United States Environmental Protection Agency

Technical Development Document for the Proposed Section 316(b) Phase III Rule

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Chapter 1: Summary of the Proposed Rule

1.0 APPLICABILITY OF THE PROPOSED RULE

The proposed 316(b) rule for Phase III would apply to two groups of facilities that use cooling water intake structures to withdraw water from waters of the U.S. First, it would apply to existing facilities not already regulated by EPA's "Phase II" regulation that withdraw above a certain flow threshold (see below). Based on the co-proposed flow thresholds, the proposed rule would, in effect, only apply to existing manufacturing and industrial facilities. *Phase III existing facilities* are defined in § 125.101 and § 125.102 of the proposed rule, and include existing manufacturing and industrial facilities (including but not limited to chemical, metal, pulp and paper, and petroleum refining facilities) that meet the criteria specified below. Under the proposed rule, these facilities would be subject to similar requirements to the final 316(b) rule for Phase II, with Phase III requirements specified in Part 125, Subpart K. Second, the proposed rule would apply to new offshore oil and gas extraction facilities, with requirements specified in Part 125, Subpart N.

Existing facilities must meet all of the following criteria to be considered a "Phase III existing facility" subject to the uniform national requirements of proposed rule:

- The facility is a point source that has or is required to have a NPDES permit under section 402 of the Clean Water Act;
- The facility is an existing facility other than a Phase II existing facility;
- The facility uses at least 25 percent of water withdrawn exclusively for cooling purposes, measured on an average annual basis; and
- The facility uses, or proposes to use, cooling water intake structures, including a cooling water intake structure operated by an independent supplier, with a total design intake flow equal to or greater than the proposed threshold in million gallons per day (MGD) to withdraw cooling water from waters of the United States.

The proposed rules describe three regulatory options based on design intake flow and source waterbody type that define which facilities would be Phase III existing facilities subject to uniform national requirements:

- The facility has a total design intake flow of 50 MGD or more, and withdraws from any source waterbody type;
- The facility has a total design intake flow of 200 MGD or more, and withdraws from any source waterbody type;
- The facility has a total design intake flow of 100 MGD or more, and withdraws water from an ocean, estuary, tidal river or stream, or Great Lake.

If a facility is a point source that uses a cooling water intake structure and has, or is required to have, an NPDES permit, but does not meet the appropriate threshold based on design intake flow/source waterbody typeor the 25% cooling purposes threshold, it would be subject to permit conditions implementing section 316(b) of the Clean Water Act set by the permit director on a case-by-case basis, using best professional judgment (BPJ). For example, under the 100 MGD coastal and Great Lakes option, facilities withdrawing from a freshwater river or stream would not be subject to national requirements, but rather to site-specific best professional judgment (BPJ)-based limits.

The proposed Phase III rule also would make new offshore oil and gas extraction facilities subject to requirements similar to those under the final Phase I new facility regulation (40 CFR 125 Subpart I). Requirements for new offshore oil and gas extraction facilities are proposed in a new Subpart N. For purposes of this proposed rule, new offshore oil and gas extraction facilities are those facilities that are subject to the Oil and Gas Extraction Point Source Category Effluent Guidelines (i.e., 435.10 Offshore Subcategory or 435.40 Coastal Subcategory), and meet the definition of "new offshore oil and gas extraction facility" in proposed Subpart N, § 125.133.

2.0 AFFECTED SUBCATEGORIES

The national requirements of the proposed rule may apply to existing facilities in the following sectors: chemical and allied products, primary metals, paper and allied products, petroleum and coal products, and other industries. In addition, facilities not covered by the national requirements would continue to be subject to permit requirements that implement section 316(b) requirements on case-by-case, BPJ basis. The following is a list of industries potentially affected by Phase III section 316(b) through either national requirements or BPJ-based limits. A detailed description of the industry sectors subject to the proposed rule is found in Chapter 2 of the TDD.

Industries Potentially Affected by Section 316(b) Phase III
Operators of steam electric generating point source dischargers that employ cooling water intake structures.
Agricultural production
Metal mining
Oil and gas extraction
Mining and quarrying of nonmetallic minerals
Food and kindred products
Tobacco products
Textile mill products
Lumber and wood products, except furniture
Paper and allied products
Chemical and allied products
Petroleum refining and related industries
Rubber and miscellaneous plastics products
Stone, clay, glass, and concrete products
Primary metal industries
Fabricated metal products, except machinery and transportation equipment
Industrial and commercial machinery and computer equipment
Transportation equipment
Measuring, analyzing, and controlling instruments; photographic, medical, and optical goods; watches and clocks
Electric, gas, and sanitary services
Educational services
Engineering, accounting, research, management and related services

3.0 OVERVIEW OF THE PROPOSED REQUIREMENTS

As in Phase I and II, section 316(b) requirements for Phase III existing facilities would be implemented through the NPDES permit program. The proposed 316(b) rule for phase III existing facilities would establish performance standards similar to those that exist in the Phase II rule for Phase II existing facilities. The performance standards would consist of ranges of reductions in impingement mortality and/or entrainment (e.g., reduce impingement mortality by 80 to 95 percent and/or entrainment by 60 to 90 percent). These performance standards reflect the best technology available for minimizing adverse environmental impacts determined on a national categorical basis. The type of performance standard applicable to a particular facility (i.e., reductions in impingement mortality only or impingement mortality and entrainment) would be based on several factors, including the facility's location (i.e., source waterbody), and the proportion of the waterbody withdrawn. The proposed rule would establish requirements for new offshore oil and gas extraction facilities that are similar to requirements established under the 316(b) Phase I rule for other new facilities. These requirements are described below.

3.1 Phase III Existing Facilities

As noted above, performance requirements would vary under the proposed rule depending upon the location (waterbody) of the facility and the proportion of the waterbody withdrawn for cooling. Exhibit 1-1 presents the proposed performance standard requirements for Phase III existing facilities.

Exhibit 1-1. Performance Standard Requirements

Waterbody Type	Design Intake Flow	Type of Performance Standard
Freshwater River or Stream	5% or less of mean annual flow	Impingement mortality only
	Greater than 5% of mean annual flow	Impingement mortality and entrainment
Tidal river, Estuary, Ocean, or Great Lakes	N/A	Impingement mortality and entrainment
Lakes or Reservoirs	Increase in design intake flow must not disrupt thermal stratification except where it does not adversely affect the management of fisheries.	Impingement mortality only

As in the Phase II final rule, the proposed Phase III rule identifies five alternatives a Phase III existing facility may use to achieve compliance with the requirements for best technology available for minimizing adverse environmental impacts associated with cooling water intake structures. Four of these alternatives are based on meeting the applicable performance standards and the fifth allows the facility to request a site-specific determination of best technology available for minimizing adverse environmental impacts under certain circumstances. Application requirements would vary based on the compliance alternative selected and, for some facilities, include development of a Comprehensive Demonstration Study (see, section VII, Implementation, of the preamble to the proposed Phase III rule).

Under the first proposed compliance alternative (at § 125.103(a)(1)(i) and (ii)), a Phase III existing facility may demonstrate to the Director that it has already reduced its flow commensurate with a closed-cycle recirculating system, or that it has already reduced its design intake velocity to 0.5 feet per second or less. If a facility can demonstrate to the Director that it has reduced, or will reduce, flow commensurate with a closed-cycle recirculating system, the facility is deemed to have met the performance standards to reduce impingement mortality and entrainment (see § 125.103(a)(1)(i)). Those facilities would not be required to submit a Comprehensive Demonstration Study with their NPDES application. If the facility can demonstrate to the Director that is has reduced, or will reduce maximum through-screen design intake velocity to 0.5 feet per second or less, the facility is deemed to have met the performance standards to reduce impingement mortality only. Facilities that meet the velocity requirements would only need to submit application studies related to determining entrainment reduction, if subject to the performance standards for entrainment.

Under § 125.103(a)(2) and (3), a Phase III existing facility may demonstrate to the Director either that its current cooling water intake structure configuration meets the applicable performance standards or that it has selected design and construction technologies, operational measures, and/or restoration measures that, in combination with any existing design and construction technologies, operational measures, and/or restoration measures, meet the specified performance standards in § 125.103(b) and/or the requirements in § 125.103(c).

Under § 125.103(a)(4), a Phase III existing facility may demonstrate to the Director that it has installed and is properly operating and maintaining a rule-specified and approved design and construction technology in accordance with § 125.108(a). Submerged cylindrical wedgewire screen technology is proposed as a rule-specified design and construction technology that may be used in instances in which a facility's cooling water intake structure is located in a freshwater river or stream and meets other criteria specified at § 125.108(a). In addition, under the fourth compliance alternative, a facility or other interested person may submit a request to the Director for approval of a different technology. If the Director approves the technology, the proposed rule states that it may be used by all facilities with similar site conditions under his or her jurisdiction if allowed under the State's administrative procedures. Under the proposed rule, a Director may only approve an alternative technology following public notice and opportunity for comment on the approval of the technology (§ 125.108(b)).

Under the fifth proposed compliance alternative (at § 125.103(a)(5) (i) or (ii)), if the Director determines that a facility's costs of compliance would be significantly greater than the costs considered by the Administrator for a like facility to meet the applicable performance standards, or that the costs of compliance would be significantly greater than the benefits of meeting the applicable performance standards at the facility, the Director must make a site-specific determination of best technology available for minimizing adverse environmental impact. Under this alternative, a facility would either compare its projected costs of compliance using a particular technology or technologies to the costs the Agency considered for a like facility in establishing the applicable performance standards, or compare its projected costs of compliance with the projected benefits at its site of meeting the applicable performance standards of this proposed rule. If in either case costs are significantly greater, the technology selected by the Director must achieve an efficacy level that comes as close as practicable to the applicable performance standards without resulting in significantly greater costs.

Additionally, the proposed rule states that during the first permit term, a facility that chooses compliance alternatives in § 125.103(a)(2), (3), (4), or (5) may request that compliance with the requirements of this rule be determined based on the implementation of a Technology Installation and Operation Plan indicating how the facility will install and ensure the efficacy, to the extent practicable, of design and construction technologies and/or operational measures, and/or a Restoration Plan (§ 125.103(d)). The Technology Installation and Operation Plan must be developed and submitted to the Director in accordance with § 125.104(b)(4)(ii). The Restoration Plan must be developed in accordance with § 125.104(b)(5). During subsequent permit terms, if the facility has been in compliance with the construction, operational, maintenance, monitoring, and adaptive management requirements in its Technology Installation and Operation Plan and/or Restoration Plan during the preceding permit term, the facility may request that compliance during subsequent permit terms be based on its remaining in compliance with its Technology Installation and Operation Plan and/or Restoration Plan, revised in accordance with applicable adaptive management requirements if the applicable performance standards are not being met.

Similar to the Phase II requirements, Phase III existing facilities would be required to submit three sets of data at least 180 days prior to expiration of a facility's existing permit by all facilities regardless of compliance alternative selected (see § 122.21(r)(2)(3) and (5)). These are:

- Source Water Physical Data: a narrative description and scaled drawings showing the physical configuration of all source waterbodies used by the facility, including areal dimensions, depths, salinity and temperature regimes, and other documentation that supports its determination of the waterbody type where each cooling water intake structure is located; identification and characterization of the source waterbody's hydrological and geomorphological features, as well as the methods used to conduct any physical studies to determine the intake's area of influence and the results of such studies; and locational maps.
- Cooling Water Intake Structure Data: a narrative description of the configuration of each of the facility's cooling water intake structures and where it is located in the waterbody and in the water column; latitude and longitude in degrees, minutes, and seconds for each of its cooling water intake structures; a narrative description of the operation of each of its cooling water intake structures, including design intake flows, daily hours of operation, number of days of the year in operation, and seasonal changes, if applicable; a flow distribution and water balance diagram that includes all sources of water to the facility, recirculating flows, and discharges; and engineering drawings of the cooling water intake structure.
- Cooling Water System Data: a narrative description of the operation of each cooling water system, its relationship to the cooling water intake structures, proportion of the design intake flow that is used in the system, the number of days of the year the system is in operation, and seasonal changes in the operation of the system, if applicable; and engineering calculations and supporting data to support the narrative description.

In addition to the specified data facilities would be required to submit, some facilities would also be required to conduct a Comprehensive Demonstration Study. Specific requirements for the Comprehensive Demonstration Study would vary based on the compliance alternative selected. Exhibit 1-2 summarizes the Comprehensive Demonstration Study requirements for each proposed compliance alternative. Specific details of each Comprehensive Demonstration Study component are provided in section VII of this preamble.

Exhibit 1-2. Summary of Comprehensive Demonstration Study Requirements for Compliance Alternatives

Compliance Alternative (§ 125.103(a))	Comprehensive Demonstration Study Requirements (§ 125.103(a))
1 - Demonstrate facility has reduced flow commensurate with closed-cycle recirculating system	None
1 - Demonstrate facility has reduced design intake velocity to ≤ 0.5 feet per second	No requirements relative to impingement mortality reduction. If subject to entrainment performance standard, the facility must only address entrainment in the applicable components of its Comprehensive Demonstration Study, based on the compliance option selected for entrainment reduction.
2 - Demonstrate that existing design and construction technologies, operational measures, and/or restoration measures meet the performance standards	Proposal for Information Collection Source Waterbody Flow Information Impingement Mortality and/or Entrainment Characterization Study (as appropriate) Technology and Compliance Assessment Information - Design and Construction Technology Plan - Technology Installation and Operation Plan Restoration Plan (if appropriate) Verification Monitoring Plan
3 - Demonstrate that facility has selected design and construction technologies, operational measures, and/or restoration measures that will, in combination with any existing design and construction technologies, operational measures, and/or restoration measures, meet the performance standards	Proposal for Information Collection Source Waterbody Flow Information Impingement Mortality and/or Entrainment Characterization Study (as appropriate) Technology and Compliance Assessment Information - Design and Construction Technology Plan - Technology Installation and Operation Plan Restoration Plan (if appropriate) Verification Monitoring Plan

Exhibit 1-2. Summary of Comprehensive Demonstration Study Requirements for Compliance Alternatives (continued)

Compliance Alternative (§ 125.103(a))	Comprehensive Demonstration Study Requirements (§ 125.103(a))
4 - Demonstrate that facility has installed and properly operates and maintains an approved technology	Technology Installation and Operation Plan Verification Monitoring Plan
Demonstrate that a site-specific determination of BTA is appropriate	Proposal for Information Collection Source Waterbody Flow Information Impingement Mortality and/or Entrainment Characterization Study (as appropriate) Technology Installation and Operation Plan Restoration Plan (if appropriate) Information to Support Site Specific Determination of BTA including: -Comprehensive Cost Evaluation Study (cost-cost test and cost-benefit test); -Valuation of Monetized Benefits of Reducing IM&E (cost-benefit test only); -Site-Specific Technology Plan (cost-cost test and cost-benefit test); Verification Monitoring Plan

3.2 New Offshore Oil and Gas Extraction Facilities

Under the proposed Subpart N, new offshore oil and gas extraction facilities that withdraw more than 2 MGD would have to comply with the requirements in § 122.21(r) and proposed § 125.134. These requirements address fixed and non-fixed (mobile) facilities with and without sea chests and are similar to requirements in the Phase I rule for new facilities. Under this proposal, new offshore oil and gas extraction facilities that are fixed facilities and withdraw more than 2 MGD and that do not employ sea chests as cooling water intake structures would have to comply with the requirements in § 125.134(b)(2) through (8). The same facilities with sea chests must comply with all of the same requirements except § 125.134(b)(5) for entrainment requirements. Proposed requirements at § 125.134(b) address intake flow velocity, proportional flow restrictions for facilities on tidal rivers or estuaries, specific impact concerns (e.g., threatened or endangered species, critical habitat, migratory or sport or commercial species), required information submission, monitoring, and recordkeeping.

Under the proposed Subpart N, new offshore oil and gas extraction facilities that are non-fixed facilities would be required to submit appropriate Track 1 application requirements under § 122.21(r) and § 125.136(b). This includes source water physical data, cooling water intake structure data, velocity information, source waterbody flow information, and a design and construction technology plan.

Facilities would also have the opportunity to request alternative requirements under proposed § 125.135 and provide data to determine if compliance with the proposed requirements would result in compliance costs wholly out of proportion to those EPA considered in establishing the requirement, or would result in significant adverse impacts on local air quality, local water resources other than impingement or entrainment, or local energy markets.

Source Water Physical Data (§ 122.21(r)(2))

The requirements are the same as those described above for Phase III existing facilities. Track I fixed facilities would submit all of the data except for proposed § 122.21(r)(2)(iv), only required by non-fixed facilities: a narrative description and/or locational maps providing information on predicted locations within the waterbody during the permit term in sufficient detail for the Director to determine the appropriateness of additional impingement requirements under § 125.134(b)(4). Non-fixed facilities would only be required to submit § 122.21(r)(2)(iv) of the § 122.21(r)(2) requirements.

Cooling Water Intake Structure Data (§ 122.21(r)(3))

The requirements are the same as those described above for Phase III existing facilities for fixed facilities; non-fixed facilities would only submit *(*§ 122.21(r)(3)(i) and (ii), narrative description of the configuration of each cooling water intake structure, and the latitude and longitude for each cooling water intake structure.

Source Water Baseline Biological Characterization Data (§ 122.21(r)(4))

Under the proposed Subpart N, new offshore oil and gas extraction fixed facilities would be required to submit source water baseline biological characterization data as required for other new facilities under Phase I. The data would be used to characterize the biological community in the vicinity of the cooling water intake structure and to characterize the operation of the cooling water intake structure. The data would include existing data (if available) supplemented with new field studies as necessary. Detailed data requirements are at § 122.21(r)(4). Under the proposed rule, facilities may choose to conduct regional studies to collect this information as approved by the Director. EPA recognizes that many offshore oil and gas extraction facilities are regulated under NPDES general permits and that regional studies are typically conducted as part of the general permit requirements. Under this proposed rule, the regional study would include annual monitoring requirements.

Velocity Information

The proposed rule would require that new offshore oil and gas extraction facilities submit velocity information consistent with Subpart N requirements found at § 125.136(b)(1). The information would be used to demonstrate to the Director that the facility is complying with the requirement to meet a maximum through-screen design intake velocity of no more than 0.5 feet per second at the cooling water intake structure. The following information would be required to be submitted: 1) a narrative description of the design, structure, equipment, and operation used to meet the velocity requirement; and 2) design calculations showing that the velocity requirement would be met at minimum ambient source water surface elevations (based on best professional judgment using available hydrological data) and maximum head loss across the screens or other device.

Source Waterbody Flow Information

The proposed rule would also require that new offshore oil and gas extraction facilities submit source waterbody flow information consistent with Phase I requirements at § 125.136(b)(2). The information would be used to demonstrate to the Director that the facility's cooling water intake structure meets the proportional flow requirements at § 125.134(b)(3). These requirements include specific provisions for facilities located on estuaries or tidal rivers to provide greater protection for these sensitive waters. Specifically, the proposed rule requires that the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level. Calculations and guidance on determining the tidal excursion is found in the preamble to the final Phase I rule at section VII.B.1.d

Design and Construction Technology Plan

The proposed rule also would require that new offshore oil and gas extraction facilities submit a design and construction technology plan at § 125.136(b)(3). The design and construction technology plan would demonstrate that the facility has selected and will implement the design and construction technologies necessary to minimize impingement mortality and/or entrainment. The design and construction technology plan would require delineation of the hydrologic zone of influence for the cooling water intake structure; a description of the technologies implemented (or to be implemented) at the facility; the basis for the selection of that technology; the expected performance of the technology, and design calculations, drawings and estimates to support the technology description and performance. The Agency recognizes that the selection of a specific technology or a group of technologies will depend on the individual facility and waterbody conditions.

Chapter 2: Description of the Industry

Today's proposed rule would apply national requirements to two general groups of facilities that use cooling water intake structures to withdraw water from waters of the U.S. First, it would apply to existing facilities not already regulated by EPA's "Phase II" regulation that withdraw above a certain flow threshold. Based on the co-proposed thresholds, the proposed rule would in effect only apply to existing manufacturing and industrial facilities. Based on the co-proposed thresholds, the national requirements would not apply to existing electric generators not covered under Phase II, existing offshore oil and gas extraction facilities, and existing seafood processing vessels. Second, the proposed rule would apply to new offshore oil and gas extraction facilities. Although EPA considered proposing requirements for new seafood processing vessels and offshore liquified natural gas terminals, EPA has opted not to do so, for reasons described in the proposed preamble and these development documents. This section presents information characterizing all of the categories of facilities that EPA considered in developing this proposed rule, even if EPA did not ultimately propose national requirements for such facilities under the proposed rule. EPA has generally categorized all of these industries into two groups: land-based facilities and offshore facilities.

I. LAND-BASED INDUSTRIES

This category includes existing electric generators not covered under the Phase II rule (those with a design intake flow (DIF) less than 50 million gallons per day (MGD)) and all existing manufacturers. This section will describe these facilities, their source waterbodies, their intakes, and their intake technologies. Much of the data in this section is derived from the industry questionnaire data.

1.0 DESCRIPTION OF THE INDUSTRIES

In 1997, EPA estimated that over 400,000 facilities could potentially be subject to a cooling water intake regulation. Given the large number of facilities potentially subject to regulation, EPA decided to focus its data collection efforts on six industrial categories that, as a whole, are estimated to account for over 99 percent of all cooling water withdrawals. These six sectors are: Utility Steam Electric, Nonutility Steam Electric, Chemicals & Allied Products, Primary Metals Industries, Petroleum & Coal Products, and Paper & Allied Products.

EPA's data collection efforts (via the 1998 industry questionnaire) focused on the electric generators (both utility and nonutility steam electric) and the four manufacturing industry groups that were identified as significant users of cooling water. EPA maintains, however, that a manufacturing facility that is not classified within one of those four groups may also be subject to requirements under today's proposed rule if it meet the requisite criteria. These industries are shown below, as described by the Standard Industrial Classification (SIC) system.

Electric Services

This industry sector is classified under SIC Major Group 49. This major group includes establishments engaged in the generation, transmission, and/or distribution of electricity or gas or steam.

Chemical and Allied Products

This industry sector is classified under SIC Major Group 28. This major group includes establishments producing basic chemicals and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals, such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture, such as synthetic fibers, plastics materials, dry colors, and pigments; and (3) finished chemical products to be used for ultimate consumption, such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries, such as paints, fertilizers, and explosives.

Primary Metals Industries

This industry sector is classified under SIC Major Group 33. This major group includes establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap; in rolling, drawing, and alloying metals; in manufacturing castings and other basic metal products; and in manufacturing nails, spikes, and insulated wire and cable.

Paper and Allied Products

This industry sector is classified under SIC Major Group 26. This major group includes establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, the manufacture of paper and paperboard, and the manufacture of paper and paperboard into converted products.

Petroleum and Coal Products

This industry sector is classified under SIC Major Group 29. This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

Other Industries

EPA sent industry questionnaires to individual facilities from a number of other industries outside of the four listed above and incorporated that data into the analysis for Phase III. In 2004, EPA also collected information on land-based liquefied natural gas (LNG) facilities.

1.1 Estimated Numbers of Land-based Facilities in Scope of 316(b)

EPA estimates that approximately 683 land-based facilities in the six industrial categories would be subject to regulation under 316(b). These facilities combine to account for a design intake flow of over 40 billion gallons per day of cooling water from approximately 908 cooling water intake structures. See Exhibit 2-1 below. For comparison, the numbers of in-scope facilities for Phase I and Phase II are also included.

Exhibit 2-1. Cooling Water Use in Surveyed Industries

	Estimated Number of Facilities	Estimated Design Intake Flow (MGD)
Phase I (new electric generators and manufacturers)	121 (over 20 years)	N/A
Phase II (existing electric generators >50 MGD)	554	367,752
Facility Potentially Regulated Under Phase III (existing electric generators <50 MGD and all existing manufacturers)	683	40,441
Existing electric generators <50 MGD	118	2,374
Existing manufacturers <50 MGD	410	7,931
Existing manufacturers >50 MGD	155	30,136

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include facilities identified as baseline closures.

1.2 Source Waterbodies

Facilities potentially regulated under Phase III can be found on all waterbody types, but are predominantly located on freshwater rivers and streams. Exhibit 2-2 below illustrates the distribution of facilities by waterbody type.

Exhibit 2-2. Distribution of Source Waterbodies for Phase III Facilities

Source of Surface Water	Estimated Number of Facilities	Percent of Facilities
Freshwater River or Stream	496	72.6
Lake or Reservoir	60	8.8
Great Lakes	77	11.3
Estuary or Tidal River	39	5.7
Ocean	11	1.6
Total	683	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

1.3 Design Intake Flows

Exhibit 2-3 below illustrates the range of design intake flows in facilities considered for regulation under the proposed Phase III rule. Of these facilities, only existing manufacturing facilities would be subject to the national requirements, as the lowest co-proposed flow threshold is 50 MGD. Therefore, power producers and manufacturers under 50 MGD would not be subject to the national requirements under Phase III. Power producers with a design intake flow of 50 million gallons per day (MGD) or greater are covered under Phase II.

Exhibit 2-3. Design Intake Flows at Facilities Potentially Regulated Under Phase III

Design Intake Flow (MGD)	Estimated Number of Facilities	Percent of Number of Facilities	Cumulative Percent	Percent of Total Design Intake Flow
0 - 2	0	0	0	0
2 - 5	83	12.2	12.2	0.6
5 - 10	84	12.3	24.5	1.5
10 - 15	74	10.8	35.3	2.3
15 - 25	104	15.2	50.5	5.1
25 - 50	183	26.8	77.3	16
50 - 100	82	12	89.3	14.2
> 100	73	10.7	100	60.3
Total	683	100		100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

Exhibit 2-4 below illustrates the range of design intake flows by industry type.

Exhibit 2-4. Design Intake Flow by Industry Type

Industry Type	Estimated Number of Facilities	Total Design Intake Flow (MGD)	Percent of Total Design Intake Flow	Average Design Intake Flow (MGD)*
Utilities	85	1,927	5	23
Nonutilities	36	482	1	16
Chemical and Allied Products	181	12,340	31	247
Primary Metals	89	8,870	22	240
Paper and Allied Products	225	11,904	30	127
Petroleum and Coal Products	39	3,259	8	112
Food Products	13	670	1	52
Textiles	<5	6	1	6
Other Manufacturing	14	983	2	98
Total	683	40,441	100	921

* Average based on surveyed facilities. May not be reflective of actual industry-wide average design intake flows.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 2-5 combines data from Exhibit 2-3 and 2-4 and provides summary-level data for all industry types.

Exhibit 2-5. Industry Overview

Design Intake Flow (MGD)	Estimated Number of Facilities	Total Design Intake Flow (MGD)	Percent of Total Design Intake Flow
2 - 20	290	2,612	6.5
20 - 50	238	7,693	19
> 50	155	30,136	74.5
Total	683	40,441	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include facilities identified as baseline closures.

1.4 Cooling Water System Configurations

Facilities potentially regulated under Phase III employ a variety of cooling water system (CWS) types. Exhibit 2-6 shows the distribution of cooling water system configurations.

Exhibit 2-6. Distribution of Cooling Water System Configurations

CWS Configuration	Estimated Number of CWS*	Percent of Total CWS	Estimated Number of CWS for Electric Generators	Percent of Total Electric Generator CWS	Estimated Number of CWS for Manufacturers	Percent of Total Manufacturer CWS
Once-through	436	49	32	25	404	53
Recirculating	285	32	93	72	192	25
Combination	92	10	3	2	89	12
Other	76	9	1	1	75	10
Total	889	100	129	100	760	100

* Some facilities have more than one cooling water system.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 2-7 illustrates the intake structure arrangements for facilities potentially regulated under Phase III.

Exhibit 2-7. Distribution of Cooling Water Intake Structure Arrangements

Intake Arrangement	Estimated Number of Arrangements	Percent of Arrangements
Canal or Channel Intake	123	16
Bay or Cove Intake	49	7
Submerged Shoreline Intake	208	28
Surface Shoreline Intake	151	20
Submerged Offshore Intake	216	29

Note: The total number of facilities exceeds 683, since some facilities employ multiple intake arrangements.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include facilities identified as baseline closures.

1.5 Design Through-Screen Velocities

Exhibit 2-8 below illustrates the wide range of design intake velocities at facilities potentially regulated under Phase III.

Exhibit 2-8. Distribution of Cooling Water Intake Structure (CWIS) Design Through-Screen Velocities

Velocity (feet per second)	Estimated Number of CWIS	Percent of CWIS	Cumulative Percent
0 - 0.5	156	31	31
0.5 - 1	112	22	53
1 - 2	112	22	75
2 - 3	71	14	89
3 - 5	26	5	94

Exhibit 2-8. Distribution of Cooling Water Intake Structure (CWIS) Design Through-Screen Velocities (continued)

Velocity (feet per second)	Estimated Number of CWIS	Percent of CWIS	Cumulative Percent
5 - 7	11	2	96
> 7	19	4	100
Total	507	100	

Note: The average design through-screen velocity for all surveyed cooling water intake structures (unweighted) is 1.67 feet per second. The median design through-screen velocity for all surveyed facilities is 0.92 feet per second.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

1.6 Existing Intake Technologies

Many facilities potentially regulated under Phase III have intake technologies already in place. Exhibit 2-9 illustrates the number of existing intake technologies. EPA notes that not all intake technologies may be sufficient to meet the performance standards or the requirements of the rule. While not using an intake technology per se, facilities with cooling towers have also been included in this table to demonstrate the usage of flow reduction as a method to reduce impingement mortality and entrainment.

Exhibit 2-9. Distribution of Intake Technologies

Intake Technology Type	Estimated Number of Technologies	Percent of Technologies
Bar Rack/Trash Rack	427	28
Screening Technologies	500	33
Passive Intake Technologies	233	15
Fish Diversion or Avoidance System	35	2
Fish Handling or Return System	33	2
No Intake Technologies	13	1
Cooling Tower	286	19

Note: The total number of technologies exceeds 683, since some facilities employ multiple intake technologies.
Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

1.7 Operating Days per Year

As a corollary to the capacity utilization rate (CUR) for electric generators, EPA attempted to analyze the number of operating days for manufacturing facilities. EPA notes, however, that it has not determined an appropriate minimum threshold, nor has it decided to propose such a threshold. Exhibit 2-10 is for informational purposes only. For more information, see the preamble to the proposed rule.

Exhibit 2-10. Distribution of Manufacturing Facilities by Number of Operating Days

Number of Operating Days	Percent of Facilities
< 60 days	4.26
60 - 180 days	3.55
> 180 days	92.18
Total	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: An electric generator operating at 15% CUR is roughly equivalent to 55 operating days per year. These data reflect the average number of facility operating hours over a three year period (1996-1998).
Note: All values are weighted and include those facilities identified as baseline closures.

1.8 Land-based Liquefied Natural Gas Facilities

EPA's research also indicates that there are five existing land-based liquefied natural gas facilities in the United States, all on the East coast. Most of these facilities do not withdraw surface water for cooling purposes and would therefore be out of scope of the regulations.

