlands have been permitted and impacted by mining activities. Suitable wetland enhancement or mitigation areas were not available in the immediate mine area at the time of permitting. Jerritt Canyon identified potential water resources and proposed replacement of wetlands in a non-traditional xeric H-Pit construction borrow area. The steps taken to evaluate this potential wetland mitigation site, regulatory and permitting processes, design, construction, planting, and restoration monitoring results are presented and described. H-Pit wetland establishment and succession development is being evaluated through revegetation monitoring designed to inventory obligate and facultative wetland species and delineate developing wetland community types. Vegetation monitoring demonstrates wetland community succession trends and provides an assessment of wetland function and wildlife habitat diversity.

Additional Key Words: Wetlands, Wetland Creation, Wetland Mitigation, Vegetation Monitoring

Introduction

AngloGold (Jerritt Canyon) Corp. operates the Jerritt Canyon mine that is west of Star Route 225, approximately 45 miles north-northwest of Elko, Nevada (Figure 1). The Jerritt Canyon mine is located at the base of the Independence Mountain Range and hosts a continental climate, where an average of 12-14 inches of precipitation annually is typical. The predominant vegetation type is sage steppe. Due to the semi-arid climate, surface water resources are very limited. The H-Pit wetlands mitigation site was formerly a borrow area used as a source of materials for construction activities at Jerritt Canyon. The site is located two miles south-east of the Jerritt Canyon mill site on private land owned by AngloGold. Evaluation of the H-Pit borrow area in 1993 identified approximately 20 acres as having high potential for reconstructed wetland mitigation development. Selection of a currently disturbed site located within a xeric rangeland area allowed Jerritt Canyon to: 1) Effectively mitigate wetlands disturbed by ongoing mining operations; and 2) Avoid enhancement or extension impacts to existing high value riparian wetland areas in the Independence Mountains. The H-Pit wetland Mitigation site was designed, constructed, planted, and monitored to determine the successful development of this wetland site. This paper describes the mitigation process and presents the vegetation monitoring information

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[1] Paper presented at the 17th National Meeting of the American Society for Surface Mining and Reclamation, Tampa, Florida, June 11-15, 2000.

[2] Lynn Gionet is an Environmental Coordinator with AngloGold (Jerritt Canyon) Corp., Elko, NV 89801.

Wayne R. Erickson is President and Senior Environmental Scientist at Habitat Management, Inc., Littleton, CO 80122.

Steven R. Viert is a Corporate Principal and Senior Range/ Wildlife Ecologist at Cedar Creek Associates, Inc., Fort Collins, CO 80521.

Proceedings America Society of Mining and Reclamation, 2000 pp 591-610
DOI: 10.21000/JASMR00010591

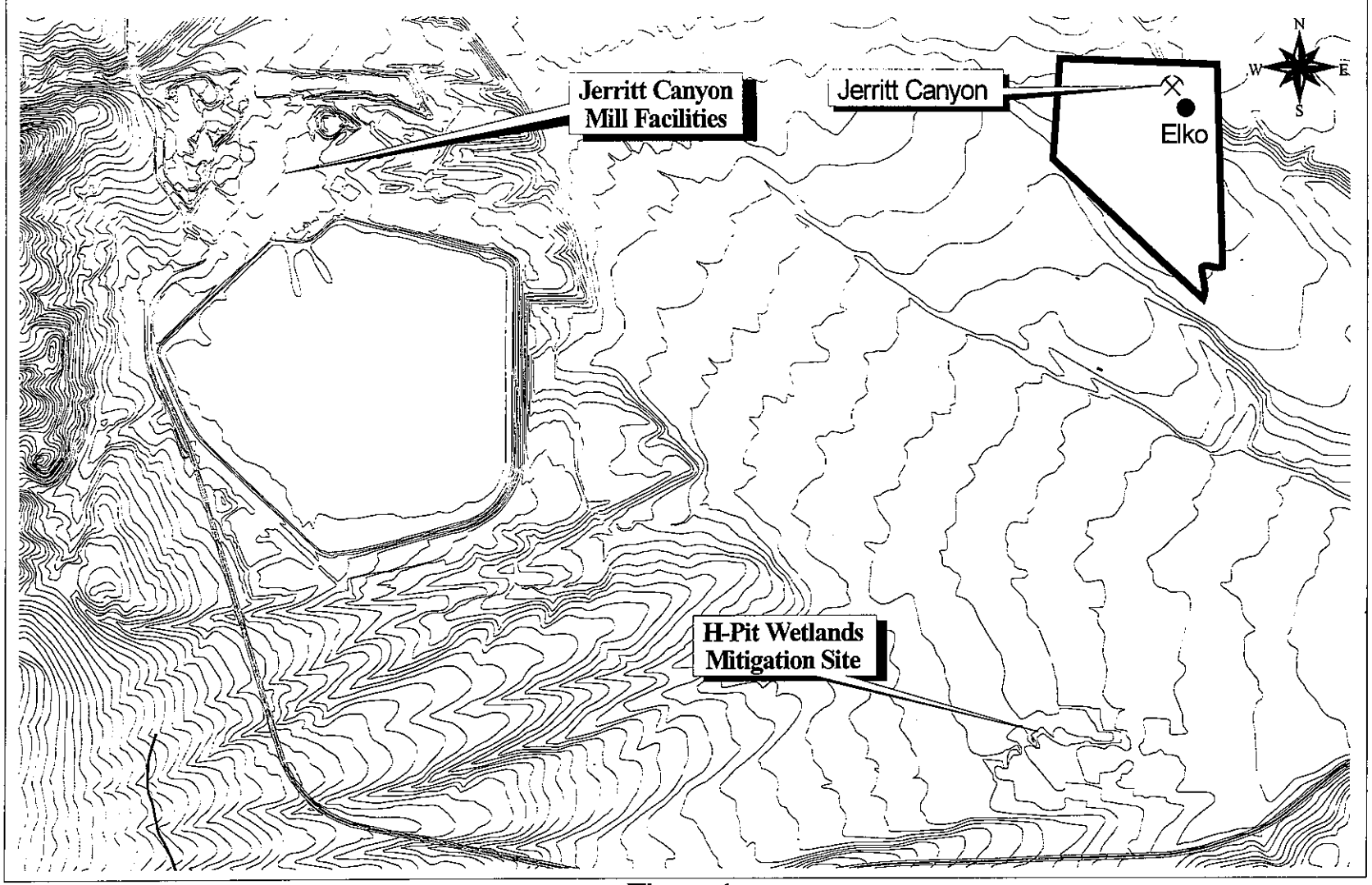

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Figure 1
Jerritt Canyon Joint Venture
H-Pit Wetlands Mitigation Site

that supports the successful development of this wetland site and its suitablility as wildlife habitat.

Regulatory Requirements

AngloGold submitted a Pre-Discharge Notification (PDN) for the Jerritt Canyon Joint Venture Project area to the United States Army Corps of Engineers (COE) in November 1992. The PDN was prepared in response to the need for a permit to conduct fill related activities within "waters of the United States" in accordance with Section 404 of the Clean Water Act. The COE issued Nationwide Permit (NW26) authorization 92000586 on January 6, 1993. Under this permit, AngloGold committed to the construction of a wetland area substantially larger than impacted to satisfy the mitigation needs associated with the COE authorization. Through permit agreements, additional acreage of successfully created self-sustaining wetlands would serve as a credit toward future mining disturbance mitigation needs.

In their authorization, the COE required AngloGold to document and evaluate the success of this mitigative strategy. Successful release of mitigation responsibility involves the production of written materials describing project specific mitigation goals, documenting pre- and post-mitigation hydrologic conditions and characteristics, characterizing established wetland vegetation community types, and demonstrating that wetland mitigation success criteria have been satisfactorily met. The COE permit also required AngloGold to conduct a wetland mitigation monitoring plan, and commitment to the development of remedial actions in the event H-Pit mitigation was unsuccessful.

H-Pit Wetlands Design & Construction

Site Selection

One of the most important factors considered in selecting potential wetland development sites was the availability of an adequate water source capable of supporting hydrophytic plant species. Other factors used to consider potential sites included property ownership, water rights, existing watershed and hydrologic conditions, soils, and effects on grazing allotments.

Based on potential wetland mitigation site evaluations that considered the factors discussed above, AngloGold proposed to construct mitigation wetlands within an idle borrow area located within a native rangeland community approximately 2 miles southeast of the Jerritt Canyon mill facility. This borrow area is referred to as H-Pit and was originally disturbed during 1980 in connection with the construction of the Jerritt Canyon Mill and Mine access road. The lands within this area are owned and controlled by AngloGold.

