RECLAIMING MILL TAILINGS AREAS

by

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Reclaiming tailings areas -- we should begin, I think, by narrowing our definition.

We will be discussing land reclamation in disposal areas, as opposed to reclaiming tailings for their residual mineral values or for utilization in other ways.

Utilization of these mineral wastes in total would, of course, obviate the need for disposal areas in the first place -- and, no doubt, in the future, uses will be found for some of these millions of tons of ground rock, including some deposits that have consumed time and money for stabilization work. If, on the other hand, a deposit is reprocessed for mineral values, then the new process plan should include provisions for stabilizing the inevitable waste that will be generated.

In any event, our subject deals with an existing problem that in many cases requires an immediate solution, so we shouldn't dwell too long on future metallurgical possibilities.

While we are on definitions, let us also try "tailings area."

This is an area adjacent to a minesite set aside to retain the finely ground waste from some type of mineral beneficiation plant --this may be froth flotation, gravity separation, heavy media separation --depending on the type of mineral values in the ore -- and eventually receives from 40 to over 95 percent of all the ore mined.

In area they may vary from a few to many thousands of acres, depending on the production rate and longevity of the mining operation. The tails are impounded by earthen dams, constructed with fill dirt, the tailings themselves, or both.

The main point here is that they are constructed and operated strictly as a pollution control device. Most operations reclaim process water from the pond, but thickeners would be more practicable and cheaper if this were the only consideration. This structure on the photomosaic is typical of a flat-land impoundment. The main breastwork is 2-1/2 miles long, 50 feet high, with wings on each side, and a 5-foot retaining berm on the uphill end. It was started in 1954 and will reach its ultimate capacity in the fall of next year. The pond area is about 1,700 acres, will be about 45 feet deep at the North end, and will contain over 80 million tons of finely ground tailings.

As you can imagine, a broad, nearly flat, unprotected expanse of unconsolidated ground rock could be the source of large quantities of wind-carried dust. In some arid areas, mining companies have fought the "tailings storm" battle for decades--using a variety of physical methods to keep the surface from moving and creating community problems.

In the past ten years -- and particularly the last four -- systematic efforts have begun to provide general, economically reasonable solutions to this problem.

Some individual mining companies have achieved spectacular successes in not only nuisance abatement, but in actually creating definite improvements when compared to the surrounding area.

Some of the larger companies have professional staffs whose primary duty is in waste area rehabilitation.

The Bureau of Mines is engaged in an extensive research project on tailings utilization, as well as stabilization, and is funding additional work at the university level.

Although the attack may be in common, the problem is not--except for a few common denominators which stand out in each set of circumstances.

These are many differences - in the bulk composition of the various deposits, in geography, in climate, in state regulations, proximity to communities, and in the resources available within and <u>to</u> each set of circumstances.

Within this framework of major differences in circumstances - and under conditions that are quite emotional on occasion - the industry, with the help of other public and private institutions, is working toward technical solutions to this very important side-issue in environmental control.

Let us examine the problem, then, as objectively as possible.

First, as we have said, the disposal areas themselves exist as a pollution control measure. As is often the case in pollution abatement, new problems are created when one is solved. In this instance, the solution to a water quality problem has caused a potential air pollution situation.

For that is really the main subject when we say "reclaim" -- in most instances this means literally to stablilize, or tie down somehow, the dry surface of the tails to prevent wind-blown dust from becoming a nuisance. There are other important considerations, of course, but this is the over-riding one.

So, in many cases, the problem is alleviated by merely keeping the surface of the tailing wet during the period of the year when blowing is a problem. Many mining operations have practiced this for years --using a variety of methods to distribute water over the flats, or by turning under the dry top and exposing wet material to the air.

However, this practice is often self-limiting. The arid areas that experience the most rapid drying are usually short on water, generally; so the process just may not be able to spare water for soaking tails.

Physical stabilization, using as a rule material at hand, is practiced with some success and often with great ingenuity. Covering with straw, bark, sagebrush, crushed rock, slag, earth -- all have been used successfully.

Chemical stablilization - where a reacting substance is applied to the surface to form a wind-resistant crust has been used. Many organic and inorganic materials are currently being evaluated in the Bureau of Mines study at Salt Lake City.

Vegetating the surface, where possible, is the ultimate solution--both practicably and esthetically.

The first problem encountered in any revegetation is stablizing the surface long enough for the plants to take over.

The straight forward way to do this is to cover the surface with soil --either by mechanical spreading or as a slurry. This, of course, minimizes the alternative problem -- that of creating an artificial soil from the tails themselves.

