CHAPTER 12

AGRICULTURE, HORTICULTURE, AND FORESTRY

12-1. General. Broad use of dredged material disposal sites has been made by the agriculture, forestry, and horticulture industries. Some disposal sites, especially in river systems, have provided livestock pastures. These pastures have not been developed in any way except by allowing natural grass colonization or by planting pasture grasses on them. Other uses involve actively incorporating dredged material into marginal soils (item 25). An attractive alternative for disposing of dredged sediments is to use these rich materials to amend marginal soils for agriculture, forestry, and horticulture purposes. Marginal soils are not intensively farmed because of inherent limitations such as poor drainage, unsuitable grain size, and poor physical and chemical conditions. They may also be of low productivity because of high water tables or frequency of flooding. Millions of acres of these marginal soils are located near waterways.

12-2. Agriculture. Item 81 notes several areas where there is currently extensive interest in the agricultural use of dredged material. For example, about 500 acres of the Old Daniel Island Disposal Site in South Carolina have been successfully truck farmed for the past 8 years, and other parts of the site are planted in soybeans, an agronomic crop. The Tulsa District has approximately 2,600 acres of dredged material containment sites leased for use as grazing land. When dredged material is free of nuisance weeds and has the proper balance of nutrients, it is similar to productive agricultural soils and can be beneficial for increasing crop production when incorporated or mixed. By the addition of dredged material, the physical and chemical characteristics of a marginal soil can be altered to such an extent that water and nutrients become more available for crop growth. In some cases, raising the elevation of the soil surface with a cover of dredged material may improve surface drainage and reduce flooding and therefore lengthen the growing season. Dredged material characteristics which influence plant growth and guidance for dredged material incorporation and cover use are discussed in this section.

a. Planning Considerations. Chemical and physical analyses of the dredged material, site locations, weed infestation potential, and possible salinity problems must be considered before deciding upon the suitability of a specific dredged material as a medium for agricultural purposes. Figure 12-1 demonstrates priority listing of these factors to be used when considering the feasibility of an agricultural use for dredged material at the containment site (item 75).

(1) Chemical analyses. Since dredging operations may take place in waterways containing industrial wastes and sediment runoff from agricultural areas, dredged material can contain heavy metals, oil and grease, high nutrient concentrations from fertilizer runoff, and other contaminants.

(a) Heavy metals. Heavy metal uptake by plants is dependent on a number of factors, primarily the form and concentration of metals in the rooting media, and the type and variety of plant. Research has shown that the heavy metal uptake by plants is normally much less than the heavy metal content of the rooting media (items 25 and 44). Table 12-1 shows the range in the concentration of heavy metal uptake by agronomic and common vegetable food crops grown under normal conditions and the suggested plant tolerance levels (item 25). The question as to whether or not to produce food or nonfood crops depends upon the chemical contaminants present in the dredged material. Agricultural service agencies and extension offices can assist with guidelines and answers to specific questions. While research has shown that relationships exist between the extractable heavy metals in the soil and the heavy metal uptake by certain plants (item 46), these data are important to dredged material applications upon soils if a food crop is to be grown, but are less