The COE and other interested regulatory agencies were presented with the plan to develop wetlands habitat within the H-Pit site, which at the time was devoid of water and vegetation. H-Pit presented unique opportunities to create one large wetland with a variety of wetland plant community types in a location where wetland had not previously existed. The size of the potential wetland acreage at this site would also allow the creation of a complex large enough to provide significant wildlife habitat. Several smaller sites were considered where mitigation actions would have simply extended the limits of existing riparian and wetland habitats. The H-Pit wetland complex was conditionally approved for mitigation purposes since: (1) smaller riparian and wetland habitats exist throughout the Independence Mountain range, (2) construction access was limited or difficult to many of the sites and because mitigation at these sites had provided fewer potential benefits, and (3) because mitigation at these small remote sites provide nominal wetland habitat benefits.

Mitigation Site Characteristics

When selected, the H- Pit wetland development site consisted of a series of topsoil and gravel stockpiles, access roads and exposed gravel areas. Earthen construction materials had been excavated to depths of ten feet. A detailed summary of site characteristics is provided below.

Vegetation. Prior to the H-Pit construction activities in 1980, vegetation surveys were completed in conjunction with the original Jerritt Canyon Environmental Impact Statement (EIS).

The entire H-Pit site was mapped as an alluvial sagebrush-grass vegetation type. The dominant shrub species occurring in this area prior to disturbance were big sagebrush and low sagebrush. Sandberg bluegrass and bottlebrush squirreltail were the most frequently encountered grasses. Goldenweed was the most frequent forb. The COE classifies these plants as upland indicator species.

Soils. A total of twenty-six test pits were excavated to obtain soils data within the H-Pit wetland development site. The results of these investigations indicated that the soil strata consisted of interbedded gravels, sands, silts and clays deposited in a heterogeneous manner. Saturated soils, exhibiting signs of mottling, were encountered at numerous test sites at varying depths.

Hydrology. Static ground water levels were monitored using the test pits constructed for soil testing. Initially, four test pits were monitored on a daily basis to evaluate the depth to ground water and to establish a baseline from which trends could be evaluated. Ground water level monitoring was later obtained from each of the test sites established in conjunction with the soil investigation on a bi-weekly basis.

Ground water monitoring data indicated that alluvial water flows were sufficient to provide for the establishment and normal growth of wetland plant communities.

An augmentative water source available for wetland development at H-Pit was available in the form of surface water runoff from the Stump Creek watershed. Runoff from this drainage area is ephemeral, flowing during annual spring snowmelt and in response to larger summer precipitation events. Provided snowfall is sufficient, this watershed is capable of delivering enough runoff to dramatically change the depth to ground water in the low-lying areas at H-Pit. Water level observations made during spring runoff seasons have recorded static water levels ranging from zero to six feet below ground surface. Since ground water monitoring commenced after construction borrow pits were established and surface water had already begun to flow into the mitigation area, it has not been possible to accurately characterize the recharge impact of this runoff on ground water tables within the H-Pit mitigation wetland.

Based on soil and ground water testing, AngloGold concluded that the H-Pit area was capable of sustaining permanent wetland vegetation communities. However, a significant concern was the limited hydrological data available during the mitigation site evaluation and selection period, and the preceding climatic conditions under which this data had been collected. Data used in evaluation was collected after a wet spring that was preceded by six years of drought. Therefore, the level of confidence in the monitored groundwater elevation data was low. Because of this concern, AngloGold proposed a two phased approach to the construction and development of the H-Pit wetland. The first phase would involve the excavation of additional materials to ensure planting zones were proximal to the water table. The second phase would involve the development of topographic features designed to provide a variety of wildlife habitats.

Conceptual Design & Construction Techniques

Because of the watershed's ephemeral nature, delivery of sufficient surface water to H-Pit wetlands was not a certainty. Such surface water was determined to be necessary to facilitate ground water recharge. Therefore, it was deemed prudent to lower the H-Pit floor to place the rooting zone in closer proximity to the ground water level. In this manner, establishment and growth of hydrophytic vegetation would be encouraged. In Phase I of the H-Pit wetland mitigation construction process, suitable wetland plant growth medium was salvaged and then cell bottoms were excavated until their surfaces were within 2 to 6 feet of the predicted ground water level. Suitable plant growth medium was replaced once the desired excavation depth had been achieved. Phase II of the construction effort included the development of nesting islands, runoff control berms, final grading of embankment slopes, construction of spillways and flow routing structures and variations in bottom topography of impoundment areas. Construction took place from October 5, 1993 to November 10, 1993.

Phase I. The perimeter of the wetland mitigation area was surveyed and staked. A majority of the

wetland mitigation area had been previously disturbed by excavation and stockpiling operations. Within undisturbed portions of H-Pit, woody vegetation was cleared and suitable topsoils were salvaged and stockpiled for later use.

Prior to commencing cell excavation, temporary diversion trenches were developed. Diversion trenches were designed and constructed to intercept and divert ground water from mitigation cell areas during the construction phase (Figure 2). This diversion was designed to eliminate or minimize the need for pumping of pit water into surface receiving waters and minimize water problems in heavy equipment construction zones.

Cell excavation consisted of stockpiling excavated material into four groups: 1) clean gravels 2) clayey and silty gravels, 3) low permeability clays and gravelly clays, and 4) suitable soil growth media. Side slopes defining the perimeter of the H-Pit wetland development area include a variety of slopes and aspects. Steeper embankments were left untouched to add topographic diversity, provide additional microhabitats and promote the "natural" aesthetics within the final landscape.

Following cell excavation, the temporary ground water diversion trenches were backfilled with low permeability clays and effectively sealed. Impermeable clays were used to reduce the potential for the conveyance of groundwater below the wetland cell basins.

Hydrologic berms were constructed along the downstream limit of the H-Pit wetland mitigation area to control the flow of surface water. Rip-rapped spillways and other flow routing structures were included in the berm designs to provide stable flow conveyance and a means to control excess drainage during heavy runoff events. The fill used to construct the hydrologic control berms consisted of clays excavated from the cells. Compaction of the berm was achieved by routing scrapers over the clay surface until adequate proctor densities were achieved. Berm side slopes were 10:1 on the upstream side (west) and 3:1 on the downstream side (east).

To monitor and control surface water entering the wetlands development area, headwater stilling basins and diversion berms were constructed northwest of Cell 1. The perimeter control berms were used to direct surface water to the stilling basin areas northwest of Cell 1 and around the perimeter of the wetlands mitigation site. Growth medium stripped from the stilling basins was placed and spread in the bottom of Cell 1. A 60- foot section of 48-inch diameter corrugated metal pipe culvert was installed perpendicular to the access road at the intersection of the road and Cell 2 to transport flow to the stilling basins or around the wetlands mitigation site. The culvert was fit against the perimeter berm raising the road elevation slightly to maintain sufficient cover over the culvert. The alignment of the perimeter hydrologic control berm, culverts, and stilling basins is shown in Figure 2.

Two stilling basins, together with the control berm and culverts, were configured to facilitate ephemeral surface flow into Cell 1's inlet. A gate valve was installed to allow control of the amount of surface water flowing into or bypassing the wetland mitigation site. Installation of a culvert and a weir at the Cell 1 inlet also allowed the placement of surface water monitoring equipment at this location. Monitoring and controlling inflow at this point allows the quantity and quality of surface runoff entering the wetlands mitigation area to be evaluated and controlled during the wetland's development phase.

Topographic features were constructed within the bottoms of the mitigation cells to provide habitat diversity for wetland plant species and to create nesting islands and resting areas for waterfowl. Suitable stockpiled plant growth media capable of supporting wetland plant communities was distributed on the bottoms of Cells 1, 2 and 3 after final topographic features were constructed.