If the first course is impractical because of the physical size of the flats, or because natural soil is unavailable, then the alternative, planting in the tails themselves, has problems in common; wherever the minesite or whatever the metal mined.

1. Smothering and cutting by drifting sands
2. Nutrient deficiency
3. Poor texture, as the material is well classified by the nature of emplacement method
4. They may contain excessive salts or metal phytotoxicants
5. May be excessively acidic or basic

The first step in any revegetation program would be to classify the tails as a soil (taking care to separate zones of significant particle size distribution difference) and then determine the soil amendments necessary to support vegetation.

Once the tails have been classified and the general amendments determined, systematic test plantings may be started of different types of vegetation --seeking, usually varieties that will survive with the minimum amendments --which will be grasses or legumes in nearly every case. This test work may be done indoors or out, but if the latter, special pains must be taken to protect the plots from drifting and cutting.

Once the test work is completed, and the site is ready for planting, plans should include provisions for rapid, extensive planting, down the prevailing wind, and for protective, temporary surface stabilization over the entire area.

This is a highly generalized description of a typical approach to, perhaps, the main aspect of any tailings area reclamation program--that of minimizing a potential nuisance: windblown dust. There would be many factors at each individual site that would require evaluation by someone knowledgeable in agronomy -- particularly in soil chemistry.

Perhaps at this point we can use our copper mine at White Pine, Michigan, as a case where a medium-sized mining company, by utilizing all available technical assistance, has started a program that includes tails stabilization as well as other reclamation projects.

First, of course, is the problem of staffing. All mining companies, large or small, whatever the metal produced, have an abundance of people competent in various fields of engineering, metallurgy, analysis and other technical services, heavy equipment use and maintenance--this list is almost endless--but it is putting it mildly to say that only a very few have staff agronomists, wildlife management experts, soil scientists, botanists, or representatives of any life science. We are one of the fortunate few in having a forestry department that manages the timber holdings of our parent company, Copper Range. This group will supervise the reforestation projects that we will discuss later.

The first step, then, is to pick an individual on the technical or engineering staff to coordinate the reclamation work as a collateral duty, and proceed from there, This individual will find that while published papers on the specific subject only date back, perhaps ten years, and are few in number, they contain much useful background information that can be adapted to his specific problem. Next, he will find that several agencies --Federal and State-- exist solely to provide technical assistance in general agronomy --principally the Federal Soil Conservation Service and the State Agriculture Extension Services, and are not only cooperative but are eager to provide expert assistance. Further, as it is difficult to travel more than 50 miles in any direction from any point in the U.S. without encountering a college or university, faculty members in the various life sciences provide an enormous reservoir of specialized talent.

At White Pine, we are very fortunate to have close at hand M.T.U. whose Ford Forestry Center personnel are engaged in research in vegetation and stabilizing iron benefeciation plant tailings that parallels the work at our plant.

The property itself is in upper Michigan, about six miles from Lake Superior. The project area is relatively flat, with heavy second growth aspen, maple, birch and scattered conifers. The white pine were mostly logged off around the turn of the century.

The project was started in 1954, mining in the pre-Cambrian Nonsuch Formation. Production is about 25,000 tons of ore per day with a grade of 1.1% copper in the form of chalcocite and native copper.

The program at White Pine is ordered as follows:

1. Reforestation, surface stabilization and water fowl habitat development in stripped borrow areas,
2. Stabilization, where necessary, of existing tailings flats with vegetation, preferably with species compatible with the habitat development, and
3. the systematic reforestation of stripped areas as a new tailings impoundment is constructed over the next 20 years, and the eventual stabilization of that tailings surface.

Part one was started in 1966 with a survey of the area. Expert advice was sought on the feasibility of the wildlife habitat development possibilities.

In the 15 years since the operation started, a natural nesting population of surface-feeding ducks had developed --which is understandable as this artificial marsh was superimposed on a forested area that offered few nesting opportunities.

The resident population was found to be predominately mallards, but a few other surface feeding varieties were present. Brood counts last spring in test areas showed a six to one ratio of mallards to all other species.

The borrow pits number 120-odd, have a total water surface of about 600 acres, with individual ponds running from one to 20 acres, and are up to 15 feet deep. All conform to the same general physical configuration, elongated north-south, deepest on the north end with steep drop offs, shallowing to the south, with a long gently sloping dry runout apron. The pits are separated by spoil banks 10 to 15 feet high.