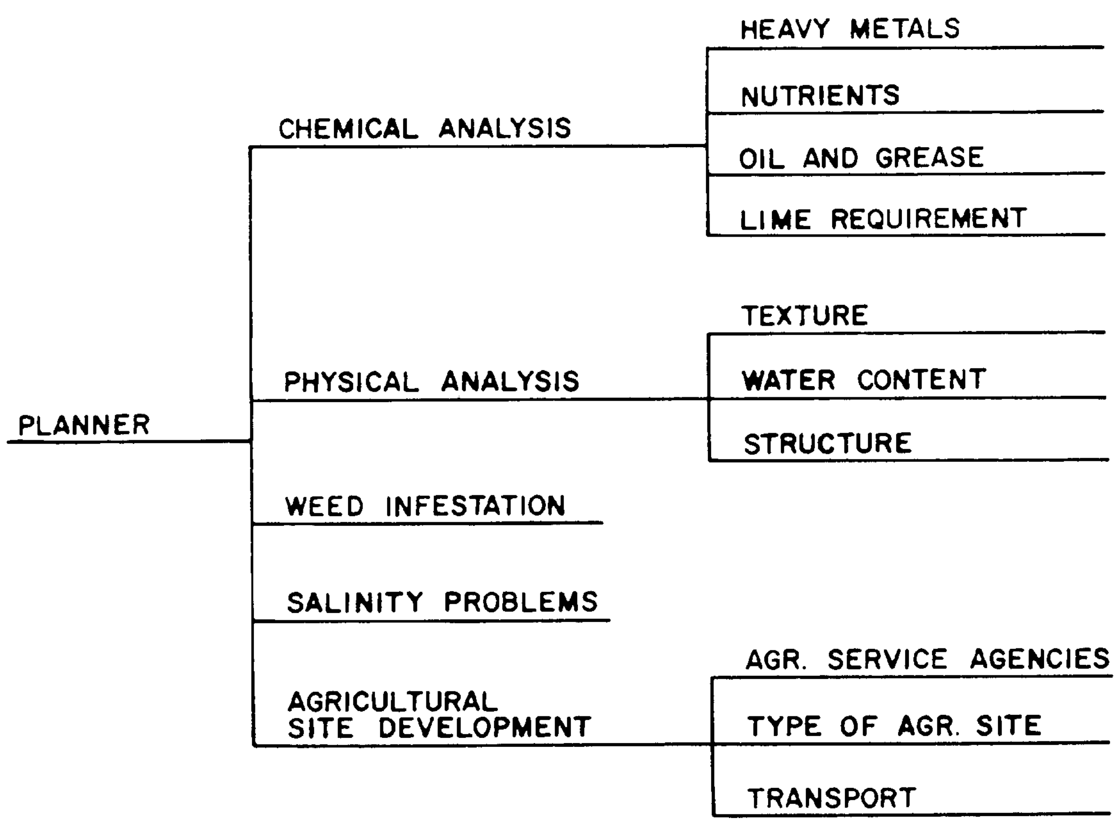

Figure 12-1. Decisional factors to be considered at the dredged material containment area before applying dredged material for agricultural purposes

important when nonfood crops are to be produced. An example of a nonfood crop is the growing of Christmas trees or pulpwood on dredged material containing concentrations of heavy metals too high for human or wildlife consumption (item 49). Another example is the uptake of minimal amounts of heavy metals in the heads of grain plants, making them a good food crop selection even if larger amounts of heavy metals are present; however, the heavy metals may concentrate in the leaves, making these grain crops less desirable when harvested as a forage.

(b) Nutrients. Nutrient analyses of dredged material should provide data to determine nutrient availability and to establish recommended fertilizer applications for vegetative production. The nutrient constituents of dredged material which require greatest attention are nitrogen, phosphorus, potassium, metallic metals, and organic compounds. Although medium- and fine-grained dredged material is normally high in nutrients available for plant uptake, the levels of these nutrients are usually not high enough to limit plant growth. However, nitrogen, which is usually in the ammonium form, will undergo nitrification rapidly in an aerobic soil. Nitrate is the readily available form of nitrogen for plant uptake or loss by surface runoff and leaching into ground water. Specific recommendations on rates of fertilizers can be obtained from the state Soil Testing Service or local agricultural extension agent, after soil tests have been conducted. A considerable portion of dredged material, especially in the Upper Mississippi River and some

Table 12-1

Average Range of Heavy Metal Uptake by Plants for Selected Food Crops* and Suggested Plant Tolerance Levels (item 25)

Element	Average Range ppm	Suggested Tolerance Level, ppm
Cadmium	0.05-0.20	4
Copper	3-40	150
Iron	20-300	850
Manganese	15-150	325
Nickel	0.01-1.0	4
Lead	0.1-5.0	10
Zinc	15-150	350
Boron	7-75	200
Chromium	0.1-0.5	2

* Corn, soybeans, tomatoes, beets, lettuce, peas, potatoes, melons, squash, alfalfa, clover, wheat, oat, barley, and pasture grasses.

coastal areas, is sterile, clean sand. In these cases, sites may never be suitable for agriculture, and will need major nutrient and soil amendment incorporation.