Wetland Seeding & Planting

Preliminary site information indicated that the H-Pit area was capable of supporting a variety of wetland vegetation communities. However, due to periods of prolonged drought known to occur in the area, it was not possible to definitively locate different wetland community planting zones. Therefore, upon completion of earth moving activities, a generalized or "shotgun"

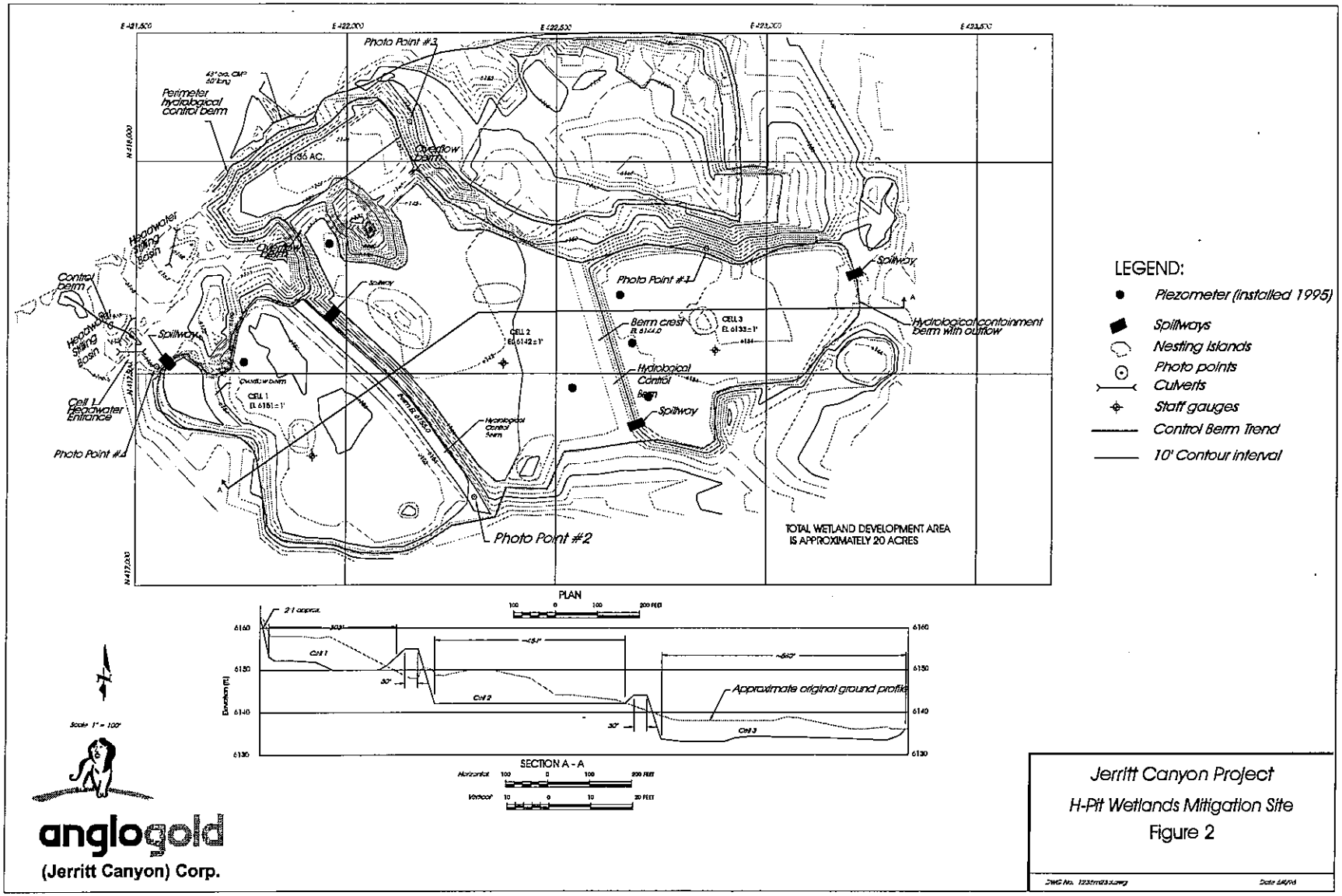
Photo Point #3
Perimeter hydrological control berm
Overflow berm
Headwater silting basin
Control berm
Spillway
Cell 1 Headwater Entrance
Photo Point #4
Photo Point #1
Berm crest
Hydrological Control Berm
Hydrological containment berm with outflow
Photo Point #2
TOTAL WETLAND DEVELOPMENT AREA IS APPROXIMATELY 20 ACRES
LEGEND:
Piezometer (installed 1995)
Spillways
Nesting Islands
Photo points
Culverts
Staff gauges
Control Berm Trend
10' Contour interval
PLAN
SECTION A - A
Approximate original ground profile
Scale 1" = 100'
anglogold
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Jerritt Canyon Project
H-Pit Wetlands Mitigation Site
Figure 2

approach to seeding and planting was initiated. Generalized planting zones were identified and a universal, predominately herbaceous seed mixture was planted. Hydrophytic plant species best adapted to the developing wetland community zones established through a process of natural selection. Augmentative seeding and transplanting of shrubs and trees was also accomplished to ensure establishment of diverse wetland vegetation communities.

Upon completion of earthmoving within the mitigation site, Boy Scouts from a local troup planted approximately 1,400 willow, cottonwood and dogwood saplings. During 1994, winter wheat and yellow sweetclover were planted in each of the wetland mitigation cells for erosion control, as a source of future organic matter, and as a potential interim food supply for migrating waterfowl.

Soil samples were collected from the H-Pit wetlands mitigation site and analyzed for nutrient content prior to planting the wetland seed mixture. Fertilizer recommendations were based upon the results of soil sample analyses. Fertilizer blends used at the mitigation site consisted of 22 pounds/acre of nitrogen, 42 pounds/acre of phosphorus and 15 pounds/acre of sulfur.

A mixture of obligate or facultative wetland grass, forb, and shrub species were broadcast seeded in Cells 1 and 2 on May 15, 1995 and in Cell 3 on January 4, 1996. Species included in this wetlands seed mixture are listed in Table 1.

The species included in the seed mix were selected from the "Wetland Plant Species List" in the Revised Mitigation Plan for the Jerritt Canyon Project Area submitted by AngloGold. The decision to defer planting until 1995-1996 was due to extremely dry conditions that were present in the region following initial construction of the mitigation site. On July 6, 1995, about 360 native willow cuttings were planted in Cell 1. An additional 800 containerized grown blueberry elderberry seedlings were planted November 4, 1995 in moist areas peripheral to visible soil saturation zones.

Table 1. H-Pit Wetland Seed Mixture

Grasses/Grass-like species	Common Name	Proportion
Beckmannia syzigachne[1]	American Sloughgrass	6.52%
Carex nebraskensis[1]	Nebraska Sedge	13.04%
Carex rostrata[1]	Beaked sedge	6.44%
Deschampsia caespitosa[2]	Tufted Hairgrass	6.52%
Juncus balticus[2]	Baltic Rush	9.70%
Phalaris arundinacea[1]	Reed Canarygrass	11.30%
Poa palustris[2]	Fowl Bluegrass	9.70%
Scirpus acutus[1]	Hardstem Bulrush	7.52%
Forbs		
Iris missouriensis[1]	Rocky Mountain Iris	8.70%
Oenothera hookeri[2]	Hooker Evening Primrose	2.61%
Shrubs		
Cornus stolonifera[2]	Red-osier Dogwood	10.43%
Rosa woodsi[2]	Woods Rose	7.52%
	Total	100.00%

[1] Obligate wetland species

[2] Facultative wetland species

Mitigation Success Criteria

H-Pit wetlands mitigation success criteria required that a self-sustaining wetlands be constructed that meets specific standards. Any additional acreage meeting the standards will be "banked" for future mitigation needs associated with ongoing mining.

1. A minimum of 7.14 acres must be saturated to the surface or inundated for at least 10 consecutive days during the growing season.
2. The existing fence around the mitigation site must be monitored and maintained to preclude livestock for at least five years.

3. Wetland areas must be dominated by wetland indicator species as identified by the COE.
4. A minimum of three nesting islands must be constructed.
5. The vegetative cover within the wetland creation area will be deemed to be successful when the vegetative sampling data collected from the site equals 80 percent of the herbaceous plant cover from undisturbed wetlands as documented in the original delineation performed in 1992 prior to mining disturbance.

A written report summarizing and documenting mitigation results and satisfaction of mitigation success criteria is required to obtain regulatory approval of the wetland mitigation work in H-Pit.

Wetland Mitigation Monitoring Requirements

Evaluation of H-Pit wetland mitigation requires monitoring of the agreed upon wetland parameters to determine the success or failure of mitigation work. AngloGold is required to monitor the constructed wetlands for at least five consecutive growing seasons beginning with the first full growing season following completion of construction .

In addition, growth and development of the wetlands mitigation, without human intervention (i.e., augmentative seeding, transplanting, etc.), has to be documented for three consecutive growing seasons once the required success criteria have been met. The three and five year periods may run concurrently should human intervention end prior to completion of the fifth year of monitoring. Mitigation monitoring will commence upon the completion of Phase II of the wetlands development activities. Constructed wetland mitigation will be deemed successful, and AngloGold's attendant responsibility will be released, when the success criteria have been met for three consecutive years without human intervention.

Mitigation monitoring entails quantitative vegetation and hydrologic data acquisition. Also, a representative number of samples must be collected to document the condition of the constructed wetland when evaluating whether or not minimum quantifiable success criteria have been met. Surface water elevations for representative areas within the mitigation cells are monitored and recorded monthly during the growing seasons using staff gauges and pieziometers (Figure 2). In addition, an annual water sample is obtained for each cell with impounded surface water to test for total dissolved solids, chloride, and electrical conductivity.

Photo points were established at the time of construction and are used to qualitatively monitor wetland vegetation trends in representative areas of H-Pit. Photos are taken annually at the peak of the growing season. AngloGold will continue photo monitoring until wetland mitigation liability has been released. Vegetation maps showing the plant community types establishing within the mitigation site are prepared and submitted annually. A description of each plant community, including the vegetation species and their estimated percent aerial cover, are also reported. Vegetation sampling is conducted by qualified personnel using scientifically proven and regulatory agency accepted methods and equipment.

