Guidelines for Gravel-Pit Wetland Creation

by

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Abstract. The frequent colonization of the margins of abandoned and unreclaimed wet sand and gravel pits by typical marsh vegetation indicates the feasibility of a created wetlands component in gravel/sand reclamation planning. Using the natural pit wetlands as models and examining the pertinent literature, guidelines were developed for: (1) selecting promising sites, (2) planning with a regional perspective, and (3) construction and monitoring. Key concepts are: hydrological stability and adjacent land uses that will not have an adverse impact; consideration given to how a pit wetland will interact with adjacent ecosystems on a regional level; grading of pit perimeters to produce irregular contours and no more than a 0.6 m change of elevation within the proposed wetland; a combination of limited deliberate planting along with natural colonization whenever the reclamation permit can be adjusted to allow the 3 to 4 years commonly necessary for such colonization; the establishment of self-perpetuating marsh vegetation confirmed over a 3-year period of observation as a minimum requirement for determining permit compliance. Longer term monitoring of pits reclaimed under these guidelines could provide information that would increase and refine post-mining land-use options for wet sites. Research projects could focus on learning more about development of wetland functions within created systems, eventually providing standards for evaluation on a functional level.

Introduction

Wetland creation is still in its infancy as an applied science and is not yet capable of producing predictable results. It is, consequently, a subject of considerable controversy. To some it appears to be a relatively simple, repeatable process; to others a minefield of assumptions regarding ecosystem structure and function. The experimental nature of wetland-creation has made it less attractive for mine reclamation proposals, resulting in very little effort made to purposefully create gravel-pit wetlands, even where conditions are very favorable. The vast majority of wetlands and waterbodies on mined lands nationwide exist not because they were planned for, but by accident as a result of the mining of gravel for highway and other construction projects (Brooks, 1990). As examples of natural regeneration, these sites can provide valuable information regarding the species composition, life-support functions, and long-term persistence that might be expected in future "successful" wetland creations.

Without substantial scientific evidence, which we do not have, there is no reason to assume that these volunteer wetlands function on the same level or provide the benefits of the long-established ecosystems which have been filled-in and lost to agriculture and development. It seems likely, however, that even disturbed and degraded wetland sites may have unknown value. Increasingly, studies indicate that these sites may be very significant for rare species, migratory birds, and regional hydrological functions (Josselyn and others, 1990). "Sites presumed to have little value may provide vital

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refuge for species during storm events or support rare and endangered species due to lower interspecific competition within these marginal habitats" (Josselyn and others, 1990).

Scientists have now begun to study wetland creation and restoration in an effort to manage and accelerate processes which may take generations to occur naturally. From these experimental studies will come information which may ultimately allow true replacement of lost or damaged ecosystems. More research is needed, and sand/gravel pits are in many instances ideal as test sites. Excavations that expose the water table commonly create the hydrological features necessary for a wetland, and they eliminate the need for diking and high-maintenance pumping and drainage systems.

The gradual colonization of numerous abandoned wet pits by wetland species indicates both their suitability for subsequent use as a planned wetland and the potential to add to the wetland resource base. Innovative reclamation could supply valuable habitat, contribute to regional hydrological resources, and provide research opportunities to improve our understanding of artificial wetlands. Sand/gravel-pit wetlands offer benefits to society with which mining companies could be pleased to be associated and identified.

Minimum Site Requirements

Hydrology

Hydrology is the key to long-term functioning of wetland ecosystems (Kusler and Kentula, 1990). Since establishment of hydrophytic vegetation will depend on both the predictability and controlled fluctuation of water levels, wetland creation should be restricted to those sites for which seasonal water-level elevations have been determined and where some manipulation is possible. Freshwater gravel-pit wetlands not in river or stream beds will be dependent on ground water and variable surface water flows. Ground water and surface runoff do not always provide dependable water sources, but in most situations they will satisfy the requirements of a wetland project (Van Egmond and Green, 1992).