(c) Oil and grease. Research has shown that the oil and grease content of some dredged material is considerably higher than that of soil. However, depressed agricultural yields attributable to high oil and grease content have not been studied. Possible effects of high oil and grease content on soil properties or plant growth are an apparent slower wetting of the soil materials, a smothering effect on plant parts, and a tendency to restrict water uptake by the plants.

(d) Lime requirements. Lime requirements for dredged material vary, but if the pH of the material is below 6.5, it should be amended with ground agricultural limestone before being applied to marginal soil for agricultural production. Large amounts of sulfur in the dredged material will require heavy initial applications of lime to neutralize the acidity, as well as succeeding applications to maintain neutral conditions. A soil pH below 4.0 indicates the presence of free acids resulting from the accumulation of sulfate and nitrate ions; a pH below 5.5 suggests the presence of toxic quantities of exchangeable aluminum, iron, and manganese; and a pH from 7.8 to 8.2 may indicate an accumulation of the bicarbonate ion, and the uptake of elements will be detrimental to plant growth. Gupta et al (item 25) provides specific recommendations on rates of both fertilizer and lime to apply at various soil (dredged material) deficiency levels. A rule of thumb for lime requirements of high sulfur dredged material is to double the usual lime requirement.

(2) Physical analyses. The physical characteristics of dredged material can assist the CE in making critical judgments of the best use of dredged material to ensure against adverse impacts on agricultural lands. The texture and water content are essential tests to aid in characterization of dredged material deposits within a containment site.

(a) Texture. Textural classification helps to determine not only the nutrient-supplying ability of soil materials, but also the supply and exchange of water and air that are so important to plant life. Therefore, an important criterion is to adjust the texture of the final mixture of dredged material and marginal soil to approximate a loam soil (USDA classification). Using the USCS classification system, a dredged material of loam texture contains silts and clays whose liquid limit is less than 50. Mixing a fine-textured dredged material (silt and clay) with a coarse-textured marginal soil (sand) to the proportions of a loam would improve its physical and chemical characteristics for crop production. Sandy, coarse-grained dredged material is generally low in organic matter content, available nutrients, and heavy metal concentrations. Dredged material of this type may have potential as an amendment to heavy impermeable clay soils, improving structure and permeability. For beneficial surface applications without incorporation with existing soils, it would be preferable to apply dredged material of loam textures only. Sandy loams are generally preferred for vegetable root crops such as carrots, beets, potatoes, and peanuts, whereas loam to silt-loam soils are preferred for row crops, orchards, and small grains.

(b) Water content. When placing dredged material on agricultural lands, it is desirable to have the water content of the material within the plastic limit range. This will present fewer problems in handling, placing, and mixing. If dredged material is to be placed in slurry form, the lift thickness should be limited to 18 inches. This thickness of dredged material will usually dry within a 6-month period, depending upon dredged material texture, to the point where soil mixing and farming operations can begin.

(3) Weeds. Weed infestation is generally a serious problem in many dewatered, inactive, fine-grained dredged material containment areas. Prior to the transport of dewatered dredged material to an agricultural site, an extensive weed control effort may have to be initiated to avoid serious weed problems to the agricultural producer. For example, an application of herbicide or removal of the top 6-inch vegetation layer of the containment area with a bulldozer before the transport of dredged material to the agricultural site would temporarily control the weed problem. Transport of such material, unless it was only to the advantage of the CE to do so, would be at the expense of the agricultural producer.