Supplement # 1 to the Jerritt Canyon Project Area Revised Mitigation Plan, states the goals for annual mitigation wetland monitoring to be:

1. Determine the success of the mitigation effort;
2. Determine annually the need for supplemental planting and/or seeding;
3. Determine the necessity of weed control;
4. Determine whether there is a need to physically modify the created wetland to ensure success.

The results are summarized in an annual report submitted to the COE by January 31 each year monitoring activities are conducted.

Vegetation Monitoring Sampling Methods

Vegetation Sample Site Selection. Each of the vegetation communities present in the H-Pit wetland mitigation area require monitoring and comparison with an undisturbed, equivalent reference area. Sample point selection for each of the four wetland cells comprising the H-Pit Wetland and their respective reference areas involves a visually based systematic procedure.

This procedure for the three communities of the reference area as well as the four communities of the H - Pit wetland mitigation site is accomplished in the following manner. First, the communities were characterized and delineated within each cell (Figure 3). Next, a minimum of five point-intercept, line-transects were spaced evenly within each vegetation community within each cell. Where a vegetation community only existed in one cell, a minimum of ten point-intercept, line-transects were taken. This distribution results in a minimum of ten transects for each cell and ten transects for each community across the entire wetland unit, and a minimum of five transects within each community in each cell. Typical point-intercept line-transect sampling procedures are presented on Figure 4.

This methodology ensures "representation" from across each reclaimed community and from all cells where a given community has established. It is superior to strict random sampling where significant pockets of vegetation could be missed entirely or over-emphasized. This systematic procedure also provides proportionate representation from across the reclaimed unit for any physiographic character of interest.

Determination of Ground Cover. Ground cover at each sampling site was determined utilizing the point-intercept line-transect methodology (Bonham 1989) (Figure 4). This methodology has been utilized for range studies over seventy years. Cedar Creek Associates, Inc. and Habitat Management, Inc. utilize proprietary state-of-the-art laser instrumentation to facilitate collection of unbiased, repeatable, accurate, precise, and cost-effective ground cover data.

H-Pit wetland vegetation sampling was performed in the following manner: First, a 10-meter transect was extended in a random direction from each systematically located sample point. Along this transect at one-meter intervals a "10-point laser point-bar" was set vertically above and parallel to the ground surface. A set of 10 readings were individually recorded by vegetation species, litter, rock (durable particles>2 mm), bare soil or water in the case of emergent communities. Recorded data was determined within each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10 centimeter intervals and recording the first variable intercepted by each of the narrow (0.020 inches) focused beams (see Figure 4). In this manner, a total of 100 intercepts per transect were recorded.

Sample Adequacy Determination. Sampling within each major vegetation community of the H-Pit Wetland and their respective reference areas involve collection of a minimum of 10 transects from each segregate unit. From these preliminary efforts, a sample mean and standard deviation for total non-overlapping vegetation ground cover was calculated. When statistical testing is required, collection of an adequate sample ($\mathbf{n}_{min}$) is typically necessary to insure reasonable estimates of the population (e.g., estimates to within 10% of the true mean (μ) with 90% confidence). In 1999, all sampling efforts on a community basis resulted in a statistically adequate sample for the population sample adequacy requirements noted above.

Although statistical testing of population sample adequacy is not required by the COE permit, the minimum samples necessary to obtain statistically valid results was determined to provide a measure of scientific defensibility. In the absence of COE guidance on statistical testing, the formula given below was used for this purpose. This formula, or a close variant, is used by the federal and state mining regulatory authorities for Colorado, Wyoming, New Mexico, Utah, Montana, Washington and on Indian lands. When the inequality ($\mathbf{n}_{min} \leq n$) is true, sampling can be considered to be adequate, and n_{min} is determined as follows:

$$n_{min} = (t^2 s^2) / (0.1 \bar{x})^2$$

where:

n = the number of actual samples collected (initial size = 10)

t = the value from the two-tailed t distribution for a specified confidence interval with n-1 degrees of freedom (CI=90%)

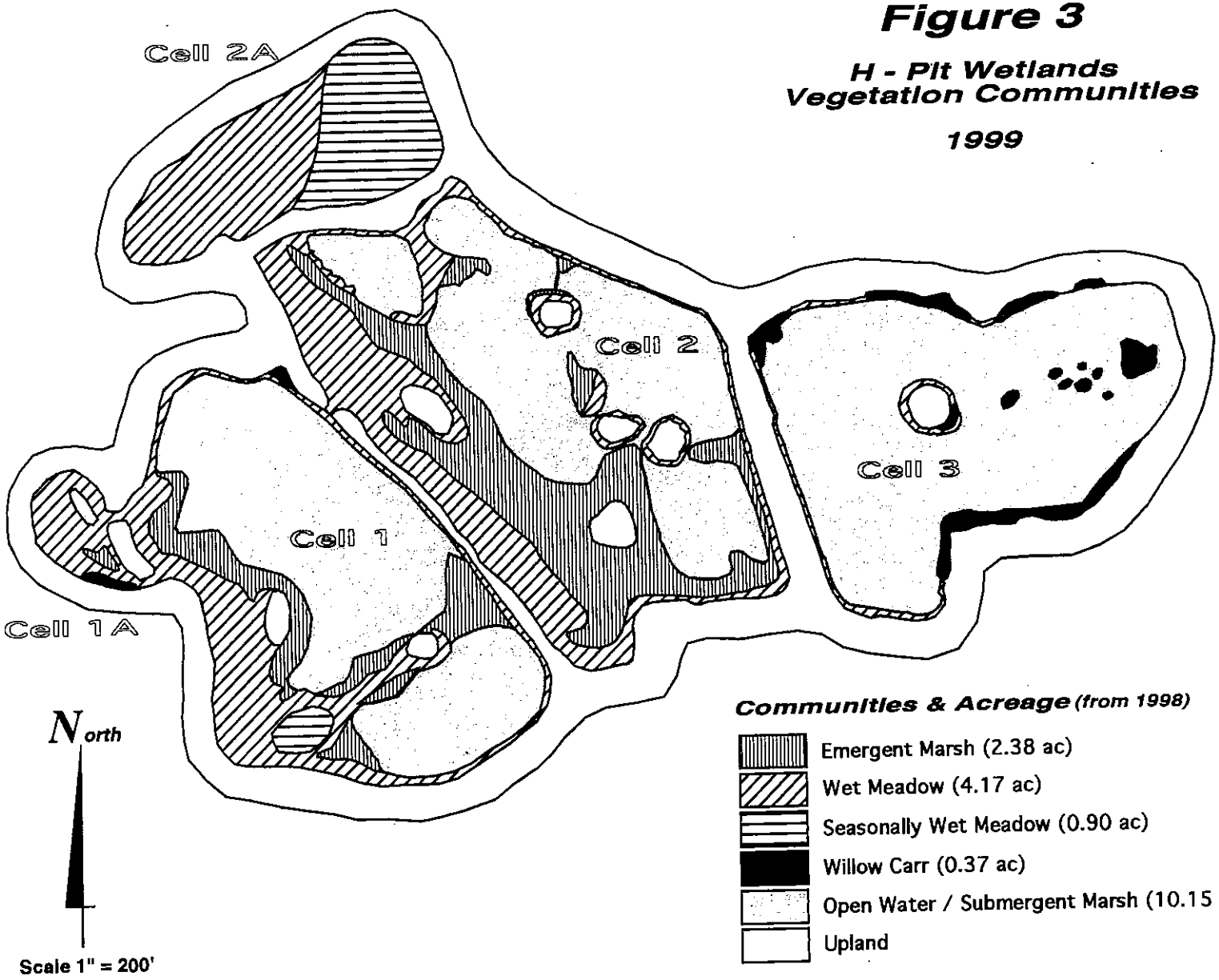
s^2 = the variance of the estimate as calculated from the initial samples

$\bar{x}$ = the mean of the estimate as calculated from the initial samples.