Assessing the reclamation potential of sand or gravel excavations as wetlands should involve monitoring test pits for annual water-level fluctuations. The amount of fluctuation depends on the nature of the aquifer and on how much water mining operations and nearby users consume. Ranges of 2 meters per year are not uncommon in porous sand and gravel aquifers with local recharge zones (Michalski and others, 1987). Some gravel-pit sites may not be suitable for wetland development due to extreme variations of the water table. Suitability can not be determined until the expected range of the water-table elevation has been established with statistically sound data. Since a successful wetland design incorporates many site-specific variables, it is not possible to generalize acceptable range maximums or periodicity. A decision must be based on project goals and the requirements and tolerances of the wetland-plant communities that project designers want to establish (T. S. Miller, King County Services, oral commun., 1992). The widely varying flooding tolerances among wetland species can be used to advantage in increasing wetland creation options for a particular site. A flexible plan that can accommodate unexpected changes in plant community composition will have a greater chance of success, especially where ground water flows are seasonally unstable.

Potential Land-Use Conflicts

Social considerations may be just as important determinants of site suitability as physical ones. "Adjacent land use . . . could detrimentally impact functioning of wetlands or the wetlands may have detrimental impacts on current or planned uses of neighboring lands" (Hammer, 1992). Intensive agriculture or heavy industry adjacent to the site might produce sediment or chemical-loaded runoff that would prevent wetland establishment.

Wetlands themselves can be unwelcome neighbors. Although some new housing developments and office complexes are planned around preserved sections of wetlands, residents of established communities may well object when wetland alternatives are proposed. Neighborhood opposition often focuses on the prospect of public use, with fears of noise, traffic, and vandalism paramount. Several mining companies have shelved plans to donate lands to the public when faced with organized community opposition (Morris, 1982).

Planning Pit-to-Wetland Conversions

Pre-planning for Realistic Goals

Wetland conversion plans should be "integrated with mining operations and reclamation at the beginning of any project" (Brooks, 1990). This ideal should not preclude adding wetlands to an existing reclamation plan. Wetland creation could be added to a previously permitted proposal for a post-mining open-water pond, for instance, assuming the hydrologic conditions to support the pond had already been established. Reclamation designed around an aquatic ecosystem goal provides direction in the early planning stages, but the decision to attempt creation of specific wetland functions might best be left until mining is nearly complete. At that point the altered hydrology of the site could be re-evaluated, and objectives could be based on several seasons of hydrological data-gathering plus assessment of regional land-use trends over the same time-span. When objectives have been established, they should be clearly described and recorded, along with any subsequent amendments, because on-site modifications during construction and planting are commonly necessary (Hammer, 1992).

Michalski and others (1987) recommend detailed studies to determine surficial characteristics of the site before, during, and after extraction. If pumping of ground water is part of the extraction process, the output could be monitored to estimate in-flow rates and the potential area of ground-water influence after mining (Michalski and others, 1987). Pre-mining planning could include provisions for hydrological monitoring and record-keeping at various stages over the life of the mine. This provides the database from which to determine the most feasible final configuration. The information would be useful for establishing other reclamation endpoints if it did not ultimately support the proposed wetland goal.

Regional Reference Wetlands as Guidelines

The most fundamental goal, regardless of the specific chosen objectives, is to develop self-maintaining systems that mimic natural ones in as many ways as possible. The study of local natural wetlands is important because artificial wetlands must closely imitate natural systems adapted to the region if a creation project is to succeed without continual operating and maintenance costs (Hammer, 1992). This means that design parameters must be appropriate to local hydrology, climate, and soil conditions. Measurements of elements of wetland structure at a natural site within the region or watershed that shares these conditions will provide insights into what is obtainable and how to evaluate progress at the constructed site (Hammer, 1992). In the context of comparisons of natural to artificial, the objectives for a created wetland must encompass "only a very early successional stage if the evaluation period is short (less than 10 years for a marsh)" (Hammer, 1992).