2.0 PRELIMINARY ASSESSMENT OF COMPLIANCE

EPA considered all of the above data in determining the scope, applicability, and flow thresholds in today's proposed rule. Exhibit 2-11 below illustrates a synthesis of some of the pertinent data.

Exhibit 2-11. Technologies Already In Place at Facilities Potentially Regulated Under Phase III.

Design Intake Flow (MGD) Threshold	**Electric Generators**		**Manufacturers**	
	% of Facilities With Technology Satisfying Phase II Requirements	% of Facilities With Closed-Cycle, Recirculating Cooling Systems	% of Facilities With Technology Satisfying Phase II Requirements	% of Facilities With Closed-Cycle, Recirculating Cooling Systems
> 50	n/a	n/a	29	4
20 - 50	69	60	54	22
2 - 20	93	82	58	29
Total	82	72	48	20

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI)
Note: All values are weighted and include those facilities identified as baseline closures.

OFFSHORE INDUSTRIES

EPA considered establishing national requirements for three additional industry groups that have been identified as potential large users of cooling water: offshore oil and gas exploration facilities , seafood processing vessels, and offshore liquefied natural gas (LNG) terminals. An industry survey was developed in 2003 to collect data on offshore oil and gas extraction facilities and seafood processing vessels and EPA independently collected information on offshore liquefied natural gas facilities in 2004.

Under the proposed rule, only new offshore oil and gas extraction facilities would be subject to national requirements.

1.0 DESCRIPTION OF THE INDUSTRIES

After EPA proposed the Phase I rule for new facilities (65 FR 49060), the Agency received adverse comment from operators of mobile offshore and coastal drilling units concerning the limited information about their cooling water intakes, associated impingement and entrainment, costs of technologies, or achievability of the controls proposed by EPA. In the Phase I final rule, EPA committed to "propose and take final action on regulations for new offshore oil and gas extraction facilities, as defined at 40 CFR 435.10 and 40 CFR 435.40, in the Phase III section 316(b) rule." EPA subsequently identified seafood processing vessels and offshore liquefied natural gas facilities as other potential large users of cooling water that may be subject to regulation under 316(b). Each of these industries are shown below, as described by the Standard Industrial Classification (SIC) system.

Offshore Oil and Gas Extraction
This industry sector is classified under SIC Major Group 13. This major group includes establishments primarily engaged in: (1) producing crude petroleum and natural gas; (2) extracting oil from oil sands and oil shale; (3) producing natural gasoline and cycle condensate; and (4) producing gas and hydrocarbon liquids from coal at the mine site.

Seafood Processing
This industry sector is classified under SIC Major Group 09. This major group includes establishments primarily engaged in commercial fishing (including crabbing, lobstering, clamming, oystering, and the gathering of sponges and seaweed), and the operation of fish hatcheries and fish and game preserves, in commercial hunting and trapping, and in game propagation.

Offshore Liquefied Natural Gas
This industry sector is classified under SIC Major Group 49. This major group includes establishments engaged in the generation, transmission, and/or distribution of electricity or gas or steam.

1.1 Estimated Numbers of Offshore Facilities Potentially Subject to Regulation

1.1.1 Existing Offshore Facilities

EPA estimated the number of existing facilities potentially regulated under Phase III in each of the three offshore industries.

Offshore Oil and Gas Extraction

Using information from industry sources and other Federal agencies, EPA determined that there were approximately 2929 offshore oil and gas extraction facilities potentially within the scope of the regulations. Of these, 2478 facilities are fixed facilities (i.e., fixed platforms) and were primarily located in the Gulf of Mexico, with some facilities also located in Alaska and along the Pacific coast. The remaining 451 facilities are mobile facilities (i.e., mobile offshore drilling units (MODU)), which can operate in or out of United States waters. Like the fixed platforms, the majority of MODUs operate in the Gulf of Mexico. All fixed platforms and MODUs were considered to be in scope of the regulation, as nearly all operate in Federal waters and are likely to meet the applicability requirements for 316(b).

Seafood Processing

Through existing databases and mailing lists, EPA determined that there were approximately 123 seafood processing vessels potentially within the scope of the regulations. Each of these vessels has been issued an NPDES permit and it was initially assumed that all vessels would meet the minimum flow threshold (greater than 2 MGD) and that at least 25% of the water withdrawn was for cooling purposes. EPA's research indicated that vessels shorter than 100 feet in length were unlikely to withdraw more than 2 MGD and these vessels were removed from the universe of facilities under consideration.

Offshore Liquefied Natural Gas

EPA's research indicates that there are currently no offshore liquefied natural gas facilities in the United States.

1.1.2 New Offshore Facilities

Offshore Oil and Gas Extraction

EPA projects approximately 20 new offshore oil and gas extraction facilities in the next 3 years.

Seafood Processing

Because seafood processing vessels were determined to be outside the scope of the proposed rule, EPA did not estimate the number of projected new seafood processing vessels.

Offshore Liquefied Natural Gas

EPA determined that there are approximately eight offshore liquefied natural gas facilities that are currently under proposal. More are likely to be proposed in the future, as this energy sector is growing rapidly.

1.2 Offshore Facility Characteristics

EPA collected somewhat less information on the offshore industries and therefore will not present detailed tables as in the section above for land-based facilities. This section will, however, provide a summary of the offshore facility characteristics.

Offshore Oil and Gas Exploration Facilities

New offshore oil and gas extraction facilities include both fixed facilities (such as platforms) and mobile facilities (such as MODUs and barges). See chapter 3 for additional details on these facilities.

Seafood Processing Vessel
In developing technology cost modules, EPA assumed that a typical seafood processing vessel was 280 feet in length and primarily used sea chests as the cooling water intake structure. Data available to EPA did not identify intake technologies designed to reduce impingement mortality or entrainment, as most vessels have a simple screen or grate to screen trash and other debris.

Data from respondents to the EPA Technical Survey for Seafood Processing Vessels indicate that the combined design intake flow from all the cooling water intakes in a vessel range from 3 MGD to 45 MGD. The total number of intakes per vessel withdrawing water for cooling purposes ranged from two to ten. These vessels had either a seachest or simple pipe intake for withdrawing cooling water.

Offshore Liquefied Natural Gas Facility

As stated above, most offshore liquefied natural gas facilities do not use surface water for cooling purposes. Some future facilities have indicated that they may use surface water, but are presently planning to use submerged cylindrical wedgewire screens as an intake technology.

2.0 PRELIMINARY ASSESSMENT OF COMPLIANCE

Based upon the information summarized above, the proposed rule would not establish natural requirements for existing offshore oil and gas extraction facilities, new or existing seafood processing vessels, and new or existing offshore liquefied natural gas facilities. For additional detail, see the preamble to today's proposed rule.

Chapter 3: Technology Cost Modules

I. TECHNOLOGY COST MODULES FOR MANUFACTURERS

INTRODUCTION
This chapter presents the technology cost modules used by the Agency to develop compliance costs at model facilities for the proposed rule. Chapter 5 of this document describes the Agency's methodology for assigning particular cost modules to model facilities.

The technology cost modules used in Phase III are the same as those used to determine the compliance costs for Phase II facilities. EPA considers the types of intakes and the technologies available to address impingement and entrainment at Phase II facilities to be consistent with the intakes and technologies at Phase III facilities. Similarly, EPA considers the intakes and technologies found at electric generators and manufacturers to be consistent with one another, again permitting EPA to apply the technology cost modules from Phase II to Phase III facilities.

Note that the cost modules presented in this chapter reference costs developed for year 2002 dollars, which were used to develop Phase II facility costs. However, all costs for Phase III facilities presented in the preamble of today's proposed rule reflect costs that were adjusted to year 2003 dollars.

1.0 SUBMERGED PASSIVE INTAKES

The modules described in this section involve submerged passive intakes, and address both adding technologies to the inlet of existing submerged intakes and converting shoreline based intakes (e.g., shoreline intakes with traveling screens) to submerged offshore intakes with added passive inlet technologies. The passive inlet technologies that are considered include passive screens and velocity caps. All intakes relocated from shore-based to submerged offshore are assumed to employ either a velocity cap or passive screens. Costs for velocity caps are presented separately in section 3.0.

1.1 Relocated Shore-based Intake to Submerged Near-Shore and Offshore with Fine Mesh Passive Screens at Inlet

This section contains three subsections. The first two sections respectively present documentation for passive screen technology selection and estimation parameters; and for development of capital costs for submerged passive intakes. This discussion includes: passive screen technology selection, selection of flow values, intake configurations, connecting walls, and connecting pipes. The second section discusses cost development for: screen construction materials, connecting walls, pipe manifolds, airburst systems, indirect costs, nuclear facilities, O&M costs, construction-related downtime. The third section presents a discussion of the applicability of this cost module.

1.1.1 Selection/Derivation of Cost Input Values

<u>Passive Screen Technology Selection</u>

Passive screens come in one of three general configurations: flat panel, cylindrical, and cylindrical T-type. Only passive screens constructed of welded wedgewire were considered due to the improved performance of wedgewire with respect to debris and fish protection. After discussion with vendors concerning the attributes and prevalence of the various passive screen technology configurations, EPA selected the T-screen configuration as the most versatile with respect to a variety of local intake and waterbody attributes. The most important screen attribute was the requirement for screen placement. Both cylindrical and T-screens allow for placement of the screens extending into the waterbody, which allows for debris to migrate away from the screens once dislodged. T-screens produce greater flow per screen unit and thus were chosen because they are more practical in multi-screen installations.

Due to the potential for build-up and plugging by debris, passive screens are usually installed with an airburst backwash system. This system includes a compressor, an accumulator (also known as, receiver), controls, a distributor and air piping that directs a burst of air into each screen. The air burst produces a rapid backflow through the screen; this air-induced turbulence dislodges accumulated debris, which then drifts away from the screen unit. Vendors claimed (although with minimal data) that only very stagnant water with a high debris load or very shallow water (<2 ft deep) would prevent use of this screen technology. Areas with low water velocities would simply require more frequent airburst backwashes, and few facilities are constrained by water depths as shallow as 2 feet.

While there are waterbodies with levels of debris low enough to preclude installation of an airburst system, EPA has chosen to include an airburst backwash system with each T-screen installation as a prudent precaution. The capital cost of the airburst backwash system is a substantial component, particularly in offshore applications, because of the need to install a separate air supply pipe from the shoreline air supply to each screen or group of smaller screens. Thus, the assumption that airburst backwash systems are needed in all applications is considered as part of an overall cost approach that increases projected capital costs to the industry to develop a high-side cost estimate.

T-screens ranging in diameter from 2 feet (T24) to 8 feet (T96), in one-foot intervals, are used in the analysis. Costs provided are for two types of screens one with a slot size of approximately 1.75 mm referred to as "fine mesh" and one with a slot size of 0.76 mm referred to as "very fine mesh." The design flow values used for each size screen correspond to wedgewire T-screens with a through screen velocity of 0.5 feet per second. Exhibits 3-1 and 3-2 presents design specifications for the fine mesh and very fine mesh wedgewire T-screens costed.

Exhibit 3-1. Fine Mesh Passive T-Screen Design Specifications

Fine Mesh Passive T-Screen Design Specifications

Screen Size	Capacity	Slot Size	Screen Length	Airburst Pipie Diameter	Screen Outlet Diameter	Screen Weight
	gpm	mm	Ft	Inches	Inches	Lbs
T24	2,500	1.75	6.3	2	18	375
T36	5,700	1.75	9.3	3	30	1,050
T48	10,000	1.75	13.3	4	36	1,600
T60	15,800	1.75	16.6	6	42	2,500
T72	22,700	1.75	19.8	8	48	4,300
T84	31,000	1.75	22.9	10	60	6,000
T96	40,750	1.75	26.4	12	72	NA

*Source: Johnson Screen - Brochure 2002 - High Capacity Screen at 50% Open Area

Exhibit 3-2. Very Fine Mesh Passive T-Screen Design Specifications

Very Fine Mesh Passive T-Screen Design Specifications

Screen Size	Capacity	Slot Size	Screen Length	Airburst Pipie Diameter	Screen Outlet Diameter	Screen Weight
	gpm	mm	Ft	Inches	Inches	Lbs
T24	1,680	0.76	6.3	2	18	375
T36	3,850	0.76	9.3	3	30	1,050
T48	6,750	0.76	13.3	4	36	1,600
T60	10,700	0.76	16.6	6	42	2,500
T72	15,300	0.76	19.8	8	48	4,300
T84	20,900	0.76	22.9	10	60	6,000
T96	27,500	0.76	26.4	12	72	NA

*Source: Johnson Screen - Brochure 2002 - High Capacity Screen at 33% Open Are

Selection of Flow Values

The flow values used in the development of cost equations range from a design flow of 2,500 gpm (which is the design flow for the smallest screen (T24) for which costs were obtained) to a flow of 163,000 gpm (which is equivalent to the design flow of four T96 screens) for fine mesh screens and 1,680 gpm to 165,000 (which is equivalent to the design flow of six T96 screens) for very fine mesh screens. The higher flow values were chosen because they were nearly equal to the flow in a 10-foot diameter pipe at a pipe velocity of just 4.6 feet per second. A 10-foot diameter pipe was chosen as the largest size for individual pipes because this size was within the range of sizes that are capable of being installed using the technology assumed in the cost model. Additionally, the need to spread out the multiple screens across the bottom is facilitated by multiple pipes. One result of this decision is that for facilities with design flows significantly greater than 165,000 gpm, the total costs are based on dividing the intake into multiple units and summing the costs of each.

Intake Configuration

The scenarios evaluated in this analysis are based on retrofit construction in which the new passive screens are connected to the existing intake by newly installed pipes, while the existing intake pumps and pump wells remain intact and functional. The cost scenario also retains the existing screen wells and bays, since in most cases they are connected directly to the pump wells. Facilities may retain the existing traveling screens as a backup, but the retention of functioning traveling screens is not necessary. No operating costs are considered for the existing screens since they are not needed. Even if they are retained, there should be almost no debris to collect on their surfaces. Thus, they would only need to be operated on an infrequent basis to ensure they remain functional.

The new passive screens are placed along the bottom of the waterway in front of the existing intake and connected to the existing intake with pipes that are laid either directly on or buried below the stream bed. The key components of the retrofit are: the transition connection to the existing intake, the connecting pipe or pipes (a.k.a. manifold or header), the passive screens or velocity cap located at the pipe inlet, and if passive screens are used, the backwash system.

At most of the T-screen retrofit installations, particularly those requiring more than one screen, the installation of passive T-screens will likely require relocating the intake to a near-shore location or to a submerged location farther offshore, depending on the screen spacing, water depth, and other requirements. An exception would be smaller flow intakes where the screen could be connected directly to the front of the intake with a minimal pipe length (e.g., half screen diameter). Other considerations that may make locating farther offshore necessary or desirable include: the availability of cooler water, lower levels of debris, and fewer aquatic organisms for placements outside the littoral zone. As such, costs have been developed for a series of distances from the shoreline.

In retrofits where flow requirements do not increase, EPA has found existing pumps and pump wells can be, and have been, retained as part of the new system. The cost scenarios assume flow volumes do not increase. Thus, using existing pumps and pump wells is both feasible and economically prudent. There are, however, two concerns regarding the use of existing pumps and pump wells. One is the degree of additional head loss associated with the new pipes and screens. The second is the intake downtime needed to complete the installation and connection of the new passive screen system or velocity cap. The downtime considerations are discussed later in a separate section.

The additional head losses associated with the passive screen retrofit scenario described here include the frictional losses in the connecting pipes and the losses through the screen surface. If the new connecting pipe velocities are kept low (e.g., 5 feet per second is used in this analysis), then the head loss in the extension pipe should remain low enough to allow the existing pumps to function properly in most instances. For example, a 48-inch diameter pipe at a flow of 28,000 gpm (average velocity of 4.96 feet per second) will have a head loss of 2.31 feet of water per 1,000-foot pipe length (Shaw and Loomis 1970). The new passive screens will contribute an additional 0.5 to 0.75 feet of water to this head loss, which will further increase when the screen is clogged by debris (Screen Services 2002). In fact, the rate at which this screen head loss increases due to debris build-up will dictate the frequency of use of the air backwash. Pump wells are generally equipped with alarms that warn of low water levels due to increased head loss through the intake. If the screen becomes plugged to the point where backwash fails to maintain the necessary water level in the pump well, the pump flow rate must be reduced. This reduction may result in a derating or shut down of the associated generating unit. Lower than normal surface water levels may exacerbate this problem.

In terms of required dimensions for installation, Exhibits 3-1 and 3-2 show screen length is just over three times the diameter and each screen requires a minimum clearance of one-half diameter on all sides except the ends. Thus, an 8-foot diameter screen will require a minimum water depth of 16 feet at the screen location (four feet above, four feet below, and eight feet for the screen itself). It is recommended that T-screens be oriented such that the long axis is parallel to the waterbody flow direction. T-screens can be arranged in an end-to-end configuration if necessary. However, using a greater separation above the minimum will facilitate dispersion of the released accumulated debris during screen backwashes.

In the retrofit scenario described here, screen size and number are based on using a single screen with the screen size increasing with increasing design flows. When flow exceeds the capacity of a single T96 screen, multiple T96 screens are used. This retrofit scenario also assumes the selected screen location has a minimum water depth equal to or greater than the values shown in Exhibit 3-3.

Exhibit 3-3. Minimum Depth at Screen Location For Single Screen Scenario

Fine Mesh Flow	Very Fine Mesh Flow	Screen Size	Minimum Depth
2,500 gpm	1,680 gpm	T24	4 ft
5,700 gpm	3,850 gpm	T36	6 ft
10,000 gpm	6,750 gpm	T48	8 ft
15,800 gpm	10,700 gpm	T60	10 ft
22,700 gpm	15,300 gpm	T72	12 ft
31,000 gpm	20,900 gpm	T84	14 ft
40,750 gpm	27,500 gpm	T96	16 ft
>40,750 gpm	>27,500 gpm	Multiple T96	16 ft

In certain instances water depth or other considerations will require using a greater number of smaller diameter screens. For these cases the same size header pipe can be used, but the intake will require either more branched piping or multiple connections along the header pipe.

Connecting Wall

The retrofit of passive T-screen technology where the existing pump well and pumps are retained will require a means of connecting the new screen pipes to the pump well. Pump wells that are an integral part of shoreline intakes (often the case) will require installing a wall in front of the existing intake pump well or screen bays. This wall serves to block the existing intake opening and to connect the T-screen pipe(s) to the existing intake pump wells. In the proposed cost scenario, the T-screen pipe(s) can be attached directly to holes passing through the wall at the bottom.

Two different types of construction have been used in past retrofits or have been proposed in feasibility studies. In one, a wall constructed of steel plates is attached to and covers the front of each intake bay or pump well, such that one or more connecting pipes feed water into each screen bay or pump well individually. In this scenario, a single steel plate or several interlocking plates are affixed to the front of the screen bays by divers, and the T-screen pipe manifolds are then attached to flanged fittings welded at the bottom of the plate(s). For smaller flow intakes that require a single screen, this may be the best configuration since the screen can be attached directly to the front of the intake minimizing the intrusion of the retrofit operation into the waterway.

In the second scenario, an interlocking sheet pile wall is installed in the waterbody directly in front of, and running the length of, the existing intake. Individual screen manifold pipe(s) are attached to holes cut in the bottom along the length of the sheet pile wall. In this case, a common plenum between the sheet pile wall and the existing intake runs the length of the intake. This configuration provides the best performance from an operational standpoint because it allows for flow balancing between the screen/pump bays and the individual manifold pipes. If there are no concerns with obstructing the waterway, the sheet pile wall can be placed far enough out so that the portion of the wall parallel to the intake can be installed first along with the pipes and screens that extend further offshore. In this case, the plenum ends are left open so that the intake can remain functional until the offshore construction is completed. At that point, the intake must shut down to install the final end portions of the wall, the air piping connection to the air supply, and make final connections of the manifold pipes. EPA is not aware of any existing retrofits where this construction technique has been used. However, it has been proposed in a feasibility study where a new, larger intake was to be constructed offshore (see discussion in Construction Downtime section).

Costs were developed for this module based on the second scenario described above. These costs are assumed equal or greater than costs for steel plate(s) affixed to the existing intake opening, and therefore inclusive of either approach. This assumption is based on the use of a greater amount of steel material for sheet piles (which is offset somewhat by the fabrication cost for the steel plates), the use of similarly-sized heavy equipment (pile driver versus crane), and similar diver costs for constructing pipe connections and reinforcements in the sheet pile wall versus installing plates. Costs were developed for both freshwater environments and, with the inclusion a cost factor for coating the steel with a corrosion-resistant material, for saltwater environments.

Connecting Pipes

The design (length and configuration) of the connecting pipes (also referred to as pipe manifold or header) is partly dictated by intake flow and water depth. A review of the pipe diameter and design flow data submitted to EPA by facilities with submerged offshore intakes indicates intake pipe velocities at design flow were typically around 5 feet per second. Note that a minimum of 2.5 to 3 feet per second is recommended to prevent deposition of sediment and sand in the pipe (Metcalf & Eddy 1972). Also, calculations based on vendor data concerning screen attachment flange size and design flow data resulted in pipe velocities ranging from 3.2 to 4.5 feet per second for the nominal size pipe connection. EPA has elected to size the connecting pipes based on a typical design pipe velocity of 5 feet per second.

Even at 5 feet per second, the piping requirements are substantial. For example, if the existing intake has traveling screens with a high velocity (e.g., 2.5 feet per second through-screen velocity), then the cross-sectional area of the intake pipe needed to provide the same flow would be approximately one-third of the existing screen area (assuming existing screen open area is 68%). Given the above assumptions, an existing intake with a 10-foot wide traveling screen and a 20-foot water depth would require a 9.4-foot diameter pipe and be connected to at least four 8-foot diameter fine mesh T-screens (T96). The flow rate for this hypothetical intake screen would be 155,000 gpm.

For small volume flows (40,750 gpm or less for fine mesh–see Exhibit 3-3), T-screens (particularly those with a single screen unit) can be installed very close to the existing intake structure, as the upstream or downstream extensions of the screen should not be an issue. In the 10-foot wide by 20-foot deep traveling screen example above, each of the T96 screens required is 26 feet long. For this example, it is possible to place the four T96 screens directly in front of the existing intake connected to a single manifold extending 56 feet (2*8+2*8+2*8+8) to the centerline of the last T-screen. This is based on a configuration where the manifold has multiple ports (four in this case) spaced along the top. However, this configuration will experience some flow imbalance between the screens. A better configuration would be a single pipe branching twice in a double "H" arrangement. In this case, the total pipe length would be 62 feet (20+26+2*8). Therefore, a minimum pipe length of 66 feet (20 meters) was selected to cover the pipe installation costs for screens installed close to the intake.

Based on the above discussion, facilities with design flow values requiring multiple manifold pipes (i.e., >163,000 gpm) will require the screens to extend even further out. In these cases, costs for a longer pipe size are appropriate. Using a longer pipe allows for individual screens to be spread out laterally and/or longitudinally. Longer pipes would also tend to provide access to deeper water where larger screens can be used. While using smaller screens allows for operations in shallower water, many more screens would be needed. This configuration covers a greater bottom area and requires more branching and longer, but smaller, pipes. Therefore, with the exception of the lower intake flow facilities, a length of connecting pipe longer than66 feet (20 meters) is assumed to be required.

The next assumed pipe length is 410 feet (125 meters), based on the Phase I proposed rule cost estimates. A length of 125 meters was selected in Phase I costing as a reasonable estimate for extending intakes beyond the littoral zone. Additional lengths of 820 feet (250 meters) and 1640 feet (500 meters) were selected to cover the possible range of intake distances. The longest distance (1640 feet) is similar in magnitude to the intake distances reported for many of the facilities with offshore intakes located on large bodies of water, such as oceans and Great Lakes.

As described in the document Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule, Appendix A, submerged intake pipes can be constructed in two ways. One construction uses steel that is concrete-lined and coated on the outside with epoxy and a concrete overcoat. The second construction uses prestressed concrete cylinder pipe (PCCP). Steel is generally used for lake applications; both steel and PCCP are used for riverine applications; PCCP is typically used in ocean applications. A review of the submerged pipe laying costs developed for the Phase I proposed rule showed that the costs of installing steel and PCCP pipe using the conventional method were similar, with steel being somewhat higher in cost. EPA has thus elected to use the Phase I cost methodology for conventional steel pipe as representative of the cost for both steel and concrete pipes installed in all waterbodies. The conventional pipe laying method was selected because it could be performed in front of an existing intake and was least affected by the limitations associated with local topography.

While other methods such as the bottom-pull or micro-tunneling methods could potentially be used, the bottom-pull method requires sufficient space for laying pipe onshore while the micro-tunneling method requires that a shaft be drilled near the shoreline, which may be difficult to perform in conjunction with an existing intake. The conventional steel pipe laying cost methodology and assumptions are described in detail in the document Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule, Appendix A.

1.1.2 Capital Cost Development

Screen Material Construction and Costs

Costs were obtained for T-screens constructed of three different types of materials: 304 stainless steel, 316 stainless steel, and copper-nickel (CuNi) alloy. In general, screens installed in freshwater are constructed of 304 stainless steel. However, where Zebra Mussels are a problem, CuNi alloys are often used because the leached copper tends to discourage screen biofouling with Zebra mussels. In corrosive environments such as brackish and saltwater, 316 stainless steel is often used. If the corrosive environment is harsh, particularly where oxygen levels are low, CuNi alloys are recommended. Since the T-screens are to be placed extending out into the waterway, such low oxygen environments are not expected to be encountered.

Based on this information, EPA has chosen to base the cost estimates on utilizing screens made of 304 stainless steel for freshwater environments without Zebra Mussels, CuNi alloy for freshwater environments with the potential for Zebra Mussels and 316 stainless steel for brackish and saltwater environments. Exhibit 3-4 provides a list of states that contain or are adjacent to waterbodies where Zebra Mussels are currently found. The cost for CuNi screens are applied to all freshwater environments located within these states. EPA notes that the screens comprise only a small portion of the total costs, particularly where the design of other components are the same, such as the proposed design scenarios for freshwater environments with Zebra Mussels versus those without.

Exhibit 3-4. List of States with Freshwater Zebra Mussels as of 2001

List of States with Freshwater Zebra Mussels as of 2001	
State Name	**Abbreviation**
Alabama	AL
Connecticut	CT
Illinois	IL
Indiana	IN
Iowa	IA
Kentucky	KY
Louisiana	LA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
New York	NY
Ohio	OH
Oklahoma	OK
Pennsylvania	PA
Tennessee	TN
Vermont	VT
West Virginia	WV
Wisconsin	WI

Exhibit 3-5 presents the component and total installed costs for the three types of screens. A vendor indicated that the per screen costs will not change significantly between those with fine mesh and very fine mesh so the same screen costs are used for each. Installation and mobilization costs are based on vendor-provided cost estimates for velocity caps, which are comparable to those for T-screens. The individual installation cost per screen of $35,000 was reduced by 30% for multiple screen installations. Costs for steel fittings are also included. These costs are based on steel fitting costs developed for the new facility Phase I effort and are adjusted for a pipe velocity of 5 feet per second and converted to 2002 dollars. An additional 5% was added to the total installed screen costs to account for installation of intake protection and warning devices such as pilings, dolphins, buoys, and warning signs.

Exhibit 3-5. T-Screen Equipment and Installation Costs

T-Screen Equipment and Installation Costs

Size	Number of Screens	Capacity	Total Screen Cost by Material			Air Burst Equipment	Screen Installation	Mobilization	Steel Fitting
		gpm	304SS	316SS	CuNi				
T24	1	2,500	$5,800	$6,100	$8,000	$10,450	$25,000	$15,000	$2,624
T36	1	5,700	$10,000	$11,200	$18,000	$15,050	$25,000	$15,000	$3,666
T48	1	10,000	$17,000	$18,800	$31,700	$22,362	$30,000	$15,000	$5,067
T60	1	15,800	$23,000	$26,200	$44,500	$28,112	$35,000	$15,000	$6,964
T72	1	22,700	$34,000	$39,500	$69,700	$35,708	$35,000	$20,000	$9,227
T84	1	31,000	$45,000	$51,900	$93,400	$43,588	$35,000	$20,000	$11,961
T96	1	40,750	$61,000	$70,200	$124,000	$49,338	$35,000	$25,000	$15,189
T96	2	81,500	$122,000	$140,400	$248,000	$49,338	$49,000	$25,000	$28,865
T96	3	122,250	$183,000	$210,600	$372,000	$49,338	$73,500	$30,000	$42,840
T96	4	163,000	$244,000	$280,800	$496,000	$49,338	$98,000	$30,000	$57,113

The same costs are used for both fine mesh and very fine mesh with major difference being the design flow for each screen size.

Connecting Wall Cost Development

The cost for the connecting wall that blocks off the existing intake and provides the connection to the screen pipes is based on the cost of an interlocking sheet pile wall constructed directly in front of the existing intake. In general, the costs are mostly a function of the total area of the wall and will vary with depth. Cost estimates were developed for a range of wall dimensions. The first step was to estimate the nominal length of the existing intake for each of the design flow values shown in Exhibits 3-1 and 3-2. The nominal length was estimated using an assumed water depth and intake velocity. The use of actual depths and intake velocities imparted too many variables for the selected costing methodology. A depth of 20 feet was selected because it was close to both the mean and median intake water depth values reported by Phase III facilities in their Detailed Technical Questionnaires.

The length of the wall was also based on an assumed existing intake, through-screen velocity of 1 feet per second and an existing screen open area of 50%. Most existing coarse screens have an open area of 68%. However, a 50% area was chosen to produce a larger (i.e., more costly) wall size. Selecting a screen velocity of 1 feet per second also will overestimate wall length (and therefore, costs) for existing screen velocities greater than 1 feet per second. This is the case for most of the facilities (approximately 50% of Phase III facilities reported screen velocities of 1 feet per second or greater for at least one cooling water intake structure and just under 70% of the Phase II Facilities reported screen velocities of 1 feet per second or greater). An additional length of 30 to 60 feet (scaled between 30 feet for 2,500 to 60 feet for 163,000 gpm with a minimum of 30 ft for lower flows) was added to cover the end portions of the wall and to cover fixed costs for smaller intakes. The costs are based on the following:

- Sheet pile unit cost of $24.50/sq ft RS Means 2001)
- An additional 50% of sheet pile cost to cover costs not included in sheet pile unit cost[1]
- Total pile length of 45 feet for 20-foot depth including 15-foot penetration and 10-foot extension above water level
- Mobilization of $18,300 for 20-foot depth RS Means 2001), added twice (assuming sheet pile would be installed in two stages to minimize generating unit downtime (see Downtime discussion). The same mobilization costs are used for both saltwater and freshwater environments.
- An additional cost of 33% for corrosion-resistant coating for saltwater environments.

Exhibits 3-6 and 3-7 present the estimated wall lengths, mobilization costs, and total costs for 20-foot depth for both freshwater and saltwater environments for fine mesh and very fine mesh screens, respectively.

