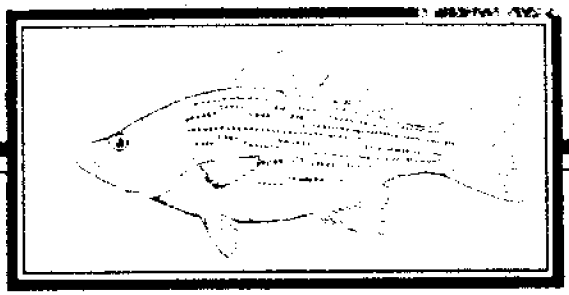


Containment Area AQUACULTURE HANDBOOK

COOPERATIVE EXTENSION SERVICE • MISSISSIPPI STATE UNIVERSITY

Contents

Part 1. Introduction and Background

Role of U.S. Army Corps of Engineers

Maintenance of harbors and navigation channels is an ongoing task that is vital to the economic well-being of the country. It is also an undertaking of considerable size. The U.S Army Corps of Engineers maintains more than 400 ports and over 25,000 miles of coastal and inland waterways. Estimates of the amount of sediment dredged by the Corps of Engineers range from 300 million cubic yards to 450 million cubic yards annually. Disposal of this material is, in many parts of the country, a constant and increasingly difficult problem.

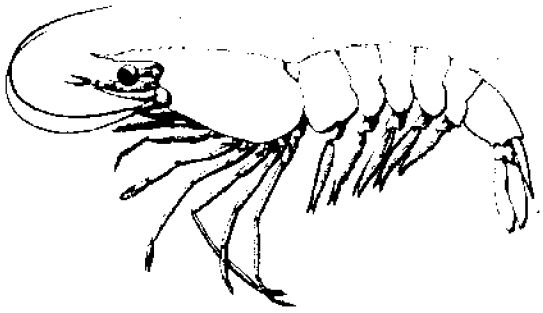
Disposal in dredged material containment areas (DMCA) is now the option that suits the needs of many dredging projects of the Corps of Engineers. DMCA's can range in size from a few acres to over a thousand acres. They typically consist of a ring levee of from 5 to as much as 50 feet in height, with a control structure to allow regulation of the interior water level. DMCA's may be divided by interior levees into cells, allowing sequential filling or increased residence time for water to lose its sediment load.

Placement of material in a particular DMCA depends on the needs of the Corps of Engineers district and is influenced by such factors as the rate of shoaling, the type of material—whether sand, silt, or clay—or the proximity of other disposal areas. A maintenance dredging operation can last from a few weeks to over a year and may need to be repeated from every 3 years to once every 10 or 15 years. For these reasons, the active life of a DMCA might be as long as 50 years, making it possible for a site to be used for other purposes much of the time.

Most DMCA's are located on private property and, because benefits of channel maintenance indirectly accrue to local communities or users, the acquisition of easements for disposal is the responsibility of the project sponsor. Project sponsors may be port and waterway districts, municipalities, state or county agencies, or navigation districts. Local sponsors work in partnership with their Corps of Engineers district to identify disposal sites in advance of the need to dredge. On the national level, an estimated 7,000 acres of new DMCA's are needed annually. In many parts of the country, finding and acquiring suitable sites are difficult tasks. Landowners may demand too high a price for their property or may be reluctant to have it used for what they perceive as waste disposal.

Origins of Containment Area Aquaculture Program

To help overcome some of the difficulties of site acquisition, the Corps of Engineers has worked to identify ways by which the landowner can use the acreage for activities that produce income but do not interfere with periodic disposal of dredged material. Research by the Corps of Engineers identified aquaculture as one such potential beneficial use of containment areas. By designing and operating a DMCA for material placement and aquaculture, benefits could be realized by the landowner, the aquaculture industry, local port and waterway authorities, and the Corps of Engineers.



For the concept to be adopted and applied as a tool for the acquisition of new sites for DMCA's, the technical and economic feasibility of DMCA aquaculture had to be demonstrated. The Containment Area Aquaculture Program (CAAP) was created to examine fully the beneficial-use concept of aquaculture with emphasis on more economical and environmentally compatible site acquisition.

The CAAP had two major activities: a field demonstration of aquaculture in a DMCA on a commercial scale; and the transfer of information on DMCA aquaculture to Corps of Engineers districts, local dredging sponsors, aquaculturists, and the interested public.

Demonstration Project

An approximately 230-acre, commercial-scale aquaculture demonstration project was established near Brownsville, Texas, in 1986. The demonstration project had multiple purposes, including:

- Determination of design specifications and construction methods that would allow multiple use of DMCA's for both aquaculture and dredged material disposal;
- Development of management strategies that would allow aquaculture operations and material disposal to coexist;
- Documentation of construction and production costs that would allow an objective evaluation of economic success to be made; and
- Compilation of the economic and technical information generated by the demonstration.

In 1986, modifications for aquaculture were made to two large containment areas, Disposal Area (DA) A of 104 acres and Disposal Area B of 116 acres. A 4-acre nursery pond was built adjacent to the two larger ponds and to the water intake structures. Structural modifications included raising the perimeter levees to a minimum of 6 feet above the pond bottom, widening the levee crown widths to between 12 and 15 feet, leveling the pond bottoms, excavating interior drainage ditches, and installing an in-levee water control/harvest structure.

Table 1 describes project stocking and production.

Table 1. CAAP demonstration project stocking and production record

	1987		1988		1989	
	Crop 1 Pond A	Crop 2 Pond A	Crop 3 Pond A	Crop 4 Pond B	Crop 5 Nursery and Pond B	Crop 6 Pond A
Species	*P. vannamei*	*P. vannamei*	*P. vannamei* *P. stylirostris*	*P. vannamei* *P. stylirostris*	*P. penicilatus*	*P. vannamei* *P. stylirostris*
Stocking month	March	July	April	March, April	Sept., Nov.	May, June, July
Harvest month	September	December	November	November	February	October
Time in pond — weeks	24	22	28	31	16 24	15-21
Days above 24 °C	132	106	170	130	N.A.	111
Days above 36 PPT salinity	103	67	142	122	N.A.	109
Stocking rate - Postlarvae/acre	40,000	40,000	22,000	42,000	N.A.	47,600
Survival	74%	56%	3.4%	50.6%	0%	23%
Management	Semi-intensive	Semi-intensive	Extensive	Semi intensive	Semi-intensive	Semi-intensive
Feeding - percent body wt/day	1½ - 3	1½ - 3	None	1½ - 3	5	1½ - 3
Feed conversion ratio	1.5:1	0 68:1	N.A.	1.77:1	Unknown	2.45:1
Yield — whole shrimp, lb	106,037	48,425	4,504	70,460	0	31,206
Yield — whole shrimp, lb/acre	1,020	466	43	607	0	286
Yield - tails only, lb	66,175	29,055	2,785	44,390	0	18,724
Yield — tails only, lb/acre	636	279 *	27	383	0	180
Majority size	36-50 tails	51-80 tails	16-35 whole	41-70 whole	0	51-80 tails

* Peeled and undeveined weight

Information Transfer

If you are seriously considering a commercial DMCA aquaculture venture, you need to obtain copies of the Cooperative Extension Service publications on the **Containment Area Aquaculture Program** available from your county Extension office or the Sea Grant Program or Advisory Service in your area. Intended primarily as reviews for aquaculturists, landowners, coastal zone planners, and other potential users of the containment area aquaculture concept, the Extension series begins with a brief, general introduction to aquaculture in DMCA's (Homziak and Veal 1992). The remaining Extension publications cover project planning and design, site selection and construction (Homziak et al. 1992), legal considerations (Konikoff et al. 1992), and economic concepts and aquaculture business planning (Roberts et al. 1992).

Technical reports published by the U.S. Army Corps of Engineers provide the most in-depth information on:

- Site selection, acquisition, and planning for aquaculture in DMCA's (Wilson et al., in press).
- Determination of the chemical suitability of a DMCA for aquaculture (Tatem 1990).
- Design and construction of aquaculture facilities in DMCA's (Homziak and Veal, in press).
- Production and harvest operations of an aquaculture crop in DMCA's (Coleman and Konikoff, in press).
- Legal and institutional constraints to the development of aquaculture in DMCA's (Robertshaw et al., in press).
- Marketing and economic analysis of DMCA aquaculture (C-K Associates, in press).

Technical reports' titles and document numbers can be obtained from the Program Manager, Containment Area Aquaculture Program, Environmental Laboratory, CEWES-ER-C, U.S. Army Corps of Engineers Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6399.

Part 2. Site Selection, Design, and Construction

Most DMCA's generally are not suitable for aquaculture without substantial modification. This section provides a general overview of site selection, project planning, and construction needed to develop a DMCA for dual use as disposal sites and aquaculture ponds.

Dredging, Disposal, and DMCA

There are two important points to remember in planning for DMCA aquaculture. First, DMCA aquaculture can only take place in newly constructed facilities. This ensures that new disposal acreage will become available for DMCA construction. Unless an idle disposal area is brought back into use, refitting existing sites for aquaculture is not an option.

Second, the primary purpose of a diked containment area is to receive and retain dredged material. Aquaculture is the secondary use. Site designs and operational requirements for aquaculture must allow for required dredged material disposal and site management without impediment.

For both material disposal and aquaculture to be successful, the containment area site must be selected, designed, and constructed with primary- and alternative-use needs in mind. Those planning such multiple-use DMCA's must be familiar with criteria and procedures established for the siting, design, construction, and operation of disposal areas (U.S. Army Corps of Engineers 1987).

Confined disposal areas receive hydraulic dredge effluent, the combined mixture of dredged material solids and overlying water from the dredging site, retaining the solids while allowing the clarified water to be released. Containment areas are designed and operated to provide adequate material storage capacity for the dredging requirements of the project and to effectively retain solids in order to meet established effluent suspended sediment guidelines (Palermo 1988). These objectives are interrelated and dictate the design, operation, and management of the containment area from the CE viewpoint.