Landscape Considerations

Even if the physical parameters of a site are favorable for reclamation as wetland, the result will be counterproductive if it conflicts with regional land-use priorities or overall ecological balance. "Land managers need to establish their mitigation policies in the context of what changes are occurring in wetland types throughout a given physiographic region, not just on a particular mine site" (Brooks, 1990). Assessing these trends to determine regional need for specific wetland types requires coordination among federal and state agencies. Cooperating agencies must then see that this information is transferred to those who will be planning wetland construction, including the mining industry (Brooks and others, 1988).

Constructing a Gravel-pit Wetland

Site-specific Considerations and Grading Plans

Since each site presents a particular combination of hydrology, topography, and substrate, only generalized instructions can be provided. There are no exact guidelines yet accepted in the very young science of wetland creation. Given favorable site hydrology, however, it is possible to proceed with assurance that the creation of gentle slopes at pit perimeters plus restoration of topsoil, or even moderately amended subsoil, will result in establishment of wetland vegetation. Many abandoned wet pits have, over time, acquired typical wetland vegetational characteristics with far less encouragement.

Although many mine reclamation plans are submitted in the initial permitting process, it may not be practical to plan the specifics of a post-mining pit wetland until the extraction is nearly complete. At that point it should be possible to draw up a detailed site grading plan which will take the site variables into account. The final hydrological parameters, in particular, may not be fully anticipated or understood until the alterations that mining imposes have actually been realized. The site grading plan is an essential element in engineering the site for wetlands because it will determine basin morphometry, which in turn determines vegetational composition (Garbisch, 1986). Because many wetland plants are sensitive to water depths within a low range of tolerance, the most useful plan would have contours of 1 foot or less at a scale of 1 inch equals 20 to 50 feet (Miller, 1987).

The precision grading required to bring the site to the final grade within the established tolerances may not be possible if water cannot be excluded from the pit (Garbisch, 1986). In these instances, "the site grading plan should reflect this . . . and specify the scattered mounding of fill materials in order to diversify the wetland habitat" (Garbisch, 1986).

Shorelines and Slopes

A common recommendation for sand-or-gravel-mine wetland construction is to increase the area of the pit basin by creating an irregular shoreline. Bays, inlets, coves, peninsulas, and islands increase topographic heterogeneity and habitat diversity and provide more "edge" by increasing percentage of shoreline per unit area (Crawford and Rossiter, 1982). Pit floors should also have an irregular topography with mounds and depressions (Norman and Lingley, 1992; Van Egmond and Green, 1992; Michalski and others, 1987). Dumping overburden in irregularly spaced piles will create rough bottom contours and perimeter landforms (Van Egmond and Green, 1992).

Construction of some of these landforms can take place during mining to simplify post-mining reclamation. Overburden and waste materials (including boulders and tree debris) can be graded into landforms above and below the water line (Michalski and others, 1987). Islands for protection of waterfowl and general ecosystem diversity can be developed in undrained pits during operations (Michalski and others, 1987). They should be separated from the shore by a permanent water depth of 1-to-2 m and a width of 4-or-5 m, with tops at least 1 m above the estimated highwater mark (Van Egmond and Green, 1992).

Slopes for a true marsh community need to be almost flat -- no more than a 0.6-m change of elevation between the deep and shallow marsh (Miller, 1987). Shallow slopes maximize flooding and minimize erosion (Kruczynski, 1990). Brooks (1990) and Crawford and Rossiter (1982) recommend gentle slopes at 10H:1V or 20H:1V; Kruczynski (1990) suggests that a range of 5H:1V to 15H:1V is acceptable. Since it is unlikely that efficient mining will be possible at these angles, the cut-and-fill method can be used to create recommended slopes (Norman and Lingley, 1992).

Unless slopes have been left ungraded and unstabilized, gravel-pit waterbodies typically have two distinct habitats: the shoreline wetland and open water. Grading plans will determine how much area will be allotted for each. Fifty percent open water to 50% marsh or swamp is often cited as optimal for fish and wildlife habitat (Van Egmond and Green, 1992; Crawford and Rossiter, 1982). Norman and Lingley (1992) suggest 25% of the waterbody in shallow water less than 0.6 m deep, 25% in shallow water 0.6-2 m deep, and 50% in water greater than 3 m as a general guideline for use by fish and waterfowl. If wetland communities are the objective, however, "the higher percentage of shallow areas the better" (Norman and Lingley, 1992).