Exhibit 3-6. Sheet Pile Wall Capital Costs for Fine Mesh Screens

Sheet Pile Wall Capital Costs for Fine Mesh Screens

Design Flow	Total Estimated Wall Length	Mobilization	Sheet Pile Wall Total Costs 20 Ft Water Depth*	
gpm	Ft		Freshwater	Saltwater
2,500	31	$36,600	$87,157	$103,840
5,700	32	$36,600	$89,351	$106,758
10,000	34	$36,600	$92,359	$110,759
15,800	36	$36,600	$96,416	$116,155
22,700	39	$36,600	$101,243	$122,575
31,000	43	$36,600	$107,049	$130,297
40,750	47	$36,600	$113,870	$139,369
81,500	64	$36,600	$142,376	$177,283
122,250	81	$36,600	$170,883	$215,196
163,000	96	$36,600	$195,960	$248,549

* Total costs include mobilization

[1]Note that this 50% value was derived by comparing the estimated costs of a sheet pile wall presented in a feasibility study for the Salem Nuclear Plant to the cost estimated for a similarly sized sheet pile wall using the EPA method described here. This factor was intended to cover the cost of items such as walers, bracing and installation costs not included in the R S Means unit cost. The Salem facility costs included bypass gates, which are assumed to be similar in cost to the pipe connections.

Exhibit 3-7. Sheet Pile Wall Capital Costs for Very Fine Mesh Screens

Sheet Pile Wall Capital Costs for Very Fine Mesh Screens

Design Flow	Total Estimated Wall Length	Mobilization	Sheet Pile Wall Costs 20 Ft Water Depth*	
gpm	Ft		Freshwater	Saltwater
1,680	30	$36,600	$86,854	$103,438
3,850	31	$36,600	$88,056	$105,037
6,750	32	$36,600	$90,085	$107,735
10,700	34	$36,600	$92,848	$111,410
15,300	36	$36,600	$96,066	$115,690
20,900	38	$36,600	$99,984	$120,900
27,500	41	$36,600	$104,601	$127,041
55,000	53	$36,600	$123,838	$152,627
82,500	64	$36,600	$143,076	$178,213
110,000	76	$36,600	$162,314	$203,799
165,000	99	$36,600	$200,789	$254,971

* Total costs include mobilization

Pipe Manifold Cost Development

For facilities with design intake flows that are 10% or more greater than the 163,000 gpm to 165,000 gpm maximum costed (i.e., above 180,000 gpm), multiple intakes are costed and the costs are summed. This approach leads to probable costing over-estimates for both the added length of end sections wall costs.

Pipe costs are developed using the same general methodology as described in Economic and Engineering Analyses of the Proposed Section 316(b) New Facility Rule, Appendix A, but modified based on a design pipe velocity of 5 feet per second. The pipe laying cost methodology was revised to include: costs for several different pipe lengths were developed. These pipe lengths include: 66 feet (20 meters), 410 feet (125 meters), 820 feet (250 meters), and 1640 feet (500 meters). The cost for pipe installation includes an equipment rental component for the pipe laying vessel, support barge, crew, and pipe laying equipment. The Phase I proposed rule Economic and Engineering Analyses document estimates that 500 feet of pipe can be laid in a day under favorable conditions. Equipment rental costs for the longer piping distances were adjusted upward, in single-day increments, to limit daily production rates not to exceed 550 feet/day. For the shorter distance of 66 feet (20 meters), the single-day pipe laying vessel/equipment costs were reduced by a factor of 40%. This reduction is based on the assumption that, in most cases, a pipe laying vessel is not needed because installation can be performed via crane located on the shoreline.

Figure 3-1 presents the capital cost curves for the pipe portion only for each of the offshore distance scenarios. The pipe cost development methodology adopted from the Phase I effort used a different set of flow values than are shown in Exhibit 3-1. Therefore, second-order, best-fit equations were derived from pipe cost data. These equations were applied to the flow values in Exhibit 3-1 to obtain the relevant installed pipe cost component.

An additional equipment component representing the cost of pipe fittings such as tees or elbows are included in the screen equipment costs. The costs are based on the cost estimates developed for the Phase I proposed rule, adjusted to a pipe velocity of 5 feet per second and 2002 dollars.

Airburst System Costs

Capital costs for airburst equipment sized to backwash each of the T-screens were obtained from vendor estimates. These costs included air supply equipment (compressor, accumulator, distributor) minus the piping to the screens, air supply housing, and utility connections and wiring. Capital costs of the airburst air supply system are shown in Exhibit 3-8. Costs for a housing structure, electrical, and controls were added based on the following:

- electrical costs = 10% of air supply equipment (BPJ)
- Controls = 5% of air supply equipment (BPJ)
- Housing = $142/sq ft for area shown in Exhibit 3-8. This cost was based on the $130/sq ft cost used in the Phase I cost for pump housing, adjusted to 2002 dollars.

Exhibit 3-8. Capital Costs of Airburst Air Supply Equipment

Screen Size	Vendor Supplied Equipment Costs	Estimated Housing Area	Housing Area	Housing Costs	Electrical	Controls	Total Airburst Minus Air Piping to Screens
			sq ft		10%	5%	
T24	$6,000	5x5	25	$3,550	$600	$300	$10,450
T36	$10,000	5x5	25	$3,550	$1,000	$500	$15,050
T48	$15,000	6x6	36	$5,112	$1,500	$750	$22,362
T60	$20,000	6x6	36	$5,112	$2,000	$1,000	$28,112
T72	$25,000	7x7	49	$6,958	$2,500	$1,250	$35,708
T84	$30,000	8x8	64	$9,088	$3,000	$1,500	$43,588
T96	$35,000	8x8	64	$9,088	$3,500	$1,750	$49,338

The costs of the air supply pipes, or "blow pipes," are calculated for each installation depending on the length of the intake pipe, plus an assumed average distance of 70 feet from the airburst system housing to the intake pipe at the front of the sheet pile wall. Pipe costs are based on this total distance multiplied by a derived unit cost of installed pipe Vendors indicated that the pipes are typically made of schedule 10 stainless steel or high density polyethylene and that material costs are only a portion of the total installed costs. Consistent with the selection of screen materials, EPA chose to assume that the blow pipes are constructed of 304 stainless steel for freshwater and 316 stainless steel for saltwater applications.

The unit costs for the installed blow pipes are based on the installed cost of similar pipe in a structure on land multiplied by an underwater installation factor. This underwater installation factor was derived by reviewing the materials-versus-total costs for underwater steel pipe installation, which ranged from about 3.2 to 4.5 with values decreasing with increasing pipe size. A review of the materials-versus-installed-on-land costs for the smaller diameter stainless steel pipe (RS Means 2001) found that if the installed-on-land unit costs are multiplied by 2.0, the resulting materials-to-total- estimated (underwater)-installed-cost ratios fell within a similar range. These costs are considered as over-estimating costs somewhat because they include 304 and 316 stainless steel where less costly materials may be used. Also, they do not consider potential savings associated with concurrent installation alongside the much larger water intake pipe.

Blow pipe sizes were provided by vendors for T60 and smaller screens. For larger screens, the blow pipe diameter was derived by calculating pipe diameters (and rounding up to even pipe sizes) using the same ratio of screen area to blow pipe area calculated for T60 screens. This is based on the assumption that blow pipe air velocities are proportional to the needed air/water backwash velocities at the screen surface. A separate blow pipe was included for each T-screen where multiple screens are included, but only one set of the air supply equipment (compressor, accumulator, distributor, controls etc.) is included in each installation. The calculated costs for the air supply pipes are shown in Exhibit 3-9.

Exhibit 3-9. Capital Costs of Installed Air Supply Pipes for Fine Mesh Screens

Design Flow Fine Mesh	Design Flow Very Fine Mesh	Air Pipe Unit Cost - Schedule 10 304 SS	Air Pipe Unit Cost - Schedule 10 316 SS	Freshwater Airburst Distribution Installed Pipe Costs				Saltwater Airburst Distribution Installed Pipe Costs			
gpm	gpm	$/Ft	$/Ft	20 Meters	125 Meters	250 Meters	500 Meters	20 Meters	125 Meters	250 Meters	500 Meters
2,500	1,680	$57.3	$119.5	$7,764	$27,485	$50,961	$97,915	$16,210	$57,379	$106,391	$204,413
5,700	3,850	$85.4	$102.0	$11,575	$40,973	$75,970	$145,966	$13,834	$48,970	$90,798	$174,454
10,000	6,750	$102.0	$118.7	$13,834	$48,970	$90,798	$174,454	$16,093	$56,966	$105,625	$202,943
15,800	10,700	$160.3	$188.4	$21,739	$76,954	$142,685	$274,147	$25,550	$90,442	$167,694	$322,198
22,700	15,300	$222.8	$279.0	$30,209	$106,934	$198,274	$380,954	$37,830	$133,910	$248,292	$477,056
31,000	20,900	$304.0	$368.5	$41,220	$145,910	$270,542	$519,806	$49,971	$176,890	$327,983	$630,169
40,750	27,500	$376.8	$456.0	$51,100	$180,883	$335,388	$644,396	$61,828	$218,861	$405,804	$779,692
81,500	55,000	$376.8	$456.0	$102,199	$361,766	$670,775	$1,288,793	$123,656	$437,722	$811,609	$1,559,383
122,250	82,500	$376.8	$456.0	$153,299	$542,650	$1,006,163	$1,933,189	$185,485	$656,582	$1,217,413	$2,339,075
163,000	110,000	$376.8	$456.0	$204,398	$723,533	$1,341,550	$2,577,586	$247,313	$875,443	$1,623,218	$3,118,766
-	165,000	$376.8	$456.0	$306,597	$1,085,299	$2,012,326	$3,866,378	$370,969	$1,313,165	$2,434,826	$4,678,150

Indirect Costs

The total calculated capital costs were adjusted to include the following added costs:

- Engineering at 10% of direct capital costs
- Contractor overhead and profit at 15% of direct capital costs (based on O&P component of installing lift station in RS Means 2001); some direct cost components, e.g., the intake pipe cost and blow pipe cost, already include costs for contractor overhead and profit
- Contingency at 10% of direct capital costs
- Sitework at 10% of direct capital costs; based on sitework component of Fairfax Water Intake costs data, including costs for erosion & sediment control, trash removal, security, dust control, access road improvements, and restoration (trees, shrubs, seeding & sodding).

Total Capital Costs

Fine Mesh

Exhibit 3-10 presents the total capital costs of the complete system for fine mesh screens including indirect costs. Figures 3-2, 3-3, and 3-4 present the plotted capital costs in Exhibit 3-10 for freshwater, saltwater, and freshwater with Zebra mussels, respectively. Figures 3-2, 3-3, and 3-4 also present the best-fit, second order equations used in estimating compliance costs.

Very Fine Mesh

Exhibit 3-11 presents the total capital costs of the complete system for very fine mesh screens including indirect costs. Figures 3-5, 3-6, and 3-7 present the plotted capital costs in Exhibit 3-11 for freshwater, saltwater, and freshwater with Zebra mussels, respectively.

Exhibit 3-10. Total Capital Costs of Installed Fine Mesh T-screen System at Existing Shoreline Based Intakes

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
2,500	$330,608	$356,632	$333,958	$458,425	$487,945	$461,775	$694,677	$728,359	$698,027	$1,007,472	$1,049,477	$1,010,822
5,700	$359,106	$389,320	$371,286	$524,990	$563,194	$537,170	$807,170	$854,887	$819,350	$1,210,950	$1,277,690	$1,223,130
10,000	$405,008	$437,575	$427,389	$612,009	$652,566	$634,390	$944,036	$994,105	$966,417	$1,446,429	$1,515,522	$1,468,810
15,800	$460,179	$498,982	$492,913	$739,998	$792,284	$772,732	$1,160,061	$1,228,398	$1,192,795	$1,837,241	$1,937,682	$1,869,975
22,700	$530,563	$580,486	$584,916	$893,959	$970,848	$948,312	$1,415,327	$1,524,319	$1,469,680	$2,293,842	$2,467,040	$2,348,195
31,000	$602,745	$659,150	$676,434	$1,069,950	$1,157,317	$1,143,639	$1,717,372	$1,841,598	$1,791,061	$2,846,829	$3,044,774	$2,920,518
40,750	$691,543	$757,467	$787,461	$1,270,404	$1,374,281	$1,366,322	$2,054,067	$2,203,125	$2,149,984	$3,455,143	$3,694,566	$3,551,061
81,500	$1,034,259	$1,142,774	$1,226,094	$2,120,425	$2,304,845	$2,312,260	$3,526,716	$3,801,500	$3,718,551	$6,175,421	$6,630,933	$6,367,256
122,250	$1,420,292	$1,571,396	$1,708,044	$3,023,393	$3,288,357	$3,311,146	$5,071,576	$5,472,086	$5,359,329	$9,016,065	$9,687,666	$9,303,817
163,000	$1,813,456	$2,005,510	$2,197,126	$3,943,125	$4,286,990	$4,326,795	$6,652,462	$7,177,056	$7,036,132	$11,940,891	$12,826,940	$12,324,561

Exhibit 3-11. Total Capital Costs of Installed Very Fine Mesh T-screen System at Existing Shoreline Based Intakes

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
1,680	$329,296	$355,254	$332,813	$451,952	$481,545	$455,469	$681,911	$715,832	$685,428	$982,352	$1,024,929	$985,869
3,850	$354,622	$384,438	$367,411	$507,964	$546,100	$520,753	$774,855	$822,895	$787,644	$1,148,553	$1,216,401	$1,161,342
6,750	$396,579	$428,325	$420,079	$580,540	$620,605	$604,039	$884,451	$934,421	$907,951	$1,331,420	$1,401,198	$1,354,919
10,700	$446,379	$483,934	$480,749	$689,904	$741,492	$724,274	$1,065,566	$1,133,860	$1,099,937	$1,655,065	$1,756,769	$1,689,435
15,300	$510,005	$558,302	$567,076	$820,297	$896,659	$877,368	$1,276,515	$1,386,288	$1,333,586	$2,026,108	$2,202,703	$2,083,179
20,900	$573,744	$627,794	$651,118	$968,061	$1,054,341	$1,045,435	$1,525,747	$1,650,395	$1,603,120	$2,477,203	$2,678,590	$2,554,577
27,500	$652,189	$714,992	$752,903	$1,134,364	$1,236,677	$1,235,077	$1,798,524	$1,947,874	$1,899,238	$2,961,902	$3,205,326	$3,062,615
55,000	$944,813	$1,047,085	$1,146,240	$1,832,361	$2,013,654	$2,033,788	$2,989,159	$3,264,526	$3,190,586	$5,136,240	$5,599,755	$5,337,667
82,500	$1,270,016	$1,411,756	$1,572,156	$2,567,323	$2,827,597	$2,869,463	$4,225,531	$4,626,915	$4,527,671	$7,378,247	$8,061,852	$7,680,387
110,000	$1,596,585	$1,777,795	$1,999,439	$3,308,039	$3,647,292	$3,710,892	$5,476,429	$6,003,830	$5,879,283	$9,656,711	$10,560,407	$10,059,565
165,000	$2,276,664	$2,536,812	$2,880,944	$4,829,568	$5,326,782	$5,433,848	$8,044,641	$8,824,075	$8,648,921	$14,345,849	$15,689,726	$14,950,129

Nuclear Facilities

Construction and material costs tend to be substantially greater for nuclear facilities due to burden of increased security and to the requirements for more robust system design. Rather than performing a detailed evaluation of the differences in capital costs for nuclear facilities, EPA has chosen to apply a simple cost factor based on total costs.

In the Phase I costing effort, EPA used data from an Argonne National Lab study on retrofitting costs of fossil fuel power plants and nuclear power plants. This study reported average, comparative costs of $171 for nuclear facilities and $108 for fossil fuel facilities, resulting in a 1.58 costing factor. In comparison, recent consultation with a traveling screen vendor, the vendor indicated costing factors in the range of 1.5-2.0 were reasonable for estimating the increase in costs associated with nuclear power plants based on their experience. Because today there are likely to be additional security burdens above that experienced when the Argonne Report was generated, EPA has selected 1.8 as a capital costing factor for nuclear facilities. Capital costs for nuclear facilities are not presented here but can be estimated by multiplying the applicable non-nuclear facility costs by the 1.8 costing factor.

O&M Costs

O&M cost are based on the sum of costs for annual inspection and cleaning of the intake screens by a dive team and for estimated operating costs for the airburst air supply system. Dive team costs were estimated for a total job duration of one to four days, and are shown in Exhibit 3-12. Dive team cleaning and inspections were estimated at once per year for low debris locations and twice per year for high debris locations. The O&M costs for the airburst system are based on power requirements of the air compressor and labor requirements for routine O&M. Vendors cited a backwash frequency per screen from as low as once per week to as high as once per hour for fine mesh screens. The time needed to recharge the accumulator is about 0.5 hours, but can be as high as 1 hour for those with smaller compressors or accumulators that backwash more than one screen simultaneously.

The Hp rating of the typical size airburst compressor for each screen size was obtained from a vendor and is presented in the table in Attachment 3A. A vendor stated that several hours per week would be more than enough labor for routine maintenance, so labor is assumed to be two to four hours per week based on roughly half-hour daily inspection of the airburst system. However, during seasonal periods of high debris such as leaves in the fall, it may be necessary for someone to man the backwash system 24 hours/day for several weeks (Frey 2002). Thus, an additional one to 4.5 weeks of 24-hour labor are included for these periods (one week low debris fine mesh; 1.5 weeks low debris very fine mesh; three weeks high debris fine mesh; and 4.5 weeks high debris very fine mesh). Since very fine mesh screens will tend to collect debris at a more rapid rate, backwash frequencies and labor requirements were increased by 50% for very fine mesh screens.

The O&M cost of the airburst system are based on the following:

- Average backwash frequency in low debris areas is 2 times per day (3 times per day for very fine mesh)
- Average backwash frequency in high debris areas is 12 times per day (18 times per day for very fine mesh)
- Time to recharge accumulator is 0.5 hours
- Compressor motor efficiency is 90%
- Cost of electric power consumed is $0.04/Kwh
- Routine inspection and maintenance labor is 3 hours per week (4.5 hours per week for very fine mesh) for systems up to 182,400 gpm
- O&M labor rate per hour is $41.10/hr. The rate is based on Bureau of Labor Statistics Data using the median labor rates for electrical equipment maintenance technical labor (SOC 49-2095) and managerial labor (SOC 11-1021); benefits and other compensation are added using factors based on SIC 29 data for blue collar and white collar labor. The two values were combined into a single rate assuming 90% technical labor and 10% managerial. See Doley 2002 for details.

Exhibit 3-13 presents the total O&M cost for relocating intakes offshore with fine mesh and very fine mesh passive screens. These data are plotted in Figures 3-8 and 3-9 which also shows the second-order equations that were fitted to these data and used to estimate the O&M costs for individual Phase III facilities. Attachment 3A presents the worksheet data used to develop the annual O&M costs. As with the capital costs, at facilities where the design flow exceeds the maximum cost model design flow of 165,000 gpm plus 10% (180,000 gpm), the design flow are divided and the corresponding costs are summed.

Exhibit 3-12. Estimated Costs for Dive Team to Inspect and Clean T-screens

Installation and Maintenance Diver Team Costs

Item	Daily Cost*	One Time Cost*	Total	Adjusted Total			
Duration			One Day	One Day	Two Day	Three Day	Four Day
Cost Year			1999	2002	2002	2002	2002
Supervisor	$575		$575	$627	$1,254	$1,880	$2,507
Tender	$200		$200	$218	$436	$654	$872
Diver	$375		$750	$818	$1,635	$2,453	$3,270
Air Packs	$100		$100	$109	$218	$327	$436
Boat	$200		$200	$218	$436	$654	$872
Mob/Demob		$3,000	$3,000	$3,270	$3,270	$3,270	$3,270
Total			$4,825	$5,260	$7,250	$9,240	$11,230

***Source: Paroby 1999 (cost adjusted to 2002 dollars).**

Exhibit 3-13. Total O&M Costs for Passive Screens Relocated Offshore

Relocate Ofshore With New Fine Mesh Screens			Relocate Ofshore With New Very Fine Mesh Screens		
Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris	Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris
gpm			gpm		
2,500	$16,463	$35,654	1,680	$22,065	$48,221
5,700	$16,500	$35,872	3,850	$22,120	$48,548
10,000	$16,560	$36,235	6,750	$22,210	$49,092
15,800	$20,712	$42,497	10,700	$27,442	$56,496
22,700	$20,748	$42,715	15,300	$27,497	$56,823
31,000	$20,808	$43,078	20,900	$27,588	$57,367
40,750	$20,869	$43,441	27,500	$27,678	$57,912
81,500	$25,299	$51,374	55,000	$33,328	$67,821
122,250	$25,601	$53,189	82,500	$33,782	$70,544
163,000	$27,894	$58,984	110,000	$36,226	$77,246
-	-	-	165000	$37,133	$82,692

Construction Related Downtime

Downtime may be a substantial cost item for retrofits using the existing pump wells and pumps. The EPA retrofit scenario includes a sheet pile wall in front of the existing intake. This scenario is modeled after a proposed scenario presented in a feasibility study for the Salem Nuclear Plant. In this scenario, a sheet pile plenum with bypass gates is constructed 40 feet in front of the existing intake with about twelve 10-foot diameter header pipes connecting the plenum to about 240 T-screens. Construction is estimated to take two years, with installation of the sheet pile plenum in the first year. The facility projects the installation of 10-foot header pipes and screens to take nine months and the air backwash piping to take two months. The feasibility study states that Units 1 & 2 would each have to be shutdown for about six months, to install the plenum, and for an additional two months to install the 10-foot header pipe connection to the plenum and to install the air piping. Thus, an estimated total of eight months downtime is estimated for this very large (near worst case) intake scenario. This scenario was discarded by the facility due to uncertainty about biofouling and debris removal at slack tides. No cost estimates were developed and, therefore no incentive to focus on a system design and a construction sequence that would minimize downtime existed.

In the same feasibility study, a scenario is proposed where a new intake with dual flow traveling screens is installed at a distance of 65 feet offshore inside a cofferdam. In this scenario, a sheet pile plenum wall connects the new intake to the existing shore intake. In this scenario the intake is constructed first; Units 1 & 2 are estimated to be shut down for about one month each to construct and connect the plenum walls to the existing intake.

It would seem that the T-screen plenum construction scenario could follow the same approach, i.e., performed while the units are operating. This approach would result in a much lower downtime, similar to that for the offshore intake, but including consideration for added time for near-shore air pipe installation. There are two relevant differences between these scenarios. One is the distance offshore to the T-screen piping connection versus the new intake structure (40 feet versus 65 feet). The second is that T-screens, pipes, and plenum would be installed underwater while the new intake would be constructed behind a coffer dam. Conceivably the offshore portion of the T-screen plenum (excluding the ends) and all pipe and screen installation on the offshore side could be performed without shutting down the intake.

The WH Zimmer plant is a facility that EPA has identified as actually having converted an existing shoreline intake with traveling screens to submerged offshore T-screens. This facility was originally constructed as a nuclear facility but was never completed. In the late 80's it was converted to a coal fired plant. The original intake was to supply service water and make-up water for recirculating wet towers, and had been completed. However, the area in front of the intake was plagued with sediment deposition. A decision was made to abandon the traveling screens and install T-screens approximately 50 feet offshore. However, because the facility was not operating at the time of this conversion, there was no monetary incentive to minimize construction time. Actual construction took six to eight months for this intake, with a design flow of about 61,000 gpm (Frey 2002). The construction method in this case used a steel wall installed in front of the existing intake pump wells.

The Agency consulted the WH Zimmer plant engineer and asked him to estimate how long it would take to perform this retrofit particularly with a goal of minimizing generating unit downtime. The estimated downtime was a minimum of seven to nine weeks, assuming mobilization goes smoothly and a tight construction schedule is maintained. A more generous estimate of a total of 12 to 15 weeks was estimated for their facility assuming some predictable disruption to construction schedules. This estimate includes five to six weeks for installing piping (some support pilings can be laid ahead of time), an additional five to six weeks to tie in piping and install the wall, and an additional two to three weeks to clean and dredge the intake area. This last two- to three-week period was a construction step somewhat unique to the Zimmer plant, especially because the presence of sediment was the driving factor in the decision to convert the system.

Based on the above information, EPA has concluded that a reasonable unit downtime should be in the range of 13 to 15 weeks for total downtime. It is reasonable to assume that this downtime can be scheduled to coincide with routine generating unit downtime of approximately four weeks, resulting in a total potential lost generation period of nine to 11 weeks. Rather than select a single downtime for all facilities installing passive screens, EPA chose to apply a 13 to 15 week total downtime duration based on variations in project size using design flow as a measure of size. As such, EPA assumed a downtime of 13 weeks for facilities with intake flow volumes of less than 400,000 gpm, 14 weeks for facilities with intake flow volumes greater than 400,000 gpm but less than 800,000 gpm, and 15 weeks for facilities with intake flow volumes greater than 800,000 gpm.

<u>Application</u>

General Applicability

The following site-related conditions may preclude the use of passive T-screens or create operational problems:

- Water depths of <2 feet at screen location; for existing facilities this should not be an issue
- Stagnant waterbodies with high debris load
- Waterbodies with frazil ice in winter.

Frazil ice consists of fine, small, needle-like structures or thin, flat, circular plates of ice suspended in water. In rivers and lakes it is formed in supercooled, turbulent water. Remedies for this problem include finding another location such as deeper water that is outside of the turbulent water or creating a provision for periodically applying heated water to the screens. The application of heated water may not be feasible or economically justifiable in many instances.

Some facilities have reported limited success in alleviating frazil ice problems by blowing a small constant stream of air through the screen backwash system (Whitaker 2002b).

Application of Different Pipe Lengths

As noted previously, the shortest pipe length cost scenario (20 meters) are assumed to be applicable only to facilities with flows less than 163,000 gpm. Conversely, facilities located on large waterbodies that are subject to wave action and shifting sediment are assumed to install the longest pipe length scenario of 500 meters. Large waterbodies in this instance will include Great Lakes, oceans, and some estuarine/tidal rivers. The matrix in Exhibit 3-14 will provide some initial guidance. Generally, if the waterbody width is known, the pipe length should not exceed half the width.

Exhibit 3-14. Selection of Applicable Relocation Offshore Pipe Lengths By Waterbody

	Freshwater Rivers/Streams	Lakes/Reservoirs	Estuaries/Tidal Rivers	Great Lakes	Oceans
20 Meters	Flow <163,000	Flow <163,000	NA	NA	NA
125 Meters	TBD	TBD	TBD	NA	NA
250 Meters	TBD	TBD	TBD	TBD	NA
500 Meters	NA	NA	TBD	TBD	ALL

TBD: Criteria or selection to be determined; criteria may include design flow, waterbody size (if readily available).

1.2 Add Submerged Fine Mesh Passive Screens to Existing Offshore Intakes

Please note that much of the supporting documentation has been previously described in section 1.1.

<u>Capital Costs</u>

Adding passive screens to an existing submerged offshore intake requires many of the same construction steps and components described in section 1.1 above, excluding those related to the main trunk of the manifold pipe and connecting wall. Similar construction components include: modifying the submerged inlet to connect the new screens, installing T-screens, and installing the airburst backwash air supply equipment and the blowpipes. Nearly all of these components will require similar equipment, construction steps and costs as described in section 1.1 for the specific components. One possible difference is that the existing submerged piping distance may not match one of the four lengths for which costs were estimated. This difference only affects this component of cost. The cost scenario distance chosen is the one that closely matches or exceeds the existing offshore distance. Exhibits 3-15 and 3-16 present the combined costs of the installed T-screens, airburst air supply system, and air supply pipes for fine mesh and very fine mesh screens, respectively. The costs in Exhibit 3-15 and 3-16 include direct and indirect costs, as described in section 1.1. Figures 3-10, 3-11, 3-12, 3-13, 3-14, and 3-15 present plots of the data in Exhibits 3-15 and 3-16. The figures include the second-order, best-fit equations are used to estimate technology costs for specific facilities.

Exhibit 3-15. Capital Cost of Installing Fine Mesh Passive T-screens at an Existing Submerged Offshore Intake

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
2,500	$100,137	$112,839	$103,487	$128,732	$172,535	$132,081	$162,773	$243,602	$166,122	$230,855	$385,735	$234,204
5,700	$120,312	$125,414	$132,492	$162,939	$176,361	$175,119	$213,685	$237,012	$225,865	$315,178	$358,314	$327,358
10,000	$154,594	$160,610	$176,975	$205,541	$219,877	$227,922	$266,192	$290,432	$288,573	$387,494	$431,543	$409,874
15,800	$194,029	$204,426	$226,763	$274,090	$298,519	$306,823	$369,400	$410,535	$402,134	$560,020	$634,566	$592,754
22,700	$245,131	$264,554	$299,484	$356,382	$403,871	$410,736	$488,825	$569,725	$543,178	$753,711	$901,432	$808,064
31,000	$293,433	$316,628	$367,122	$445,234	$500,659	$518,923	$625,950	$719,744	$699,639	$987,382	$1,157,915	$1,061,071
40,750	$352,983	$382,546	$448,900	$541,169	$610,243	$637,086	$765,200	$881,312	$861,118	$1,213,263	$1,423,448	$1,309,181
81,500	$562,086	$621,213	$753,921	$938,458	$1,076,608	$1,130,293	$1,386,521	$1,618,744	$1,578,356	$2,282,647	$2,703,017	$2,474,482
122,250	$795,243	$883,934	$1,082,995	$1,359,802	$1,567,025	$1,647,554	$2,031,896	$2,380,230	$2,319,649	$3,376,084	$4,006,639	$3,663,837
163,000	$1,021,242	$1,139,497	$1,404,912	$1,773,988	$2,050,286	$2,157,658	$2,670,113	$3,134,559	$3,053,783	$4,462,364	$5,303,105	$4,846,034

Exhibit 3-16. Capital Cost of Installing Very Fine Mesh Passive T-screens at an Existing Submerged Offshore Intake

Design Flow	Total Costs 20 Meters Offshore			Total Costs 125 Meters Offshore			Total Costs 250 Meters Offshore			Total Costs 500 Meters Offshore		
gpm	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi	304 SS	316 SS	CuNi
	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels	Freshwater	Saltwater	Zebra Mussels
1,680	$100,173	$102,084	$103,690	$128,768	$134,314	$132,284	$162,809	$172,683	$166,326	$230,891	$249,421	$234,408
3,850	$120,156	$125,350	$132,945	$162,783	$176,297	$175,572	$213,530	$236,948	$226,319	$315,023	$358,250	$327,812
6,750	$154,275	$160,428	$177,774	$205,221	$219,694	$228,721	$265,872	$290,250	$289,372	$387,174	$431,360	$410,674
10,700	$193,241	$203,882	$227,611	$273,302	$297,975	$307,672	$368,612	$409,990	$402,982	$559,232	$634,022	$593,603
15,300	$244,023	$263,866	$301,094	$355,275	$403,183	$412,346	$487,718	$569,036	$544,789	$752,603	$900,743	$809,674
20,900	$291,795	$315,515	$369,168	$443,596	$499,547	$520,970	$624,313	$718,632	$701,686	$985,745	$1,156,802	$1,063,118
27,500	$350,954	$381,218	$451,667	$539,140	$608,915	$639,854	$763,172	$879,984	$863,885	$1,211,235	$1,422,120	$1,311,948
55,000	$557,781	$618,309	$759,208	$934,154	$1,073,703	$1,135,580	$1,382,216	$1,615,840	$1,583,643	$2,278,342	$2,700,113	$2,479,769
82,500	$788,414	$879,206	$1,090,554	$1,352,973	$1,562,298	$1,655,113	$2,025,067	$2,375,502	$2,327,207	$3,369,255	$4,001,912	$3,671,395
110,000	$1,011,641	$1,132,697	$1,414,495	$1,764,387	$2,043,486	$2,167,240	$2,660,512	$3,127,759	$3,063,366	$4,452,763	$5,296,305	$4,855,617
165,000	$1,458,718	$1,640,302	$2,062,999	$2,587,837	$3,006,486	$3,192,117	$3,932,025	$4,632,895	$4,536,305	$6,620,401	$7,885,714	$7,224,682

O&M Costs

O&M costs are assumed to be nearly the same as for relocating the intake offshore with passive screens. EPA assumes there are some offsetting costs associated with the fact that the existing intake should already have periodic inspection/cleaning by divers. The portion of the costs representing a single annual inspection has therefore been deducted. Exhibits 3-17 and 3-18 presents the annual O&M costs for fine mesh and very fine mesh screens, respectively. Separate costs are provided for low debris and high debris locations. Figures 3-16 and 3-17 present the plotted O&M data along with the second-order, best fit equations.