The water level in these flooded pits fluctuates very little, and normal marsh vegetation has taken to some degree in all of them.

The plan, then, is to supplement the natural cover with preferred food and cover species, stressing perennials that are useful from spring through fall. Soil tests on both the bank and pond bottom material indicated marginal fertility, but sufficient to support selected vegetation.

Of the varieties tested in 1967 and 1968, the following have been selected for planting this year: sago pond weed, wild celery, hard stem bulrush, giant bur reed, smartweed, muskgrass, wild rice, and reed canary grass.

These are all perennials and require no fertilizer to start, except for the canary grass and the wild rice. The rice plots are restricted to a few ponds with flowing water. Once seed beds are established, several beaver sloughs in the surrounding woods will be planted.

Still in this phase of the program, we will plant red pine and white spruce at the head end of each of the dry clay areas. Between the trees and the water in each pit, ground cover will be introduced for two purposes --to retard the sheet wash that would eventually silt the ponds up completely, and to provide forage for grazing water fowl.

Not too much art is involved in this operation. Our forestry department has a wealth of experience in planting conifers in stripped areas and we plan to use the same mix of clover, alfalfa, fescue, vetch and timothy that have been successfully used to stabilize the slopes of the berms built with the material from the borrow pits.

Still, the coming growing season will be used to refine techniques, and, incidentally, costs, on the use of a road patrol or bulldozer-drawn tree planter. Only about 25 acres of tree plantings are scheduled, which is a rather puny area when compared to "Operation Green Earth"--but you will see later, we need this preliminary testing for future projects.

In selected areas, one-half to one acre test plots of buckwheat, barley and rye will be planted. We want to see if these will help to furnish late-summer food for the resident birds as well as for migrating geese and ducks.

About 10% of the ponds, and the edges of the front and back berms, have been designated as sample areas for population studies. Two careful foot traverses are made each year around each of the areas--one in July after the young are out, and another in late September. Last year 21 broods were counted in these test pond areas: 18 mallard, 2 greenwing teal, and one blackduck. Also, planted areas as well as unplanted are checked for growth progress, and specimens of unidentified plants are taken for later classification. An undergraduate in wildlife management is hired for this summer work.

No pretense is made that this brood count can be extrapolated by ten, or that the methods are very scientific, but we feel that it shows the potential of the site as a nesting area. Also, from the young birds seen in the tailings area in early September, we know that a significant number of blacks and woodduck nest in the dozens of beaver sloughs around the tailings area.

The area is used very little by transient birds in the spring, but is heavily used during the fall migration. Large numbers of diving ducks, mostly bluebill, rest on the main pond and feed in the burrow pits. Large numbers of dark geese use the area every fall for feeding and rest. During bad weather, great numbers of snows and blues also appear. None of these birds remains in the area very long, but will probably hold better after the preferred food species take over more of the area.

There is a steadily growing colony of blue heron that nests in this area using dead trees that protrude through the tailings. The borrow pits all have minnows and frogs in abundance, so these birds have an ideal environment. Many shore and wading birds nest on the edges of the tailings impoundment.

The second part of the program, stabilizing the existing flat after it is abandoned in 1970, presents entirely different problems than vegetating the stripped clay areas --not the least of which is getting around for sampling--we do this in the winter when the surface is frozen.

Use of the impoundment will cease in late 1970, so the actual stabilization work will start in the spring of 1971.

The first step in this program was a literature survey, then soil analyses on three general particle size zones. These analyses were obtained through the County Extension Service whose service also included fertilizer needs for various field crops that could be tried.

During the first growing season, 1967, the only test area available was cycloned sands that had been placed along the west wing of the dam to create a beach against wave erosion. Clover, alfalfa, timothy, Kentucky blue grass, reed canary grass, and mixed rye, fescue blue grass and clover were planted in 50-foot by 20-foot test plots on this coarse fraction, with fertilizer application ranging from zero to the recommended. As it has been found elsewhere, small test plots on unstabilized coarse tails inevitably are abraded or covered by windblown material. Some indication of germination and rooting success was gained, but the plots had mostly disappeared by summer's end.

Another problem with this before--the-fact approach is that the flats themselves are unavailable for testing. With 8 - 10 feet of tailings yet to come over the entire area, any test plots would be innundated.

In the planning for the 1968 growing season, then, two needs became evident: first, temporary chemical or physical stabilization of any test areas in relatively coarse sands; and, second, emplacement of significant amount of tailings outside the main impoundment for a stable test area.