Water Level Adjustment

Gravel and sand pit-wetland creations are primarily ground water-fed and therefore may not require elaborate water-control mechanisms. According to Van Egmond and Green (1992), "natural cycles of drought and wet spells will sometimes provide adequate changes in water levels." An outlet with a controllable weir will increase management options, however, and will enable periodic partial drainage which helps reestablish wetland vegetation. Van Egmond and Green (1992) recommend that a water-level drawdown should occur every 3 to 10 years. Boule (1988) emphasizes the importance of simple systems which are more likely to be self-regulating and self-maintaining. He advocates relatively inexpensive weirs or other similar devices which are unlikely to fail and disrupt the entire system. Outlets should be identified on-site and recorded in plans so that they can be periodically inspected and protected from erosion (Norman and Lingley 1992).

Branch (1985) reported successful vegetation establishment on a 5-ha portion of an abandoned sand and gravel mine in Maryland using a device with a removable weir plate which controlled the top 0.3 m of water in the basin. Removal of the weir plate exposed perimeter areas for planting; once this was complete, the plate was reinstalled to restore the project design water levels. Garbisch (1986) suggests that incorporation of an adjustable weir in the project design may compensate for less-than-precise grading.

Although periodic "drawdowns" are important for waterbodies that function as waterfowl habitat, many pit ponds lack surface drainage and "cannot be drawn down using standard dikes and weirs" (Michalski and others, 1987). For landlocked ponds receiving supplemental water from surface runoff, a partial drawdown can be engineered by periodically diverting this surface flow (Michalski and others, 1987). Unless there are concerns about contaminants in the surface water, it can be directed toward the pit-pond impoundments (Van Egmond and Green, 1992). The drainage channels "should have a natural sinuosity and gradient", should be stabilized with riprap or vegetation, and should be directed through upland "vegetated areas to slow runoffs and aid in water filtration" (Norman and Lingley, 1992).

Sealing and Lining

Since "most natural wetlands are perched above an impervious layer that reduces or prevents water loss", Hammer (1992) believes that there are few situations in which a basin can sustain a wetlands ecosystem without an impermeable lining. Brooks (1990), on the other hand, states that "basins constructed below the water table rarely need to be sealed." Wet pits have an advantage as wetland creation sites not only because they are filled primarily by ground water flow, but also because natural sealing is common. The material left behind after gravel mining usually has a fairly high percentage of clay or silt, especially if aggregate was washed on site (Bradshaw and Chadwick, 1980). These "fines" will contribute to the blocking of water movement, and over time additional fine sediments will be eroded or carried into the pit lake with surface runoff (Evoy and Holland, 1989). The extent of this natural sealing will vary from site to site depending on the shape of the pit, bank materials, perimeter vegetation and water turbidity (Durbec and others, 1987). It seems likely, however, that even a partial lining of sediments within the pit would be beneficial from a wetland creation perspective.

Soils

An appropriate substrate for plant establishment can be created by placing topsoil on banks, islands, and submerged areas that have the recommended shallow grade. Norman and Lingley (1992) recommend a 15-to-20 cm layer of topsoil over a thicker layer of subsoil; Hammer (1992) suggests a 40-to-60 cm total soil layer (topsoil and subsoil) will be needed to provide adequate substrate for root growth. This soil layer should be placed on islands and down to 1.5 m below the expected highwater mark for the wetland perimeter (Van Egmond and Green, 1992). If grading-plan configurations are to remain accurate, the pre-final grades will have to be made lower than the final design elevations to allow room for the topsoil (Miller, 1987).