(4) Salinity. If the dredged material is from a coastal or tidal region, special attention must be given to salinity because crops will not grow on highly saline soils, and few agronomic crops will grow in brackish soils. The electrical conductivity of a soil water extract gives an indication of the total concentration of soluble salts in the soil. The term “soluble salts” refers to the inorganic soil constituents that are soluble in water. Excess soluble salts not only limit the availability of water to plants but also restrict growth. Salt-tolerant plant species are available and research on salt-tolerant agriculture crops is under way, but none have been found to be economically productive to date. Techniques for treating dredged material with high salinity problems are available and should be completed before the material is transported to an agricultural site.

(5) Agricultural site selection. The distance and mode of transportation utilized for the movement of dredged material will determine the major costs of its application to agricultural lands. Thus, the agricultural site selected should be in reasonable proximity to the dredged material disposal site and adaptable to the long-range disposal needs of the CE.

(a) Agricultural service agencies. In most areas of the country, a variety of suitable locations of marginal soils can be found by contacting the local offices of the SCS and U.S. Forest Service, as well as the local Agricultural Extension Service. Soil classification and land use maps are available from these agencies, as is direct assistance in locating marginal soils suitable for amendment with dredged material.

(b) Type of agricultural site. The type of site determines whether it can be used for agriculture, i.e., a short-term or long-term disposal area. Short-term usage means 1 to 3 months' time for the transfer of dredged material from a containment site, and for the transport, spread, mix, and cultivation of the dredged material for seedbed preparation at the agricultural site. Long-term usage implies that the agricultural site can be used as an active disposal area over a long period of time (5 or 10 years). This would involve only a few acres of the agricultural site at any one time in applications of dredged material, so that the rest of the field could be planted in crops. A schematic of a long-term disposal area is shown in Figure 12-2, where various levels of dredged material are being used for different activities. Shallow-rooted crops such as grasses, small grains, soybeans, and vegetables can be cultivated in designated areas when dredged material is first applied (6- to 12-inch depth). However, as the application of dredged material is continued in specific areas of the field (3 feet or more in depth), deep-rooted crops such as corn, sorghum, cotton, alfalfa, and trees can be successfully cultivated.

(c) Transport. The accessibility to the dredged material containment site and the agricultural site determines project viability and mode of transport. The agricultural site may have limited access due to field roads, drainage ditches, and fence locations; therefore, access routes on a farm may require design and construction to facilitate the disposal and spreading of dredged material. If the application of dredged material is to be efficient and effective, scheduling of application should not interfere with normal farm operations. Access roads to the disposal site should circumvent the farmstead and avoid the location of poultry and livestock.

b. Agricultural Site Considerations. With an understanding of the characteristics of the dredged material at the various disposal sites, consideration should be given to the potential problems at the agricultural site. Factors which must be considered at the agricultural site are properties of the marginal soil, application depth of dredged material, land preparation needs, compaction, erosion potential, flood/drainage area, and seedbed preparation (item 75).

(1) Incorporation. The beneficial effects of incorporating dredged material into marginal soils are increased available water capacity, increased nutrient supply when fine-grained dredged material is mixed with coarse-grained marginal soils, and improved drainage when coarse-grained dredged material is mixed with fine-grained marginal soils (item 52).

(a) Marginal soil. Marginal soils are not used for production of crops due to low economic return. These soils can be unproductive pastures, abandoned fields, fields requiring excessive irrigation or drainage, or areas in various stages of degradation. These soils can be made productive for a variety of economic crops by incorporating dredged material of desirable grain sizes to bring these marginal soils to a loam soil classification.