Exhibit 3-17. Net Intake O&M Costs for Fine Mesh Passive T-screens Installed at Existing Submerged Offshore Intakes

Existing Offshore With New Fine Mesh Screens			Existing Offshore With New Very Fine Mesh Screens		
Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris	Design Flow	Total O&M Costs - Low Debris	Total O&M Costs - High Debris
gpm			gpm		
2,500	$11,203	$30,394	1,680	$16,805	$42,961
5,700	$11,240	$30,612	3,850	$16,860	$43,288
10,000	$11,300	$30,975	6,750	$16,950	$43,832
15,800	$13,462	$35,247	10,700	$20,192	$49,246
22,700	$13,498	$35,465	15,300	$20,247	$49,573
31,000	$13,558	$35,828	20,900	$20,338	$50,117
40,750	$13,619	$36,191	27,500	$20,428	$50,662
81,500	$16,059	$42,134	55,000	$24,088	$58,581
122,250	$16,361	$43,949	82,500	$24,542	$61,304
163,000	$16,664	$47,754	110,000	$24,996	$66,016
-	-	-	165000	$25,903	$71,462

Construction Downtime

Unlike the cost for relocating the intake from shore-based to submerged offshore, the only construction activities that would require shutting down the intake is to modify the inlet and install the T-screens. Installing the air supply system and the major portion of the air blowpipes can be performed while the intake is operating. Downtimes are assumed to be similar to those for adding velocity caps, which were reported to range from two to seven days. An additional one to two days may be needed to connect the blowpipes to the T-screens. The total estimated intake downtime of three to nine days can easily be scheduled to coincide with the routine maintenance period for power plants (which the Agency assumed to be four weeks for typical plants).

Application

Separate capital costs have been developed for freshwater, freshwater with Zebra mussels, and saltwater environments. In selecting the materials of construction, the same methodology described in section 1.1 is used. Because the retrofit is an addition to an existing intake, selecting the distance offshore involves matching the existing distance to the nearest or next highest distance costed.

Similarly, the O&M costs are applied using the same method as described in section 1.1.

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ATTACHMENT A3
O&M DEVELOPMENT DATA

Exhibit 3A-1. O&M Development Data - Relocate Offshore with Fine Mesh Screens

Design Flow	Compressor Power	Low Debris Backwash Frequency	High Debris Backwash Frequency	Annual Power Required - Low Debris	Annual Power Required - High Debris	Annual Power Costs - Low Debris*	Annual Power Costs - High Debris*	Annual Labor Required - Low Debris	Annual Labor Cost - Low Debris	Annual Labor Required - High Debris	Annual Labor Cost - High Debris	Dive Team Days Low Debris	Dive Team Costs Low Debris	Dive Team Costs High Debris
		Events/day	Events/day	Kwh	Kwh	$0.04	$0.04	Hours		Hours				
2,500	2	2	12	605	3,631	$24	$145	272	$11,179	608	$24,989	1	$5,260	$10,520
5,700	5	2	12	1,513	9,076	$61	$363	272	$11,179	608	$24,989	1	$5,260	$10,520
10,000	10	2	12	3,025	18,153	$121	$726	272	$11,179	608	$24,989	1	$5,260	$10,520
15,800	12	2	12	3,631	21,783	$145	$871	324	$13,316	660	$27,126	2	$7,250	$14,500
22,700	15	2	12	4,538	27,229	$182	$1,089	324	$13,316	660	$27,126	2	$7,250	$14,500
31,000	20	2	12	6,051	36,305	$242	$1,452	324	$13,316	660	$27,126	2	$7,250	$14,500
40,750	25	2	12	7,564	45,382	$303	$1,815	324	$13,316	660	$27,126	2	$7,250	$14,500
81,500	25	4	24	15,127	90,763	$605	$3,631	376	$15,454	712	$29,263	3	$9,240	$18,480
122,250	25	6	36	22,691	136,145	$908	$5,446	376	$15,454	712	$29,263	3	$9,240	$18,480
163,000	25	8	48	30,254	181,527	$1,210	$7,261	376	$15,454	712	$29,263	4	$11,230	$22,460

Exhibit 3A-2. O&M Development Data - Relocate Offshore with Very Fine Mesh Screens

Design Flow	Compressor Power	Low Debris Backwash Frequency	High Debris Backwash Frequency	Annual Power Required - Low Debris	Annual Power Required - High Debris	Annual Power Costs - Low Debris*	Annual Power Costs - High Debris*	Annual Labor Required - Low Debris	Annual Labor Cost - Low Debris	Annual Labor Required - High Debris	Annual Labor Cost - High Debris	Dive Team Days Low Debris	Dive Team Costs Low Debris	Dive Team Costs High Debris
gpm	Hp					at $/kw =	at $/kw =							
		Events/day	Events/day	Kwh	Kwh	$0.04	$0.04	Hours		Hours				
1,680	2	3	18	908	5,446	$36	$218	408	$16,769	912	$37,483	1	$5,260	$10,520
3,850	5	3	18	2,269	13,615	$91	$545	408	$16,769	912	$37,483	1	$5,260	$10,520
6,750	10	3	18	4,538	27,229	$182	$1,089	408	$16,769	912	$37,483	1	$5,260	$10,520
10,700	12	3	18	5,446	32,675	$218	$1,307	486	$19,975	990	$40,689	2	$7,250	$14,500
15,300	15	3	18	6,807	40,844	$272	$1,634	486	$19,975	990	$40,689	2	$7,250	$14,500
20,900	20	3	18	9,076	54,458	$363	$2,178	486	$19,975	990	$40,689	2	$7,250	$14,500
27,500	25	3	18	11,345	68,073	$454	$2,723	486	$19,975	990	$40,689	2	$7,250	$14,500
55,000	25	6	36	22,691	136,145	$908	$5,446	564	$23,180	1068	$43,895	3	$9,240	$18,480
82,500	25	9	54	34,036	204,218	$1,361	$8,169	564	$23,180	1068	$43,895	3	$9,240	$18,480
110,000	25	12	72	45,382	272,290	$1,815	$10,892	564	$23,180	1068	$43,895	4	$11,230	$22,460
165000	25	18	108	68,073	408,435	$2,723	$16,337	564	$23,180	1068	$43,895	4	$11,230	$22,460

Figure 3-1. Capital Costs Conventional Steel Pipe Laying Method at Various Offshore Distances

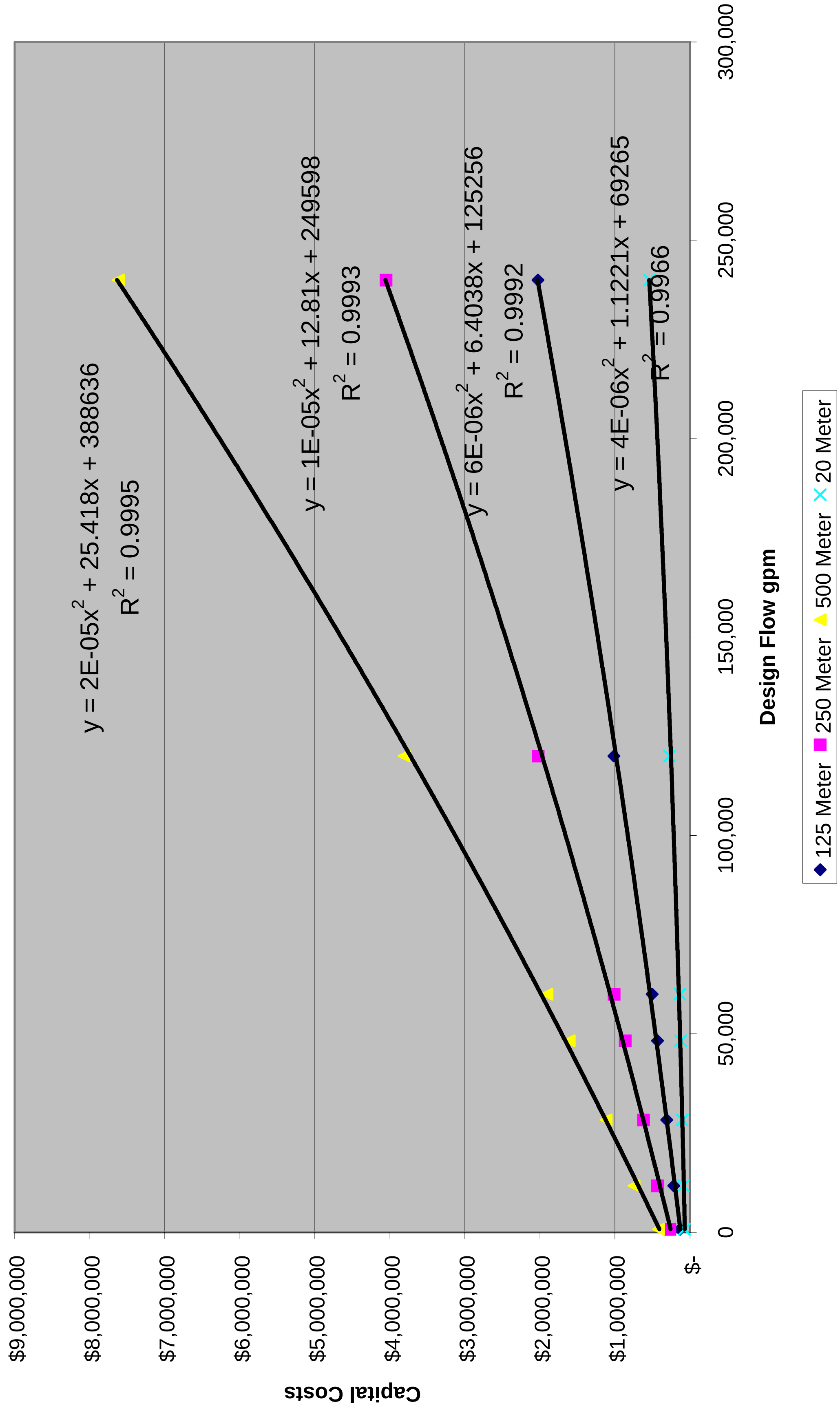


Figure 3-2. Capital Costs for Fine Mesh Passive Screen Relocation Offshore in Freshwater at Selected Offshore Distances

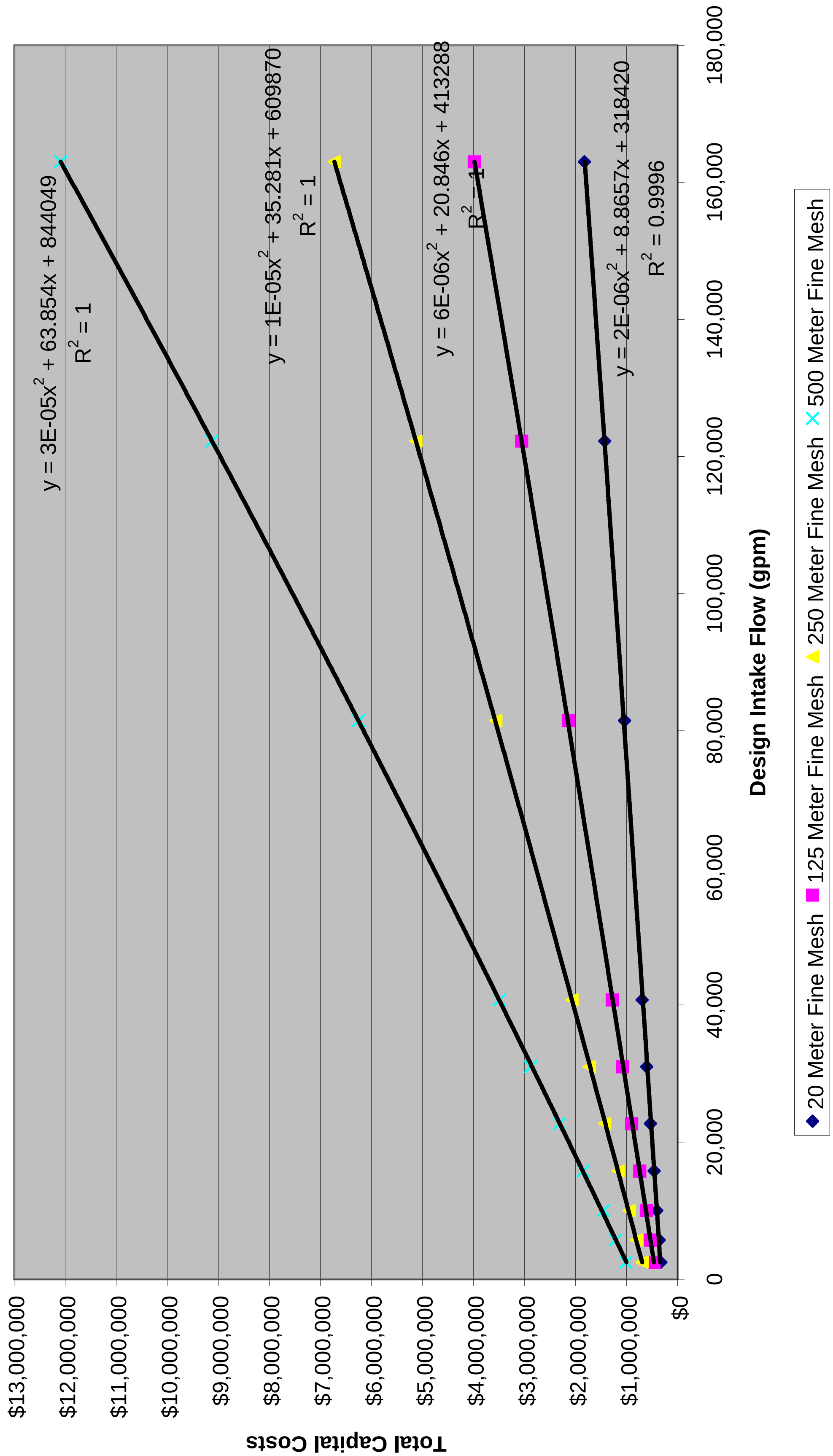


Figure 3-3. Capital Costs for Mesh Passive Screen Relocation Offshore in Saltwater at Selected Offshore Distances

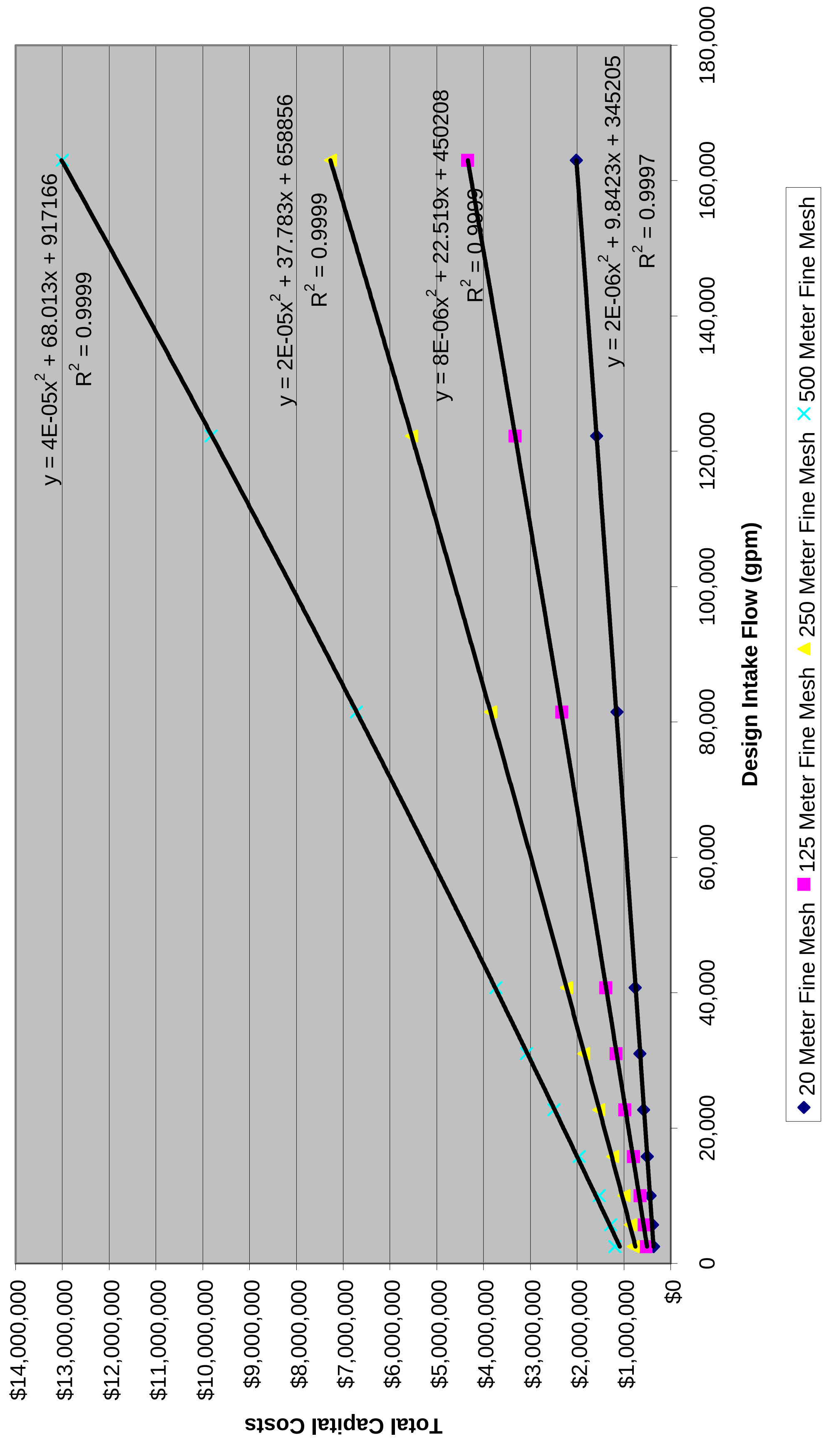


Figure 3-4. Capital Costs for Fine Mesh Passive Screen Relocation Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

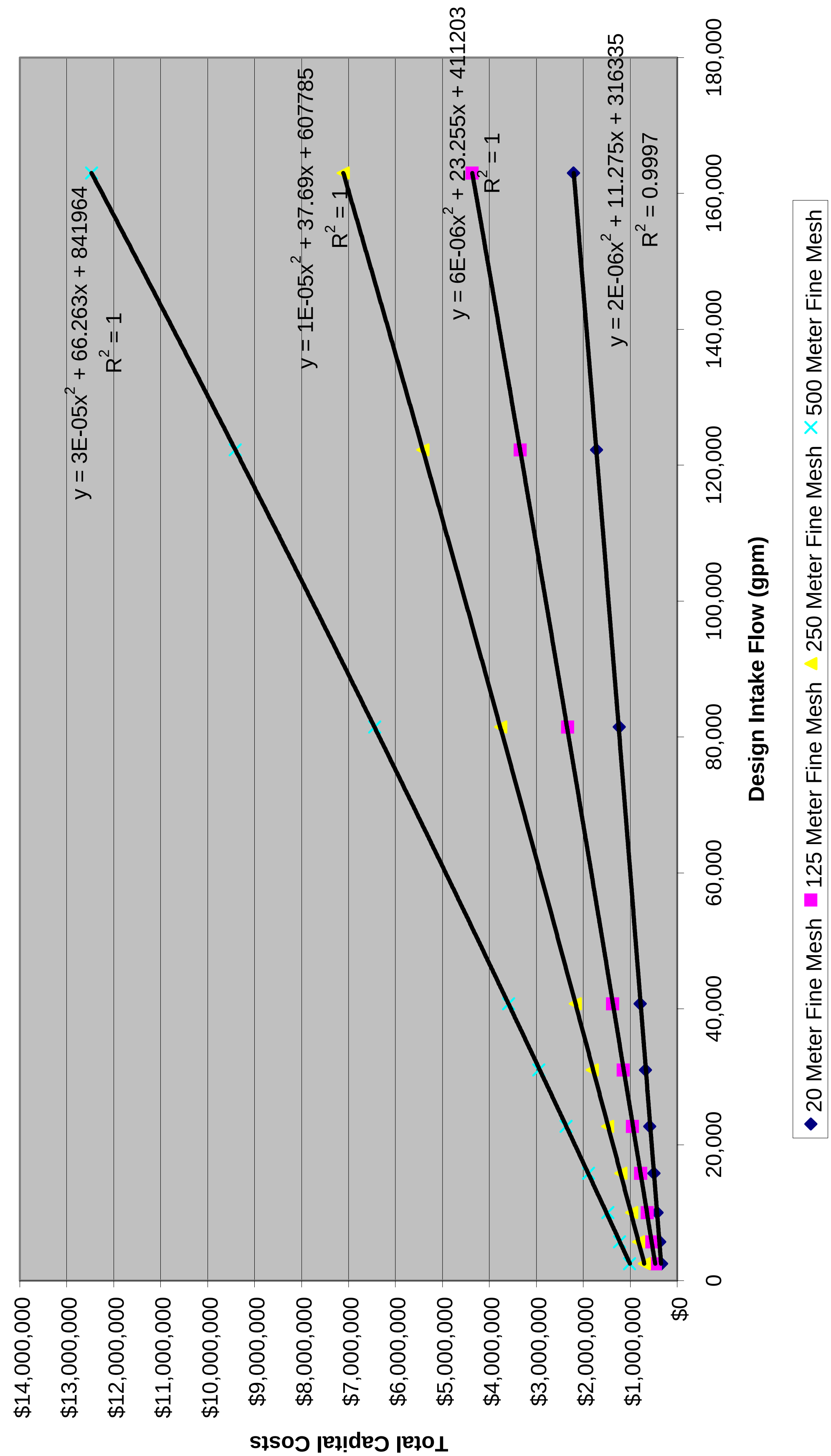


Figure 3-5. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Freshwater at Selected Offshore Distances

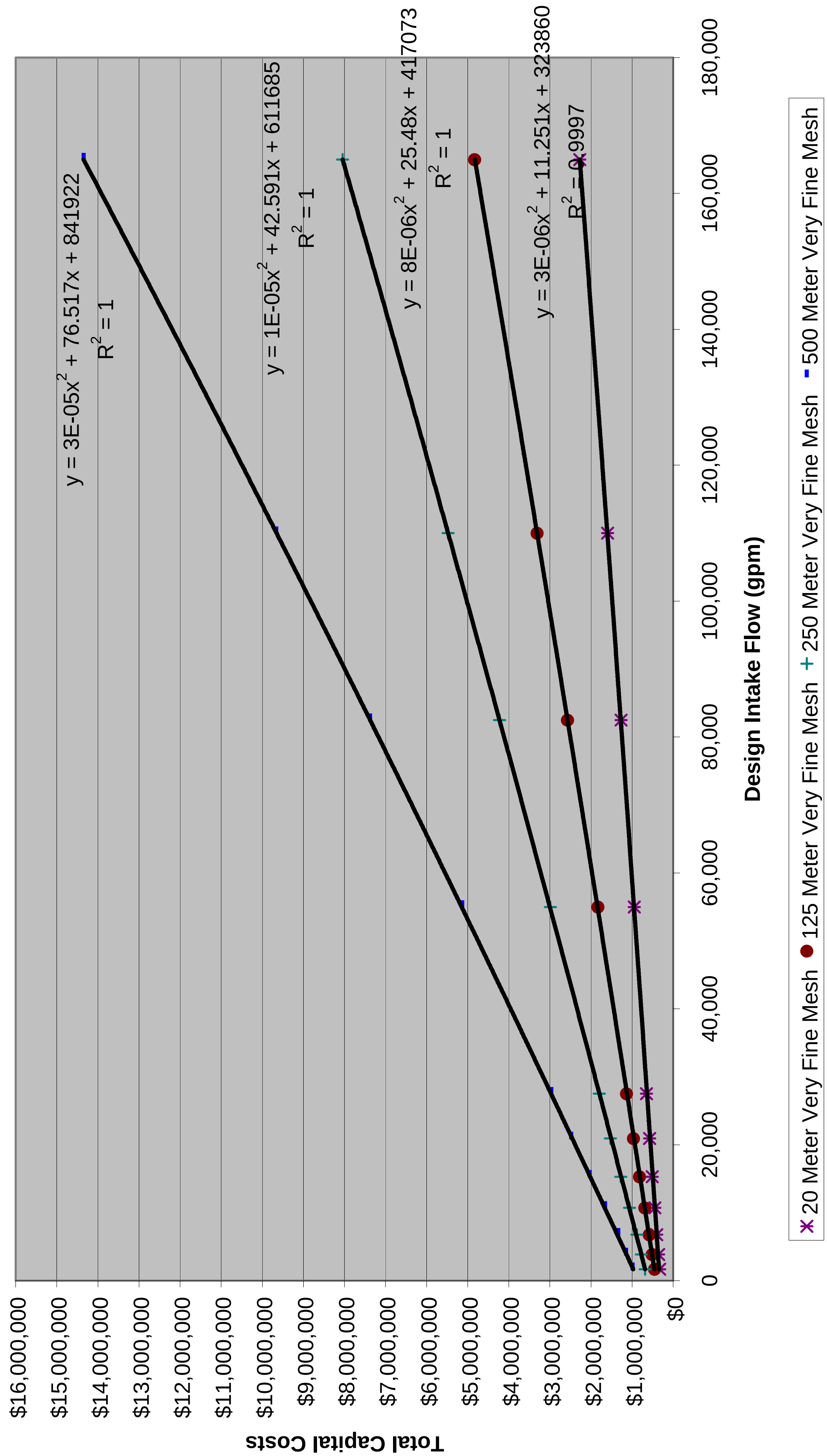


Figure 3-6. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Selected Offshore Distances

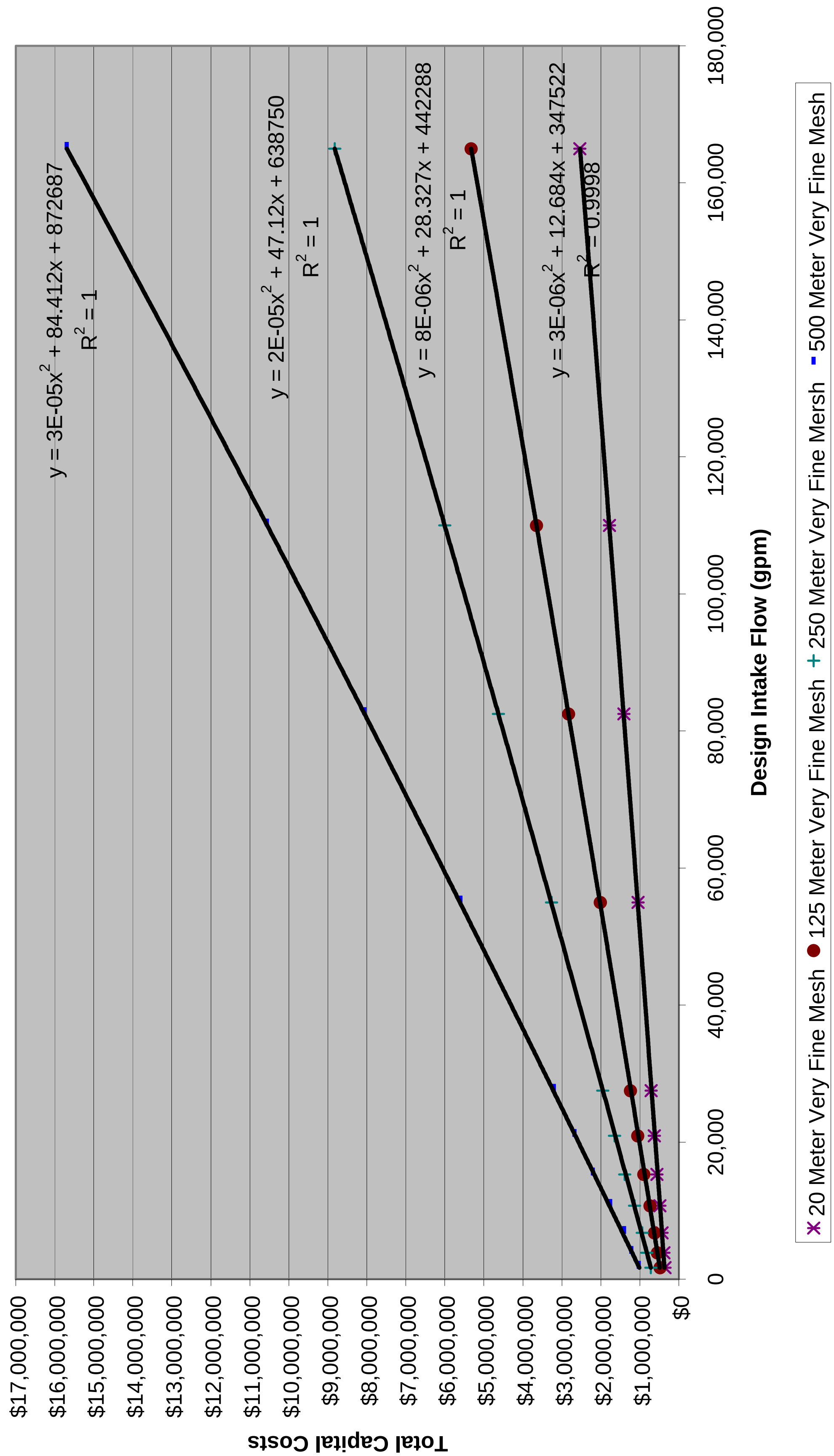


Figure 3-7. Capital Costs for Very Fine Mesh Passive Screen Relocation Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