While project-specific characteristics make each confined disposal site unique, the main design components of a DMCA are shown in Figure 1. A tract of land is surrounded by dikes to form the containment area. The hydraulic dredge effluent is discharged at one end of the structure. The coarse material settles out rapidly, forming a mound near the inlet pipe while fine-grained materials settle as the discharge flows through the containment area. The clarified water is discharged from the containment area over a weir. Adjusting weir height to maintain appropriate water depth within the disposal area promotes effective sedimentation.

Long-term-storage capacity is a major concern in the design and operation of a DMCA. In most cases, DMCA's are used for many years, storing material from repeated dredging cycles. Over time, the thickness of the deposited material increases, eventually filling the available volume. Sites are managed to consolidate the retained material, increasing storage capacity and design life of a containment area. The need to consolidate deposited material may modify or even preclude use of the DMCA for aquaculture.

Site Selection and Evaluation

Selection and evaluation of an area for material disposal and aquaculture can be viewed as a four-step process determining project feasibility, compatibility of operations, site suitability for confined disposal, and suitability for aquaculture. Aquaculture suitability is determined only for those sites found suitable for DMCA construction.

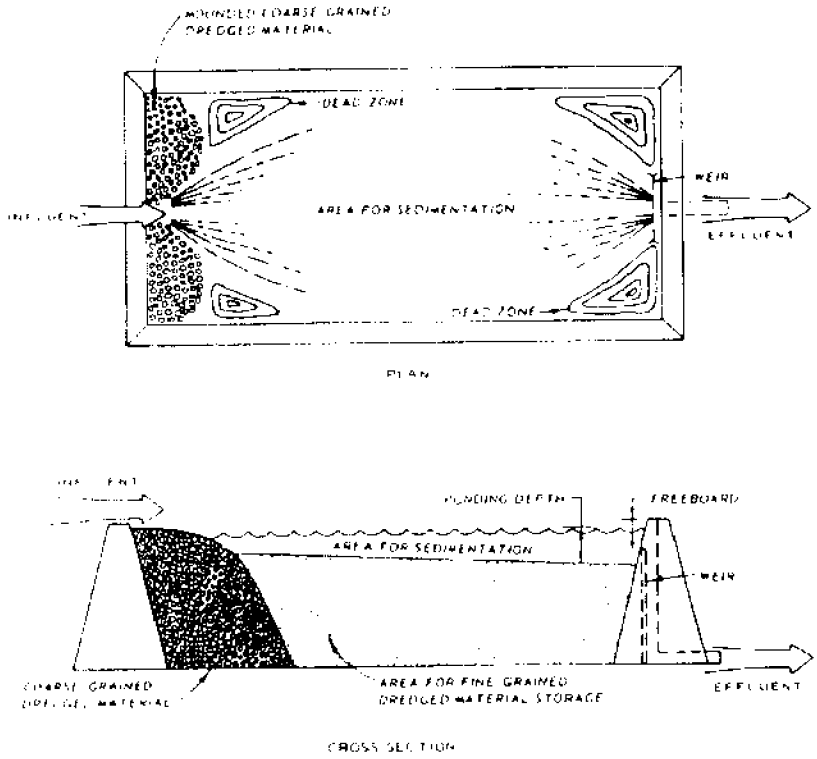


Figure 1. Diagram of a typical dredged material containment area. U.S. Army Corps of Engineers, 1987.

Concept Feasibility

Determinations of feasibility and compatibility are closely related and may not be clearly distinguishable in all cases. Both steps require close coordination with the responsible CE district and the dredging project sponsor. Four factors that help determine initial feasibility:

- There are active dredging projects which use DMCA for disposal.
- Additional diked disposal acreage is needed.
- Interest in developing a dual-use DMCA exists at the district.
- Aquaculture will allow consideration of sites otherwise unavailable.

The CE district office can assist in making contacts with the local dredging sponsor and owners of potential sites.

Compatibility of Operations

Aquaculture operations that do not substantially interfere with the use of the site for dredged material disposal will generally meet the compatibility requirement. At least the following dredging project information will be needed from the responsible CE district and local dredging sponsor:

- Project locations that would require additional confined disposal areas, along with potential sites for such areas.
- Project schedules, particularly frequency and duration of dredging cycles, and any restrictions on dredging to specific times of the year.
- Volume of material to be removed, per dredging cycle and capacity/projected life of a given confined disposal area.
- Physico-chemical characteristics of the material to be dredged. This includes the presence (and amounts) of any contaminants of potential concern or a "reason to believe" that contaminants may be present (Tatem 1990).
- DMCA design specifications, including location of dredge discharge point.
- DMCA management strategies for increasing site capacity (dewatering, raising dikes).

Site Suitability for a DMCA

Containment area design objectives, to provide adequate storage capacity for the dredging project and to meet effluent suspended sediment guidelines, are interrelated. The U.S. Army Corps of Engineers (1987) reviews design, operation, and management procedures for dredged material containment areas. Table 2 summarizes the main points considered in evaluating a site for construction of a confined disposal area.

Table 2. Summary of Dredged Material Containment Area site selection factors (Wilson et al., in press)

Factor	Criteria
Land use	Material disposal should be compatible with adjacent land use.
Water quality/Hydrology	No long-term effects on water quality.
Soil characteristics/ Geological conditions	No leachate migration to groundwater; good foundation soils.
Meteorological conditions	Sites not subject to flooding, runoff, extreme winds.
Access	Construction of access routes possible.
Environmental concerns	Environmental and historical features of the area must be protected.
Social factors	Public input required for sites near populated areas.
Institutional factors	Regulations on material disposal and land use must be identified.
Economic factors	Cost of building and operating site, environmental protection, pumping /transportation acceptable.

Site Suitability for Aquaculture

The following are minimum suggested requirements to be investigated during aquaculture site selection (Wilson et al., in press). Additional site-specific or project-specific items may be required.

I. Background work

1. Determine feasibility of a dual-use DMCA. Contact the CE and solicit its cooperation. Contact project sponsor to establish support.
2. Determine project locations that require additional DMCA's.
3. Identify and secure all relevant documents and maps, and identify information resources:
   - Large-scale base maps
   - Topographic maps
   - Aerial photographs
   - CE dredging project documents
   - Port management plans
     a. Postdisposal evaluation report
     b. Environmental reports and assessments
     c. Project documents, including previous projects in area
     d. Construction and project specifications and invitations for bids
   - Contacts and information sources
     a. Permit and review agencies
     b. Site owners and landowners along access routes
     c. Dredging contractors
     d. Local economic development assistance groups
     e. Other aquaculture operations in local area
4. Review culture techniques and biology of the target species.
5. Develop preliminary production and business plans.

II. Preliminary survey

1. Locate all candidate sites in area.
2. Determine dredging schedule, season, and lengths of time site will be used for disposal.
3. Determine access, power-supply lines, and other basic services to site.
4. Determine characteristics and volume of material to be deposited at site.
   - Estimates of in situ sediment volume
   - In situ sediment concentration, void ratio or water content
   - Specific gravity of material
   - Degree of saturation
   - Coarse-grained fraction (> No. 200 sieve)
   - Settling behavior of the material
   - Contaminant status (present, reason to believe, absent)
5. Evaluate current soil characteristics at site.
   - Soil classification
   - Particle size and shape
   - Permeability/porosity of soil
   - Percent clay content
   - History of contamination (agricultural, industrial)
6. Evaluate hydrological properties of source water (monthly means, ranges, monthly and annual minima and maxima).
   - Temperature
   - Salinity
   - Tidal range (average and maximum)
   - Solutes
   - Nutrients
   - Dissolved gases
   - Contaminants, agricultural runoff, sewage, wastewater
   - National Shellfish Sanitation Program (NSSP) classification (surface marine water sources)

III. Evaluate disposal operations data

1. Frequency of disposal operations.
2. Duration of site closure.
3. Season(s) or months of year dredging scheduled (include regulated restrictions).
4. Discharge rate, net volume retained.
5. How long will site be used?
6. Determine if new work or maintenance work.
   - If new work, repeat evaluation of dredged materials and site design for maintenance work conditions
7. Compatibility of site for disposal of dredged material and aquaculture based on dredging operations schedule.

IV. Evaluate disposal site data

1. Foundation conditions of base strata.
   - Depth
   - Thickness
   - Extent
   - Composition
2. Groundwater conditions.
   - Depth
   - Hydraulic gradients
   - Down gradient use
3. Site location and topography.
4. Proposed disposal area design.
   - Dike dimensions
   - Weirs (number and placement)
   - Spur dikes
   - Intended ponding depth
   - Average height (consolidated) of each lift of material
   - Intended storage capacity of site
   - Other features
5. Soil properties (for new disposal site; repeat for material after disposal).
   - Soil type
   - Ph
   - Eh
   - Organic carbon
   - Cation exchange capacity
   - Engineering data
6. Site-specific meteorology and climate.
   - Water budget (rainfall, evapotranspiration)
   - Wind data (direction, average speed, maxima)
   - Tidal data (cycle, maximum and minimum heights)
7. Site-specific management plans.
   - Proposed future site refurbishing plans
   - Dewatering
   - Future dike elevation methods
   - Borrow area placement
   - Other management requirements

Coordinate site evaluation for aquaculture with the DMCA site-selection process. The Soil Conservation Service (SCS) or aquaculture experts associated with university-based Cooperative Extension Service or Sea Grant Advisory programs can provide valuable professional advice in evaluating sites for aquaculture.