Stripping and stockpiling of topsoil before mining will reduce reclamation costs later on. To maximize efficient use of on-site materials, clean process-waste fines can be used to augment salvaged topsoil (Hart and Keammerer, 1992). Structural damage can be minimized if soil stripping and replacement is limited to dry periods and if proper machinery (e.g., wide-track crawler bulldozers) is used in re-application (Norman and Lingley, 1992). Any sort of unnecessary equipment movement over the soil should be avoided.

There are varied estimations of appropriate topsoil storage periods. Brooks (1990) specifies a maximum of 3 months. Garbisch (1986) says stockpile duration must be less than 4 weeks. Segmental reclamation is the only procedure that will be compatible with these storage times, because it allows transfer of topsoil directly from an active mining segment to another segment which is in the process of being reclaimed. This reclamation approach is ideal for larger sites and long-term operations, but it is not always an option where deposit heterogeneity and market fluctuations prevent continual movement of the operation from one segment to the next (Norman and Lingley, 1992). Where longer storage periods are necessary, Michalski and others (1987) suggest seeding of the piles as a way to reduce loss of quality.

For mined sites that have no salvaged topsoil available, the partially weathered subsoil may be an acceptable substitute (Michalski and others, 1987). Garbisch (1986) goes so far as to say that most clean (uncontaminated) inorganic borrow and dredged fill materials will be satisfactory substrates for wetland establishment. Hammer (1992) agrees that "most common substrates are suitable for wetland establishment" and that "wetland plants thrive in a broad range of soil types", but adds that topsoil replacement may eliminate the need for soil amendments.

If subsoil or overburden material is the only planting medium available, then a controlled time-release fertilizer that performs in saturated soils should be put into the substrate together with the transplant (Garbisch, 1986). If the planting is occurring underwater, Garbisch (1986) suggests placing the fertilizer in burlap sacks underneath the transplant. Fertilizers should never be broadcast or spread on the soil surface of wetlands (Shapiro and Associates, 1991). The cost and additional labor necessary to apply these fertilizers would seem to argue for on-site salvaging or site-to-site transfer of topsoil whenever possible.

Straw or hay mulch is another option to consider for any reclaimed site where the substrate lacks organic matter (Brooks, 1990) and could be an inexpensive adjunct or alternative to commercial fertilizer for wetland applications. Street (1982) recommends 1 kg straw mulch per square meter.

Wetland Vegetation

For wetland creations, there are only two basic reasons for choosing managed revegetation over natural colonization: timing and species composition (Josselyn and others, 1990). Composition, especially, is a factor in many mitigation proposals. Revegetation by artificial means may be required, for example, if a specific wetland plant community is necessary to replace habitat for wildlife species that are loosing habitat elsewhere. In these situations it may be advisable to salvage plants from wetland sites that are being destroyed and transfer them to a new site where their genetic diversity is likely to be preserved.

Managed revegetation programs are also generally more successful in controlling exotic species which commonly invade disturbed areas and become established first (Josselyn and others, 1990). These exotics usually have a competitive edge over native marsh species and may form extensive monotypic or low diversity stands that decrease the wildlife habitat or nutrient processing functions of the wetlands they take over. Reed canarygrass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*) are notorious local examples in freshwater wetlands.

There are also a few ubiquitous native wetland plants which may be considered undesirable due to their aggressive, weedy characteristics. Many wetland ecologists would advise control of dominants such as common cattail (*Typha latifolia*), willow (*Salix* spp.), and cottonwood (*Populus* spp.) because of their tendency to reduce system diversity and crowd out plants more valuable to wildlife (Hammer, 1992; Odum, 1988; Erwin and Best, 1985). These pioneer colonizers are adapted to invade disturbed sites, and "creation projects often behave like disturbed wetlands" (Odum, 1988). Nonetheless, dominant natives such as cattail, willows and cottonwoods remain popular components of revegetation projects and are found on many lists of suggested species for wetland plantings. As naturally occurring features on most disturbed freshwater wetland sites, they would seem to be far preferable to weedy exotics and perhaps not worth great effort and expense to control unless their establishment would conflict with project goals.