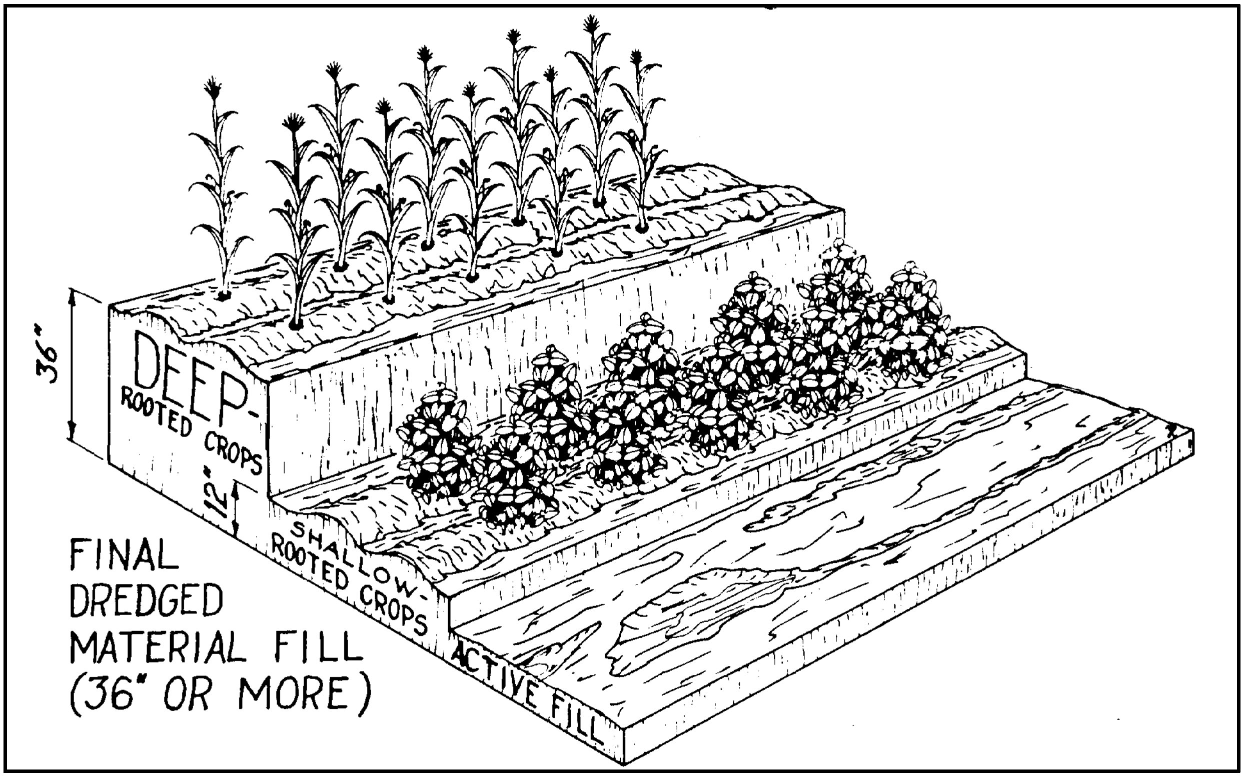

Figure 2-12. Long-term agricultural dredged material disposal site (item 75)

(b) Depth. Plant growth can be limited by root development; therefore, it is important to increase the depth of rooting media on marginal soils with applications of dredged material. To obtain an optimal mixture under normal field conditions, the depth of dredged material to be incorporated is limited to a 6-inch cover. At this depth, a 16-inch moldboard plow can furrow the 6 inches of dredged material to a depth of 12 inches using a tractor-plow combination. If incorporation of greater depths of dredged material is required, then special types of plows not common to normal farm operations must be used.

(c) Land preparation. Tillage operations prior to the application of dredged material may be useful to speed surface drying and eradicate weeds. The application of dry dredged material to level soil surfaces presents few problems when the soil surfaces are dry. If the agricultural site has poor drainage, the application of dredged material should be done after the area has had an opportunity to dry. Row drains can be constructed with a plow that cuts through low areas to provide drainage into field laterals. The addition of dredged material to slopes ranging from 5 to 10 percent may increase operational problems and the potential for erosion, as well as the sediment content in runoff water. If steep slopes (greater than 10 percent) are to be used, standard conservation practices should apply, possibly including terraces, grassed waterways, diversion channels, and supplemental practices such as contour farming, strip-cropping, and crop rotation (item 75).