Project Planning and Design

Planning Outline

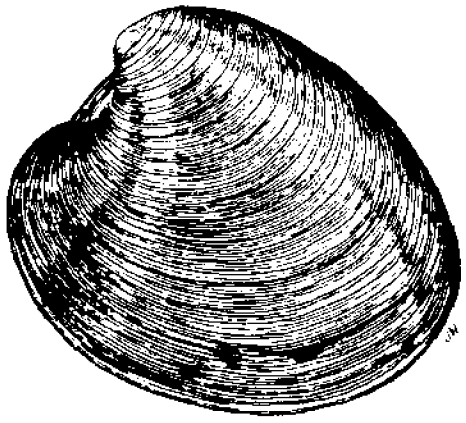
Project preparation and planning, adapted from Kovari (1984) and Huguenin and Colt (1989), should include the following steps:

- Identification of the project; a broad outline defining species cultured, culture system, and production target.
- Feasibility plan.
- Detailed production plan.
- Preparation of cost estimates.
- Preparation of contractual documents.

Design Considerations

Avoidable mistakes in pond design and construction are the most common reasons for the failure of aquaculture ventures. It is not uncommon in aquaculture projects for major design decisions to have been made and fixed before seeking engineering assistance. This can be a serious problem that may threaten project viability or add considerable cost to the operation. Professional advice in site selection, design, and construction should be sought early. Coordinated decision making is even more important in containment area aquaculture where site selection, design, and construction inputs from the local CE district are essential to project success.

Figure 2 summarizes the aquaculture design process.



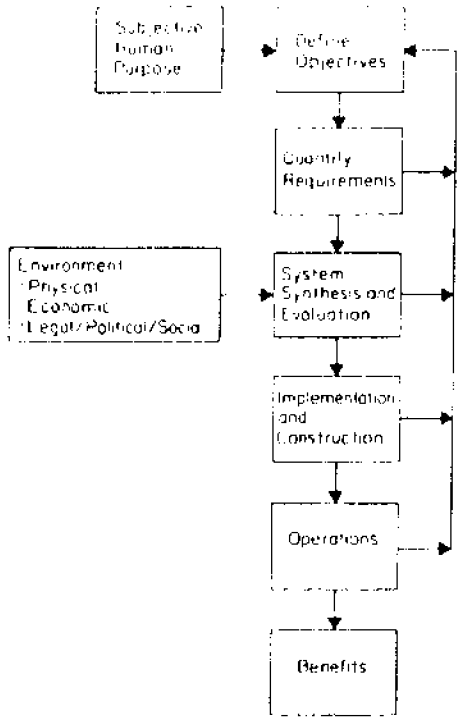


Figure 2. Simplified aquaculture design process. Huguenin and Colt, 1989.

Identification of the Project

Project planning is usually considered to include all of the activities short of the decision to implement the project. The first steps in project planning are the definition of the project, identification of project objectives, and a broad concept of the design of the production facilities.

Project objectives and physical data for a particular site are linked during the design process. Design is a complex and repetitious process. Decisions (including future plans) must be made early and in detail. All explicit and implied assumptions included in the project objectives must be clearly identified. As initial project decisions are combined with information developed during the planning process, broad project objectives will be refined into increasingly detailed statements.

The following basic data and maps should be available for the selected site.

1. Maps
   - Contour maps (1:25,000 to 1:50,000)
   - Map showing legal ownership
   - Soil or geological map
   - Water resources map, including surface water sources, dry water courses, wells, water tables, and aquifer water characteristics and yield estimates
   - Climatological map showing nearest meteorological stations and mean monthly values of temperature and rainfall
2. Meteorological data, mean monthly rainfall, evaporation humidity, wind speed and direction, and sunlight (solar radiant flux)
3. Hydrological data
   - Measured well yields and flood and water elevations for existing water sources, including any data on restrictions or competing uses
   - Tidal data for marine/brackish water sites

Feasibility Plan

The feasibility plan is a working project statement that combines project decisions, objectives, and physical data. The objectives of the feasibility plan are to confirm that the project can be developed at the selected site and to collect and provide all data, calculations, and plans needed for project approval and detailed planning. The feasibility plan is usually the basis for permit applications and for securing external financing for the project.

The main parts of the feasibility plan include:

Report. This should contain the most important information on the project, including a site description, soil characteristics, water sources, and results of water analysis, pond discharge estimates, and meteorological data used in planning. The report should provide the proposed operations plan with production calculations, planning considerations, site layout (with roads, buildings, and other facilities), arrangements of the water supply, and drainage. An abstract of capital, operational, and production costs, analysis of benefits, and the proposed construction program should be included. A list of legal documents acquired or applied for to allow the project to proceed should be added as well.

Maps and plans should include the following. The project site should be shown on an unscaled general location map and on a site map (scale 1:2000 to 1:5000). The site map should show surveyed boundary lines, existing features, contour lines, water source and drainage locations, and the locations of soil test pits. A layout map (scale 1:1000 to 1:5000) should show the arrangement of ponds, water supply and drainage systems, locations of buildings and other works, proposed approach roads, and utility lines.

Structures. A list of all proposed buildings and their plinth areas and a list of equipment needed for the project.

Soil and water tests. Soil and water test results for engineering and production calculations, in tabular form.

Cross sections. Typical outline cross sections of earth work (dikes and channels), showing slopes and dimensions.

Cost estimates. The feasibility plan should include cost estimates for civil works. Estimating costs is a multistage process. First, a complete estimate of the quantities of materials required is made from the plans and specifications. A detailed estimate of the cost of everything required to complete the work is then made. Finally, a complete estimate of all costs associated with the project is made.

Schedules, organization, and supervision. A schedule, based on project characteristics and quantity calculations, should show the time required for the activities required to complete the detailed plans. Because of the importance of completing construction on time and within budget, the work has to be organized. Adequate supervision must also be

provided to insure that all the work is being performed in accordance with plans and specifications. Further, the duties and responsibilities of the supervisory engineer, owner or owners representative, and various contractors need to be clearly defined. Because of the importance of this aspect of project development, it is strongly recommended that the procedure outlined by Homziak and Veal (in press) and Homziak et al. (1992) be reviewed.

Production plan. The feasibility plan is based on the production cycle. The production assumptions and targets are used to calculate all of the major project variables. The production plan and production calculations are the core of the planning process. While these calculations depend on the type of farm under development and the scale, they typically contain the following information (taken from Kovari 1984, for a planned fish farm).

1. Production facility data.
   - Production target
   - Culture method
   - Species cultured
     - Stocking rate
     - Initial weight
     - Harvest weight
     - Survival rate
   - Requirements for broodstock, fry, fingerlings
   - Seed stock sources
     - Reliability
     - Quantity
     - Quality
   - Feed requirements
     - Types
     - Storage and delivery
     - Feed conversion
   - Fertilizer
   - Pond management
     - Water quality standards
     - Pretreatment needs
     - Aeration
     - Treatment of effluent
   - Pond specifications
     - Types
     - Size and number
     - Water depths
   - Harvesting specifications
     - Methods
     - Schedule
     - Facilities
   - Operations plan
   - Marketing plan

2. Hatchery.
   - Production goals
   - Proposed technology
   - Operations plan
   - Facility specifications
   - Management requirements

Project financial information. In addition to project development costs, estimates of fixed and variable production costs and other financial data for the project should be provided (see C-K Associates, in press, and Roberts et al. 1992).

Once the feasibility plan has been completed and approved, the data should be reviewed and any deficiencies should be corrected. The final plan should include the modified and corrected version of the feasibility plan plus the production plan, final site plans and layout, cost and quantity estimates, completion schedules, and project organization and supervision.

Part 3. Pond Construction

Physical Factors

Land surfaces with a moderate slope (1-2 percent) in one or two directions are preferred. Topography around ponds should allow gravity drainage of the pond in any season. Ponds, facilities, and access must be designed to protect them from excessive runoff and flooding.

Soils that are adequate for the construction of containment dikes will also suffice for dikes modified for aquaculture. However, soil data should be reviewed by a qualified aquaculture engineer or a specialist from the Soil Conservation Service. Site surveys and soil sampling, if needed, should be done by professional survey staff or in cooperation with the local Soil Conservation Service office. The data should include information on chemical contaminants at the site. Tatem (1990) reviews procedures for evaluating contaminant levels at DMCA aquaculture sites.

Water quality information is essential to calculate water budgets, to determine site design and layout, and to plan production strategies. Water for aquaculture must possess several characteristics to be considered "good" quality water. Oxygen content, temperature, salinity, and hardness of the water supply should be at or near optimum levels for the type and number of aquatic organisms cultured. Pollutants, especially organic wastes, chemical compounds, and toxic or pathogenic organisms, should not be allowed to contaminate the water supply. Filters or provisions for water treatment should be made if the possibility of pollution of the water supply exists.

All factors that influence annual water use, including soil conditions, environmental factors, species cultured, and culture and harvest methods, need to be considered in the calculation of water requirements (see Homziak and Veal, in press, and Homziak et al. 1992 for details). Adequate water must be available for initial and future needs, including any planned expansion of the facility, changes in species cultured, or management intensity.

There are two sources of water for aquacultural enterprises: surface water and groundwater. Each has advantages and disadvantages that must be considered.