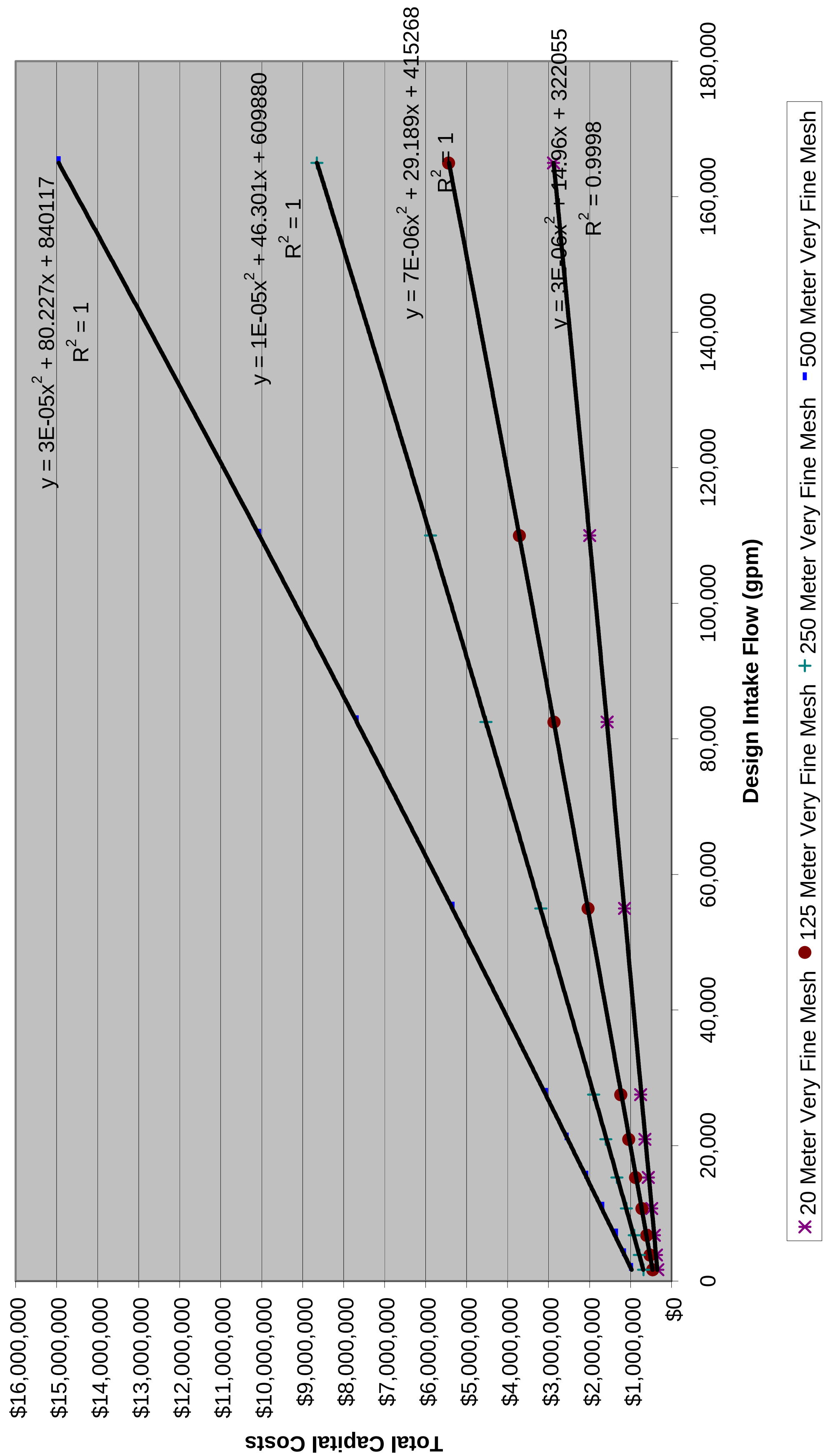


Figure 3-8. Total O&M Cost for Fine Mesh Passive Screen Relocated Offshore with Airburst Backwash

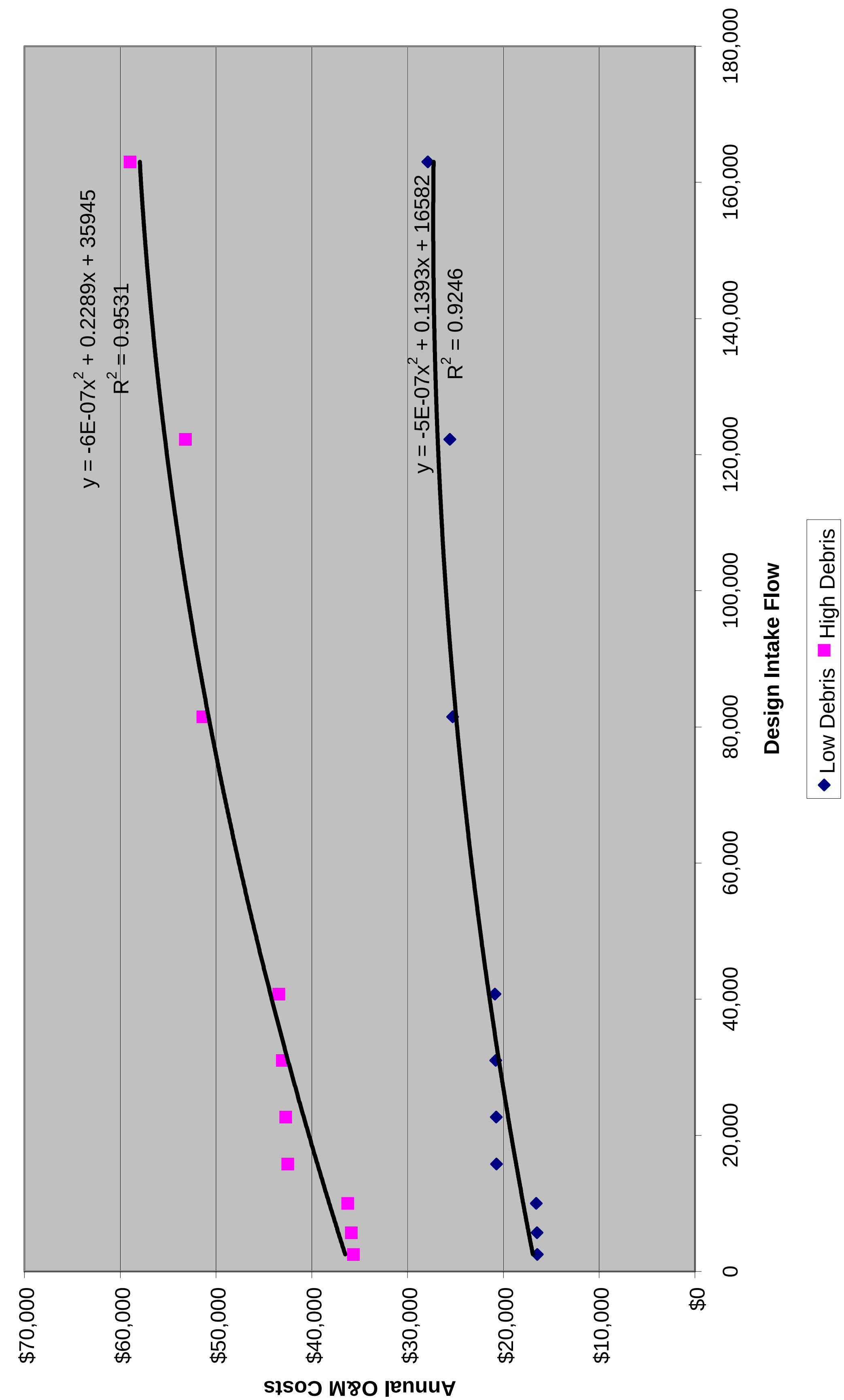


Figure 3-9. Total O&M Cost for Very Fine Mesh Passive Screen Relocated Offshore with Airburst Backwash

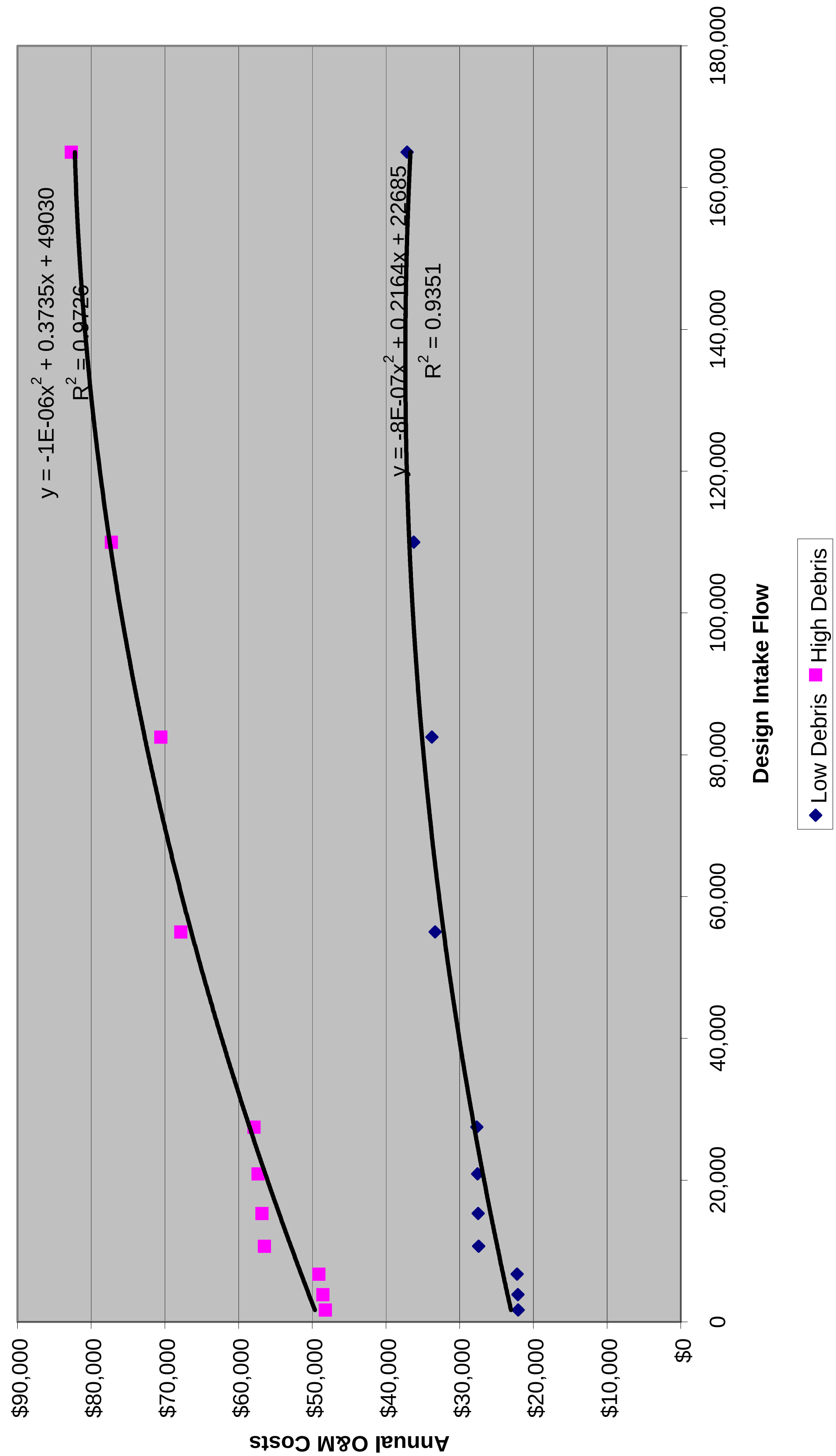


Figure 3-10. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Freshwater at Selected Offshore Distances

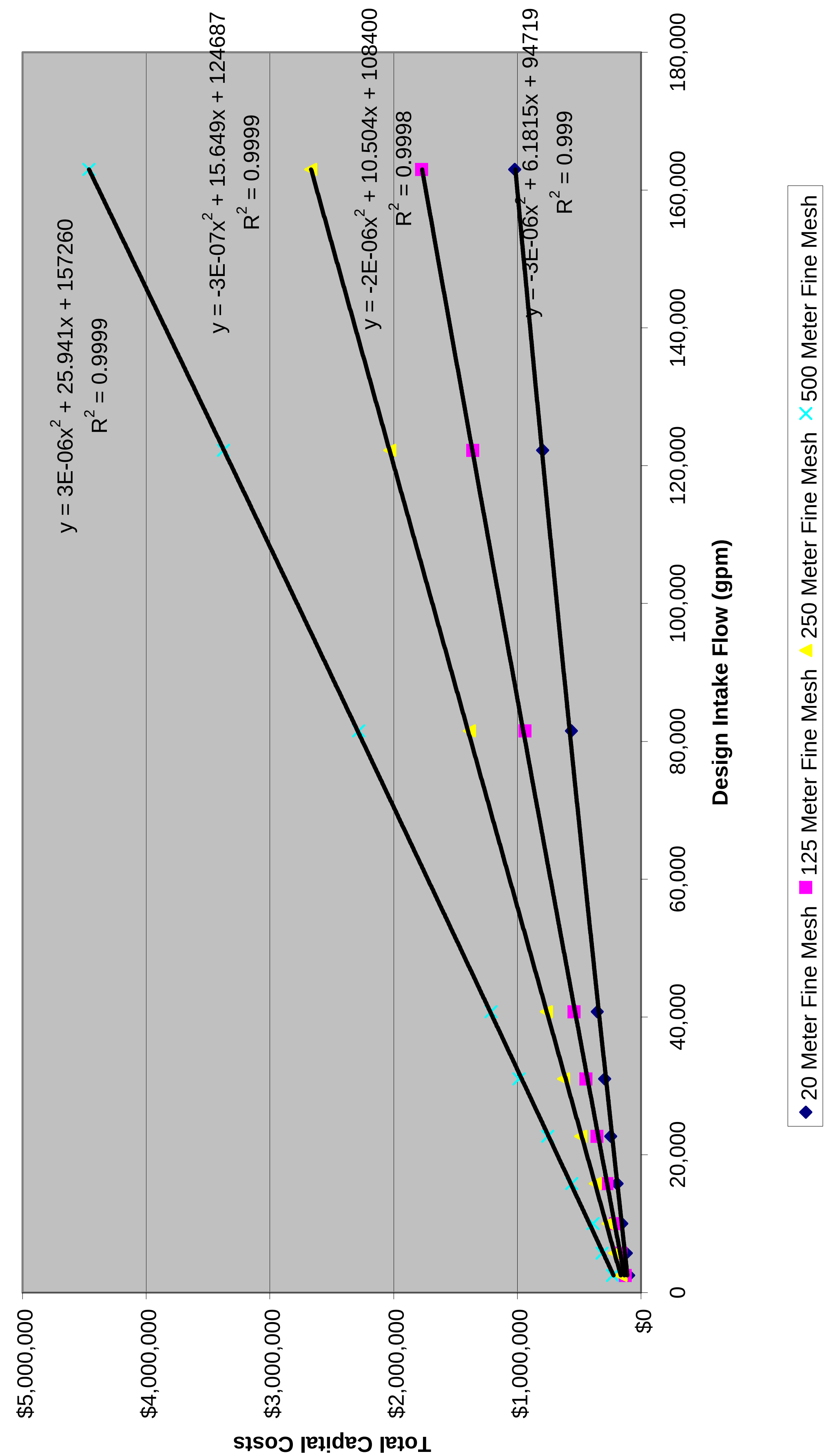


Figure 3-11. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Saltwater at Selected Offshore Distances

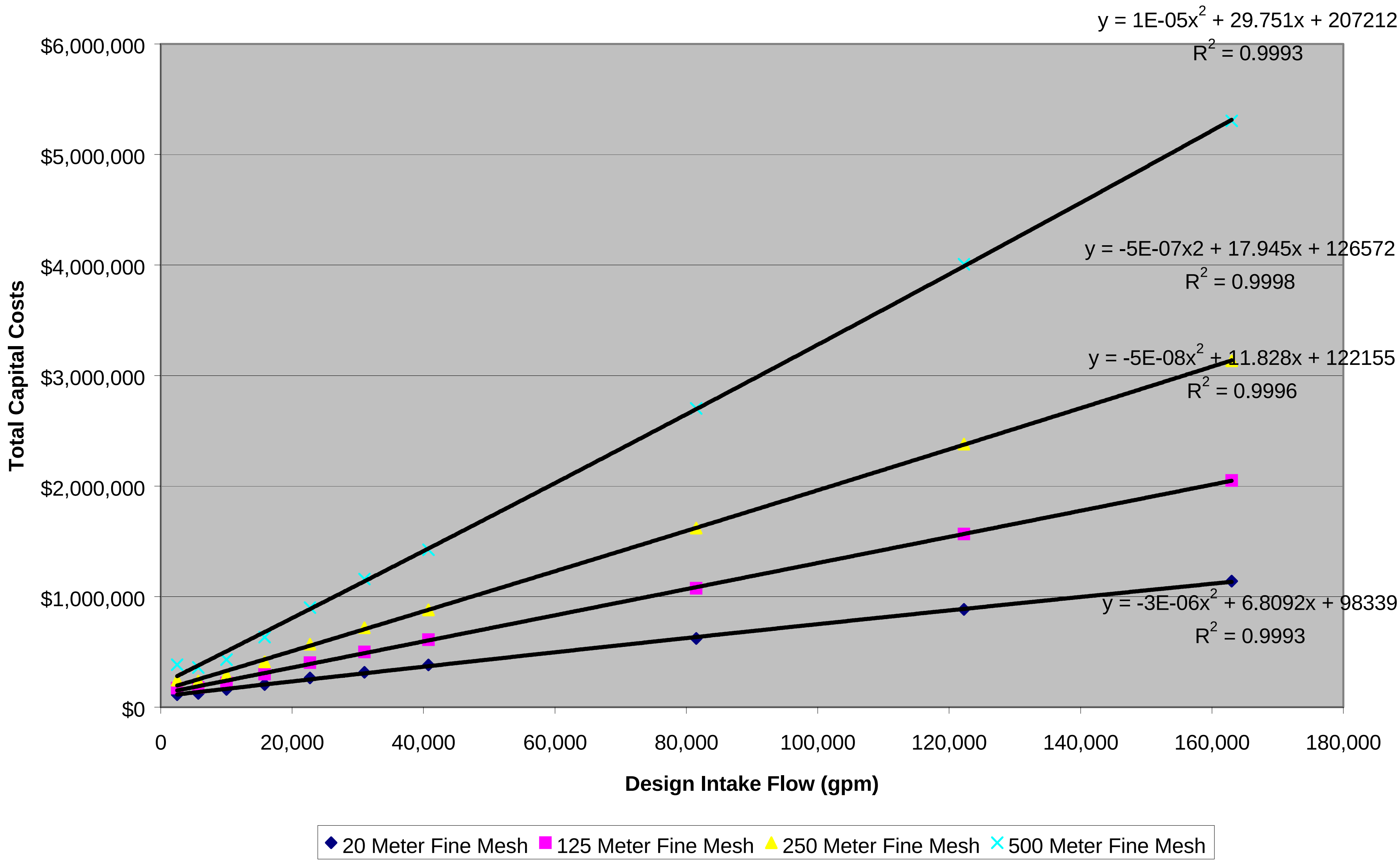


Figure 3-12. Capital Costs for Fine Mesh Passive Screen Existing Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

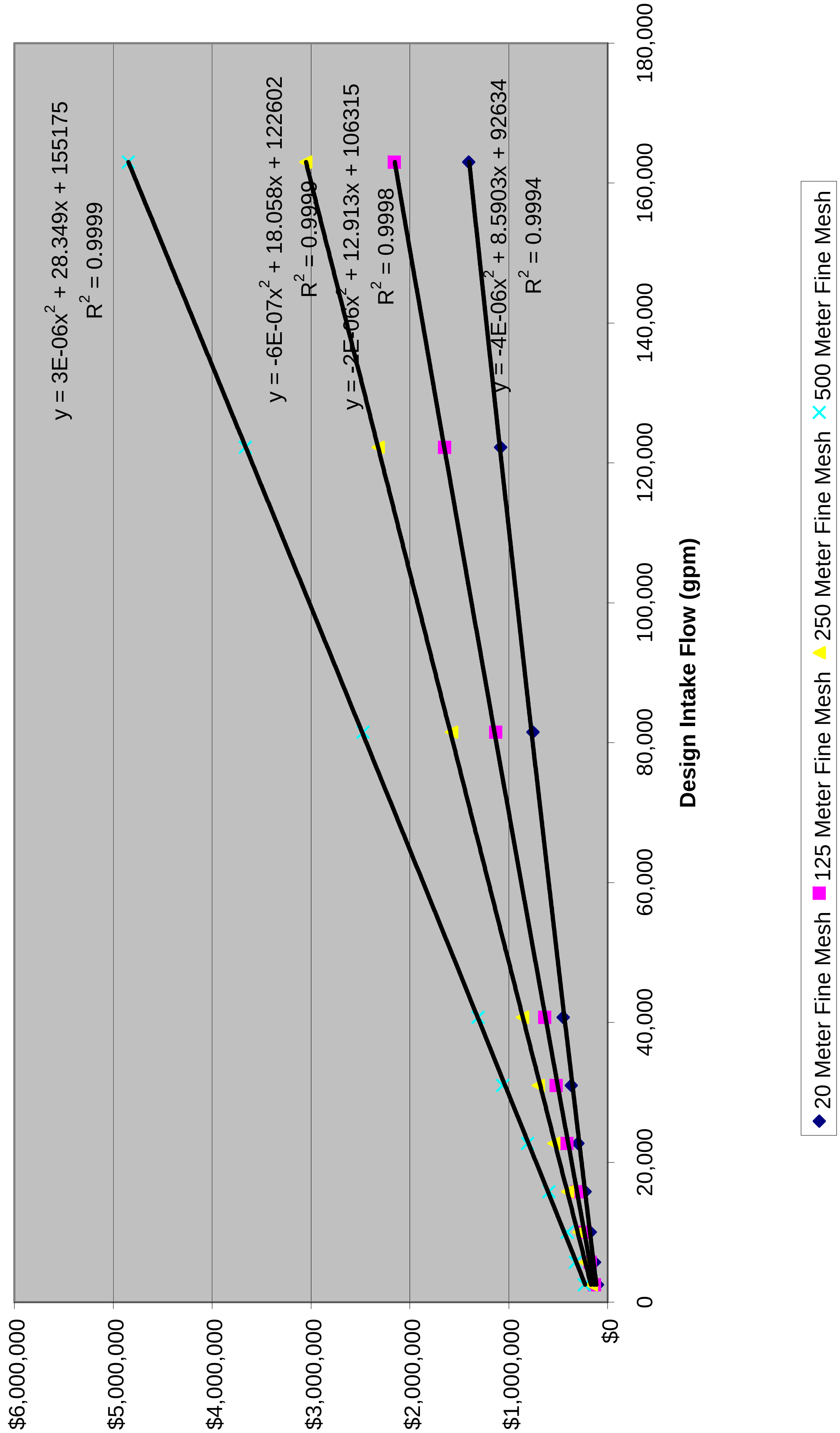


Figure 3-13. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Freshwater at Selected Offshore Distances

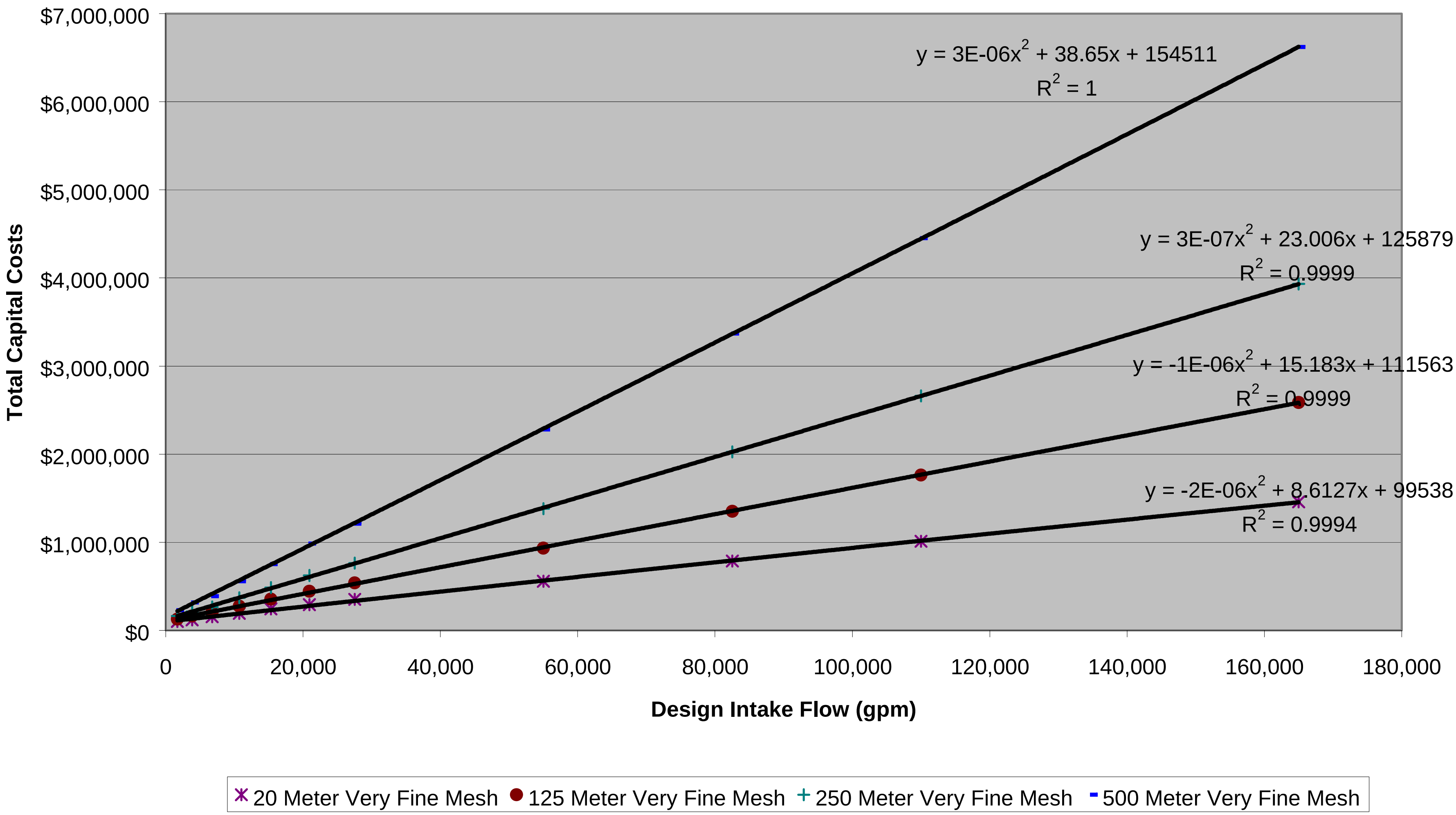


Figure 3-14. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Saltwater at Selected Offshore Distances

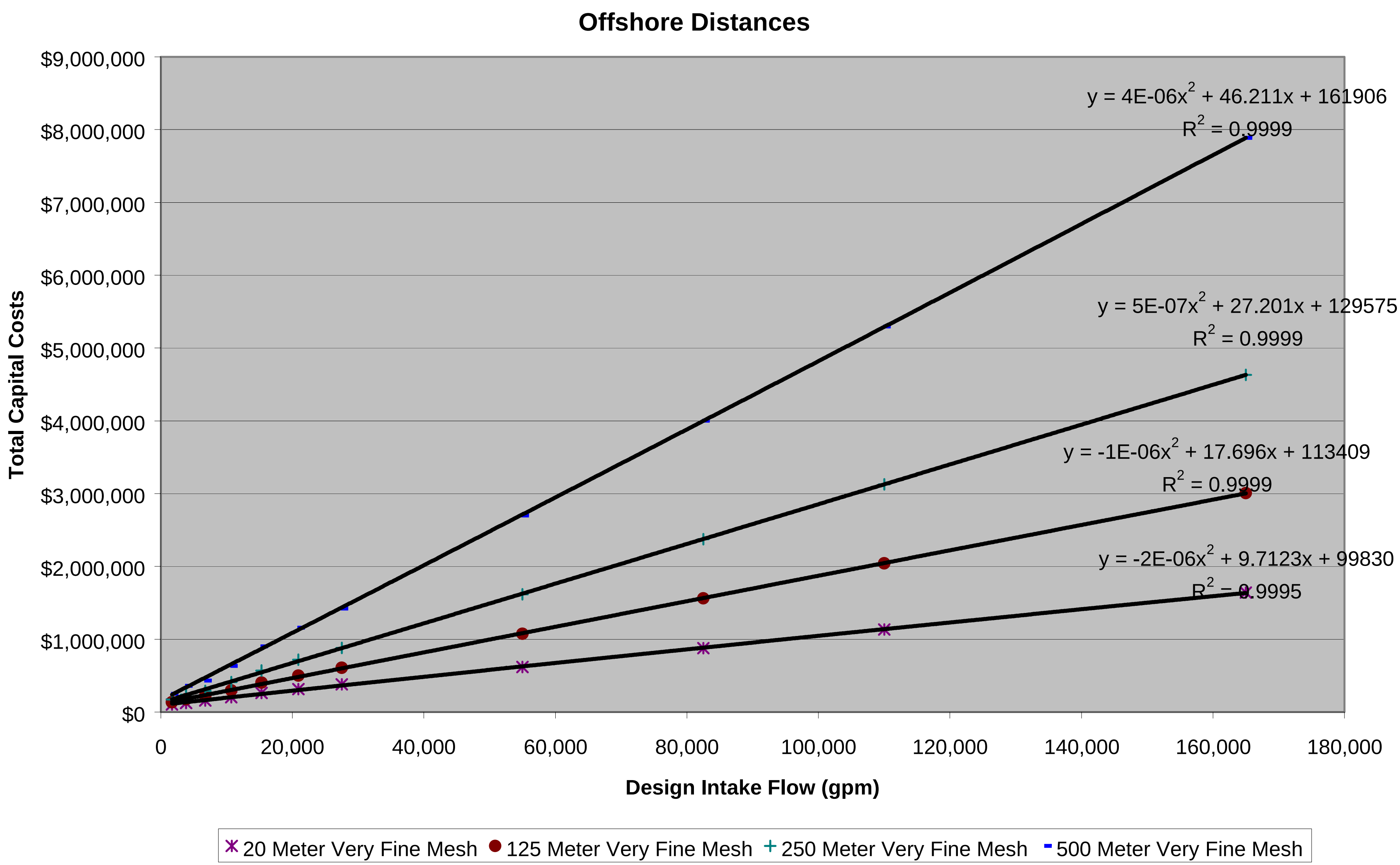


Figure 3-15. Capital Costs for Very Fine Mesh Passive Screen Existing Offshore in Freshwater with Zebra Mussels at Selected Offshore Distances