The surface stabilization I'll describe later. The test plots were obtained by filling three small borrow pits, totaling about four acres, with general tails which include both sand and slime fractions. This will allow four acres to be test planted under conditions close to those expected after abandonment.

In 1968, more test plots were set out in the coarse tailings piled on the west wing, but with an elastomeric polymer cover applied immediately after seeding. This forms a crust that stabilizes the surface and slows water evaporation, but allows the plants to sprout through.

This polymer was tested for several features-minimum effective solids per unit area, application on both wet and dry surfaces, penetration, and effectiveness as a growth-assisting protective cover.

Legumes and grasses with varying fertilizer ratios were set out, along with a few hundred pine and spruce seedlings. While recognizing that the trees are out of the natural order, we wanted to get a rough idea of survival and growth rates, with and without fertilization. Having wintered once, this growing season should produce some meaningful data. The return from the stabilized legume test plots, and particularly the condition of the crust, will also be closely checked for wintering capabilities.

The tailings-filled borrow pits mentioned before were not used in 1968. The excess water will be decanted and test plots set up this year.

During the past winter, tests were conducted indoors to determine what will actually happen to the tails surface under the worst possible weather conditions. Samples were taken from the three zones, set up in 4 by 4-foot by 4-inch flats, dried completely, and a 30 mph breeze passed over the surface. It was determined that the south portion, about 600 to 700 acres will need to be stabilized. The fines on the north side set up like adobe on drying and should be self-stabilizing.

The coming growing season will be used:

1. To test different legumes--birdsfoot trefoil and crown vetch--as a supplement to the standard alfalfa-clover mixtures.
2. Evaluate 1968 work in polymer--stabilized areas, and extend these tests to wider coverage. The Ford Forestry Center of Michigan Technological University will supervise this work.
3. Test calcium lignosulfonate as a soil conditioner and surface stabilizer on five tests acres of coarse and intermediate size fractions. Indoor tests this winter showed excellent potential for this paper-mill byproduct for pH modification as well as for its water holding capabilities.

4. Set out test plots of cedar and forage shrubs in the tailings.
5. Evaluate the entire program in terms of cots per acre.

The third phase of the program started last summer. This 5-1/2-mile swath has been cleared and grubbed for the new tailings dam which will impound about 2,700 acres. This structure will be raised each construction season for 20 years, keeping ahead of the pond level as it rises to the final level of 100 feet at the crest. The core of the dam will use coarse tailings for construction, but the upstream and downstream faces will be rolled fill. This means that the east and north sides will be cleared for borrow - eventually for a mile or more out from the breastworks. This will result in dozens of new ponds and many hundreds of acres of cleared land.

Periodically during the 20 years of construction, as the available borrow is depleted, the dry parts of the stripped areas will be planted to conifers or ground cover. The flooded portion of the borrow pits will be seeded with aquatic and shore plants using starts from the ponds in the original area.

We will end, then, with about 10,000 acres of affected area - 4,500 for actual tailings storage - and the balance in ponds and open flats with scattered groves of conifers and hardwoods.

We envision the area eventually as a wildlife reserve which will blend with the surrounding area, but will actually be an improvement in terms of wildlife habitat for waterfowl as well as other game birds and animals native to the area.

I have tried to outline some of the common problems in tailings area rehabilitation, while recognizing that each individual situation is almost unique. Current research and testing on techniques and materials useful in stabilization is resulting in methods that will have very broad application.

Individual mining companies are becoming more and more systematic in their approach to these post-deposition tailings problems. Research grants to colleges for studies at individual minesites are becoming common place.

As more data is published by the various interested groups - and as methods become more and more scientific and less arty - it is not difficult to envision that mining companies will come to accept rehabilitation of disposal areas as a normal cost of doing business, as they have always accepted the tremendously expensive tailings impoundments themselves.

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COMMENTS

QUESTION: One thing I'd like to know is what is the pH of what you're tailing?

ANSWER: It's about 8.9 to 9.0.

QUESTION: The second question is what did you find that would survive in the tailings alone?

ANSWER: The soil conservation service selected 2 or 3 clover species they felt would do all right and one alfalfa. This year we're going to try the crown vetch and we're going to put tree foil in it. They feel this species will do pretty well too. But the '68 growing season will tell the tale on what is going to take the best.

QUESTION: Did you add fertilizer?

ANSWER: Yes.

QUESTION: What kind?

ANSWER: The potash is plenty high so we're using 10-10-0. We're not adding any potash, just phosphorus and nitrogen.