Groundwater sources are the most desirable as a water supply for aquaculture. Groundwater is usually at constant

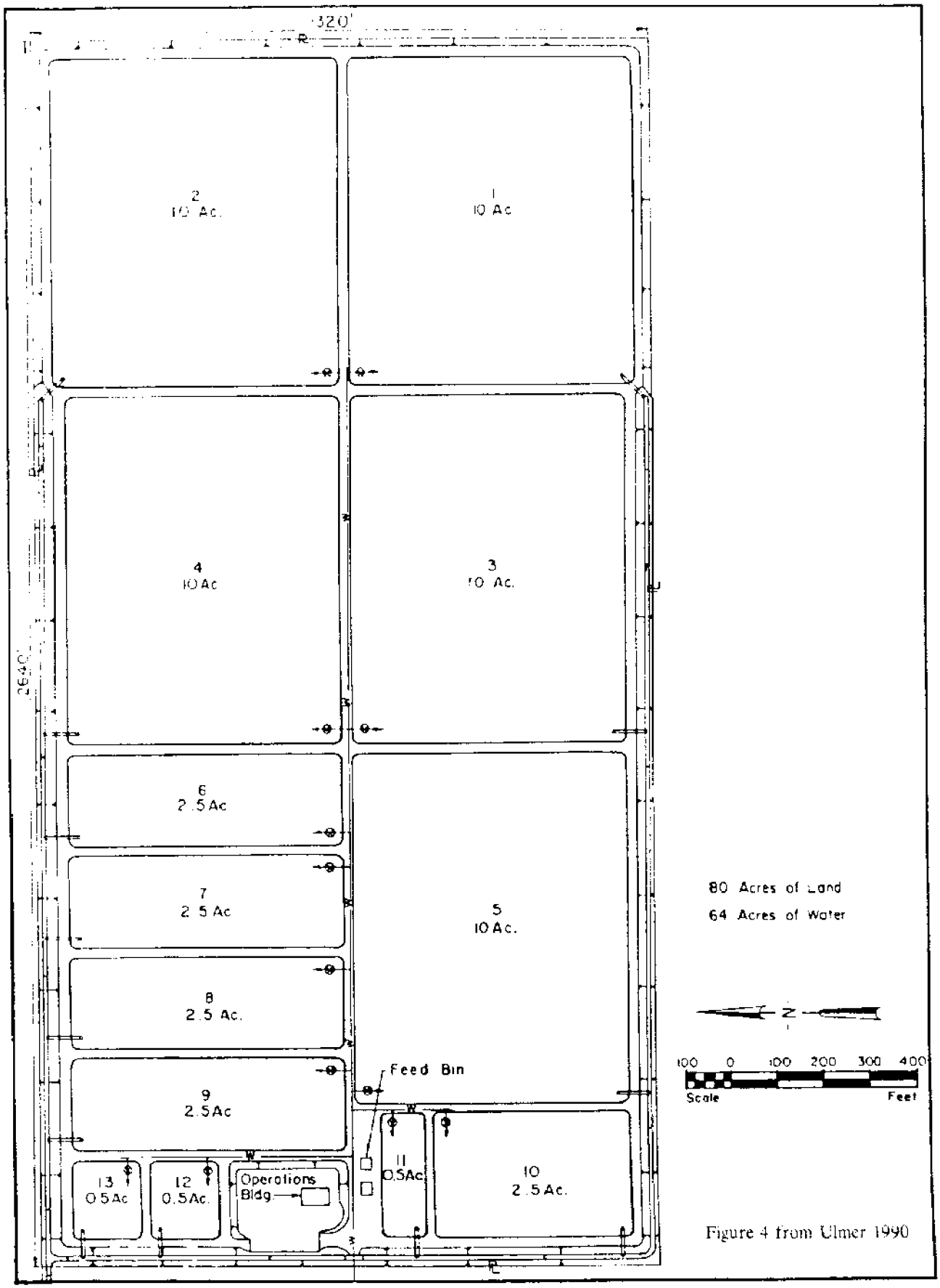


Figure 4 from Ulmer 1990

Figure 3. Layout of a marine fish grow-out facility. Ulmer, 1990.

temperatures year-round and free of pollutants. The added costs of using wells (installation, pumping) and the low dissolved oxygen content of groundwater are the most apparent disadvantages. Information on aquifer depth, available volume, and water quality of sub-surface water sources is needed. Professional advice should be sought in locating wells.

All surface waters suffer from the disadvantages of being exposed to pollution, seasonal or long-term changes in water quality characteristics, and habitation by potential predators, competitors, and disease organisms. However, most sources tend to be well-oxygenated and are usually less expensive to develop than are the groundwater sources. Water quality of the intake water at the times that ponds would be filled should be known. The physical characteristics of the source body should also be known, especially fluctuations in quality and quantity.

Permits that specify the volumes of water that can be withdrawn and discharged should be in hand before construction proceeds. Effluents from fish culture operations are considered potential sources of pollution. Existing or proposed standards for settleable material, BOD, COD, total phosphorous, and total ammonia nitrogen will vary among states. Seek local expertise to help determine treatment needs for pond effluent.

Water for use in oyster or clam culture must also meet National Shellfish Sanitation Program (NSSP) standards for harvesting of shellfish. Information on NSSP classification of shellfish harvesting waters is available from individual state shellfish control agencies or from the Public Health Service of the U.S. Department of Health and Human Services.

Pond Design

Any modifications to the dikes or water-control structure must retain the safety and stability built into the DMCA design. Designs calling for such modifications should be developed in coordination with the responsible CE district office.

Aquaculture facilities may contain a number of ponds of different sizes and depths (Figure 3), performing different functions. The main factors affecting pond dimensions, positions, and orientation are dredging project requirements, management requirements for the species cultured, cost considerations, and production level.

Pond bottoms should slope from 1000:3 to 1000:6 towards the drain. Each pond should have separate drain and fill connections preventing the mingling of drain and fill water. Ponds can be designed for drain-harvest or for harvest by seining. Drain-harvested ponds may incorporate an external harvest basin or an internal harvest basin near the pond drain.

Dike side slopes are commonly 3:1 (horizontal to vertical). Highly stable soils can have slopes of 2.5:1 on the upstream side and 2:1 on the downstream side. Dike heights are primarily a function of design depths, although wave height, a function of pond size, must be considered in estimating dike height and freeboard. (Freeboard is the vertical distance from the pond surface at its design depth to the top of the dike after settlement.) Minimum crown width for a dike up to 10 feet high should be 7.5 feet, 12 to 15 feet if used for vehicle traffic. At least one side of each pond should be made wide enough for vehicles. It is best if all dikes can accommodate vehicles.

Designs for water-control structures, dikes, pond dimensions, internal drains, and other structures should anticipate future changes in dike height, height of pond bottom over initial levels, and changes in particle size of bottom soils. Periodic disposal will raise the elevation of the pond bottom, requiring that the dikes be raised as well. Figure 4 illustrates the two ways in which dikes may be raised.

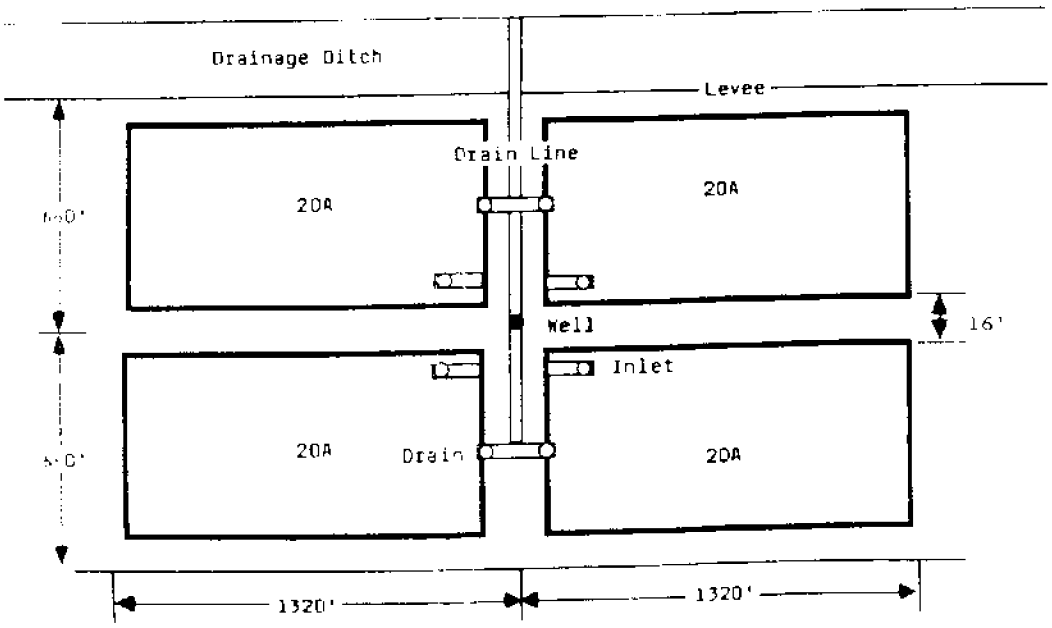


Figure 4. Typical catfish pond layout. Wellborn, 1989.

Two water control structure designs are commonly encountered—a drop inlet structure and a movable standpipe or riser. Drop inlets can replace a section of the dike or can be located within the pond. Both designs, when located in a fill canal, can also be used for water intakes. Inlet and outlet sizes are determined by the time needed to fill or drain the pond, in turn determined by species cultured, pond dimensions, stocking density, management level, and other factors.

Both feeder canals, which supply water to the ponds, and drainage canals, which carry discharge water away, must be sized to handle maximum projected flows, including storm water. A professional engineer should be consulted on the design of these structures.

Selecting the proper pumping design is critical. Poor pump choices can significantly increase production costs and risk to the crop from pump failure or water quality problems. Aquaculture engineering texts or production handbooks (e.g., Baker and Bankston 1988) can provide general information for selecting a water pumping system, including power requirements.

Practical information on design and construction of fish ponds has been developed. Texts such as FAO/UNDP (1984), Huguenin and Colt (1989), and Wheaton (1977) are excellent sources of aquaculture project design and engineering information. Widely available manuals produced by the Cooperative Extension Service, USDA Regional Aquaculture Centers, and Sea Grant programs provide guidelines to the construction of typical pond production systems, based on the experience of commercial operations in a given area (see Homziak and Veal, in press, and Homziak et al. 1992 for a listing of references). The Soil Conservation Service provides information on site evaluation, pond design, and construction (e.g., Soil Conservation Service 1971, 1982).

Part 4. Economics and Business Planning

Summary of Economic Benefits

The Brownsville (Texas) demonstration project documented a significant value to lowered start-up or entry costs for a DMCA-based aquaculture facility. For the demonstration project, the combined capital savings for construction, engineering, surveying, design, and permitting work performed by the CE produced an estimated combined capital savings of $271,000. The annual drain on cash flow of the estimated $271,000 start-up capital needs would have been $63,000 (Roberts et al. 1992).