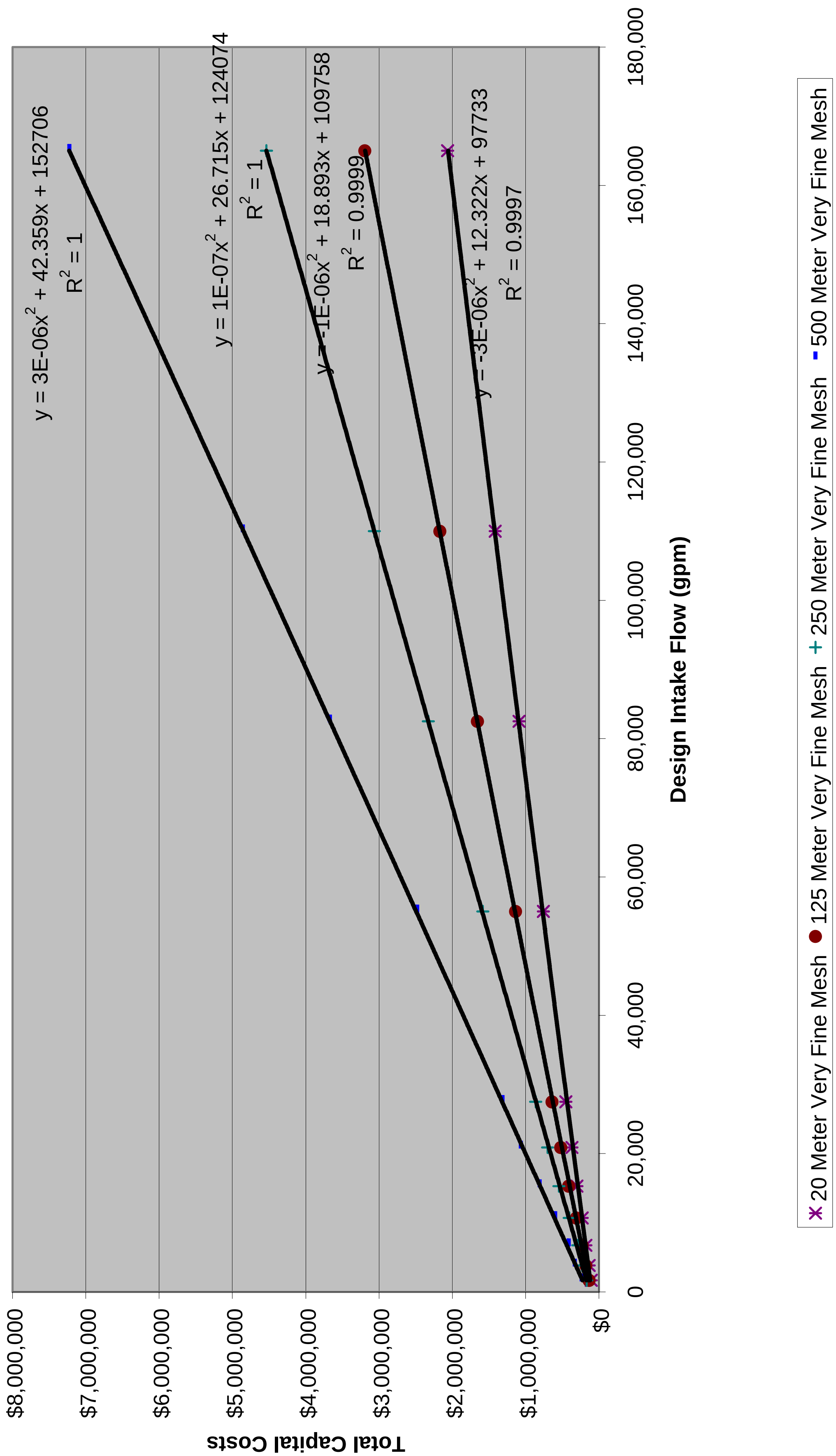


Figure 3-16. Total O&M Costs for Fine Mesh Passive Screen Existing Offshore with Airburst Backwash

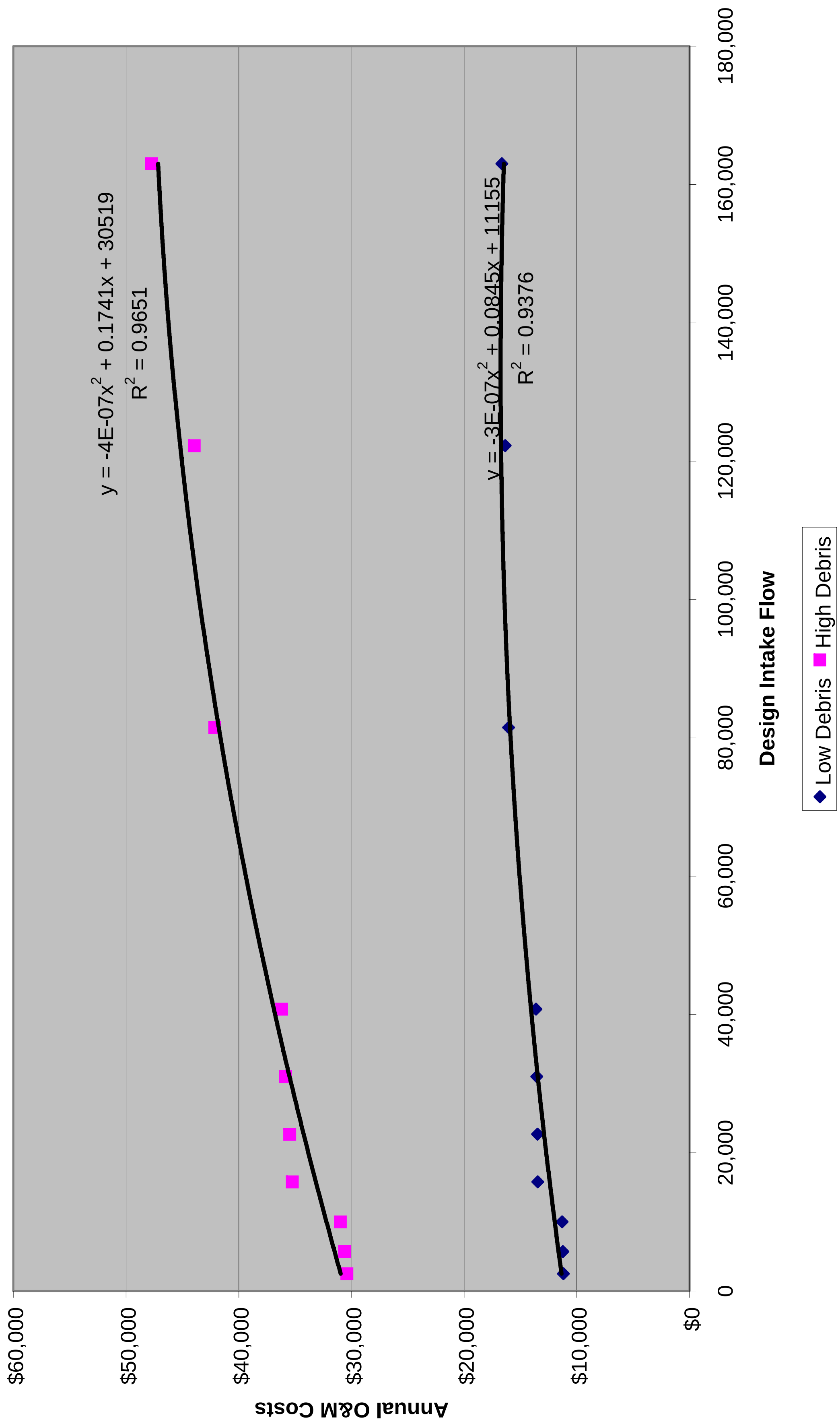
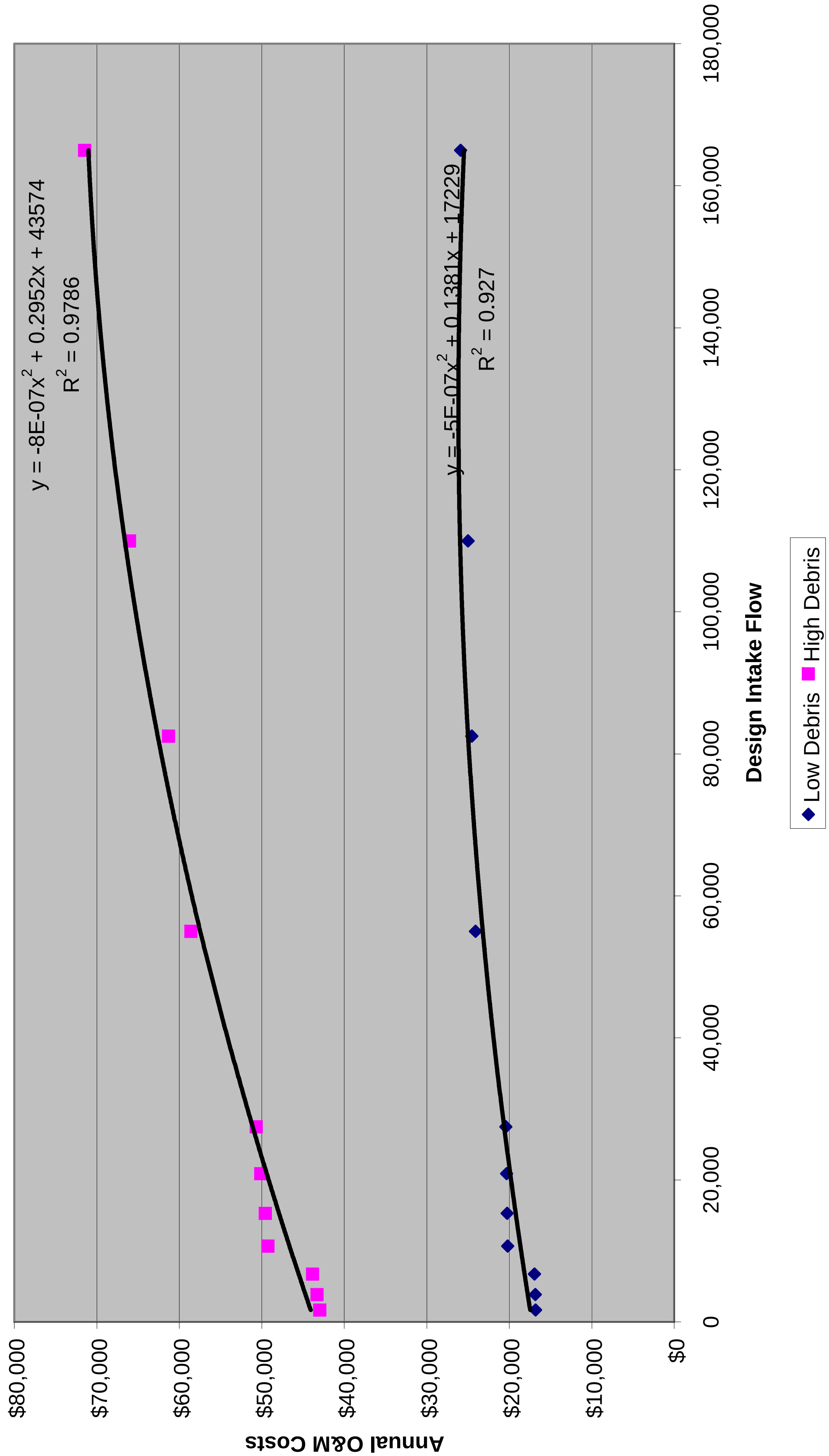


Figure 3-17. Total O&M Costs for Very Fine Mesh Passive Screen Existing Offshore with Airburst Backwash



2.0 IMPROVEMENTS TO EXISTING SHORELINE INTAKES WITH TRAVELING SCREENS

2.1 Replace Existing Traveling Screens with New Traveling Screen Equipment

The methodology described below is based on data, where available, from the Detailed Technical Questionnaires. Where certain facility data are unavailable (e.g., Short Technical Questionnaire facilities), the methodology generally uses statistical values (e.g., median values). The costs for traveling screen improvements described below are for installation in an existing or newly built intake structure. Where the existing intake is of insufficient design or size, construction costs for increasing the intake size are developed in a separate cost module and the cost for screen modification/installation at both the existing and/or new intake structure(s) are applied according to the estimated size of each.

Estimating Existing Intake Size

The capital cost of traveling screen equipment is highly dependent on the size and surface area of the screens employed. In developing compliance costs for existing facilities in Phase I, a single target, through-screen velocity was used. This decision ensured the overall screen area of the units being costed was a direct function of design flow. Thus, EPA could rely on a cost estimating methodology for traveling screens that focused primarily on design flow. In the Phase I approach, a single screen width was chosen for a given flow range. Variations in cost were generally based on differences in screen well depth. Where the flow exceeded the maximum flow for the largest screen costed, multiples of the largest (14 feet wide) screens were costed. Because, in this instance, EPA was applying it’s cost methodology to hypothetical facilities, screen well depth could be left as a dependent variable. However, for existing facilities this approach is not tenable because existing screen velocities vary considerably between facilities. Because the size of the screens is very much dependent on design flow and screen velocity, a different approach -- one that first estimates the size of the existing screens -- is warranted.

Estimating Total Screen Width

Available data from the Detailed Questionnaires concerning the physical size of existing intake structures and screens are limited to vertical dimensions (e.g., water depth, distance of water surface to intake deck, and intake bottom to water surface). Screen width dimensions (parallel to shore) are not provided. For each model facility EPA has developed data concerning actual and estimated design flow. Through-screen velocity is available for most facilities--even those that completed only the Short Technical Questionnaire. Given the water depth, intake flow, and through screen velocity, the aggregate width of the intake screens can be estimated using the following equation:

Screen Width (Ft) = Design Flow (cfs) / (Screen Velocity (feet per second) x Water Depth (Ft) x Open Area (decimal %))

The variables “design Flow,” “screen velocity,” and “water depth” can be obtained from the database for most facilities that completed the Detailed Technical Questionnaire. These database values may not always correspond to the same waterbody conditions. For example, the screen velocity may correspond to low flow conditions while the water depth may represent average conditions. Thus, calculated screen widths may differ from actual values, but likely represents a reasonable estimate, especially given the limited available data. EPA considers the above equation to be a reasonable method for estimating the general size of the existing intake for cost estimation purposes. Determining the value for water depth at the intake, where no data is available, is described below.

The last variable in the screen width equation is the percent open area, which is not available in the database. However, the majority of the existing traveling screens are coarse mesh screens (particularly those requiring equipment upgrades). In most cases (at least for power plants), the typical mesh size is 3/8 inch (Petrovs 2002, Gathright 2002). This mesh size corresponds to an industry standard that states the mesh size should be half the diameter of the downstream heat exchanger tubes. These tubes are typically around 7/8 inch in diameter for power plant steam condensers. For a mesh size of 3/8 inch, the corresponding percent open area for a square mesh screen using 14 gauge wire is 68%. This combination was reported as “typical” for coarse mesh screens (Gathright 2002). Thus, EPA will use an assumed percent open area value of 68% in the above equation.

At facilities where the existing through-screen velocity has been determined to be too high for fine mesh traveling screens to perform properly, a target velocity of 1.0 feet per second was used in the above equation to estimate the screen width that would correspond to the larger size intake that would be needed.

Screen Well Depth

The costs for traveling screens are also a function of screen well depth, which is not the same as the water depth. The EPA cost estimates for selected screen widths have been derived for a range of screen well depths ranging from 10 feet to 100 feet. The screen well depth is the distance from the intake deck to the bottom of the screen well, and includes both water depth and distance from the water surface to the deck. For those facilities that reported "distance from intake bottom to water surface" and "distance from water surface to intake top," the sum of these two values can be used to determine actual screen well depth. For those Phase III facilities that did not report this data, statistical values such as the median were used. The median value of the ratio of the water depth to the screen well depth for all facilities that reported such data was 0.66. Thus, based on median reported values, the screen well depth can be estimated by assuming it is 1.5 times the water depth where only water depth is reported. For those Phase III facilities that reported water depth data, the median water depth at the intake was 18.0 feet.

Based on this discussion, screen well depth and intake water depth are estimated using the following hierarchy:

- If "distance from intake bottom to water surface" plus "distance from water surface to intake top" are reported, then the sum of these values are used for screen well depth
- If only the "distance from intake bottom to water surface" and/or the "depth of water at intake" are reported, one of these values (if both are known, the former selected is over the latter) is multiplied by a factor of 1.5
- If no depth data are reported, this factor is applied to the median water depth value of 18 feet (i.e., 27 feet) and this value is used.

This approach leaves open the question of which costing scenario well depth should be used where the calculated or estimated well depth does not correspond to the depths selected for cost estimates. EPA has selected a factor of 1.2 as the cutoff for using a shallower costing well depth. Exhibit 3-18 shows the range of estimated well depths that correspond to the specific well depths used for costing.

Exhibit 3-18. Guidance for Selecting Screen Well Depth for Cost Estimation

Calculated or Estimated Screen Well Depth (Ft)	Well Depth to be Costed
0-12 ft	10 ft
>12-30 ft	25 ft
>30-60 ft	50 ft
>60-90 ft	75 ft

Traveling Screen Replacement Options

Compliance action requirements developed for each facility may result in one of the following traveling screen improvement options:

- No Action.
- Add Fine Mesh Only (improves entrainment performance).
- Add Fish Handling Only (improves impingement performance).
- Add Fine Mesh and Fish Handling (improves entrainment and impingement performance).

Exhibit 3-19 shows potential combinations of existing screen technology and replacement technologies that are applied to these traveling screen improvement options. In each case, there are separate costs for freshwater and saltwater environments.

Areas highlighted in grey in Exhibit 3-19 indicate that the compliance scenario is not compatible with the existing technology combination. The table shows there are three possible technology combination scenarios that for a retrofit involving modifying the existing intake structure only,. Each scenario is described briefly below:

Scenario A - Add fine mesh only

This scenario involves simply purchasing a separate set of fine mesh screen overlay panels and installing them in front of the existing coarse mesh screens. This placement may be performed on a seasonal basis. This option is not considered applicable to existing screens without fish handling and return systems, since the addition of fine mesh will retain additional aquatic organisms that would require some means for returning them to the waterbody. Corresponding compliance O&M costs include seasonal placement and removal of fine mesh screen overlay panels.

Exhibit 3-19. Compliance Action Scenarios and Corresponding Cost Components

Compliance Action	Cost Component Included in EPA Cost Estimates	Existing Technology	
		Traveling Screens Without Fish Return	Traveling Screens With Fish Return
Add Fine Mesh Only (Scenario A)	New Screen Unit	NA	No
	Add Fine Mesh Screen Overlay	NA	Yes
	Fish Buckets	NA	No
	Add Spray Water Pumps	NA	No
	Add Fish Flume	NA	No
Add Fish Handling Only (Scenario B)	New Screen Unit[1]	Yes	NA
	Add Fine Mesh Screen Overlay[2]	No	NA
	Fish Buckets	Yes	NA
	Add Spray Water Pumps	Yes	NA
	Add Fish Flume	Yes	NA
Add Fine Mesh With Fish Handling (Scenario C and Dual-Flow Traveling Screens)	New Screen Unit	Yes	NA
	Add Fine Mesh Screen Overlay	Yes[3]	NA
	Fish Buckets	Yes	NA
	Add Spray Water Pumps	Yes	NA
	Add Fish Flume	Yes	NA

[1] Replace entire screen unit, includes one set of smooth top or fine mesh screen.
[2] Add fine mesh includes costs for a separate set of overlay fine mesh screen panels that can be placed in front of coarser mesh screens on a seasonal basis.
[3] Does not include initial installation labor for fine mesh overlays. Seasonal deployment and removal of fine mesh overlays is included in O&M costs.

Scenario B - Add fish handling and return

This scenario requires the replacement of all of the traveling screen units with new ones that include fish handling features, but no specific mesh requirements are included. Mesh size is assumed to be 1/8-inch by ½-inch smooth top. A less costly option would be to retain and retrofit portions of the existing screen units. However, vendors noted that approximately 75% of the existing screen components would require replacement and it would be more prudent to replace the entire screen unit (Gathright 2002, Petrovs 2002). Costs for additional spray water pumps and a fish return flume are included. Capital and O&M costs do not include any component for seasonal placement of fine mesh overlays.

Scenario C - Add fine mesh with fish handling and return

This scenario requires replacement of all screen units with units that include fish handling and return features plus additional spray water pumps and a fish return flume. Costs for a separate set of fine mesh screen overlay panels with seasonal placement are included.

Double Entry-Single Exit (Dual-Flow) Traveling Screens

The conditions for scenario C also apply to dual-flow traveling screens described separately below.

Fine Mesh Screen Overlay

Several facilities that have installed fine mesh screens found that during certain periods of the year the debris loading created operating problems. These problems prompted operators to remove fine mesh screens and replace them with coarser screens for the duration of the period of high and/or troublesome debris. As a high-side approach, when fine mesh screens replace coarse mesh screens (Scenarios A and C), EPA has decided to include costs for using two sets of screens (one coarser mesh screen such as 1/8-inch by 1/4-inch smooth top and one fine mesh overlay) with annual placement and removal of the fine mesh overlay. This placement of fine mesh overlay can occur for short periods when sensitive aquatic organisms are present or for longer periods being removed only during a the period when troublesome debris is present. Fine mesh screen overlays are also included in the costs for dual-flow traveling screens described separately below.

Mesh Type

In general three different types of mesh are considered here. One is the coarse mesh which is typical in older installations. Coarse mesh is considered to be the baseline mesh type and the typical mesh size is 3/8 inch square mesh. When screens are replaced, two types of mesh are considered. One is fine mesh, which is assumed to have openings in the 1 to 2 mm range. The other mesh type is the smooth top mesh. Smooth top mesh has smaller openings (at least in one dimension) than coarse mesh (e.g., 1/8-inch by ½-inch is a common size) and is manufactured in a way that reduces the roughness that is associated with coarse mesh. Smooth top mesh is used in conjunction with screens that have fish handling and return systems. The roughness of standard coarse mesh has been blamed for injuring (descaling) fish as they are washed over the screen surface when they pass from the fish bucket to the return trough during the fish wash step. Due to the tighter weave of fine mesh screens, roughness is not an issue when using fine mesh.

2.1.1 Traveling Screen Capital Costs

The capital cost of traveling screen equipment is generally based on the size of the screen well (width and depth), construction materials, type of screen baskets, and ancillary equipment requirements. While EPA has chosen to use the same mix of standard screen widths and screen well depths as were developed for the new facility Phase I effort, as described above, the corresponding water depth, design flow, and through-screen velocities in most cases differ. As presented in Exhibit 3-19, cost estimates do not need to include a compliance scenario where replacement screen units without fish handling and return equipment are installed. Unlike the cost methodology developed for Phase I, separate costs are developed in Phase III costing for equipment suitable for freshwater and saltwater environments. Costs for added spray water pumps and fish return flumes are described below, but unlike the screening equipment are generally a function of screen width only.

Screen Equipment Costs

EPA contacted traveling screen vendors to obtain updated costs for traveling screens with fine mesh screens and fish handling equipment for comparison to the 1999 costs developed for Phase I. Specifically, costs for single entry-single exit (through-flow) screens with the following attributes were requested:

-Spray systems
-Fish trough
-Housings and transitions
-Continuous operating features
-Drive unit
-Frame seals
-Engineering
-Freshwater versus saltwater environments.

Only one vendor provided comparable costs (Gathright 2002). The costs for freshwater environments were based on equipment constructed primarily of epoxy-coated carbon steel with stainless steel mesh and fasteners. Costs for saltwater and brackish water environments were based on equipment constructed primarily of 316 stainless steel with stainless steel mesh and fasteners.

EPA compared these newly obtained equipment costs to the costs for similar freshwater equipment developed for Phase I, adjusted for inflation to July 2002 dollars. EPA found that the newly obtained equipment costs were lower by 10% to 30%. In addition, a comparison of the newly obtained costs for brackish water and freshwater screens showed that the costs for saltwater equipment were roughly 2.0 times the costs for freshwater equipment. This factor of approximately 2.0 was also suggested by a separate vendor (Petrovs 2002). Rather than adjust the Phase I equipment costs downward, EPA chose to conclude that the Phase I freshwater equipment costs adjusted to 2002 were valid (if not somewhat overestimated), and that a factor of 2.0 would be reasonable for estimating the cost of comparable saltwater/brackish water equipment. Exhibits 3-20 and 3-21 present the Phase I equipment costs, adjusted for inflation to July 2002 dollars, for freshwater and saltwater environments respectively.

Exhibit 3-20. Equipment Costs for Traveling Screens with Fish Handling for Freshwater Environments, 2002 Dollars

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$69,200	$80,100	$102,500	$147,700
25	$88,600	$106,300	$145,000	$233,800
50	$133,500	$166,200	$237,600	$348,300
75	$178,500	$228,900	$308,500	$451,800
100	$245,300	$291,600	$379,300	$549,900

Exhibit 3-21. Equipment Costs for Traveling Screens with Fish Handling for Saltwater Environments, 2002 Dollars

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$138,400	$160,200	$205,000	$295,400
25	$177,200	$212,600	$290,000	$467,600
50	$267,000	$332,400	$475,200	$696,600
75	$357,000	$457,800	$617,000	$903,600
100	$490,600	$583,200	$758,600	$1,099,800

Costs for fine mesh screen overlay panels were cited as approximately 8% to 10% of the total screen unit costs (Gathright 2002). The EPA cost estimates for fine mesh overlay screen panels are based on a 10% factor applied to the screen equipment costs shown in Exhibit 3-20 and 3-21. Note that if the entire screen basket required replacement, then the costs would increase to about 25% to 30% of the screen unit costs (Gathright 2002, Petrovs 2002). However, in the scenarios considered here, basket replacement would occur only when fish handling is being added. In those scenarios, EPA has chosen to assume that the entire screen unit will require replacement. The cost of new traveling screen units with smooth top mesh is only about 2% above that for fine mesh (Gathright 2002). EPA has concluded that the cost for traveling screen units with smooth top mesh is nearly indistinguishable from that for fine mesh. Therefore, EPA has not developed separate costs for each.

Screen Unit Installation Costs

Vendors indicated that the majority of intakes have stop gates or stop log channels that enable the isolation and dewatering of the screen wells. Thus, EPA assumes, in most cases, screens can be replaced and installed in dewatered screen wells without the use of divers. When asked whether most screens were accessible by crane, a vendor did note that about 70% to 75% may have problems accessing the intake screens by crane from overhead. In such cases, the screens are dismantled (screen panels are removed, chains are removed and screen structure is removed in sections that key into each other). Such overhead access problems may be due to structural cover or buildings, and access is often through the side wall. According to one vendor, this screen dismantling requirement may add 30% to the installation costs. For those installations that do not need to dismantle screens, these costs typically are $15,000 to $30,000 per unit (Petrovs 2002). Another vendor cited screen installation costs as +/- $45,000 per screen giving an example of $20,000 for a 15-foot screen plus the costs of a crane and forklift ($15,000 - $20,000 divided between screens) (Gathright 2002). Note that these installation costs are for the typical range of screen sizes; vendors noted that screens in the range of the 100-foot well depth are rarely encountered.

Exhibit 3-22 presents the installation costs developed from vendor supplied data. These costs include crane and forklift costs and are presented on a per screen basis. Phase I installation costs included an intake construction component not included in Phase III costs. The costs shown here assume the intake structure and screen wells are already in-place. Therefore, installation involves removing existing screens and installing new screens in their place. Any costs for increasing the intake size are developed as a separate module. Vendors indicated costs for disposing of the existing screens were minimal. The cost of removal and disposal of old screens, therefore, are assumed to be included in the Exhibit 3-22 estimates.

Exhibit 3-22. Traveling Screen Installation Costs

Well Depth	Basket Screening Panel Width (Ft)			
(Ft)	2	5	10	14
10	$15,000	$18,000	$21,000	$25,000
25	$22,500	$27,000	$31,500	$37,000
50	$30,000	$36,000	$42,000	$50,000
75	$37,500	$45,000	$52,500	$62,500
100	$45,000	$54,000	$63,000	$75,000

Installation of Fine Mesh Screen Panel Overlays

Screen panel overlay installation and removal costs are based on an estimate of the amount of labor required to replace each screen panel. Vendors provided the following estimates for labor to replace screen baskets and panels (Petrovs 2002, Gathright 2002):

- 1.0 hours per screen panel overlay (1.5 hours to replace baskets and panel)
- Requires two-man team for small screen widths (assumed to be 2- and 5-foot wide screens)
- Requires three-man team for large screen widths (assumed to be 10- and 14-foot wide screens)
- Number of screen panels is based on 2-foot tall screen panels on front and back extending 6 feet above the deck. Thus, a screen for a 25-foot screen well is estimated to have 28 panels.

Labor costs are based on a composite labor rate of $41.10/hr (See O&M cost section).

These assumptions apply to installation costs for Scenario A. These same assumptions also apply to O&M costs for fine mesh screen overlay in Scenarios A and C, where it is applied twice for seasonal placement and removal.

Indirect Costs Associated with Replacement of Traveling Screens

EPA noted that equipment costs (Exhibits 3-20 and 3-21) included the engineering component and that installation costs (Exhibit 3-22) included costs for contractor overhead and profit. Because the new screens are designed to fit the existing screen well channels and the existing structure is of a known design, contingency and allowance costs should be minimal. Also, no costs for sitework were included because existing intakes, in most cases, should already have provisions for equipment access. Because inflation-adjusted equipment costs exceeded the recently obtained equipment vendor quotation by 10% to 30%, EPA has concluded any indirect costs are already included in the equipment cost component.

Combining Per Screen Costs with Total Screen Width

As noted above, total screen costs are estimated using a calculated screen width as the independent variable. In many cases, this calculated width will involve using more than one screen, particularly if the width is greater than 10 to 14 feet. Vendors have indicated there is a general preference for using 10-foot wide screens over 14-foot screens, but that 14-foot screens are more economical (reducing civil structure costs) for larger installations. The screen widths and corresponding number and screens used to plot screen cost data and develop cost equations are as follows:

2 ft	=	a single	2-ft screen
5 ft	=	a single	5-ft screen
10 ft	=	a single	10-ft screen

20 ft	=	two	10-ft screens
30 ft	=	three	10-ft screens
40 ft	=	four	10-ft screens
50 ft	=	five	10-ft screens
60 ft	=	six	10-ft screens
70 ft	=	five	14-ft screens
84 ft	=	six	14-ft screens
98 ft	=	seven	14-ft screens
112 ft	=	eight	14-ft screens
126 ft	=	nine	14-ft screens
140 ft	=	ten	14-ft screens.

Any widths greater than 140 feet are divided and the costs for the divisions are summed.

Ancillary Equipment Costs for Fish Handling and Return System

When adding a screen with a fish handling and return system where no fish handling system existed before, there are additional requirements for spray water and a fish return flume. The equipment and installation costs for the fish troughs directly adjacent to the screen and spray system are included in the screen unit and installation costs. However, the costs for pumping additional water for the new fish spray nozzles and the costs for the fish return flume from the end of the intake structure to the discharge point are not included. Fish spray and flume volume requirements are based solely on screen width and are independent of depth.