Figure 3

H - Pit Wetlands Vegetation Communities

1999



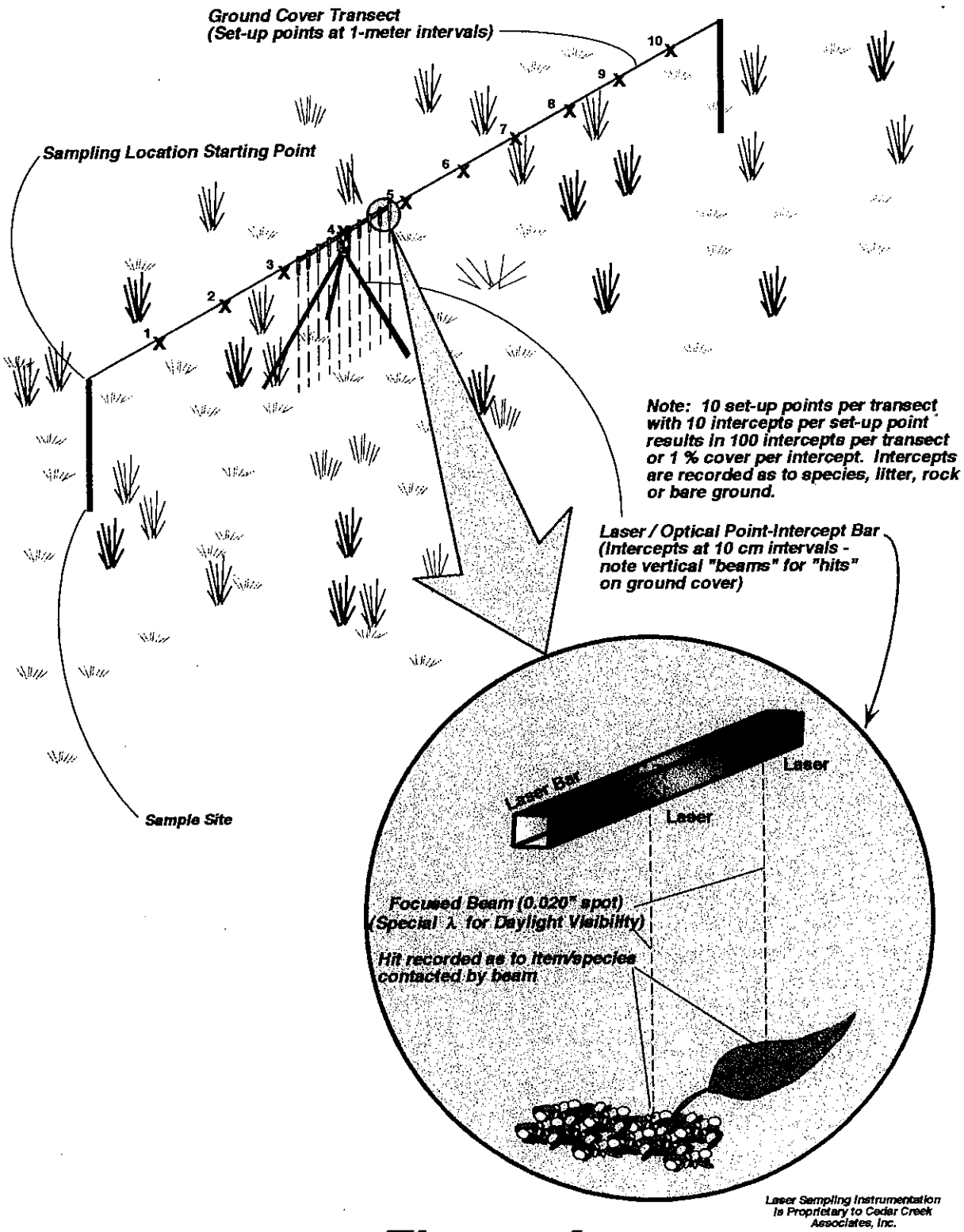


Figure 4

Ground Cover Sampling Procedure at Systematic Sample Site Locations

If the initial 10 samples in each area had not provided a suitable estimate of the mean (i.e., the inequality was false), additional samples would have been collected until the inequality ($n_{min} \leq n$) became true.

Determination of Floral Species Presence. In 1998 and to a lesser extent in 1999, species presence within the wetland complex was determined by extending random pedestrian transects across each revegetated community while maintaining a record of all observed flora by revegetated wetland cell. As commonly implemented, transects were discontinued in each unit once the rate of discovery of new taxa dropped below 1 per 5 minutes of searching. This typically accounted for a period of 60 to 70 minutes of search time within each unit.

Results

The first two years of monitoring at H-Pit will be discussed in terms of ability to satisfy, or trends towards meeting, Mitigation Success Criteria requirements for wetland reconstruction. Mitigation requirements and the ability or degree to which the current reconstructed wetland qualifies as successful mitigation will be discussed in this section individually for each of the criteria. A review of each requirement is provided, followed by a discussion of progress made to date in accomplishing successful mitigation.

Success Criterion #1 – A minimum of 7.14 acres of self-sustaining wetlands must be constructed and must meet criteria #2 through #6. Any additional acreage meeting the following criteria will be "banked" for future mitigation needs.

Approximate areal distribution of the five wetland vegetation community types surveyed in 1998 are contained in Table 2.

Table 2. H-Pit Wetland Habitat Types & Distribution, 1998 Survey

Habitat Type	1998 Acreage
Emergent Marsh	2.38 acres
Wet Meadow	4.17 acres
Seasonally Wet Meadow	0.90 acres
Willow Carr	0.37 acres
Aquatic Bed/Submergent	10.15 acres
Total	17.97 acres

(Note that the "seasonally wet meadow" is predominated by hydrophytic floral species and qualifies as a wetland community. The primary difference between the seasonally wet meadow and the wet meadow is the persistence of saturated soils for extended time periods during the growing season, and the resultant variations in hydrophytic plant species composition and density).

Currently a total of five wetland community types have been successfully established and are progressing normally on approximately 18 acres at H-Pit. In 1999, the seasonally wet meadow and willow carr acreages remained approximately the same as 1998. It was noted that the willow carr community was increasing in some areas, and is anticipated to increase substantially over the next 2-3 years. The rate of increase is expected to decrease as the wetlands develop and mature. There was a modest increase in 1999 from the 1998 acreage values in emergent marsh and wet meadow community types. This resulted in a slight decrease in the aquatic bed/submergent vegetation community type.

Success Criterion #2 - A minimum of 7.14 acres must be saturated to the surface or inundated for at least 10 consecutive days (12%) during the growing season.

The 10.15 acres of aquatic bed/submergent habitat by itself satisfies this requirement. Additionally there are 2.38 acres of Emergent Marsh and 4.17 acres of Wet Meadow whose soils are saturated for periods well in excess of 10 days during the growing season. With at least 16.7 acres at H-Pit currently meeting soil saturation period requirements, minimum acreage required for successful wetland

reconstruction have been surpassed. Achieving this increased saturated soil acreage may be attributed to the additional pit floor excavation, selective placement of suitable wetland soil during the construction phase and successful reintroduction of ephemeral surface flows to H-Pit wetlands from Stump Creek.

Success Criterion #3 - The existing fence around the mitigation site must be monitored and maintained to preclude livestock for at least five years.

The existing fence surrounding the H-Pit Wetland Mitigation Site remains intact and has yet to show any sign of wear or breach by livestock. The integrity of livestock access control fencing is inspected routinely throughout the year and during annual vegetation monitoring.

Success Criterion #4 – Wetland areas must be dominated by wetland indicator species as identified by the COE.

Review of 1998 and 1999 monitoring data provides definitive evidence that all five vegetation habitat types within H–Pit Wetland Mitigation cells are dominated by wetland indicator species and have, therefore, easily met or exceeded success requirements set in criterion # 4. The emergent marsh exhibits 100% wetland indicator species, whereas the wet meadow, seasonally wet meadow, and willow communities exhibit 70.7%, 52.0%, and 62.5% composition of hydrophytic plant species, respectively. Review of the data also reveals that many of the subdominant early to mid-successional species are classified as wetland indicators. As natural succession progresses in this young wetland community, early seral species such as knotweed (*Polygonum aviculare*) will decline in dominance and be replaced by later-stage seral wetland indicator species that are more reflective of the reconstructed wetland site's potential (unpublished proprietary monitoring data). This successional process is progressing rapidly as evidenced by dramatic changes in floral species composition from 1997 through 1999 and the substantial increase in ground cover dominance by wetland indicators (see Figure 5). Requirements of the fourth criterion were surpassed in 1998, if not the previous year, due to the rapid establishment of planted materials and invasion by wetland plant species through various sources: 1) seed rain, and 2) importation by wildlife.

Success Criterion #5 - A minimum of three nesting islands must be constructed.

The success requirement for three "nesting islands" was met shortly following construction when a total of eight larger islands and several smaller islands were built within the wetland cells. Cell 1 contains two large islands, Cell 2 has five, and Cell 3 one. These islands contribute significantly to landscape diversity for the H - Pit Wetland Mitigation site. Diversity is also being provided by the variation in construction design, retopsoiling practices, seed mixtures, a variety of inundation depths and depths to groundwater, and the microtopography incorporated into the site during construction. Principal design components of this landscape include areas of open water, emergent marsh, riparian shrublands, and wet and seasonally wet meadow.