The major potential investment-reducing incentive to using a DMCA is the pond construction cost. Parker and Hayenga (1979) identified coastal pond construction costs of $1,000 per acre in Texas. Keenum and Waldrop (1988) provide an estimate of $840 per acre for catfish pond construction. Soils of coastal areas and the remoteness of sites could make DMCA projects more costly. However, the large pond size should make construction costs lower on a per-acre basis. An estimated $800-per-acre pond construction value can be realized by prospective culturists using DMCA culture.

There is also value to reducing investment capital needs for engineering, design, surveying, and permitting. To the extent that the Corps of Engineers district or the local dredging sponsor provides these services, an additional value of $400 per acre could occur. Using estimates of investment needs from the aquaculture literature, a combined value of $1,200 per acre can accrue for pond engineering, design, surveying, permitting, and construction.

The reduction of investment capital needs may be as important to increasing lender support as it is to lowering breakeven costs, since capital availability is a well-known constraint in the aquaculture industry. In an industry known for scarcity of funds available from financial institutions, this capital savings is both real and valuable. Investors characteristically provide a high share of an aquaculture project's start-up capital, because most projects lack full institutional support. Not only could the lowered immediate demand on cash outflow increase chances for company success, but a DMCA aquaculture venture would be available to a wider number of prospective companies. This is an outlook that will be of value to large containment areas like those at the demonstration project, and to smaller sites suited to more intensive operations or part-time operators.

DMCA Aquaculture Economics Computer Model

A PC-based computer model that allows a user to "test" the economic feasibility of raising various animals in DMCA's of different sizes has been developed (see C-K Associates, in press, for details of the model). A copy of the computer model and the Economics Technical Report are available from the Program Manager, Containment Area Aquaculture Program, Environmental Laboratory, CE-WES-ER-C, U.S. Army Corps of Engineers Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6399.

The primary objective of the DMCA economics model was to provide a spreadsheet template with the features necessary to input specific data, perform "what-if" scenarios, and obtain calculated results. This information will enable the user to make sound economic and marketing decisions before starting an aquaculture business.

Specific requirements of the model were to:

- Be useful to CE district personnel and the landowners who are not experts at dredging or aquaculture;
- Be flexible to analyze selected variables that may be peculiar to certain species in different parts of the country;
- Allow separation of expenditures of the aquaculturist and the CE district; and
- Be PC-compatible, portable, and designed for the novice PC user to operate with a minimum amount of computer knowledge.

After reviewing several existing aquaculture economics models, a special model for DMCA aquaculture was developed and tested with live data to identify specific start-up

investments, variable and fixed costs, and potential crop returns over a specified period of time. The final analysis of the computer model provides the aquaculturist with differences in annual expenses, net income/loss, and cash balance figures with and without financial assistance from the CE district.

The DMCA model is a combination of six worksheets developed with Lotus 1-2-3, a spreadsheet software product of the Lotus Corporation. There are six worksheets that accept and calculate data for:

1) Construction Costs
2) Initial Investment Costs
3) Annual Variable Costs
4) Annual Fixed Costs
5) Annual Sales Summary, and
6) Annual Income Statement and Annual Cash Balance Statement.

The spreadsheet format will accept initial input, perform required calculations, and update figures. Once the worksheets are filled in, individual or multiple parameters can be changed and the results can be viewed immediately. This is a significant advantage of the spreadsheet format. However, the six worksheets are designed so that they can be used without the computer performing all of the calculations.

The worksheets require the user to input a number of cost figures. These figures may have to be estimates, as in the length of a pond levee, or they may require some research into typical values either from aquaculture literature or experts. Examples of these are the cost of fingerlings or the number of pounds of a species that may be harvested per acre.

Although the worksheets require considerable input, they are structured to assist the potential aquaculturist in initiating a thorough preproject evaluation. Standard financial analysis concepts are incorporated to prompt the user to consider the full range of factors and to appreciate their relationships.

Economic Potential of Selected Species

Four evaluations were conducted: catfish, crawfish, hybrid striped bass, and hard clams. Each species was examined under two scenarios: "low/break even" and "average." Crop values and harvest-per-acre values were taken from published information to create the "average" scenarios. Adjusting the input figures in the models produced the "low/break even" scenario.

The analyses examine facilities in a range of DMCA sizes; but all are considered on a scale that could be managed by an owner/operator with part-time help. All returns are to the owner/operator, whose salary has not been included as a project expense. Yields used in the analyses are below reported averages to reflect the uncertainties of operating in DMCA's. Prices for harvested products are average to below average to reflect potentially higher transportation costs.

For catfish, the DMCA economics computer model evaluated a system of four 20-acre ponds, and assumed growth to market size of 1.25 pounds within one year. A yield of 3,500 pounds of whole catfish per acre was also assumed.

For crawfish, the model evaluated a system of two 20-acre ponds. Levee height was assumed to be only 3 feet, and yield was assumed to be 1,000 pounds of whole crawfish per acre.

A hard clam operation, consisting of a single 40-acre pond, was analyzed with the computer model. Assumptions included harvest in year two of one million clams (25,000 per acre) and sale at $0.17 each.

Finally, hybrid striped bass were examined because they represent an emerging culture species that may be well-suited to DMCA's. A two-pond system of 40 acres total with 2 years to harvest was assumed. At $2.50 per pound, a break-even yield was slightly below 2,000 pounds per acre.

Corps of Engineers participation in an aquaculture project results in savings, reflected in the net income statement, and has an impact on the cash balance of the operation. The estimated effects of Corps of Engineers participation on each species by crop cycle are shown in Table 3. **These are sample calculations for illustration only.** These values must be estimated using project-specific data to obtain values representative of specific projects.

Table 3. Estimated effects on net income and cash balances of Corps of Engineers participation in aquaculture projects producing selected species [1]

Species	Net income	Cash balance
Catfish	$27,000	$16,200
Crawfish	$4,700	$3,000
Clams	$12,000	$2,600
Hybrid striped bass	$34,000	$20,000

[1]See C-K Associates (in press) and Roberts et al. (1992) for further details.

Aquaculture Business Planning

Planning an aquaculture business requires, among other things, a forecast of the future. This makes it difficult for the prospective aquaculturist or his investors to settle on the specifics of their business. However, only by careful financial analysis will the aquaculturist produce a plan with sufficient documentation to convince investors or lenders. Analysis forces the individual to identify weaknesses in what may have begun as a general idea. In fact, the very enthusiasm to take advantage of the gap between seafood supply and future demand can obscure the need for planning. The prospective aquaculturist must put personal interests to the test of thorough evaluation in the business plan. Such plans require support-

ing information, logical organization, emphasis on marketing as well as production, and an array of financial statements.

An aquaculture business plan must be clear as to:

1. Species to be cultured
2. Size of the operation
3. Use of broodstock or purchased "seed"
4. Technology to be used
5. Time horizon of going from) planning to construction to production
6. Yield and target size of fish or shellfish
7. Marketing channels
8. Site evaluation and permits

This list of components should not be considered complete. However, these are the critical components that would serve the aquaculturist and the lender and investor reviewing the material. The first seven items listed can be analyzed almost theoretically because results and answers are not specific to a particular location. The final item requires a different level of planning and will not be completely settled until much work is done.

Business plans for aquaculture in a dredged material containment area should be no different from plans for conventional aquaculture businesses. With a containment area, however, the local Corps of Engineers district may be able to assist with many of the site evaluation factors. For instance, assistance may be available with chemical testing of sediments or with permits for structures in navigable waterways. Working in partnership with the Corps of Engineers may reduce the expense and delays in obtaining CE permits. These advantages should be highlighted by the aquaculturist in his business plan. In addition, a significant lowering of initial capital needs has a value that can be quantified in the business plan. When provided at the site, levees, water-control structures, access roads, and water availability represent capital and, therefore, reduced costs. Start-up of a system can certainly be faster in a DMCA, and the need for investment capital can be reduced because revenues will be received sooner.

The plan must also address any aspects (of a containment area) that are less than optimum. A site may be too remote for inexpensive power to be used. This may result in more extensive culture being attempted at a containment site. Another shortcoming of a DMCA could be that the ability to expand the site may be limited.

The aspiring containment area aquaculturist is advised to follow a good business plan outline that includes all of the items noted herein. Dredged material containment areas will be financially attractive in many situations. Planning identifies those situations and can result in positive economic benefits from otherwise idle property.

Lenders and investors expect detailed information on marketing. An aquaculture business planner is advised to meet early with wholesalers, food-service buyers, local processors, or brokers to secure specific information and possibly to reach agreements on marketing relationships.

Sources of Additional Economics Information

The DMCA computer model — the six worksheets — and the aquaculture business planning guide make clear the need for research into all aspects of an aquaculture business venture. As much data as possible on the species to be grown, the machinery and equipment needed, and the costs involved should be collected in advance of borrowing or spending. A variety of sources should be consulted, and should include those providing financial, technical, and regulatory information.

Part 5. Containment Area Aquaculture—A Regulatory Overview

Specific steps needed to insure compliance with federal and state laws ultimately depend on site-specific considerations. Since federal and state laws governing aquaculture and dredging change frequently, this publication only briefly reviews some of the more important permit requirements, laws, and regulations that may apply to aquaculture in DMCA. This information is drawn from the summary document prepared by Konikoff et al. (1992). For more complete information, consult Robertshaw et al. (in press). Consult a qualified attorney for site-specific legal recommendations and advice.

Federal Regulation of DMCA

CE district personnel are familiar with the regulatory steps to take for a new DMCA approval. The steps taken for a DMCA associated with aquaculture will be essentially the same, and these will be described first. Additional permit steps will be required for specialized additional features required for aquaculture, such as water intake structures, feed storage buildings, electrical generating and distribution systems, and access roads. These will be discussed later.