Pumps for Spray Water

Wash water requirements for the debris wash and fish spray were obtained from several sources. Where possible, the water volume was divided by the total effective screen width to obtain the unit flow requirements (gpm/ft). Total unit flow requirements for both debris wash and fish spray combined ranged from 26.7 gpm/ft to 74.5 gpm/ft. The only data with a breakdown between the two uses reported a flow of 17.4 gpm/ft for debris removal and 20.2 gpm/ft for fish spray, with a total of 37.5 gpm/ft (Petrovs 2002). Based on these data, EPA assumed a total of 60 gpm/ft with each component being equal at 30 gpm/ft. These values are near the high end of the ranges reported and were selected to account for additional water needed at the upstream end of the fish trough to maintain a minimum depth.

Because the existing screens already have pumps to provide the necessary debris spray flow, only the costs for pumps sized to deliver the added fish spray are included in the capital cost totals. Costs for the added fish spray pumps are based on the installed equipment cost estimates developed for Phase I, adjusted to July 2002 dollars. These costs already include an engineering component. An additional 10% was added for contingency and allowance. Also, 20% was added to theses costs to account for any necessary modifications to the existing intake (based on BPJ). Exhibit 3-23 presents the costs for adding pumps for the added fish spray volume.

The costs in Exhibit 3-23 were plotted and a best-fit, second-order equation derived from the data. Pump costs were then projected from this equation for the total screen widths described earlier.

Exhibit 3-23. Fish Spray Pump Equipment and Installation Costs

Centrifugal Pump Flow (gpm)	Costs for Centrifugal Pumps - Installed (1999 Dollars)	Pump Costs Adjusted to July 2002	Retrofit Cost & Indirect Costs	Total Installed Cost
10	$800	$872	$262	$1,134
50	$2,250	$2,453	$736	$3,189
75	$2,500	$2,725	$818	$3,543
100	$2,800	$3,052	$916	$3,968
500	$3,700	$4,033	$1,210	$5,243
1,000	$4,400	$4,796	$1,439	$6,235
2,000	$9,000	$9,810	$2,943	$12,753
4,000	$18,000	$19,620	$5,886	$25,506

Fish Return Flume

In the case of the fish return flume, the total volume of water to be carried was assumed to include both the fish spray water and the debris wash water. A total unit flow of 60 gpm/ft screen width was assumed as a conservative value for estimating the volume to be conveyed. Return flumes may take the form of open troughs or closed pipe and are often constructed of reinforced fiberglass (Gathright 2002, Petrovs 2002). The pipe diameter is based on an assumed velocity of 1.5 feet per second, which is at the low end of the range of pipe flow velocities. Higher velocities will result in smaller pipes. Actual velocities may be much higher in order to ensure fish are transported out of the pipe. With lower velocities fish can continually swim upstream. Vendors have noted that the pipes do not tend to flow full, so basing the cost on a larger pipe sized on the basis of a low velocity is a reasonable approach.

Observed flume return lengths varied considerably. In some cases, where the intake is on a tidal waterbody, two return flumes may be used alternately to maintain the discharge in the downstream direction of the receiving water flow. A traveling screen vendor suggested lengths of 75 to 150 feet (Gathright 2002). EPA reviewed facility description data and found example flume lengths ranging from 30 ft to 300 ft for intakes without canals, and up to several thousand feet for those with canals. For the compliance scenario typical flume length, EPA chose the upper end of the range of examples for facilities without intake canals (300 ft). For those intakes located at the end of a canal, the cost for the added flume length to get to the waterway (assumed equal to canal length) is estimated by multiplying an additional unit cost-per-ft times the canal length. This added length cost is added to the non-canal facility total cost.

To simplify the cost estimation approach, a unit pipe/support structure cost ($/inch-diameter/ft-length) was developed based on the unit cost of a 12-inch reinforced fiberglass pipe at $70/ft installed (RS Means 2001) and the use of wood pilings at 10-foot intervals as the support structure. Piling costs assume that the average piling length is 15 feet and unit cost for installed pilings is $15.80/ft (RS Means 2001). The unit costs already include the indirect costs for contractor overhead and profit. Additional costs include 10% for engineering, 10% for contingency and allowance, and 10% for sitework. Sitework costs are intended to cover preparation and restoration of the work area adjacent to the flume. Based on these cost applied to an assumed 300-foot flume, a unit cost of $10.15/in diameter/ft was derived. Flume costs for the specific total screen widths were then derived based on a calculated flume diameter (using the assumed flow volume of 60 gpm/ft, the 1.5-feet per second velocity when full) times the unit cost and the length.

EPA was initially concerned whether there would be enough vertical head available to provide the needed gradient, particularly for the longer applications. In a typical application, the upstream end of the flume is located above the intake deck and the water flows down the flume to the water surface below. A vendor cited a minimum gradient requirement in the range of 0.001 to 0.005 ft drop/ft length. For a 300-foot pipe, the needed vertical head based on these gradients is only 0.3 feet to 1.5 feet. The longest example fish return length identified by EPA was 4,600 feet at the Brunswick, SC plant. The head needed for that return, based on the above minimum gradient range, is 4.6 feet to 23 feet. Based on median values from the industry questionnaire data base, intake decks are often about half the intake water depth above the water surface, EPA has concluded in most cases there was more than enough gradient available. Indeed, the data suggest if the return length is too short, there may be a potential problem from too great a gradient producing velocities that could injure fish.

Exhibit 3-24 presents the added spray water pumps costs, 300-foot flume costs and the unit cost for additional flume length above 300 feet. Note that a feasibility study for the Drayton Point power plant cited an estimated flume unit cost of $100/ft which does not include indirect costs but is still well below comparable costs shown in Exhibit 3-24.

Exhibit 3-24. Spray Pump and Flume Costs

Total Screen Width (ft)	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Fish Spray Flow at 30 gpm/ft (gpm)	60	150	300	600	900	1200	1500	1800	2100	2520	2940	3360	3780	4200
Pump Costs	$3,400	$3,900	$4,400	$5,500	$6,700	$8,100	$9,500	$11,100	$12,800	$15,300	$18,000	$21,000	$24,100	$27,500
Total Wash Flow at 60 gpm/ft (gpm)	120	300	600	1200	1800	2400	3000	3600	4200	5040	5880	6720	7560	8400
Pipe Dia at 1.5 fps (In)	6.0	8.0	12.0	16.0	20.0	23.0	25.0	28.0	30.0	33.0	35.0	38.0	40.0	42.0
Flume Costs at $10.15	$18,272	$24,362	$36,543	$48,724	$60,905	$70,041	$76,131	$85,267	$91,358	$100,493	$106,584	$115,720	$121,810	$127,901
Flume Cost per Ft Added	$61	$81	$122	$162	$203	$233	$254	$284	$305	$335	$355	$386	$406	$426

Total Capital Costs

Indirect costs such as engineering, contractor overhead and profit, and contingency and allowance have been included in the individual component costs as they apply. Exhibit 3-25 through 3-30 (at the end of this section) present the total capital costs for compliance scenarios A, B, and C for both freshwater and saltwater environments. These costs are then plotted in Figures 3-18 through 3-23, which also include the best-fit, second-order equations of the data. These equations are used in the estimation of capital costs for the various technology applications.

2.1.2 Downtime Requirements

Placement of the fine screen overlay panels (Scenario A & C) can be done while the screen is operating. The screens are stopped during the placement and, between the placement of each panel, the screen rotated once. Installation of the ancillary equipment for the fish return system can be performed prior to screen replacement. Only the step of replacing the screen units would require shutdown of that portion of the intake. Vendors have reported that it would take from one to three days to replace traveling screen units where fish troughs and new spray piping are needed. The total should be no more than two weeks for multiple screens (Gathright 2002). If necessary, facilities with multiple screens and pumps could operate at the reduced capacity associated with taking a single pump out of service. However, it would be more prudent to schedule the screen replacement during a scheduled maintenance shutdown which typically occurs on an annual basis. Even at the largest installations with numerous screens, there should be sufficient time during the scheduled maintenance period to replace the screens and install controls and piping. Therefore, EPA is not including any monetary consideration for unit downtime associated with screen replacement or installation. Downtime for modification or addition to the intake structure to increase its size are discussed in a separate cost module.

Nuclear Facilities

Costs for nuclear facilities are not presented here. However, these costs were estimated applying a 1.8 cost factor to the applicable non-nuclear facility costs (see passive screen module for discussion).

2.1.3 O&M Cost Development

In general, O&M costs for intake system retrofit involve calculating the net difference between the existing system O&M costs and the new system O&M costs. The Phase I O&M cost estimates for traveling screens were generally derived as a percentage of the capital costs. This approach, however, does not lend itself well to estimating differences in operating costs for retrofits that involve similar equipment but have different operating and maintenance requirements such as changes in the duration of the screen operation. Therefore, a more detailed approach was developed.

The O&M costs developed here include only those components associated with traveling screens. Because cooling water flow rates are assumed not to change as a result of the retrofit, the O&M costs associated with the intake pumps are not considered. For traveling screens, the O&M costs are broken down into three components: labor, power requirements, and parts replacement. The basis and assumptions for each are described below.

Labor Requirements

The basis for estimating the total annual labor cost is based on labor hours as described below. In each baseline and compliance scenario the estimated number of hours is multiplied times a single hourly rate of $41.10/hour. This rate was derived by first estimating the hourly rate for a manager and a technician. The estimated management and technician rates were based on Bureau of Labor Statistics hourly rates for management and electrical equipment technicians. These rates were multiplied by factors that estimate the additional costs of other compensation (e.g., benefits) to yield estimates of the total labor costs to the employer. These rates were adjusted for inflation to represent June 2002 dollars (see Doley 2002 for details). The two labor category rates were combined into one compound rate using the assumption that 90% of the hours applied to the technicians and 10% to management. A 10% management component was considered as reasonable because the majority of the work involves physical labor, with managers providing oversight and coordination with the operation of the generating units.

A vendor provided general guidelines for estimating basic labor requirements for traveling screens as averaging 200 hours and ranging from 100 to 300 hours per year per screen for coarse mesh screens without fish handling and double that for fine mesh screens with fish handling (Gathright 2002). The lower end of the range corresponds to shallow narrow screens and the high end of the range corresponds to the widest deepest screens. Exhibits 3-31 and 3-32 present the estimated annual number of labor hours required to operate and maintain a "typical" traveling screen.

Exhibit 3-31. Basic Annual O&M Labor Hours for Coarse Mesh Traveling Screens Without Fish Handling

Well Depth	Basket Screening Panel Width			
feet	2	5	10	14
10	100	150	175	200
25	120	175	200	225
50	130	200	225	250
75	140	225	250	275
100	150	250	275	300

Exhibit 3-32. Basic Annual O&M Labor Hours for Traveling Screens With Fish Handling

Well Depth	Basket Screening Panel Width (Ft)			
feet	2	5	10	14
10	78	78	117	117
25	168	168	252	252
50	318	318	477	477
75	468	468	702	702
100	618	618	927	927

When fine mesh screens are added as part of a compliance option, they are included as a screen overlay. EPA has assumed when sensitive aquatic organisms are present these fine mesh screens will be in place. EPA also assumes during times when levels of troublesome debris are present the facility will remove the fine mesh screen panels leaving the coarse mesh screen panels in place. The labor assumptions for replacing the screen panels are described earlier, but in this application the placement and removal steps occur once each per year. Exhibit 3-33 presents the estimated annual labor hours for placement and removal of the fine mesh overlay screens.

Exhibit 3-33. Total Annual O&M Hours for Fine Mesh Overlay Screen Placement and Removal

Well Depth	Basket Screening Panel Width			
feet	2	5	10	14
10	78	78	117	117
25	168	168	252	252
50	318	318	477	477
75	468	468	702	702
100	618	618	927	927

Operating Power Requirement

Power is needed to operate the mechanical equipment, specifically the motor drives for the traveling screens and the pumps that deliver the spray water for both the debris wash and the fish spray.

<u>Screen Drive Motor Power Requirement</u>

Coarse mesh traveling screens without fish handling are typically operated on an intermittent basis. When debris loading is low the screens may be operated several times per day for relatively short durations. Traveling screens with fish handling and return systems, however, must operate continuously if the fish return system is to function properly.

A vendor provided typical values for the horsepower rating for the drive motors for traveling screens which are shown in Exhibit 3-34. These values were assumed to be similar for all of the traveling screen combinations considered here. Different operating hours are assumed for screens with and without fish handling. This is due to the fact that screens with fish handling must be operated continuously. A vendor estimated that coarse mesh screens without fish handling are typically operated for a total of 4 to 6 hrs/day (Gathright 2002). The following assumptions apply:

- The system will be shut down for four weeks out of the year for routine maintenance
- For fine mesh, operating hours will be continuous (24 hrs/day)
- For coarse mesh, operating hours will be an average of 5 hours/day (range of 4 to 6)
- Electric motor efficiency of 90%
- Power cost of $0.04/kWh for power plants.

<u>Wash Water and Fish Spray Pump Power Requirement</u>

As noted previously, spray water is needed for both washing debris off of the screens (which occurs at all traveling screens) and for a fish spray (which is needed for screens with fish handling and return systems). The nozzle pressure for the debris spray can range from 80 to 120 psi. A value of 120 psi was chosen as a high value which would include any static pressure component. The following assumptions apply:

- Spray water pumps operate for the same duration as the traveling screen drive motors
- Debris wash requires 30 gpm/ft screen length
- Fish spray requires 30 gpm/ft screen length
- Pumping pressure is 120 psi (277 ft of water) for both
- Combined pump and motor efficiency is 70%
- Electricity cost is $0.04/KWh for power plants.

The pressure needed for fish spray is considerably less than that required for debris, but it is assumed that all wash water is pumped to the higher pressure and regulators are used to step down the pressure for the fish wash. Exhibits 3-35 and 3-36 present the power costs for the spray water for traveling screens without and with fish handling, respectively. Spray water requirements depend on the presence of a fish return system but are assumed to otherwise be the same regardless of the screen mesh size.

Exhibit 3-34. Screen Drive Motor Power Costs

				Power Costs - Fine Mesh			Power Costs - Coarse Mesh		
Screen Width	Well Depth	Motor Power	Electric Power	Operating Hours	Annual Power	Annual Power Costs at $/Kwh of	Operating Hours	Annual Power	Annual Power Costs at $/Kwh of
Ft	Ft	Hp	Kw		Kwh	$0.04		Kwh	$0.04
2	10	0.5	0.414	8,064	3,342	$134	1,680	696	$28
2	25	1	0.829	8,064	6,684	$267	1,680	1,393	$56
2	50	2.7	2.210	8,064	17,824	$713	1,680	3,713	$149
2	75	5	4.144	8,064	33,421	$1,337	1,680	6,963	$279
2	100	6.7	5.512	8,064	44,450	$1,778	1,680	9,260	$370
5	10	0.75	0.622	8,064	5,013	$201	1,680	1,044	$42
5	25	1.5	1.243	8,064	10,026	$401	1,680	2,089	$84
5	50	4	3.316	8,064	26,737	$1,069	1,680	5,570	$223
5	75	7.5	6.217	8,064	50,131	$2,005	1,680	10,444	$418
5	100	10.0	8.268	8,064	66,674	$2,667	1,680	13,891	$556
10	10	1	0.829	8,064	6,684	$267	1,680	1,393	$56
10	25	3.5	2.901	8,064	23,395	$936	1,680	4,874	$195
10	50	10	8.289	8,064	66,842	$2,674	1,680	13,925	$557
10	75	15	12.433	8,064	100,262	$4,010	1,680	20,888	$836
10	100	20.0	16.536	8,064	133,349	$5,334	1,680	27,781	$1,111
14	10	2	1.658	8,064	13,368	$535	1,680	2,785	$111
14	25	6.25	5.181	8,064	41,776	$1,671	1,680	8,703	$348
14	50	15	12.433	8,064	100,262	$4,010	1,680	20,888	$836
14	75	20	16.578	8,064	133,683	$5,347	1,680	27,851	$1,114
14	75	26.6	22.048	8,064	177,799	$7,112	1,680	37,041	$1,482

Exhibit 3-35. Wash Water Power Costs Traveling Screens Without Fish Handling

						Fine Mesh			Coarse Mesh		
Screen Width	Flow Rate	Total Head	Hydraulic-Hp	Brake-Hp	Power Requirement	Annual Hours	Annual Power	Total Costs at $/Kwh of	Annual Hours	Annual Power	Total Costs at $/Kwh of
ft	gpm	ft	Hp	Hp	Kw	hr	Kwh	$0.04	hr	Kwh	$0.04
2	60	277	4.20	6.0	4.5	8064	36,072	$1,443	1680	7,515	$301
5	150	277	10.49	15.0	11.2	8064	90,179	$3,607	1680	18787	$751
10	300	277.1	20.98	30.0	22.4	8064	180,359	$7,214	1680	37575	$1,503
14	420	277	29.37	42.0	31.3	8064	252,502	$10,100	1680	52605	$2,104

Exhibit 3-36. Wash Water and Fish Spray Power Costs Traveling Screens With Fish Handling

						Fine Mesh			Coarse Mesh		
Screen Width	Flow Rate	Total Head	Hydraulic-Hp	Brake-Hp	Power Requirement	Annual Hours	Annual Power	Total Costs at $/Kwh of	Annual Hours	Annual Power	Total Costs at $/Kwh of
ft	gpm	ft	Hp	Hp	Kw	hr	Kwh	$0.04	hr	Kwh	$0.04
2	120	277	8.39	12.0	8.9	8064	72,143	$2,886	1680	15,030	$601
5	300	277	20.98	30.0	22.4	8064	180,359	$7,214	1680	37575	$1,503
10	600	277	41.97	60.0	44.7	8064	360,717	$14,429	1680	75149	$3,006
14	840	277	58.76	83.9	62.6	8064	505,004	$20,200	1680	105209	$4,208

Parts Replacement

A vendor estimated that the cost of parts replacement for coarse mesh traveling screens without fish handling would be approximately 15% of the equipment costs every 5 years (Gathright 2002). For traveling screens with fish handling, the same 15% would be replaced every 2.5 years. EPA has assumed for all screens that the annual parts replacement costs would be 6% of the equipment costs for those operating continuously and 3% for those operating intermittently. These factors are applied to the equipment costs in Exhibits 3-20 and 3-21. Traveling screens without fish handling (coarse mesh) operate fewer hours (estimated at 5 hrs/day) and should therefore experience less wear on the equipment. While the time of operation is nearly five times longer for continuous operation, the screen speed used is generally lower for continuous operation. Therefore, the wear and tear, hence O&M costs, are not directly proportional.

Baseline and Compliance O&M Scenarios

Exhibit 3-37 presents the six baseline and compliance O&M scenario cost combinations developed by EPA.

For the few baseline operations with fine mesh, nearly all had fish returns and or low screen velocities, indicating that such facilities will likely not require compliance action. Thus, there is no baseline cost scenario for traveling screens with fine mesh without fish handling and return. Exhibits 3-38 through 3-43 (at the end of this section) present the O&M costs for the cost scenarios shown in Exhibit 3-37. Figures 3-24 through 3-29 present the graphic plots of the O&M costs shown in these tables with best-fit, second-order equations of the plots. These equations are used in the estimation of O&M costs for the various technology applications.

Exhibit 3-37. Mix of O&M Cost Components for Various Scenarios

	Baseline Without Fish Handling	Baseline Without Fish Handling	Baseline with Fish Handling & Scenario B Compliance	Baseline with Fish Handling & Scenario B Compliance	Scenario A & C Compliance	Scenario A & C Compliance
Mesh Type	Coarse	Coarse	Coarse or Smooth Top	Coarse or Smooth Top	Smooth Top & Fine	Smooth Top & Fine
Fish Handling	None	None	Yes	Yes	Yes	Yes
Water Type	Freshwater	Saltwater	Freshwater	Saltwater	Freshwater	Saltwater
Screen Operation	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous
Basic Labor	100-300 hrs	100-300 hrs	200-600 hrs	200-600 hrs	200-600 hrs	200-600 hrs
Screen Overlay Labor	None	None	None	None	Yes	Yes
Screen Motor Power	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous
Debris Spray Pump Power	5 hrs/day	5 hrs/day	Continuous	Continuous	Continuous	Continuous
Fish Spray Pump Power	None	None	Continuous	Continuous	Continuous	Continuous
Parts Replacement - % Equipment Costs	3%	3%	6%	6%	6%	6%

O&M for Nuclear Facilities

Unlike the assumption for capital costs, the O&M costs for nuclear facilities consider the differences in the component costs. The power cost component is assumed to be the same. The equipment replacement cost component uses the same annual percentage of equipment cost factors, but is increased by the same factor as the capital costs (2.0). A Bureau of Labor Statistics document (BLS 2002) reported that the median annual earnings of a nuclear plant operator were $57,220 in 2002 compared to $46,090 for power plant operators in general. Thus, nuclear operators earnings were 24% higher than the industry average. No comparable data were available for maintenance personnel. This factor of 24% is used for estimating the increase in labor costs for nuclear facilities. This factor may be an overestimation: nuclear plant operators require a proportionally greater amount of training and the consequences of their actions engender greater overall risks than the intake maintenance personnel. EPA recalculated the O&M costs using the revised equipment replacement and labor costs. EPA found that the ratio of non-nuclear to nuclear O&M costs did not vary much for each scenario and water depth. Therefore, EPA chose to use the factor derived from the average ratio (across total width values) of estimated nuclear facility O&M to non-nuclear facility O&M for each scenario and well depth to estimate the nuclear facility O&M costs. Exhibit 3-44 presents the cost factors to be used to estimate nuclear facility O&M costs for each cost scenario and well depth using the non-nuclear O&M values as the basis.

Exhibit 3-44. Nuclear Facility O&M Cost Factors

Well Depth	Baseline O&M Traveling Screens Without Fish Handling	Baseline O&M Traveling Screens Without Fish Handling	Baseline & Scenario B Compliance O&M Traveling Screens With Fish Handling	Baseline & Scenario B Compliance O&M Traveling Screens With Fish Handling	Scenario A & C Compliance O&M Traveling Screens With Fish Handling	Scenario A & C Compliance O&M Traveling Screens With Fish Handling
Ft	Freshwater	Saltwater	Freshwater	Saltwater	Freshwater	Saltwater
10	1.32	1.41	1.29	1.40	1.28	1.39
25	1.35	1.46	1.33	1.46	1.32	1.44
50	1.39	1.51	1.39	1.53	1.36	1.49
75	1.41	1.53	1.43	1.57	1.38	1.51
100	1.42	1.55	1.45	1.60	1.40	1.53

2.1.4 Double Entry-Single Exit (Dual-flow) Traveling Screens

Another option for replacing coarse mesh single entry-single exit (through-flow) traveling screens is to install double entry-single exit (dual-flow) traveling screens. Such screens are designed and installed to filter water continuously, using both upward and downward moving parts of the screen. The interior space between the upward and downward moving screen panels is closed off on one side (oriented in the upstream direction), while screened water exits towards the pump well through the open end on the other side.

One major advantage of dual-flow screens is that the direction of flow through the screen does not reverse as it does on the back side of a through-flow screen. As such, there is no opportunity for debris stuck on the screen to dislodge on the downstream side. In through-flow screens, debris that fails to dislodge as it passes the spray wash can become dislodged on the downstream side (essentially bypassing the screen). Such debris continues downstream where it can plug condenser tubes or require more frequent cleaning of fixed screens set downstream of the intake screen to prevent condenser tube plugging. Such maintenance typically requires the shut down of the generating units. Since dual-flow screens eliminate the opportunity for debris carryover, the spray water pressure requirements are reduced with dual-flow screens requiring a wash water spray pressure of 30 psi compared to 80 to 120 psi for through-flow screens (Gathright 2002). Dual-flow screens are oriented such that the screen face is parallel to the direction of flow. By extending the screen width forward (perpendicular to the flow) to a size greater than one half the screen well width, the total screen surface area of a dual-flow screen can exceed that of a through-flow screen in the same application. Therefore, if high through-screen velocities are affecting the survival of impinged organisms in existing through-flow screens, the retrofit of dual-flow screens may help alleviate this problem. The degree of through-screen velocity reduction will be dependent on the space constraints of the existing intake configuration. In new intake construction, dual-flow screens can be installed with no walls separating the screens.

Retrofitting existing intakes containing through-flow screens with dual-flow screens can be performed with little or minor modifications to the existing intake structure. In this application, the dual-flow screens are constructed such that the open outlet side will align with the previous location of the downstream side of the through-flow screen. The screen is constructed with supports that slide into the existing screen slots and with “gull wing” baffles that close off the area between the screens downstream end and the screen well walls. The baffles are curved to better direct the flow. For many existing screen structures, the opening where the screen passes through the intake deck (including the open space in front of the screen) is limited to a five-foot opening front to back which limits the equivalent total overall per screen width of just under 10 ft for dual-flow retrofit screens. Because dual-flow screens filter on both sides the effective width is twice that of one screen panel. However, a vendor indicated, in many instances the screen well opening can be extended forward by demolishing a portion of the concrete deck at the front end. The feasibility and extent of such a modification (such as maximum width of the retrofit screen) is dependent on specific design of the existing intake, particularly concerning the proximity of obstructions upstream of the existing screen units. Certainly, most through-flow screens of less than 10 ft widths could be retrofitted with dual-flow screens that result in greater effective screen widths. Those 10 ft wide or greater that have large deck openings and/or available space could also install dual-flow screens with greater effective screen widths.

Capital Cost for Dual-Flow Screens

A screen vendor provided general guidance for both capital and O&M costs for dual-flow screens (Gathright 2002). The cost of dual-flow screens with fish handling sized to fit in existing intake screen wells could be estimated using the following factors applied to the costs of a traveling screen with fish handling that fit the existing screen well:

- For a screen well depth of 0 to <20 ft add 15% to the cost of a similarly sized through-flow screen.
- For a screen well depth of 20 ft to <40 ft add 10% to the cost of a similarly sized through-flow screen.
- For a screen well depth of greater than 40 ft add 5% to the cost of a similarly sized through-flow screen.

Installation costs are assumed to be similar to that for through-flow screens. The above factors were applied to the total installed cost of similarly sized through-flow screens, however, an additional 5% was added to the above cost factors to account for modifications that may be necessary to accommodate the new dual-flow screens such as demolition of a portion of the deck area. It is assumed that dual-flow screens can be installed in place of most through-flow screens but the benefit of lower through screen velocities may be limited for larger width (e.g., 14-ft) existing screens. The dual-flow screens are assumed to include fine mesh overlays and fish return systems, so the cost factors are applied to the scenario C through-flow screens only. The costs for dual-flow screens are not presented here but can be derived by applying the factor shown in Exhibit 3-45 below.

The capital costs for adding fine mesh overlays to existing dual-flow screens (scenario A) is assumed to be the same as for through-flow screens. This assumption is based on the fact that installation labor is based on the number of screen panels and should be the nearly the same and that the cost of the screen overlays themselves should be nearly the same. The higher equipment costs for dual-flow screens is mostly due to the equipment and equipment modifications located above the deck.

Exhibit 3-45. Capital Cost Factors for Dual-Flow Screens

Screen Depth	Capital Cost Factor[1]
10 Ft	1.2
25 Ft	1.15
50 Ft	1.1
75 Ft	1.1

[1] Applied to capital costs for similarly sized through-flow screens derived from equations shown in Figures 3-22 and 3-23 (Scenario C freshwater and saltwater)

O&M Costs for Dual-Flow Screens

A vendor indicated that a significant benefit of dual-flow screens is reduced O&M costs compared to similarly sized through-flow screens. O&M labor was reported to be as low as one tenth that for similarly sized through-flow traveling screens (Bracket Green 2002). Also, wash water flow is nearly cut in half and the spray water pressure requirement drops from 80 to 120 psi for through-flow screens to about 30 psi. Examples were cited where dual-flow retrofits paid for themselves in a two to five year period. Using an assumption of 90% reduction in routine O&M labor combined with an estimated reduction of 70% in wash water energy requirements (based on combined reduction in flow and pressure), EPA calculated that the O&M costs for dual-flow screens would be equal approximately 30% of the O&M costs for similarly sized through-flow screens with fine mesh overlays and fish handling and return systems. O&M costs for dual-flow screens were calculated as 30% of the O&M costs for similarly sized through-flow screens derived from the equations shown in Figures 3-26 and 3-27 (Scenario C freshwater and saltwater).

The O&M costs for adding fine mesh overlays to existing dual-flow screens (scenario A) is assumed to be the same as the net difference between through-flow screens with fish handling with and without fine mesh overlays (net O&M costs for scenario A versus scenario B). The majority of the net O&M costs are for deployment and removal of the fine mesh overlays.

Downtime for Dual-Flow Screens

As with through-flow screens dual-flow screens can be retrofitted with minimal generating unit downtime and can be scheduled to occur during routine maintenance downtime. While there may be some additional deck demolition work, this effort should add no more than one week to the two week estimate for multiple through-flow screens described above.

Technology Application

Capital Costs

The cost scenarios included here assume that the existing intake structure is designed for and includes through-flow (single entry, single exit) traveling screens, either with or without fish handling and return. For those systems with different types of traveling screens or fixed screens, the cost estimates derived here may also be applied. However, they should be viewed as a rough estimate for a retrofit that would result in similar performance enhancement. The cost scenario applied to each facility is based on the compliance action required and whether or not a fish handling and return system is in place. For those facilities with acceptable through-screen velocities no modification, other than described above, is considered as necessary. For those with high through-screen velocities that would result in unacceptable performance, costs for modifications/additions to the existing intake are developed through another cost module. The costs for new screens to be installed in these new intake structures will be based on the design criteria of the new structure.

Capital costs are applied based on waterbody type with costs for freshwater environments being applied to facilities in freshwater rivers/streams, lakes/reservoirs and the Great Lakes, and costs for saltwater environments being applied to facilities in estuaries/tidal rivers and oceans.

No distinction is being made here for freshwater environments with Zebra mussels. A vendor indicated that the mechanical movement and spray action of the traveling screens tend to prevent mussel attachment on the screens.

For facilities with intake canals, an added capital cost component for the additional length of the fish return flume (where applicable) are added. Where the canal length is not reported. The median canal length for other facilities with the same waterbody type are used.

O&M Costs

The compliance O&M costs are calculated as the net difference between the compliance scenario O&M costs and the baseline scenario O&M costs. For compliance scenarios that start with traveling screens where the traveling screens are then rendered unnecessary (e.g., relocating a shoreline intake to submerged offshore), the baseline scenario O&M costs presented here can be used to determine the net O&M cost difference for those technologies.