If a natural seed source is nearby, or if the substrate contains a seedbank from another location, periodic manipulation of water levels in the constructed wetland basin can be sufficient to start germination and retard growth of terrestrial species. Miller (1987) suggests that a seed source can be obtained from mud removed from shorelines of existing ponds and marshes and spread in the shallows (water depth less than 10 cm) of the created site. Brooks (1990) mentions the possible transfer of seed-bearing hydric soils from wetlands scheduled to be altered or filled-in for development. The removal of plants or soil can be justified only when the destruction of the natural wetland is a legally sanctioned certainty and all relevant government regulations have been followed. If these conditions are met, salvaging of plants and hydric soils from nearby development sites or during segmental reclamation should be encouraged as a means of preserving what would otherwise be lost.

A post-reclamation study comparing treatments in a central Florida marshland reclaimed from a phosphate mine provides support for the use of relocated hydric soils. The study determined that topsoiling with a 2-to-10cm-thick layer of "mulch" containing seed and root material obtained from a wetland borrow site showed "distinct advantages over natural revegetation of overburden" (Erwin and Best, 1985). After two full growing seasons, the mulched areas had higher species diversity and more complete vegetative cover than the untreated overburden areas. More importantly, this topsoiling method "appears to encourage the accelerated establishment of late successional plants in sufficient quantities to compete with aggressive weedy species" (Erwin and Best, 1985).

Natural hydric soil seedbanks thus obtained should not be stockpiled for longer than 1 month to avoid desiccation and possible re-oxidation of metals (Brooks, 1990). Hammer (1992) advises that any wetlands soil reserved for later use should be stored underwater to prevent release of bound metals.

If a legally and ecologically acceptable donor site is available, Hammer (1992) recommends an alternative to digging out and spreading a layer of wetland soils. This method involves collecting cores of wetland soil (10-12 cm diameter and 15-25 cm long) and inserting them in the substrate at the reclamation site. The cores contain seeds as well as roots, tubers and rhizomes and can rapidly develop into a complex wetland community. They are also a reservoir of propagules that may produce additional plant growth for several years after they are installed at the new site. Disadvantages center around labor costs involved in collecting, transporting, and installing the cumbersome and somewhat fragile cores.

If species composition for a particular mitigation purpose is not a concern, and if establishment within a limited time frame and budget is the priority, then a combination of natural colonization and deliberate planting may be the most effective way to establish vegetation on gravel-pit wetlands. Natural regeneration, while not "manageable" enough for situations where precise control over outcome is important (Garbisch, 1986), may provide the best long-term results because the plants will grow where they are best adapted (Clewell and Lea, 1990). The availability of natural seed sources adjacent to the project site or the possibility of seed transport into the site via flood waters needs to be evaluated if natural revegetation is part of the reclamation plan (Clewell and Lea, 1990). The amount of hand planting undertaken should depend on the proximity or reliability of a seed source, labor and materials costs, and time allotted to complete the project.

For those pit wetlands that can or must be hand planted, the best guide for species selection will be found in the vegetative composition of similar nearby wetlands (Hammer, 1992). Local native-plant nurseries, a few of which specialize in wetland vegetation, are sources of advice on what species combinations will produce the most natural plant communities. The objectives of the reclamation plan, which might include wildlife habitat, aesthetic enhancement, and/or storm-water detention and purification, will also help determine appropriate plant species (McMullen, 1988). The limiting factors, however, will be the physical conditions at the site and the environmental tolerances of available nursery stock.

The type of plant stock chosen will influence timing of planting and vice versa. Spring is usually the best time to plant, with fall the next best choice (McMullen, 1988). Propagules planted in late spring may be less susceptible to wildlife damage due to the shorter time to be expected between planting and germination. These timing recommendations generally apply to the seeds, rhizomes, corms, and tubers of herbaceous species, as well as to the whole plants. Woody vegetation such as trees and shrubs should be planted in the dormant state which generally extends from November through March in the Pacific Northwest (Norman and Lingley, 1992).