There are four main federal regulations that must be addressed in order to construct and operate a DMCA:

1) National Environmental Policy Act (NEPA),
2) Section 404 of the Clean Water Act,
3) Section 401 of the Clean Water Act, and
4) Coastal Zone Management Act (CZMA). In addition there are several minor ones that bear attention.

National Environmental Policy Act

The NEPA of 1969 requires full disclosure and consideration of the environmental impacts of any federal agency project that significantly affects the environment. This would include CE projects that involve the discharge of dredged material; therefore, the act requires a detailed accounting of disposal alternatives. As a practical matter, for each such project, an Environmental Impact Statement (EIS) or an Environmental Assessment (EA) must be prepared.

An EIS is a complex and time-consuming document that thoroughly explores the environmental consequences of the project to the extent scientifically and practically feasible. It requires formal interagency coordination, generates a record of decision on the proposed project, and usually takes over a year to complete. The EA alternative, however, briefly discusses the need for the proposed action and alternatives to it. It also analyzes the adverse environmental impacts and positive aspects of the proposed action. The EA must be accompanied by a finding of no significant impact (FONSI) detailing reasons why an EIS is not required. An EA for most beneficial-use activities can be prepared in about 2 weeks. An example of an action that would normally require an EA, but not necessarily an EIS, would be the use of a new disposal area not covered by the overall project EA or EIS, but in a similar habitat to an area that had been covered by an EIS (Mathis 1989).

Some actions, such as minor maintenance dredging along existing disposal sites, are exempt from NEPA requirements. However, these exemptions likely would not affect DMCA aquaculture projects since these are designed to facilitate the acquisition of additional disposal acreage, rather than the conversion of existing sites. Furthermore, even if an activity falls within the category of an exempted activity, "extraordinary circumstances" may exist that mandate the preparation of at least an EA. Building a new commercial-sized aquaculture facility would generally qualify as an extraordinary circumstance.

Section 404

Section 404 of the Clean Water Act (also known as the Federal Water Pollution Control Act Amendments of 1972, 1977, and 1987) regulates and requires a permit for construction and dredging activity (including disposal) associated with navigable waters, tidelands, and wetlands. The CE serves as the regulatory agency for Section 404, and private parties wishing to dispose of dredged material (or do any sort of construction in a wetland or a navigable waterway) must secure a permit from the CE (Leibesman 1990).

Part of the permitting process allows for public notice, review by federal and state resource management agencies, and opportunity for public comment and hearing. Although the CE does not issue itself a permit for its own projects, it does undertake an internal compliance process, including notice to and coordination with other federal and state agencies. In addition, in the 404 permit process, the CE must comply with other federal environmental laws, such as the NEPA, CZMA, and the National Pollution Discharge Elimination Act (NPDES).

One of the most sensitive issues associated with Section 404 is wetlands protection. According to Section 404(b)(1) guidelines for CE projects, uplands are to be preferred over wetlands for disposal of dredged material, and wetland disposal can take place only when certain restrictive requirements are met. These include: no practicable alternative; no significant adverse impacts on aquatic resources; all reasonable mitigation is employed; and no statutory violations.

Although the guidelines seem straightforward, the delineation of wetlands is a complex subject. Over the years, the various federal agencies (with an interest in wetlands) developed different methods of determining whether a given site is a wetland (with various emphases on hydrophytic vegetation, hydrology, and hydric soils), and often there were uncertainties. In an attempt to resolve the resulting inconsistencies, a unified Federal Manual for Identifying and Delineating Jurisdictional Wetlands (Federal Interagency Committee for Wetland Delineation 1989) was adopted by several agencies and is in current use. It is, however, being challenged in both the courts and in Congress and could be altered. In the meantime, the CE uses the unified manual to determine whether a site is a wetland and if so, applies Section 404(b)(1) guidelines.

Two other Section 404 stipulations that could affect DMCA aquaculture are 404(c), which gives the Environmental Protection Agency (EPA) veto power as to the use of a particular site, and 404(e), under which general, regional, or national permits are allowed. Under Section 404(c) the EPA administrator may decide, after notice, hearing, and consulting with the CE, that discharge at a site will have unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreation areas. The EPA then may prohibit or restrict the use of the proposed site. However, if a site is acceptable under Section 401 (which deals with water quality and is discussed below), it is not likely to trigger Section 404(c).

General permits for certain frequently occurring activities are allowed under Section 404(e). These permits are often used for disposal in upland sites as long as the runoff from the site is acceptable under Section 401 (water quality, discussed below). If a DMCA aquaculture project is proposed for an upland site, the use of one of the existing 404(e) permits would be desirable.

Section 401

Section 401 of the Clean Water Act requires that the CE secure a certification from the appropriate state agency attesting that the discharges from DMCA do not violate state water quality standards. The standards are set by the states, subject to the EPA's minimum standards and review. Early in the Section 404 compliance process, the CE evaluates the water quality impacts of the proposed project and requests a Section 401 water quality certification from the state. Within 2 months of this request, the state must take action on it or ask for an extension. If, after 2 months, no action is taken, the CE will then notify the state of its intention to presume a waiver of the water quality certification requirement. If no action is taken for 6 months, a waiver can be conclusively presumed.

Coastal Zone Management Act

Section 307 of the CZMA requires that any federal development projects in the coastal zone or any projects in the coastal

zone that are supported by a federal agency must be consistent to the maximum extent practicable with the federally-approved state coastal zone management plan. Procedural steps are similar to those in securing a state water quality certification. Early in the Section 404 compliance process, the CE requests concurrence from the appropriate state agency that its proposed project complies with the state's coastal plan and that the activity will be conducted in a manner consistent with the plan. The state must respond to the request within 45 days or file for an extension. The entire period from the date of the initial consistency determination to the date of final action by the state should not exceed 6 months.

Other Federal Regulations and Executive Orders

Although there are over 30 federal laws and presidential Executive Orders (EO) that may apply to CE dredging and disposal activities, compliance often can be demonstrated with a sentence or two on the NEPA document (Mathis 1989). Furthermore, not all of the laws and EO apply to every dredging project. Early in the planning and site selection stage, care should be exercised to determine what laws and EO apply to the specific site and how these may affect the proposed project. A summary of federal laws and EO that are likely to affect aquaculture follows.

The National Historic Preservation Act (NHPA) requires that a federal agency consult the state historical preservation authority to determine whether significant historical structures or archaeological sites will be affected by that project. **The Endangered Species Act** provides generally that federal agencies may not take actions that jeopardize the continued existence of endangered species, designated threatened species, or their critical habitat. It is administered by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. This requires that the CE coordinate its activities with both federal **Fish and Wildlife Coordination Act** and state fish and game agencies and fully consider their recommendations and ways to prevent loss and damage of fish and wildlife resources due to the proposed operations (Mathis 1989). **The Wild and Scenic Rivers Act** provides protection of designated rivers. **The Estuaries Protection Act** is designed to protect and improve water quality of designated estuaries threatened by overdevelopment and pollution. It is administered by the EPA.

There are several EO's that may apply to DMCA's to be used in aquaculture. **EO 12372** provides state and local officials with a chance to consult with federal agencies like the CE when federal activities are proposed. **EO 11990** prohibits construction in wetlands unless no practical alternative exists. **EO 11988** requires the evaluation of the potential effect of CE actions on floodplain areas. **EO 11593** requires the CE to take into account laws designed for the protection of cultural resources when making development plans. If it is determined that an EO applies to a proposed project, it can usually be addressed in the NEPA document.

State Regulation of DMCA

Although dredging and DMCA mostly fall under federal regulations due to their connection to interstate commerce, states also have the power to regulate disposal of dredged material because of their ownership interest in uplands and submerged lands within their borders. Because of the limited scope of this report, it does not cover regulations at the state level, except to note their importance. Because of the many differences among states, individual state regulatory agencies should be consulted for information on laws and regulations applicable to aquaculture and dredging and disposal. In addition, local-level regulations, such as zoning requirements, may also affect aquaculture and confined disposal area development. Local expertise, often available through the CE District office, should be sought to clarify these issues.

Robertshaw et al. (in press) examined state regulations that would affect containment area aquaculture in six model states: Alabama, Florida, Louisiana, Maryland, South Carolina, and Texas. These states were chosen because 1) they represent a variety of regulatory environments, 2) they have confined dredge material disposal on-going, requiring future additional DMCA acreage, and 3) they are states in which aquaculture is a potentially significant industry.

A summary of the regulatory process in each model state examined by Robertshaw et al. (in press) includes the following concerns: 1) land protection and management (including coastal lands, wetlands, public lands, and land-use planning; 2) water resource protection (including water quality, water management, and levee construction); and 3) biological resource protection.

Aquaculture Permitting Within The Federal Statutory Framework

Aquaculture is regulated in varying degrees within the states. Federal regulation further adds to the framework within which the aquaculturist will operate. This section is designed to provide the reader with a look at the various federal agencies involved in the permitting process. A brief description of the jurisdictional parameters of those agencies also is provided.

It is important to note that some aquaculture activities will not require permitting; however, the aquaculturist should become familiar with the overall regulatory framework of aquaculture within a particular state and vigorously attempt to comply with all related laws.

The information contained herein is intended as a guide to permitting agencies, and it is not intended to supplant the need for legal counsel, where required.

Environmental Protection Agency (EPA)

The Environmental Protection Agency (EPA) is charged with ensuring the protection of the nation's water and air quality, which includes the prevention of adverse impacts to fish

and wildlife resources and the public health in general. EPA has responsibility for issuing National Pollution Elimination Discharge System (NPDES) Permits. EPA also regulates pesticide use and application through registration and the establishment of tolerance levels. Aquaculturists should become familiar with the various tolerance levels of any pesticide to be used. See the Federal Insecticide, Fungicide, and Rodenticide Act, 7 U.S.C., Section 136 (Robertshaw et al., in press).