(d) Compaction. The purpose of using dredged material is to improve the agricultural site; therefore, the application and spreading of the dredged material should not impair agricultural production by severely compacting the marginal soil. For example, soil compaction problems associated with the weight per axle load of large (25-ton) dump trucks may necessitate using smaller (9-ton) dump trucks which would reduce soil compaction but increase transportation costs by 25 percent.

(e) Seedbed preparation. The use of various types of tillage equipment is, to some extent, dependent on the type of crop to be produced. However, tillage operations such as plowing and harrowing are common to all types of seedbed preparation. Cultivation and planting of the newly incorporated mixtures should be accomplished as soon as possible because tillage will increase the infiltration of water and reduce surface runoff, therefore lowering the potential for erosion.

(2) Cover. When the area to be covered is too rocky, gravelly, or otherwise unsuitable for cultivation, additions or capping with dry dredged material to depths of 1 foot or more without incorporation into the existing site may be required to improve the area for agronomic production. When dredged material is to be used as a surface cover or cap, it is best that the texture approximate a loam soil for crop production (item 25).

(a) Depth. The depth of dry dredged material to be applied in increments as a surface cover or cap should be at least 3 feet to ensure good drainage and an adequate rooting medium. This depth of 3 feet or more can be achieved by additions of 6-inch layers if the agricultural site can be used as an active dredged material disposal site over a period of years.

(b) Drainage/flood. When the soil depth is increased by additions of dredged material, the depth to the water table increases and reduces wet spots in the field, thus extending the period available for farming operations. If the area is only briefly and intermittently flooded, additions of 3 feet or more of dredged material may completely eliminate the flooding problem. If it is flooded enough to have reduced soil conditions, it is a wetland and should not be farmed.

(c) Erosion. Slopes greater than 10 percent are not generally used for the application of dredged material because the establishment of a vegetative ground cover is more difficult. When the dredged material is to be placed on erodible slopes, it should be planted in grass cover immediately until the dredged material has stabilized. If the agricultural site is a terraced area, the terraces should be seeded in a permanent vegetation cover to prevent accelerated erosion. Flat or nearly level agricultural fields are the most satisfactory for dredged material application and farming operations.

(d) Seedbed preparation. When the marginal soil is to be buried with over 2-foot depths of dredged material, it should be leveled with a bulldozer and other tractor-plow or disk combinations used for seedbed preparation. Any application of dredged material will require standard seedbed preparations to level and till the site.

c. Crop selection. There are a number of agricultural, or food, crops which have been or may be grown on dredged material. These include pasture grasses; food grains such as rice, corn, wheat, oats, rye, barley, and millet; soybeans; sunflowers; truck crops; and cotton. Crop selection for food and forage use is dependent upon climate, culture, and regional markets. The varieties of agricultural crops typically selected for production in any given area can be obtained from county and local Agricultural Extension Services and the county Soil Conservation District offices.

12-3. Horticulture. Horticulture crops are generally considered vegetable, fruit, nut, and ornamental varieties of commercially grown plants. Dredged material applications on soils for vegetable production, orchards, and nurseries will not differ from the guidelines discussed under agricultural planning and site considerations. Discussion will be limited to special horticultural crops.

a. Vegetable Production. All commercially grown vegetable truck crops can be produced on dredged material amended soils. Vegetables grow best on sandy loam soils of good texture, drainage, and aeration. The best types of dredged material mixtures for such crops would be sandy silts or silty dredged material which can be incorporated into an existing sandy site, or sandy dredged material which can be incorporated into an existing silt or clay site. Clays in general are too heavy for good vegetable production, but they could be improved by applications of sandy material.