A biologist familiar with local wetlands should review the proposed planting design. "The number of each plant species to be used will be based on the type of community, the plant's position in the community, and the required spacing between plants" (Miller, 1987). Miller (1987) generally recommends that trees planted on 4.6-to-7.6-m centers, shrubs on 0.9-to-2.4-m centers and groundcovers on 1.0-m centers would be appropriate for the emergent shorelines of created freshwater wetlands. Marshes created in standing water deeper than 10 cm are most easily established using sprigs (culms), tubers, or rhizomes (Miller, 1987). These propagules are pushed into the mud/mulch substrate on 0.3-to-1.5-meter centers (Brooks, 1990). Plantings should be irregularly spaced in clumps to mimic natural spacing as closely as possible.

The cost of managed revegetation with nursery stock and labor intensive hand planting can be substantial (Brooks and others, 1988). Miller (1987) estimates that approximately 27,000 transplants per hectare will be necessary to establish a created marsh wetland. Costs can be greatly reduced if time expectations and reclamation objectives allow at least partial natural colonization. If the hydrological aspects of a site are favorable to begin with, precise grading and substrate preparation should be enough to assure emergence of at least a few native and/or naturalized wetland species. On sites being created as a diversity-enhancing feature of a mine reclamation plan and not as mitigations for specific wetland losses, this may be all that is needed.

Buffer areas consisting of native upland vegetation and at least 30 meters wide will increase habitat diversity and protect the shoreline and should be planted/seeded on the higher ground surrounding the pit impoundment and created perimeter wetland (Norman and Lingley, 1992). According to Munro (1991), vegetated areas should be provided as buffers between wetlands and adjacent developed land or as transition zones between wetlands and adjacent natural areas even if not required by regulations.

Post-construction Monitoring

Evaluating Success

The construction process, if carefully planned and well executed, should produce a site on which the altered hydrologic conditions favor wetland development. The introduction of wetland plant species, whether by natural colonization or managed revegetation, is only the first step in that development. Wetland functions for which the project was designed might not develop for decades, if at all. According to Hammer (1992), it is "grossly unrealistic to expect to create even the simplest type of natural wetlands systems" within 2 or 3 years after construction. This makes it very difficult for regulators to determine whether a wetland reclamation has been "successful", particularly if the site is part of a mitigation effort to replace the functions of natural wetlands sacrificed to development.

The time limits for completion of revegetation that are specified by many surface-mine regulatory programs are inadequate for the evaluation of created wetlands. Washington State allows 2 years or "such later date as may be authorized by the department" (Chapter 332-18-050 WAC). The literature on wetland creation and restoration indicates that 2 years is not sufficient time for stabilization of new emergent marsh ecosystems. Boule (1988) suggests that establishment and natural perpetuation of plants in marsh and shrub-swamp systems would require 3 to 5 years. Brooks (1990) states that "there is some scientific evidence for the stabilization of emergent marsh systems after three years." Josselyn and others (1990) report their observations that many San Francisco Bay area wetland restoration projects which had been considered revegetation failures became fully vegetated when allowed a 3-to-4-year period of natural regeneration.

Past experience with restored or created wetlands also indicates that revegetation over 1 or 2 years is "no guarantee that the area will continue to function over time" (Kusler and Kentula, 1990). Active monitoring, with periodic review by qualified personnel, would provide some perspective on the direction that site development is following and would allow for timely mid-course corrections if necessary. Reports, submitted within 90 days following sampling, should document any vegetation changes including percent survival and cover of planted and/or volunteer species (Erwin, 1990). Monitoring reports should also document issues related to water levels, water quality, and sedimentation and discuss recommendations for improving the degree of success observed (Erwin, 1990).