Food and Drug Administration (FDA)

The U.S. Food and Drug Administration (FDA) is responsible for approving and regulating drugs that may be used in aquaculture operations (Federal Food, Drug and Cosmetic Act. 21 USC 301 et seq.). Note also that drugs do not include pesticides, which are regulated by the EPA.

Drugs used to treat diseases and parasite infections must be approved, and then they must be approved for aquaculture operations, including dosage. The aquaculturist must follow instructions for each drug to be in compliance with the law. For example, one drug, tricaine methanesulfonate, can be used during transport to immobilize certain fish intended for food. However, the drug should not be used within 21 days of harvesting the fish for food.

Fish and Wildlife Service (FWS)

The U.S. Fish and Wildlife Service (FWS), under the Department of the Interior, is responsible for ensuring the protection and proper management of wildlife, including fish. The FWS regulates and permits international and interstate import and export of fish and wildlife. Shipments of wildlife must enter and leave the United States only through ports designated by the FWS. (See 50 CFR 10-24.)

The FWS is also a commenting agency under the Fish and Wildlife Coordination Act—reviewing, commenting, and making recommendations on such things as proposed alterations to any water body by the federal government and the effect on fish and wildlife under protection by the FWS.

According to the FWS, it is the intent of the FWS to build a strong and mutually beneficial relationship with the private aquaculture industry, and to the extent possible, make its scientific and technical resources available to further the development of private aquaculture.

Other Legal Issues

In addition to the regulatory environment in which confined disposal of dredged material and aquaculture must operate, there are also a variety of significant legal issues that must be considered. These are complex issues treated in more detail in Konikoff and Love (1992) and Robertshaw et al. (in press).

Chemical Suitability and Soil Testing

If a seafood consumer becomes ill after eating seafood produced on a Contaminant Area Aquaculture Site, that consumer might raise the argument that the Corps failed to screen the site, although it actively promoted the site as suitable for the production of food for human consumption.

Involved parties will be held to a higher standard of care when dredged material is going to be involved in the production of food for human consumption than when no aquaculture is involved.

Misrepresentation or Fraud

If affirmative representations were made to the aquaculturist that the proposed site was "chemically suitable for aquaculture," and, after a significant financial investment, the site turned out to be chemically unsuitable, the aquaculturist might sue to recover his investment. Prosser (see Keaton 1984) indicates that, to establish a claim under this theory, one would have to prove an element of negligence.

Waste by the Tenant or Easement-Holder

The argument that the tenant is guilty of "waste" may arise when the tenant does or doesn't do something he is obligated to do, and thereby reduces the value of the property for the owner. An aquaculturist, as the lessee of the site, may be subject to this type of liability, particularly with respect to the maintenance of the levees and the drain/harvest structures that had been tailored by the Corps to meet the special needs of the aquaculturist.

Private Nuisance

The private nuisance issue might arise where the owner of property adjacent to or near the site complains that an activity on the site constitutes a nuisance. The actual legal test for nuisance liability varies from state to state. However, in general, a number of points must be legally proven in order for a landowner to recover damages under the "private nuisance" theory of liability.

Contractual Issues

Aquaculturists will have in place service contracts on their major pieces of equipment, and may engage contractors to harvest the crop. In addition, there will be in place various other contracts, such as land leases, easement, equipment leases, and operating agreements. The general principles of contract law vary from state to state. Contract law is often more complex than the tort issues discussed previously; but the elements of proof are roughly parallel to those in a tort claim. It is difficult to generalize further about how a contractual claim might turn out, because any contractual claims that arise will depend on the language of the particular contract on which the person sues.

"Joint Venture" Vicarious Liability

There is one practical reason the issue may come up (although the argument itself may not be that strong)—the Corps is perceived as a "deep pocket." The joint venture

theory of liability is a category of vicarious responsibility (i.e., holding someone else liable for an act committed by another). The idea is that a joint venture is a kind of temporary partnership where it makes sense to treat the participants like you would treat partners. Although the precise legal test to determine whether a joint venture exists varies from state to state, courts look at some combination of factors to decide (Robertshaw et al. 1991). However, it is unlikely that most courts would find the Corps and the aquaculturist joint venturers for several reasons.

Contracts Among Parties

This section focuses on the legal and operational issues that should be covered in the documents used to establish the legal relationships among the parties. The purpose is two-fold. The information includes a checklist of issues that should be discussed during negotiations and/or included in the documents, and the obligations and responsibilities peculiar to the coincidence of aquaculture and dredged material disposal—beyond those contained in the conventional aquaculture lease and disposal easement—that should be included in the documents. Second, models of the documents that establish the legal relationships among the various parties to the operation in each of four potential contractual situations are provided.

How responsibilities and obligations will ultimately be allocated is a site-specific proposition. Since no two sites will be alike, no two sets of documents will be alike. However, it is possible to identify and highlight, by means of sample documents and document checklists, the important matters that should be covered in the documents, and the types of documents needed to set up the legal relationships among the parties and to allocate risks in an equitable fashion.

Substantive Provisions—A Checklist

This section discusses how the documents for a DMCA aquaculture operation might be different or more complicated when compared to a straightforward aquaculture lease or a typical easement for the disposal of dredged material.

The parties negotiating a containment area aquaculture operation should consider including in the documents provisions allocating the following obligations and responsibilities:

- Responsibility for the security of the site;
- Site suitability investigative responsibilities, such as sediment testing and study of land-use history, with specific guidelines on what testing should be done when, as well as who will be financially responsible for each test;
- Securing and maintaining insurance on the site and equipment;
- Construction and maintenance of levees; water intake structures; drain structures; roads on levees; and access roads to site;
- Construction and maintenance of an on-site office;
- Indemnity or "hold harmless" provisions;
- Division of responsibility for securing permits and coordination of the acquisition of the necessary state, federal, and local permits for both the aquaculture operation and the dredged material disposal operation;
- Provisions describing access for each party in the event of emergency, such as a hurricane, including the Corps' agreement to use its best efforts to avoid disposing of dredged material during the growing cycle of the aquaculturist, except in extreme emergencies.;
- Responsibility for returning the site to an agreed-upon condition at the termination of the Corps' easement and/or the aquaculturist's lease; and
- Arbitration provision to govern disputes that may arise during the operation of the project.

Model Contractual Documents

Figures 5, 6, 7, and 8 depict schematically the documents needed in the four situations likely to exist for a DMCA project. As Figures 5 and 6 illustrate, the most likely situation (where the land is privately owned or state-owned) will require three documents among the three parties:

(1) An easement from the landowner to the Corps;

(2) A lease from the landowner to the aquaculturist; and

(3) Some form of operating agreement or coordination document between the Corps and the aquaculturist, in order to coordinate the disposal of dredged material with the operation of the aquaculture facility.

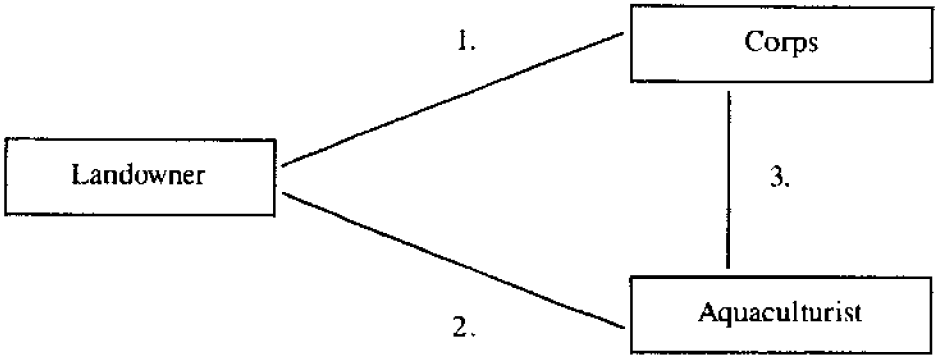
In these situations (Figures 5 and 6), the easement may look like the sample easements in attached Appendix A.

Where the land is privately owned, state-owned, or owned by the local sponsor, the easement in favor of the Corps will look the same as the Corps' usual Easement for the Disposal of Dredged Material—the involvement of the aquaculturist and the aquaculture surface use should make no difference in the way the Easement is drafted. Whether aquaculture is involved or not, the Corps needs the legal right to dispose of dredged material on the site and to take other measures necessary to create and maintain an upland DMCA. The sample easements in Appendix A are of the type usually used to give the Corps the legal rights and access it needs to dispose of dredged material in a DMCA on the property of another. Probably, under all circumstances, the Corps will want its dredged material disposal rights to be superior to the aquaculturist's rights. The aquaculturist's lease and any other estates in that property must be subject to the Corps' disposal rights. For this reason, it is not legally necessary for the Easement for Dredged Material Disposal between the landowner and the Corps to even mention the aquaculture surface use. While it is certainly fine to state in the easement that the Corps' access rights are superior to the aquaculturist's, it is not necessary as long as the lease so states.

Figure 5.

Where Land Is Privately Owned:

Documents recommended for establishment of a Containment Area Aquaculture Project



1. Easement for Disposal of Dredged Material

2. Lease to aquaculturist (subject to Corps Disposal Easement)

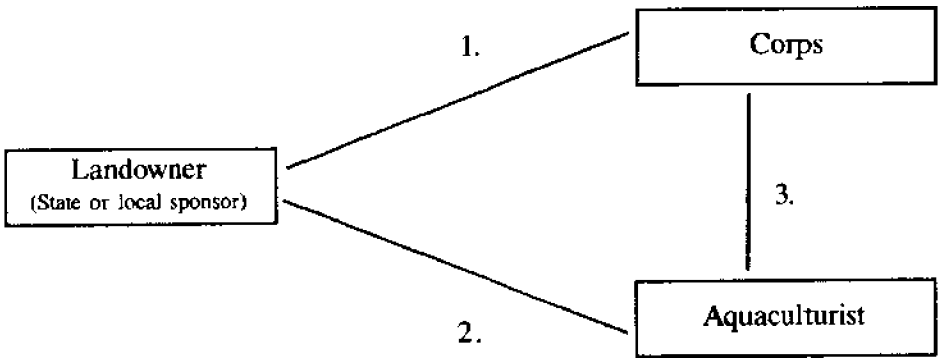
3. Operating agreement (or other coordination document)

Note: Preliminary agreements may precede adoption of these final documents, reducing the parties' agreement to writing.