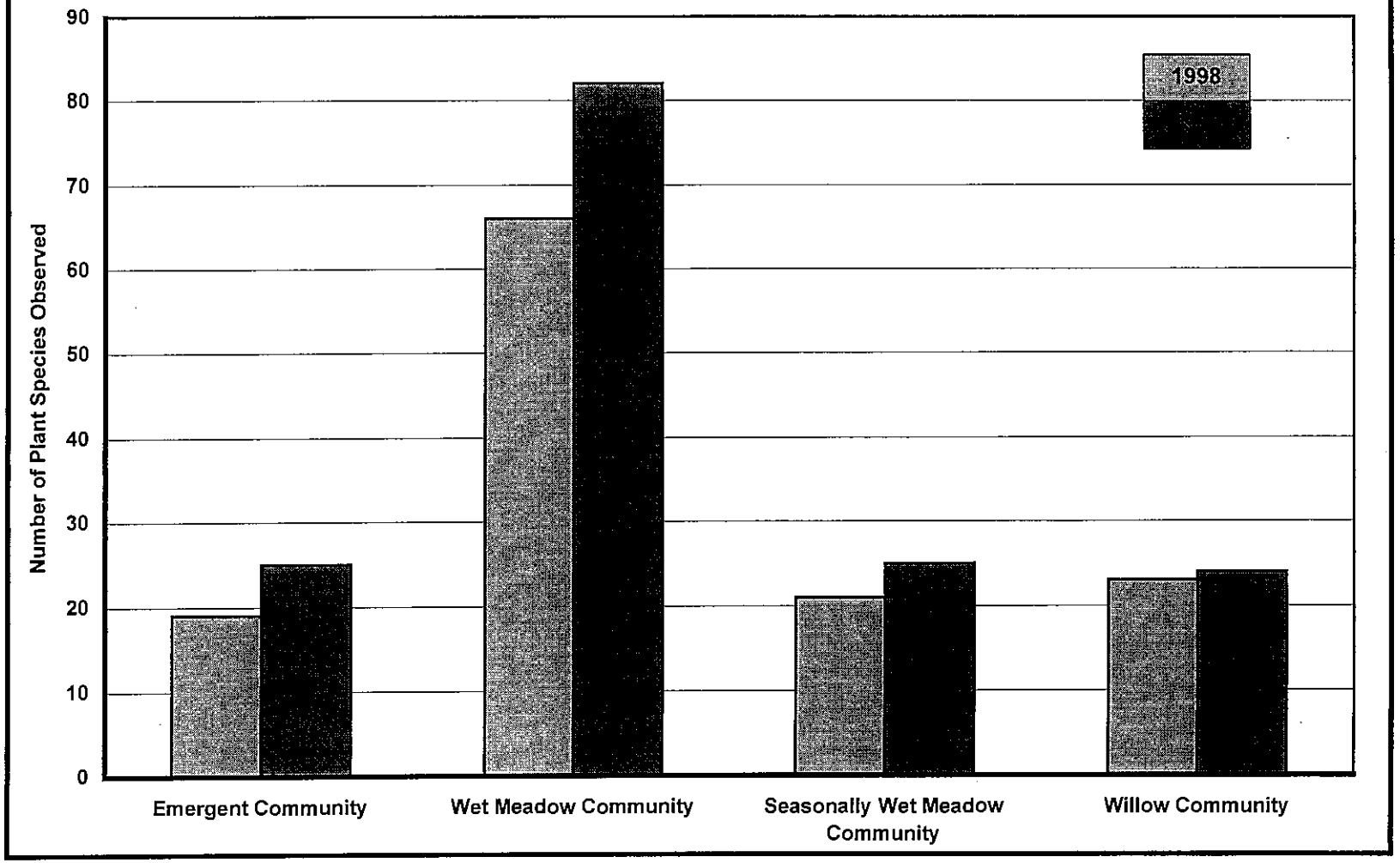
Success Criterion #6 - The vegetative cover within the wetland creation area will be deemed to be successful when the vegetative sampling data collected from the site equals 80 percent of the herbaceous plant cover from undisturbed wetlands as documented in the undisturbed wetlands inventory conducted in 1992.

In order to determine if H-Pit was successful in this regard, a reference wetland site was selected and sampled in the same manner and using the same methods and equipment as the H-Pit Wetland Mitigation site. The reference area is composed of one minor and two primary vegetation communities: emergent marsh, wet meadow and willow carr, respectively. The ground cover of these three communities was measured by point-intercept line-transects with sample estimates meeting statistical adequacy at or above the specified minimum requirements.

Reference area monitoring during 1999 in the emergent marsh established a total vegetation cover of 63.2%, 22.2% litter, 0% rock and 14.6% bare ground (or water). Predominant taxa observed were spikerush (*Eleocharis palustris*), shortawn foxtail (*Alopecurus aequalis*), Baltic rush, (*Juncus balticus*), and American speedwell (*Veronica americana*), with 37.3%, 6.5%, 4.7%,

Figure 5

Plant Species Diversity within the H-Pit Wetland Mitigation Site - 1998 vs 1999



and 4.3% constributions to vegetation cover, respectively.

The reference area wet meadow produced a total plant cover of 59.8%, 32.4% litter, 0% rock, and only 7.8% bare ground. Predominant taxa detected by sampling were spikerush, rush (*Juncus* spp.), pullup muhly (*Muhlenbergia filiformis*), and Baltic rush, with 13.4%, 11.9%, 10.8%, and 10.3% contributions to vegetation cover, respectively.

The reference area willow community exhibited a total vegetation cover of 61.8%, 25.8% litter, 0.5% rock, and 11.9% bare ground. The predominant taxa detected by sampling were yellow willow (*Salix lutea*), coyote willow (*Salix exigua*), poverty sumpweed (*Iva axillaris*), foxtail barley (*Hordeum jubatum*), and Baltic rush with 15.2%, 10.9%, 7.1%, 6.3%, and 4.0% ground cover, respectively.

Monitoring data compiled for each of the H-Pit Wetland cells are presented by cell below. H-Pit was sampled using the point-intercept line-transect method to determine the ground cover of each of the vegetation community types identified within each cell. Ground cover sampling within each community met or exceeded specified statistical sampling requirements.

Cell 1. This cell contains three primary vegetation communities, emergent marsh, wet meadow, and aquatic bed/submergent marsh. Point-intercept line-transects are not implemented in the aquatic bed/submergent marsh. In 1999, total plant cover in the emergent marsh averaged 60.2% while the vegetation cover in wet meadow averaged 68.8%, (slightly down from 1998 levels most likely due to limited summer precipitation). Rock cover averaged 0% for both of these vegetation communities. Litter averaged 12.0% and 30% in the emergent and wet meadow communities, respectively. Bare ground or water surface averaged 27.8% in the emergent marsh and 1.2% in the wet meadow. In Cell 1, these two vegetation communities almost meet minimum requirements for total plant and ground cover established by their respective reference areas after three growing seasons. The predominant taxa observed in 1999 in Cell 1 are spikerush, hardstem bulrush (*Scirpus acutus*), reed canarygrass (*Phalaris arundinacea*), rush species, American speedwell, and spike bentgrass (*Agrostis exarata*) with 13.1%, 9.4%, 8.3%, 6.5%, 3.8%, and 3.4% ground cover, respectively. In addition to total vegetation and ground cover measurements, a running inventory of floral species was made. Cell 1 exhibits a remarkably diverse vegetation community with 18 species contributing more than 1% each to relative vegetation cover (composition) within their respective communities. This represents an increase of 14 more species than in 1998. (A species contribution of 1% or more to relative cover is commonly used as a criterion for the identification of significant species in mine land revegetation evaluations, with 5 or more significant species usually being required for adequate diversity.) Based on such a standard, the H-Pit revegetation effort has achieved excellent diversity in Cell 1 with 6 and 12 significant species having established in the emergent and wet meadow communities within the short period that has elapsed since wetland construction.

Cell 2. This cell also exhibits three primary vegetation communities including emergent marsh, wet meadow, and aquatic bed/submergent marsh. Total plant cover in the emergent marsh averages 55.6%, while plant cover in the wet meadow averages 76.2%. Rock cover across the cell averaged 0%, litter averaged 24.1%, while bare ground exposure (or water surface in the emergent marsh area) averaged 10.0%.

The predominant taxa detected by sampling in this area in 1999 are hardstem bulrush, reed canarygrass, spikerush, Nebraska sedge (*Carex nebrascensis*), and tufted hairgrass (*Deschampsia caespitosa*) with 15.2%, 12.2%, 7.9%, 5.6%, and 5.0% vegetation cover values, respectively. Cell 2 also exhibits a diverse community with 17 species contributing more than 1% relative cover to the community, up 6 species from 1998. As in Cell 1, excellent diversity has been achieved in Cell 2 with 17 significant species having established in the emergent and wet meadow communities within the short period that has elapsed since wetland construction.