b. Orchards. Few fruit and nut crops are produced close to waterways and dredging sites, with the exception of pecan orchards. In general, pear/peach/apple orchards and other pome fruits grow best on hillsides and out of low bottomlands, and citrus orchards generally grow best away from the influence of salt-spray. Although no disposal sites have been planted as orchards, such application is probably feasible. However, additional applications of dredged material once trees are established would have to be limited to not more than 6 inches to prevent damage to root systems due to soil aeration changes.

c. Ornamental Plant Nurseries. Ornamental liner shrubs in nurseries are grown two ways: potted or set in the ground in a high-quality soil mixture. Either type requires horticultural soil mixes of loamy soil, sand, peat, and vermiculite. Dewatered dredged material could be applied as a part of the soil mix in areas where soil must be trucked into nursery sites at considerable expense. Most commercial nurseries make their own soil mixes, and may be amenable to use of good quality dredged material. The major disadvantage would be the limited quantities of material a nursery would require.

d. Sod Farms. Urban and suburban areas require large quantities of readily available grass sod for such uses as residential lawns, parks, golf courses, and rights-of-way. Unless sites are available near these high-population areas for sod production, sod must be trucked into the area for sale by retail nurseries and shops. Marginal soils near urban centers could be brought into grass sod production through applications of dredged material. Since grass sod is less exacting in its growth requirements than most food crops, the type of dredged material used is not as critical. However, the material should be a loamy or silty sand substrate, if possible, to ensure best grass growth.

e. Christmas Tree Farms. Another specialized use of dredged material is the cultivation of Christmas trees on disposal sites (item 75). This has already been carried out successfully in the Baltimore District. Since Christmas trees require 5 to 8 years to reach marketable size, the disposal site or compartment on larger disposal sites is generally unavailable for such beneficial use. This will limit the feasibility of this option in most waterways where dredging occurs. If dewatered material is trucked (at sponsor expense) to a marginal soil site, then planted with trees, this beneficial use option would be more acceptable.

12-4. <u>Forestry</u>.

a. For a number of years, the timber industry has been working with tree genetics to produce faster growing, stronger trees, and with reclamation of disturbed eroding sites using trees, primarily pines. However, some hardwoods and black walnut have been tested in the northcentral United States, and numerous cottonwood, sycamore, and eucalyptus plantations for paper production have been planted in the southern United States. The improvement of marginal timber land with applications of dredged material would be received with interest and enthusiasm from foresters who have the problem of trying to produce timber on poor soil. There are several rapidly growing pulpwood species that may be grown in large disposal sites with several compartments once the compartments are nearing completion. Dewatered dredged material trucked to marginal land or abandoned disposal sites would be the sites most appropriate for timber production.

b. The same physical and chemical soil properties discussed under agricultural considerations would apply to forestry, except that trees could be grown safely on dredged material with higher contaminant levels than could food crops. The tolerance level of each timber crop for heavy metals and other contaminants and the physical characteristics of the material would be forestry limiting factors.

c. Since land would be tied up in tree production after planting for 10 to 30 years, the primary disadvantage of this beneficial use would be loss of disposal sites. An advantage would be use of moderately contaminated dredged material not suitable for many other beneficial uses. Dredged material trucked into a site could be spread with heavy equipment as deeply as desired by the forester since tree roots penetrate several feet into the substrate. Large quantities of dredged material could be disposed of on marginal sites in this manner, and made productive.

d. Commercial tree species that would be suitable for timber production on dredged material would be eastern cottonwood, American sycamore, eucalyptus, green ash, water oak, and sweet gum on periodically flooded (limited flooding) sites. These species would also have a shorter rotational requirement of 5 to 15 years. Long-leaf pine, slash pine, loblolly pine, black walnut, white ash, pecan, and several oak and hickory species would grow best on upland sites amended by dredged material applications.