Figure 6.

Where Land Is Owned by the State or a Local Sponsor:

Documents recommended for establishment of a Containment Area Aquaculture Project



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1. Easement for Disposal of Dredged Material

2. Lease to aquaculturist (subject to Corps Disposal Easement)

3. Operating agreement (or other coordination document)

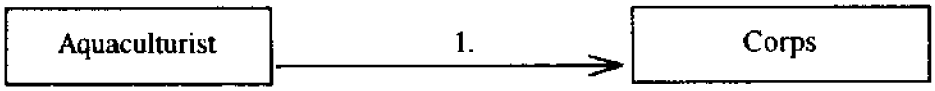
Where the **state** is the owner of the land, state law should be reviewed to see whether any laws exist governing the leasing of state-owned lands for aquaculture purposes. Where the **local sponsor** is the owner of the property, any leases or easements must fall within the entity's scope of authority in the deed, enabling legislation, or charter.

Note: Preliminary agreements may precede adoption of these final documents, reducing the parties' agreement to writing.

Figure 7.

When the Land Is Federally Owned and the Corps Is the Agency Administering It:

Documents recommended for establishment of a Containment Area Aquaculture Project

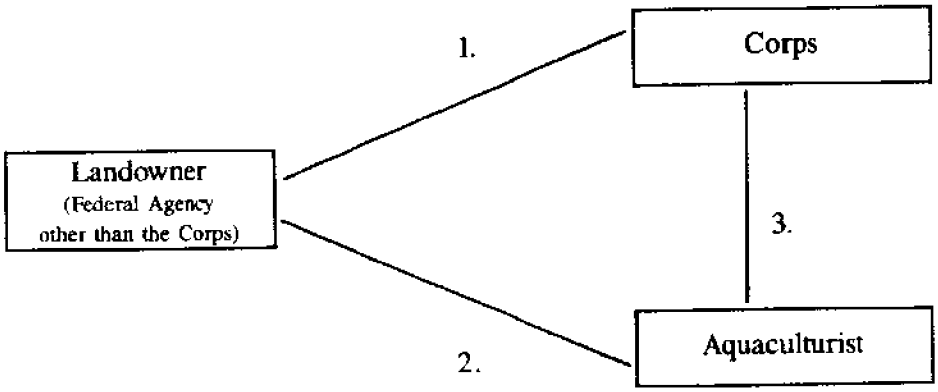


1. Lease (from Corps to aquaculturist) which may also contain provisions as to operations.

Figure 8.

Where Land Is Federally Owned and the Agency Administering It Is Not The Corps:

Documents recommended for establishment of a Containment Area Aquaculture Project



1. Easement or some combination of Interagency Agreement or permit allowing the Corps to use the property for the disposal of dredged material

2. Lease to aquaculturist (subject to Corps' disposal rights)

3. Operating Agreement (or other coordination document)

Note: Preliminary agreements may precede adoption of these final documents, reducing the parties' agreement to writing.

Appendix

1. SAMPLE SPOIL DISPOSAL EASEMENT: BALTIMORE DISTRICT

This easement deed made this _____ day of _____, 19 _____, between _____, Grantor, and _____ County, a political subdivision of the _____, Grantee.

Witnesseth:

WHEREAS, construction _____ of the _____;

WHEREAS, such authorization is subject to the condition that local interests furnish free of cost to the United States necessary rights-of-way and suitable spoil disposal easements for the _____, and hold and save the United States free from damages due to construction _____, except damages due to the fault or negligence of the Government or its contractors: and

WHEREAS, by agreement dated _____, _____ County agreed to furnish, free of cost to the United States, necessary rights-of-way and suitable spoil disposal areas _____;

WHEREAS, the Grantor is the owner in fee simple of a tract of land situated in the _____ Election District, _____ County, _____, BEING all that tract or parcel of land which by a Deed dated _____ and recorded among the land records of _____ County, _____, at Deed Book Vol. _____, Page _____, was conveyed by _____ to the said Grantor.

AND WHEREAS, the Grantee desires to acquire an interest in the said tract of land so the United States might use a portion of it for the purpose of depositing spoil from dredging operations and other uses incidental thereto which said portion of said above described parcel of land is delineated on Schedule "A" attached hereto and made a part hereof.

NOW THEREFORE, in consideration of the sum of One Dollar ($1.00), the receipt of which is hereby acknowledged, paid by _____ County, a political subdivision of the _____, and the benefit to the Grantor from the _____, the sufficiency of which is hereby expressly acknowledged, the Grantor does hereby give, grant, and convey unto said Grantee, its successors and assigns, a right and privilege, of a period beginning with the date of this instrument and terminating in years, to enter upon, occupy and use part of the land described above as delineated in Schedule "A" or any portion thereof for the purpose of depositing spoil and other dredged material excavated as a result of the _____.

RESERVING HOWEVER, to the Grantor all such rights and privileges as may be used without interferring with or abridging the rights and easement hereby conveyed to the Grantee; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Grantee shall have the right to clear and keep clear all trees, or undergrowth and other obstruction from the herein granted easement, and the Grantor agrees not to do any filling, upgrading, or other activity during stated period on the herein granted easement that will interefere with the normal operation and maintenance of said dredged material disposal area. It is agreed that the within named consideration is in full payment for any timber cut or to be cut in the deposit of dredged material and earth, or in the operation and/or maintenance of said dredged material disposal area.

TO HAVE AND TO HOLD FOR A PERIOD OF YEARS, unto said Grantee, its successors and assigns, the rights herein granted.

THE GRANTOR does hereby expressly and fully release the United States of America, its officers, agents, servants, and contractors, from liability for any and all damages done or caused to be done and from any claim or demand whatsoever or injuries suffered by or done to the said premises by reason of the deposit of such spoil or other material, excepting damages or injuries due to the fault or negligence of the Government or its contractors.

AND THE SAID Grantor will warrant and defend, for the period of the easement the right and title to the portion of the above described property which is delineated or further described in Schedule "A" unto the said Grantee against the claims of all persons whatsoever.

This easement is being acquired for use by the United States Army Corps of Engineers, Baltimore District, Baltimore, Maryland.

IN WITNESS WHEREOF, the Grantor has hereunto set hand and seal, the _____ day of

_____ _____, 19 _____.

_____ (SEAL)

_____ (SEAL)

COUNTY OF _____)

)ss:

STATE OF MARYLAND)

I hereby certify, that on this _____ day of _____ in the year _____ ___ before the subscribed _____ personally appeared _____ and acknowledged the foregoing deed to be his act.

(NOTARY)
(SEAL)

_____
NOTARY PUBLIC

2. LANGUAGE FROM SAMPLE

DREDGED MATERIAL DISPOSAL EASEMENT:

MOBILE DISTRICT

A perpetual and assignable right and easement to construct, operate and maintain a dredged material disposal area on (the land described in Schedule "A") (Tracts Nos. _____ , _____ and _____) including the right to construct and maintain dikes and buffer zone; to deposit dredged material and accomplish any alterations of contours on the land as necessary in connection with such work; to clear, borrow, excavate and remove soil, dirt, and other materials including dredged material from the land; title to and the continuing right to grow, plant, replant, cut, fell, harvest and remove all timber trees and other vegetation thereon; to remove and dispose of any and all buildings, and/or other obstructions therefrom; and for such other purposes as may be required in connection with said works within the limits of subject tract; provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; subject to all interest in and to oil, gas and other minerals in, on and under the herein described property outstanding in third parties, including leases, assignments and mortgages thereof; reserving, however, to the landowner, his heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purpose authorized by Congress or abridging the rights and easement hereby acquired.

3. SAMPLE DREDGED MATERIAL DISPOSAL EASEMENT:

NEW ORLEANS DISTRICT

FROM: _____ STATE OF LOUISIANA

TO: _____ PARRISH OF _____

The undersigned hereby grant(s) to the _____ _____ Parish Council, and its assigns, a temporary easement and right-of-way in, on, over and across the hereinafter described and, for a period not to exceed _____ _____, beginning with the date possession of the land is granted to the Lafourche _____ _____, for use by the _____ _____, and its assigns, as a dredged material disposal area, including the right to enter upon the land and deposit dredged material thereon, and the right to lay or place disposal pipelines, with full rights of ingress and egress on the land, and the right to perform any other work necessary and incident to the _____ Waterway, together with the right to trim, cut, fell, and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles with the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interefering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

The consideration for this easement is the increased value to adjacent lands of the undersigned, the added convenience in use of the improved waterway, and other good and valuable considerations.

The land in, on and to which this easement applies is described as follows:

(insert legal description of property)

The undersigned hereby waive(s) and release(s) the _____ _____ and its assigns from any and all claims for damages arising from the activity of the Council, its officers, contractors, agents, employees, representatives or assigns on said land in the reasonable exercise of this easement.

This easement includes the right of egress on adjacent lands of the owner(s) not described above, provided such ingress and egress is necessary and not otherwise conveniently available to the grantee and its assigns.

All tools, equipment, improvements or other properties placed upon the land by the council or its assigns during the exercise of this easement shall remain the property of the council or its assigns and may be removed by the council or its assigns at any time within a reasonable period after completion of the work or after the expiration of this easement.

WITNESS MY HAND AND SEAL this _____ day of _____ 19 _____ .

WITNESSES:

_____ _____

_____ _____

_____

NOTARY PUBLIC

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NOTES

Mississippi State University

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