Cell 2A. This cell exhibits two primary vegetation communities, wet meadow and seasonally wet meadow. Total plant cover in the

wet meadow averages 43.8%, while the plant cover in the seasonally wet meadow averages only 17.3%. Rock cover across the cell averaged 5.5%, litter averaged 16.3%, while bare ground exposure averaged 52.1%. As indicated on Figure 6, Cell 2A exhibits the least total plant cover in the wetland complex. Lower plant cover in Cell 2A may be attributed to it's "immature" status (i.e., it is one of the youngest reclaimed areas within the H-Pit complex) and it has a floor elevation which is slightly higher than the adjacent wet meadow communities in Cells 1 and 2.

Predominant taxa detected by sampling in this area in 1999 are green muhly (*Muhlenbergia racemosa*), reed canarygrass, and redtop (*Agrostis alba*) with 6.7%, 4.0%, and 3.7% ground cover, respectively. In addition to the ground cover evaluation, Cell 2A exhibits a reasonably diverse community with 15 species contributing more than 1% relative cover to the community, up 5 species from 1998. Once again, very good diversity has been achieved within Cell 2A since construction.

Cell 3. This cell, the youngest of the wetland units within the complex, also exhibits two primary vegetation communities, wet meadow and willow, in addition to a very significant component of open water / mudflat. Total plant cover in the wet meadow vegetation community averages 79.0% (the only community within a cell to show an increase over 1998 values) while the plant cover in the willow area averages 49.6%. Rock cover across the cell averaged 2.5%, litter averaged 13.8%, while bare ground exposure averaged 24.3%. As indicated on Figure 6, Cell 3 exhibits ground cover values similar to Cells 1 and 2, as well as its appropriate reference areas.

Predominant taxa detected by sampling in this area in 1999 are coyote willow, reed canarygrass, yellow sweetclover (*Melilotus officinalis*), and hairy willowweed (*Epilobium ciliatum*) with 30.6%, 9.13%, 3.67%, and 3.27% ground cover, respectively. In addition to the ground cover evaluation, Cell 3 exhibits a diverse community with 11 species contributing more than 1% relative cover to the community, down one taxon from 1998. Again this represents outstanding diversity given Cell 3's recent construction.

Plant Communities. Figure 7 provides an evaluation of average values for vegetation success criteria established through 1999 reference area and H-Pit wetland complex vegetation communities (combined Cell data). The wet meadow exhibits the greatest total plant cover with 67.0%, followed by emergent marsh (57.9%), willow (49.6%) and finally seasonally wet meadow (17.3%). Species diversity is also greatest for the wet meadow community with 43 species documented by point-intercept sampling. Emergent marsh and seasonally wet meadow were a distant second and third with 16 and 9 species per community, respectively. The young willow community was least diverse with only 6 species being documented by point-intercept sampling. The reference area averaged 21 species for the three communities measured.

Considering the enitre H-Pit wetland as a whole (i.e., without regard to community boundaries) coyote willow dominated with an average of 9.4% ground cover. Co-dominants include: reed canarygrass, hardstem bulrush and spikerush with 8.0%, 5.0%, and 4.6% cover, respectively. Overall, a total of 51 of the 105 species exhibited sufficient dominance within the wetland complex to be intercepted by point-intercept line-transect sampling. This compares very favorably with the 38 species intercepted within the reference area wetland communities (see Figure 8). Given that only 5 of the 12 planted species were detected by sampling in 1999, the invasion (volunteering) of 46 species during the establishment period may be considered excellent.

Wildlife Habitat

In addition to their excellent floral diversity, the aquatic community and four vegetation communities within the H-Pit wetland are contributing excellent overall ecological diversity as well. Topography, developing floral structural diversity, and the sinuous wetland community boundaries provide a diversity of habitat superior to the surrounding upland communities, especially when the impact of edge effect is considered. The structural diversity of the developing willow community provides significant neotropical bird habitat, both for nesting and escape cover. The aquatic bed and submergent marsh provide required habitat for a large variety of waterfowl, wading and shore