Short-term vs. Long-term Monitoring

The evidence regarding the establishment of marsh vegetation seems to indicate a minimum 3-year monitoring program for wetland creation projects. Brooks (1990) suggests that expenses for a 3-year monitoring period be included in the cost projections for any mine reclamation plan with a wetlands component. This allows for assessing of varying conditions over three growing seasons and should not result in unbearable economic burdens on the permittee (Brooks, 1990). Boule (1988) feels that annual monitoring of wetland creations over a 3-year period is the minimum acceptable term; 5 years would be more appropriate for some complex projects. Erwin (1990) agrees that post-construction monitoring should be conducted over a 5-year period, with a minimum of 3 years, and with annual inspections at the end of each wet season.

The short-term monitoring proposed here will not be sufficient for scientific research and data collection, and it will not help redirect evaluations toward establishment of wetland functions rather than appearance. Success in a 3-year time-frame may have to be measured in terms of survival and growth of plant species characteristic of a wetland community with no consideration of functional attributes.

Long-term research projects that will enhance our ability to predict the outcomes of mitigation policy should be encouraged and carried out whenever possible. These projects can focus on learning more about development of wetland functions within created systems and may eventually provide standards for evaluating function. Until such standards exist, personnel responsible for judging compliance with permit requirements will have to rely on the tools at hand. For wetlands created outside a mitigation context the establishment of self-perpetuating marsh vegetation, confirmed over a 3-year period of observation, seems a realistic and appropriately flexible reclamation objective.

Correcting Problems

In addition to verifying compliance with reclamation plan requirements, monitoring programs can also identify problems which might eventually lead to failure. Miller (1987) and Garbisch (1986) list several reasons for poor results at some wetland creation projects: improper final grade, invasion or deliberate planting of nonnative plant species, poor planting techniques, inadequate water levels, vandalism, and wildlife predation. Mid-course corrections can often mitigate these problems before the project becomes a lost cause, but corrective measures are best determined by professionals qualified in fields such as wetland science or restoration ecology.

Some created wetlands need long-term management to survive and function as they were intended. This "may include water level manipulation, control of exotics, controlled burns, predator control, and periodic sediment removal" (Kusler and Kentula, 1990). Management of this type beyond a 3-to-5-year program coordinated with annual monitoring is probably not feasible for most reclaimed pit sites. Once the mine operator is released from further obligations under the reclamation permit, the site will have to be self-sustaining. This means that problems that are not correctable within the proposed 3-year monitoring period will continue to have a detrimental influence, perhaps a regional one.

This further emphasizes the importance of site-specific project designs developed from data gathered both before and during the mining operation. Although each site is an experiment within which complete control is never possible, development of a practical, self-sustaining design that uses knowledge of site characteristics is the best defense against the unexpected. Larson (1988) suggests that minimum data requirements for freshwater wetland creation projects include a baseline of information on land-use history, macrotopography, general surficial geology, streamflow, lake hydraulics, and ground water levels and quality. Hart and Keammerer (1992) stress the importance of accurate historical project records documenting the techniques used, including a detailed photographic record. "This information is of paramount importance relative to understanding successes or failures" (Hart and Keammerer, 1992).

Conclusions

The sand and gravel industry, increasingly under public scrutiny as its operations are encroached upon by suburban development, must now focus on the long-term regional implications of post-mining land-use decisions. It has been proven that worked-out pits lend themselves to a wide range of subsequent uses, but the majority of these uses have come about by accident rather than intent through planning. The natural regeneration that has occurred at many abandoned wet-pit sites indicates tremendous potential for increasing the nation's freshwater aquatic ecosystem resources, but this potential is not being fully used. Wetlands, in particular, have been neglected or overlooked in sand-and-gravel-mine reclamation planning.

Opportunities to balance use of an essential non-renewable resource with development of new resources may in time prove more valuable than the materials which have been extracted. Wetlands are in short supply and increasingly threatened. While creations are not a substitute for mature natural systems, they have the potential to initiate functional wetlands for future generations. For the immediate future, they can add to regional ecosystem diversity and provide habitat for many species of plants and animals. The hydrology of worked-out sand and gravel pits is typically ideal for wetland creation projects. What is needed is industry commitment, cooperation among government agencies, and support from an informed public.

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