Figure 6

1998 vs. 1999 - H-Pit Wetland Ground Cover Attributes - by Cell

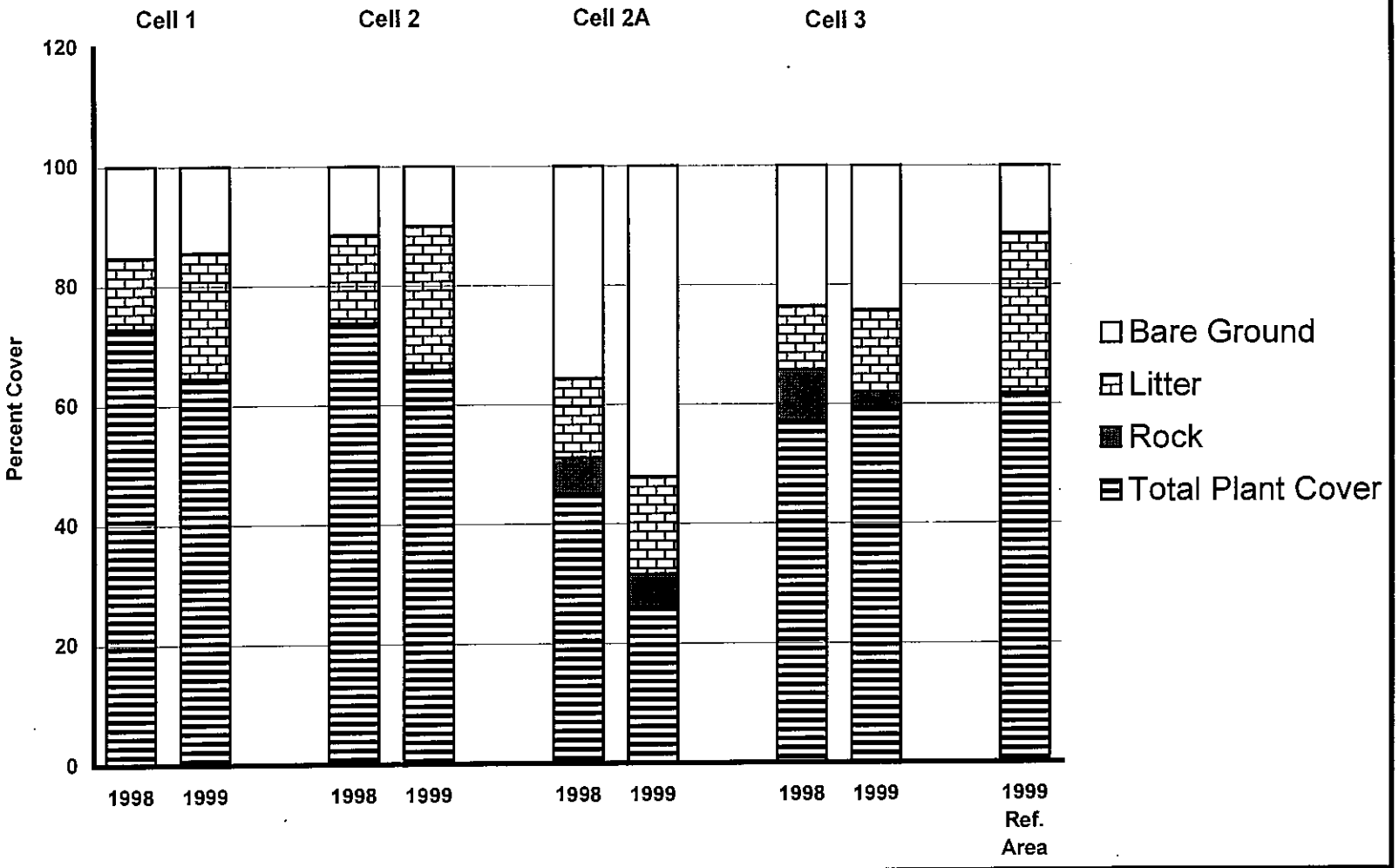


Figure 7 - 1999

H - Pit Wetland: Ground Cover Attributes by Vegetation Community- 1998 vs. 1999

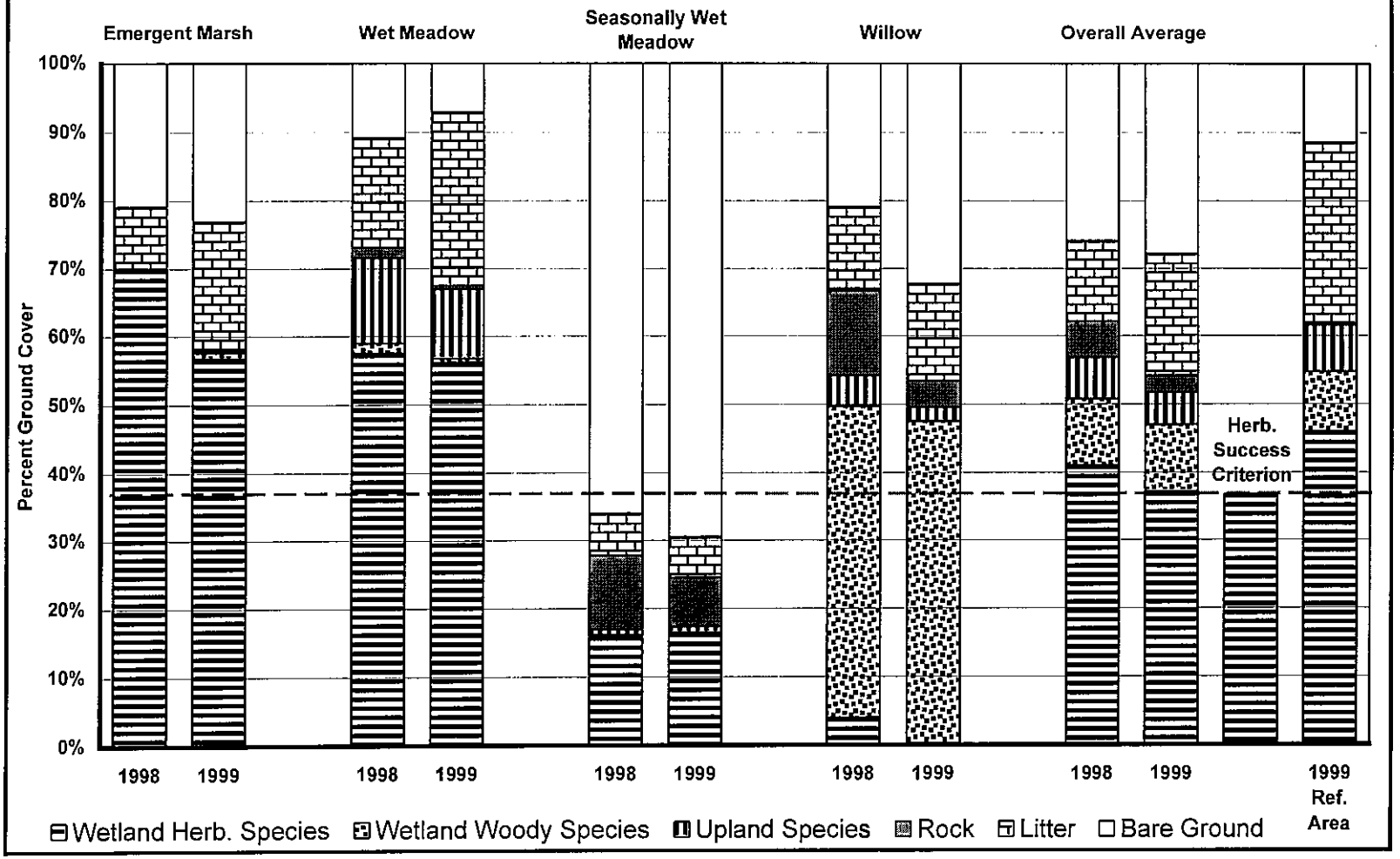
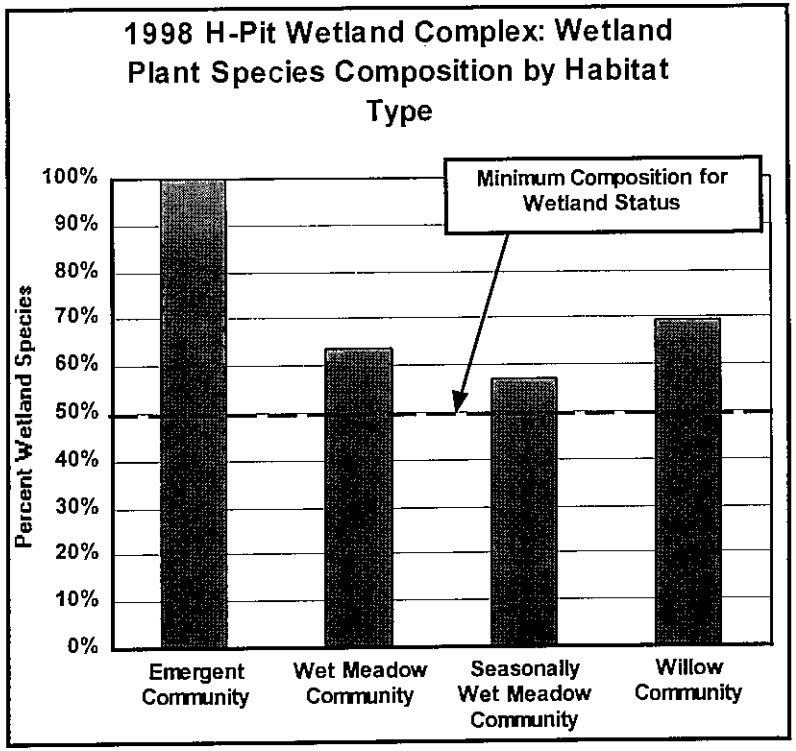
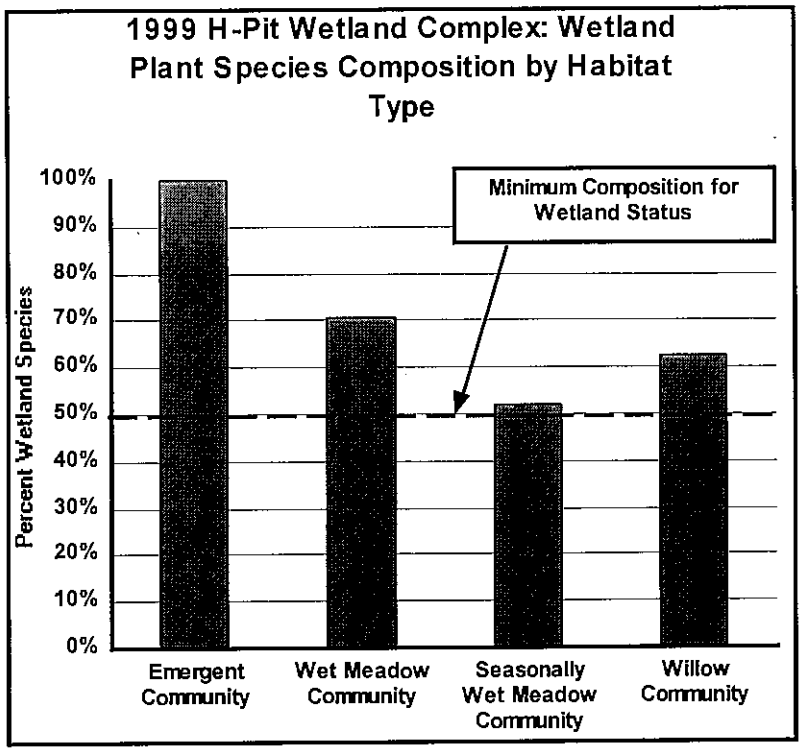


Figure 8 - H-Pit Wetland: Wetland Plant Species Composition by Habitat Type - 1998 vs. 1999





birds. Topographic diversity, especially the islands in aquatic bed areas, offer excellent cover and nesting sites for a variety of wildlife. The dense herbaceous layers, especially of the wet meadow, provide excellent small mammal habitat and plentiful forage, as well as prolific seed production. Documented heavy use of the H-Pit wetland by wildlife initiated with completion of its construction and is expected to continue. Floral species diversity is being promoted through the introduction of plant materials carried by the wildlife that frequent this new "oasis" at the foot of the Independence Mountains.

Summary / Discussion of Development Toward Wetlands

The creation of wetlands at H-Pit has been successful in accordance with the six identified success criteria at this site. Approximately 18 acres of wetland have been created which satisfies the requirement of 7.14 acres (success criterion # 1). These 18 acres are either inundated or saturated to the surface for a minimum of 10 days during the growing season as required by success criterion # 2. The perimeter fence is in good repair and continues to successfully preclude livestock from the establishing wetland as required by success criterion # 3. Of the 105 species of plants observed within the wetland complex since 1997, well over half (72) are wetland indicators. A total of 68.6% of all taxa observed in the wetland complex and 90.8% of the ground cover (47.0% ÷ 51.74%) are classified as wetland indicators,which exceeds the requirements of success criterion #4. A total of eight larger islands and several small islands were constructed which significantly exceeds the three island requirement of success criterion # 5. And finally, the average herbaceous ground cover of the H - Pit wetland complex equals or exceeds 80% of the herbaceous ground cover of the most similar natural wetland (reference area) in accordance with success criterion # 6.

Based on site-specific experience, and with other similar wetland construction projects in the region, wetland community development at H-Pit has proceeded rapidly and is highly successful. As the wetland vegetation communities develop and mature, early seral species are beginning to diminish in frequency, while mid- to late-seral species begin to exert greater dominance.

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