2.2 New Larger Intake Structure for Decreasing Intake Velocities

The efficacy of traveling screens can be affected by both through-screen and approach velocities. Through-screen velocity affects: the rate of debris accumulation; the potential for entrainment and impingement of swimming organisms; and the amount of injury that may occur when organisms become impinged and a fish return system is in use. Performance, with respect to impingement and entrainment, generally tends to deteriorate as intake velocities increase. For older intake structures, the primary function of the screen was to ensure downstream cooling system components continued to function without becoming plugged with debris. The design often did not take into consideration the effect of through-screen velocity on entrainment and impingement of aquatic organisms. For these older structures, the standard design value for through-screen velocity was in the range of 2.0 to 2.5 feet per second (Gathright 2002). These design velocities were based on the performance of coarse mesh traveling screens with respect to their ability to remove debris as quickly as it collected on the screen surface. As demonstrated in the Facility Questionnaire database, actual velocities may be even higher than standard design values. These higher velocities may result from cost-saving, site-specific designs or from an increased withdrawal rate compared to the original design.

As described previously, solutions considered for reducing entrainment on traveling screens are to replace the coarse mesh screens with finer mesh screens or to install fine mesh screen overlays. However, a potential problem with replacing the existing intake screens with finer mesh screens is that a finer mesh will accumulate larger quantities of debris. Thus, retrofitting existing coarse mesh screens with fine mesh may affect the ability of screens to remove debris quickly enough to function properly. Exacerbating this potential problem is finer mesh may result in slightly higher through-screen velocities (Gathright 2002). If the debris problems associated with using fine mesh occur on a seasonal basis, then one possible solution (see section 2.1, above) is to use fine mesh overlays during the period when sensitive aquatic organisms are present. This solution is predicated on the assumption that the period of high debris loading does not substantially coincide with the period when sensitive aquatic organisms are most prevalent. When such an approach is not feasible, some means of decreasing the intake velocities may be necessary.

The primary intake attributes that determine intake through-screen velocities are the flow volume, effective screen area, and percent open area of the screen. The primary intake attributes that determine approach velocity are flow volume and cross-sectional area of the intake. In instances where flow volume cannot be reduced, a reduction in intake velocities can only be obtained in two ways: for through-screen velocities, an increased screen area and/or percent open area, or for approach velocity, an increased intake cross-sectional area. In general, there are practical limits regarding screen materials and percent open area. These limits prevent significant modification of this attribute to reduce through-screen velocities. Thus, an increase in the screen area and/or intake cross-sectional area generally must be accomplished in order to reduce intake velocities. Passive screen technology (such as T-screens) relies on lower screen velocities to improve performance with respect to impingement and entrainment and to reduce the rate of debris accumulation. For technology options that rely on the continued use of traveling screens, a means of increasing the effective area of the screens is warranted. EPA has researched this problem and has identified the following three approaches to increasing the screen size:

- Replace existing through flow (single entry-single exit) traveling screens with dual-flow (double entry-double exit) traveling screens. Dual-flow screens can be placed in the same screen well as existing through flow screens. However, they are oriented perpendicular to the orientation of the original through-flow screens and extend outward towards the front of the intake. Installation may require some demolition of the existing intake deck. This solution may work where screen velocities do not need to be reduced appreciably. This technology has a much improved performance with respect to debris carry over and is often selected based on this attribute alone (Gathright 2002; see also section 2.1.4 above).

- Replace the function of the existing intake screen wells with larger wells constructed in front of the existing intake and hydraulically connected to the intake front opening. This approach retains the use and function of the existing intake pumps and pump wells with little or no modification to the original structure. A concern with this approach (besides construction costs) is whether the construction can be performed without significant downtime for the generating units.

- Add a new intake structure adjacent to, or in close proximity to, the existing intake. The old intake remains functional, but with the drive system for the existing pumps modified to reduce the flow rate. The new structure will include new pumps sized to pump an additional flow. The new structure can be built without a significant shutdown of the existing intake. Shutdown would only be required at the final construction step, where the pipes from new pumps are connected to the existing piping and the pumps and/or pump drives for the existing pumps are modified or replaced. In this case, generating downtime is minimized. However, the need for new pumps, and the modification to existing pumps that reduce their original flow, entail significant additional costs.

Option 3 is a seemingly simple solution where the addition of new intake bays adjacent or in close proximity to the existing intake would add to the total intake and screen cross-sectional area. A problem with this approach is that the current pumping capacity needs to be distributed between the old and new intake bays. Utilizing the existing pump wells and pumps is desirable to help minimize costs. However, where the existing pumps utilize single speed drives, the distribution of flow to the new intake bays would require either an upstream hydraulic connection or a pump system modification. Where the existing intake has only one or two pump wells a hydraulic connection with a new adjacent intake bay could be created through demolition of a sidewall downstream of the traveling screen. While this approach is certainly feasible in certain instances, the limitations regarding intake configurations prevents EPA from considering this a viable regulatory compliance alternative for all but a few existing systems. A more widely applicable solution would be to reduce pump flow rate of the existing pumps either by modifying the pump drive to a multi-speed or variable speed drive system, or by replacing the existing pumps with smaller ones. The new intake bays would be constructed with new smaller pumps that produce lower flow rates. The combined flows of the new and older, modified pumps satisfies the existing intake flow requirement. The costs of modifying existing pumps, plus the new pumps and pump wells, represents a substantial cost component.

Option 2 does not require modifications or additions to the existing pumping equipment. In this approach a new intake structure to house more and/or larger screen wells would be constructed in front of the existing intake. The old and new intake structures could then be hydraulically connected by closing off the ends with sheet pile walls or similar structures. EPA is not aware of any installations that have performed this retrofit but it was proposed as an option in the Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that proposal the new screens were to be dual-flow screens but the driving factor for the new structure was a need to increase the intake size.

EPA initially developed rough estimates of the comparative costs of applying option 2 versus option 3 (in the hypothetical case the intake area was doubled in size). The results indicated that adding a new screen well structure in front of the existing intake was less costly and therefore, this option was selected for consideration as a compliance technology option. This cost efficiency is primarily due to the reuse of the existing intake in a more cost efficient manner in option 2. However, option 2 has one important drawback: it may not be feasible where sufficient space is not available in front of the existing intake. To minimize construction downtime, EPA assumes the new intake structure is placed far enough in front of the existing intake to allow the existing intake to continue functioning until construction of the structure is completed. As a result of the need for sufficient space in front of the intake, the Agency has applied the technology in appropriate circumstances in developing model facility costs.

Scenario Description

In this scenario, modeled on option 2 described above, a new reinforced concrete structure is designed for new through-flow or dual-flow intake screens. This structure will be built directly in front of the existing intake. The structure will be built inside a temporary sheet pile coffer dam. Upon completion of the concrete structure, the coffer dam will be removed. A permanent sheet pile wall will be installed at both ends, connecting the rear of the new structure to the front of the old intake structure hydraulically. Such a configuration has the advantage of providing for flow equalization between multiple new intake screens and multiple existing pumps. The construction includes costs for site development for equipment access. Capital costs were developed for the same set of screen widths (2 feet through 140 feet) and depths (10 feet through 100 feet) used in the traveling screen cost methodology. Best-fit, second-order equations were used to estimated costs for each different screen well depth, using total screen width as the independent variable. Construction duration is estimated to be nine months.

Capital Costs

Capital costs were derived for different well depths and total screen widths based on the following assumptions.

<u>Design Assumptions - On-shore Activities</u>

- Clearing and grabbing: this is based on clearing with a dozer, and clearing light to medium brush to 4" diameter; clearing assumes a 40 feet width for equipment maneuverability near the shore line and 500 feet accessibility lengthwise at $3,075/acre (RS Means 2001); surveying costs are estimated at $1,673/ acre (RS Means 2001), covering twice the access area.
- Earth work costs: these include mobilization, excavation, and hauling, etc., along a water front width, with a 500-foot inland length; backfill with structural sand and grave (backfill structural based on using a 200 HP bulldozer, 300-foot haul, sand and gravel; unit earthwork cost is $395/ cu yd (RS Means 2001)
- Paving and surfacing, using concrete 10" thick; assuming a need for a 20-foot wide and 2- foot long equipment staging area at a unit cost of $33.5/ sq yd (RS Means 2001)
- Structural cost is calculated @ $1250/CY (RS Means 2001),assuming two wing walls 1.5 feet thick and 26 feet high, with 10 feet above ground level, and 36 feet long with 16 feet onshore (these walls are for tying in the connecting sheet pile walls).
- Sheet piling, steel, no wales, 38 psf, left in place; these are assumed to have a width twice the width of the screens + 20 feet, with onshore construction distance, and be 30 feet deep, at $24.5/ sq ft (RS Means 2001).

<u>Design Assumptions - Offshore Components</u>

- Structure width is 20% greater than total screen width and 20 ft front to back
- Structural support consists of the equivalent of four 3-foot by 3-foot reinforced concrete columns at $935/ cu yd RS Means 2001) plus two additional columns for each additional screen well (a 2-foot wide screen assumes an equivalent of 2-foot by 2 feet columns)
- Overall structure height is equal to the well depth plus 10%
- The elevated concrete deck is 1.5 ft thick at $48/ cu yd RS Means 2001)
- Dredging mobilization is $9,925 if total screen width is less than 10 feet; is $25,890 if total screen width is 10 feet to 25 feet; and is $52,500 if total screen width is greater than 25 ft RS Means 2001)
- The cost of dredging in the offshore work area is $23/cu yd to a depth of 10 feet
- The cost of the temporary coffer dam for the structure is $22.5/ sq ft RS Means 2001), with total length equal to the structure perimeter times a factor of 1.5 and the height equal to 1.3 times well depth.

<u>Field Project Personnel Not Included in Unit Costs</u>:

- Project Field Manager at $2,525 per week RS Means 2001)
- Project Field Superintendent at $2,375 per week RS Means 2001)
- Project Field Clerk at $440 per week RS Means 2001).

The above cost components were estimated and summed and the costs were expanded using the following cost factors.

<u>Add-on and Indirect Costs</u>:

- Construction Management is 4.5% of direct costs
- Engineering and Architectural fees for new construction is 17% of direct costs
- Contingency is 10% of direct costs
- Overhead and profit is 15% of direct costs
- Permits are 2% of direct costs
- Metalwork is 5% of direct costs
- Performance bond is 2.5% of direct costs
- Insurance is 1.5% of direct costs.

The total capital costs were then adjusted for inflation from 2001 dollars to July 2002 dollars using the ENR Construction Cost Index. Exhibit 3-46 presents the total capital costs for various screen well depths and total screen widths. No distinction was made between freshwater and brackish or saltwater environments. Figure 3-30 plots the data in Exhibit 3-46 and presents the best-fit cost equations. The shape of these curves indicates a need for separate equations for structures with widths less than and greater than 10 feet. In general, however, the Phase III compliance applications of this technology option included only new structures greater than 10 feet wide.

Exhibit 3-46. Total Capital Costs for Adding New Larger Intake Screen Well Structure in Front of Existing Shoreline Intake

Well Depth	10 Ft	25 Ft	50 Ft	75 ft	100 Ft
Width (Ft)					
2	$ 291,480	$ 562,140	$ 1,176,330	$ 1,842,570	$ 2,581,680
5	$ 333,120	$ 624,600	$ 1,290,840	$ 1,998,720	$ 2,800,290
10	$ 916,080	$ 1,957,080	$ 4,361,790	$ 6,922,650	$ 9,806,220
20	$ 1,051,410	$ 2,175,690	$ 4,757,370	$ 7,484,790	$ 10,545,330
30	$ 1,270,020	$ 2,487,990	$ 5,236,230	$ 8,130,210	$ 11,378,130
40	$ 1,426,170	$ 2,727,420	$ 5,642,220	$ 8,713,170	$ 12,138,060
50	$ 1,582,320	$ 2,977,260	$ 6,058,620	$ 9,306,540	$ 12,908,400
60	$ 1,748,880	$ 3,227,100	$ 6,485,430	$ 9,899,910	$ 13,689,150
70	$ 1,925,850	$ 3,487,350	$ 6,922,650	$ 10,503,690	$ 14,469,900
84	$ 2,165,280	$ 3,851,700	$ 7,536,840	$ 11,367,720	$ 15,583,770
98	$ 2,425,530	$ 4,236,870	$ 8,161,440	$ 12,242,160	$ 16,718,460
112	$ 2,696,190	$ 4,622,040	$ 8,994,240	$ 13,127,010	$ 17,863,560
126	$ 2,977,260	$ 5,028,030	$ 9,462,690	$ 14,032,680	$ 19,029,480
140	$ 3,268,740	$ 5,444,430	$ 10,139,340	$ 14,948,760	$ 20,205,810

O&M Costs

No separate O&M costs were derived for the structure itself since the majority of the O&M activities are covered in the O&M costs for the traveling screens to be installed in the new structure.

Construction Downtime

As described above, this scenario is modeled after an option described in a 316(b) Demonstration Study for the Salem Nuclear Plant (PSE&G 2001). In that scenario which applies to a very large nuclear facility, the existing intake continues to operate during the construction of the offshore intake structure inside the sheet pile cofferdam. Upon completion of the offshore structure and removal of the cofferdam, the final phase on the construction requires the shut down of the generating units for the placement of the sheet pile end walls. The feasibility study states that units 1 and 2 would be required to shut down for one month each. Based on this estimate and the size of the Salem facility (average daily flow of over 2 million gpm), EPA has concluded that a total construction downtime estimate in the range of 6 to 8 weeks is reasonable. EPA did not select a single downtime for all facilities installing an offshore structure. Instead, EPA applied a six- to eight-week downtime duration based on variations in project size, using design flow as a measure of size. EPA assumed a total downtime of six weeks for facilities with intake flow volumes of less than 400,000 gpm; seven weeks for facilities with intake flow volumes greater than 400,000 gpm but less than 800,000 gpm; and eight weeks for facilities with intake flow volumes greater than 800,000 gpm.

Application

The input value for the cost equation is the screen well depth and the total screen width (see section 1.1 for a discussion of the methodology for determining the screen well depth). The width of the new larger screen well intake structure was based on the design flow, and an assumed through-screen velocity of 1.0 feet per second and a percent open area of 50%. The 50 % open area value used is consistent with the percent open area of a fine mesh screen. The same well depth and width values are used for estimating the costs of new screen equipment for the new structure. New screen equipment consisted of fine mesh dual flow (double entry single exit) traveling screens with fish handling and return system.

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Exhibit 3-25. Total Capital Costs for Scenario A - Adding Fine Mesh Without Fish Handling Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$7,989	$9,079	$11,853	$23,706	$35,559	$47,412	$59,265	$71,117	$81,865	$98,237	$114,610	$143,806	$147,356	$163,729
25'-0	$11,162	$12,932	$17,952	$35,905	$53,857	$71,810	$89,762	$107,714	$134,162	$160,994	$187,827	$242,278	$241,492	$268,324
50'-0	$17,707	$20,977	$30,295	$60,590	$90,885	$121,180	$151,475	$181,769	$206,825	$248,189	$289,554	$383,198	$372,284	$413,649
75'-0	$24,262	$29,302	$40,467	$80,935	$121,402	$161,870	$202,337	$242,804	$273,987	$328,784	$383,582	$515,318	$493,177	$547,974
100'-0	$32,997	$37,627	$50,630	$101,260	$151,890	$202,520	$253,150	$303,779	$338,450	$406,139	$473,829	$643,118	$609,209	$676,899

Exhibit 3-26. Total Capital Costs for Scenario A - Adding Fine Mesh Without Fish Handling Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$14,909	$17,089	$22,103	$44,206	$66,309	$88,412	$110,515	$132,617	$155,715	$186,857	$218,000	$249,143	$280,286	$311,429
25'-0	$20,022	$23,562	$32,452	$64,905	$97,357	$129,810	$162,262	$194,714	$251,062	$301,274	$351,487	$401,699	$451,912	$502,124
50'-0	$31,057	$37,597	$54,055	$108,110	$162,165	$216,220	$270,275	$324,329	$380,975	$457,169	$533,364	$609,559	$685,754	$761,949
75'-0	$42,112	$52,192	$71,317	$142,635	$213,952	$285,270	$356,587	$427,904	$499,887	$599,864	$699,842	$799,819	$899,797	$999,774
100'-0	$57,527	$66,787	$88,560	$177,120	$265,680	$354,240	$442,800	$531,359	$613,400	$736,079	$858,759	$981,439	$1,104,119	$1,226,799

Exhibit 3-27. Total Capital Costs for Scenario B - Adding Fish Handling and Return Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$105,872	$126,362	$164,443	$301,224	$438,105	$572,141	$703,131	$837,367	$967,658	$1,151,993	$1,333,484	$1,518,320	$1,700,210	$1,882,401
25'-0	$132,772	$161,562	$217,443	$407,224	$597,105	$784,141	$968,131	$1,155,367	$1,460,658	$1,743,593	$2,023,684	$2,307,120	$2,587,610	$2,868,401
50'-0	$185,172	$230,462	$320,543	$613,424	$906,405	$1,196,541	$1,483,631	$1,773,967	$2,095,658	$2,505,593	$2,912,684	$3,323,120	$3,730,610	$4,138,401
75'-0	$237,672	$302,162	$401,943	$776,224	$1,150,605	$1,522,141	$1,890,631	$2,262,367	$2,675,658	$3,201,593	$3,724,684	$4,251,120	$4,774,610	$5,298,401
100'-0	$311,972	$373,862	$483,243	$938,824	$1,394,505	$1,847,341	$2,297,131	$2,750,167	$3,228,658	$3,865,193	$4,498,884	$5,135,920	$5,770,010	$6,404,401

Exhibit 3-28. Total Capital Costs for Scenario B - Adding Fish Handling and Return Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$175,072	$206,462	$266,943	$506,224	$745,605	$982,141	$1,215,631	$1,452,367	$1,706,158	$2,038,193	$2,367,384	$2,699,920	$3,029,510	$3,359,401
25'-0	$221,372	$267,862	$362,443	$697,224	$1,032,105	$1,364,141	$1,693,131	$2,025,367	$2,629,658	$3,146,393	$3,660,284	$4,177,520	$4,691,810	$5,206,401
50'-0	$318,672	$396,662	$558,143	$1,088,624	$1,619,205	$2,146,941	$2,671,631	$3,199,567	$3,837,158	$4,595,393	$5,350,784	$6,109,520	$6,865,310	$7,621,401
75'-0	$416,172	$531,062	$710,443	$1,393,224	$2,076,105	$2,756,141	$3,433,131	$4,113,367	$4,934,658	$5,912,393	$6,887,284	$7,865,520	$8,840,810	$9,816,401
100'-0	$557,272	$665,462	$862,543	$1,697,424	$2,532,405	$3,364,541	$4,193,631	$5,025,967	$5,978,158	$7,164,593	$8,348,184	$9,535,120	$10,719,110	$11,903,401

Exhibit 3-29. Total Capital Costs for Scenario C - Adding Fine Mesh with Fish Handling and Return Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$112,772	$134,362	$174,743	$321,824	$469,005	$613,341	$754,631	$899,167	$1,041,658	$1,240,793	$1,437,084	$1,636,720	$1,833,410	$2,030,401
25'-0	$141,672	$172,162	$231,943	$436,224	$640,605	$842,141	$1,040,631	$1,242,367	$1,577,658	$1,883,993	$2,187,484	$2,494,320	$2,798,210	$3,102,401
50'-0	$198,572	$247,062	$344,343	$661,024	$977,805	$1,291,741	$1,602,631	$1,916,767	$2,269,658	$2,714,393	$3,156,284	$3,601,520	$4,043,810	$4,486,401
75'-0	$255,572	$325,062	$432,843	$838,024	$1,243,305	$1,645,741	$2,045,131	$2,447,767	$2,901,658	$3,472,793	$4,041,084	$4,612,720	$5,181,410	$5,750,401
100'-0	$336,472	$403,062	$521,143	$1,014,624	$1,508,205	$1,998,941	$2,486,631	$2,977,567	$3,503,658	$4,195,193	$4,883,884	$5,575,920	$6,265,010	$6,954,401

Exhibit 3-30. Total Capital Costs for Scenario C - Adding Fine Mesh with Fish Handling and Return Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10'-0	$188,872	$222,462	$287,543	$547,424	$807,405	$1,064,541	$1,318,631	$1,575,967	$1,854,158	$2,215,793	$2,574,584	$2,936,720	$3,295,910	$3,655,401
25'-0	$239,172	$289,062	$391,443	$755,224	$1,119,105	$1,480,141	$1,838,131	$2,199,367	$2,863,658	$3,427,193	$3,987,884	$4,551,920	$5,113,010	$5,674,401
50'-0	$345,472	$429,862	$605,743	$1,183,824	$1,762,005	$2,337,341	$2,909,631	$3,485,167	$4,185,158	$5,012,993	$5,837,984	$6,666,320	$7,491,710	$8,317,401
75'-0	$451,972	$576,862	$772,243	$1,516,824	$2,261,505	$3,003,341	$3,742,131	$4,484,167	$5,386,658	$6,454,793	$7,520,084	$8,588,720	$9,654,410	$10,720,401
100'-0	$606,272	$723,862	$938,343	$1,849,024	$2,759,805	$3,667,741	$4,572,631	$5,480,767	$6,528,158	$7,824,593	$9,118,184	$10,415,120	$11,709,110	$13,003,401

Exhibit 3-38. Baseline O&M Costs for Traveling Screens Without Fish Handling Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$5,419	$8,103	$10,223	$20,445	$30,668	$40,891	$51,113	$61,336	$62,805	$75,367	$87,928	$100,489	$113,050	$125,611
25	$6,433	$9,499	$11,880	$23,760	$35,640	$47,520	$59,400	$71,280	$75,667	$90,800	$105,933	$121,067	$136,200	$151,333
50	$7,591	$11,483	$14,741	$29,482	$44,223	$58,964	$73,705	$88,446	$89,781	$107,737	$125,693	$143,650	$161,606	$179,562
75	$8,786	$13,687	$16,865	$33,729	$50,594	$67,458	$84,323	$101,187	$101,216	$121,459	$141,702	$161,946	$182,189	$202,432
100	$10,597	$15,833	$18,985	$37,970	$56,956	$75,941	$94,926	$113,911	$112,279	$134,735	$157,191	$179,647	$202,103	$224,558

Exhibit 3-39. Baseline O&M Costs for Traveling Screens Without Fish Handling Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 f	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$6,400	$9,247	$11,694	$23,388	$35,083	$46,777	$58,471	$70,165	$73,433	$88,120	$102,806	$117,493	$132,179	$146,866
25	$7,577	$10,971	$13,842	$27,684	$41,526	$55,368	$69,210	$83,052	$92,834	$111,401	$129,968	$148,535	$167,101	$185,668
50	$9,389	$13,772	$18,175	$36,349	$54,524	$72,698	$90,873	$109,047	$113,498	$136,186	$158,884	$181,582	$204,279	$226,977
75	$11,238	$16,957	$21,116	$42,231	$63,347	$84,462	$105,578	$126,693	$129,829	$155,794	$181,760	$207,726	$233,691	$259,657
100	$14,357	$20,084	$24,054	$48,107	$72,161	$96,215	$120,269	$144,322	$144,979	$173,975	$202,971	$231,967	$260,963	$289,958

Exhibit 3-40. Baseline & Scenario B Compliance O&M Totals for Traveling Screens With Fish Handling Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$15,391	$24,551	$35,231	$70,462	$105,693	$140,924	$176,155	$211,386	$230,185	$276,221	$322,258	$368,295	$414,332	$460,369
25	$18,333	$28,378	$40,504	$81,009	$121,513	$162,018	$202,522	$243,027	$271,971	$326,365	$380,759	$435,154	$489,548	$543,942
50	$22,295	$34,696	$49,853	$99,707	$149,560	$199,413	$249,267	$299,120	$328,293	$393,952	$459,611	$525,269	$590,928	$656,587
75	$26,441	$41,449	$57,499	$114,998	$172,498	$229,997	$287,496	$344,995	$376,302	$451,563	$526,823	$602,084	$677,344	$752,605
100	$31,712	$47,927	$65,126	$130,251	$195,377	$260,503	$325,628	$390,754	$424,831	$509,797	$594,763	$679,729	$764,695	$849,661

Exhibit 3-41. Baseline & Scenario B Compliance O&M Totals for Traveling Screens With Fish Handling Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$19,543	$29,357	$41,381	$82,762	$124,143	$165,524	$206,905	$248,286	$274,495	$329,393	$384,292	$439,191	$494,090	$548,989
25	$23,649	$34,756	$49,204	$98,409	$147,613	$196,818	$246,022	$295,227	$342,111	$410,533	$478,955	$547,378	$615,800	$684,222
50	$30,305	$44,668	$64,109	$128,219	$192,328	$256,437	$320,547	$384,656	$432,783	$519,340	$605,897	$692,453	$779,010	$865,567
75	$37,151	$55,183	$76,009	$152,018	$228,028	$304,037	$380,046	$456,055	$511,842	$614,211	$716,579	$818,948	$921,316	$1,023,685
100	$46,430	$65,423	$87,884	$175,767	$263,651	$351,535	$439,418	$527,302	$589,801	$707,761	$825,721	$943,681	$1,061,641	$1,179,601

Exhibit 3-42. Scenario A & C Compliance O&M Totals for Traveling Screens With Fish Handling Freshwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$17,529	$26,688	$38,437	$76,874	$115,311	$153,747	$192,184	$230,621	$246,214	$295,456	$344,699	$393,942	$443,184	$492,427
25	$22,936	$32,982	$47,409	$94,819	$142,228	$189,637	$237,046	$284,456	$306,495	$367,794	$429,093	$490,392	$551,691	$612,990
50	$31,008	$43,409	$62,923	$125,846	$188,769	$251,693	$314,616	$377,539	$393,642	$472,371	$551,099	$629,828	$708,556	$787,285
75	$39,264	$54,272	$76,734	$153,468	$230,202	$306,936	$383,670	$460,404	$472,476	$566,972	$661,467	$755,962	$850,458	$944,953
100	$48,645	$64,861	$90,525	$181,051	$271,576	$362,102	$452,627	$543,153	$551,830	$662,195	$772,561	$882,927	$993,293	$1,103,659

Exhibit 3-43. Scenario A & C Compliance O&M Totals for Traveling Screens With Fish Handling Saltwater Environments

Total Width	2	5	10	20	30	40	50	60	70	84	98	112	126	140
Well Depth (Ft)	One 2 ft	One 5 ft	One 10 ft	Two 10 ft	Three 10 ft	Four 10 ft	Five 10 ft	Six 10 ft	Five 14 ft	Six 14 ft	Seven 14 ft	Eight 14 ft	Nine 14 ft	Ten 14 ft
10	$21,681	$31,494	$44,587	$89,174	$133,761	$178,347	$222,934	$267,521	$290,524	$348,628	$406,733	$464,838	$522,942	$581,047
25	$28,252	$39,360	$56,109	$112,219	$168,328	$224,437	$280,546	$336,656	$376,635	$451,962	$527,289	$602,616	$677,943	$753,270
50	$39,018	$53,381	$77,179	$154,358	$231,537	$308,717	$385,896	$463,075	$498,132	$597,759	$697,385	$797,012	$896,638	$996,265
75	$49,974	$68,006	$95,244	$190,488	$285,732	$380,976	$476,220	$571,464	$608,016	$729,620	$851,223	$972,826	$1,094,430	$1,216,033
100	$63,363	$82,357	$113,283	$226,567	$339,850	$453,134	$566,417	$679,701	$716,800	$860,159	$1,003,519	$1,146,879	$1,290,239	$1,433,599

Figure 3-18. Scenario A - Capital Cost -Add Fine Mesh Replacement Screen Panels Freshwater

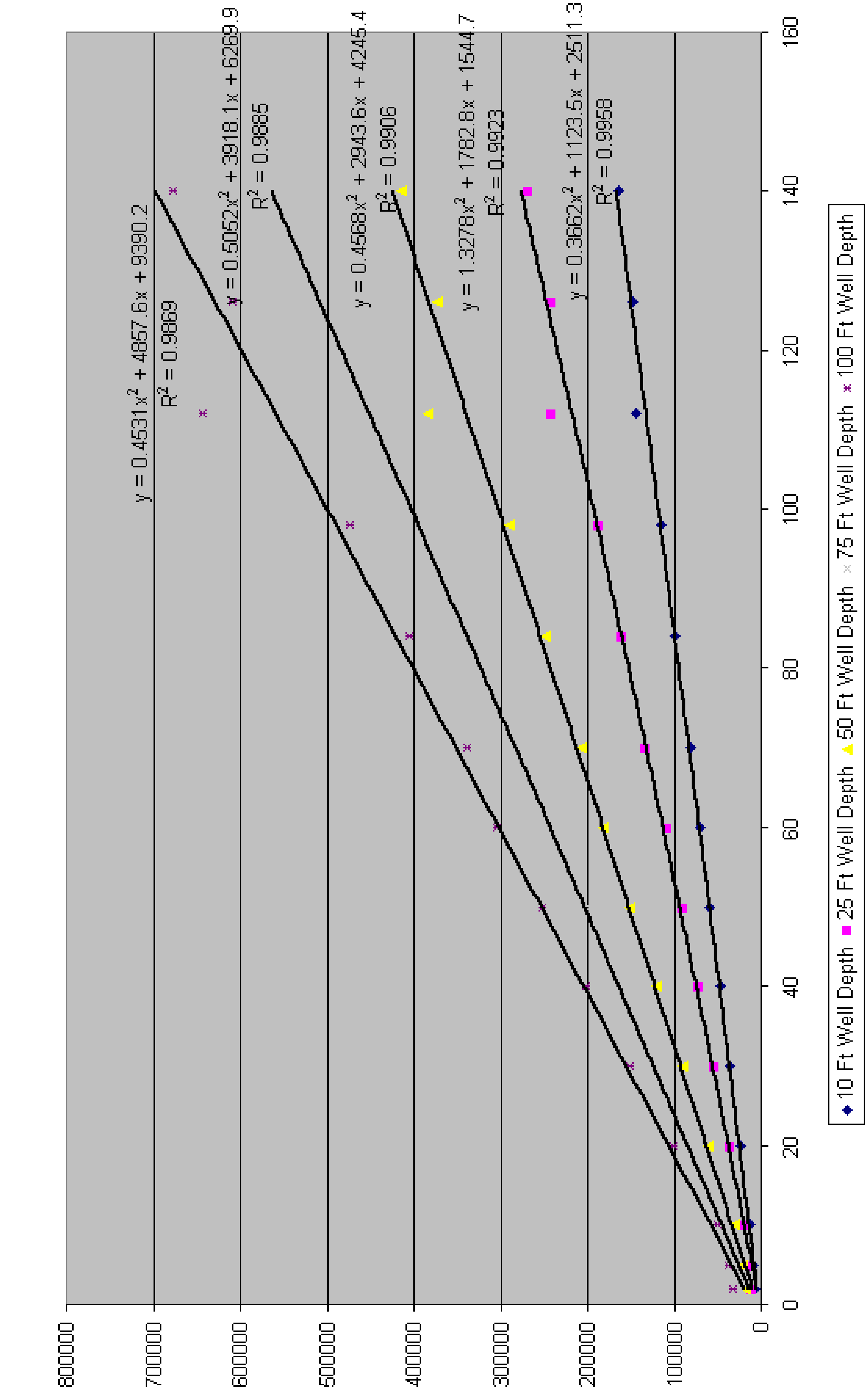


Figure 3-19. Scenario A - Capital Cost -Add Fine Mesh Replacement Screen Panels - Saltwater

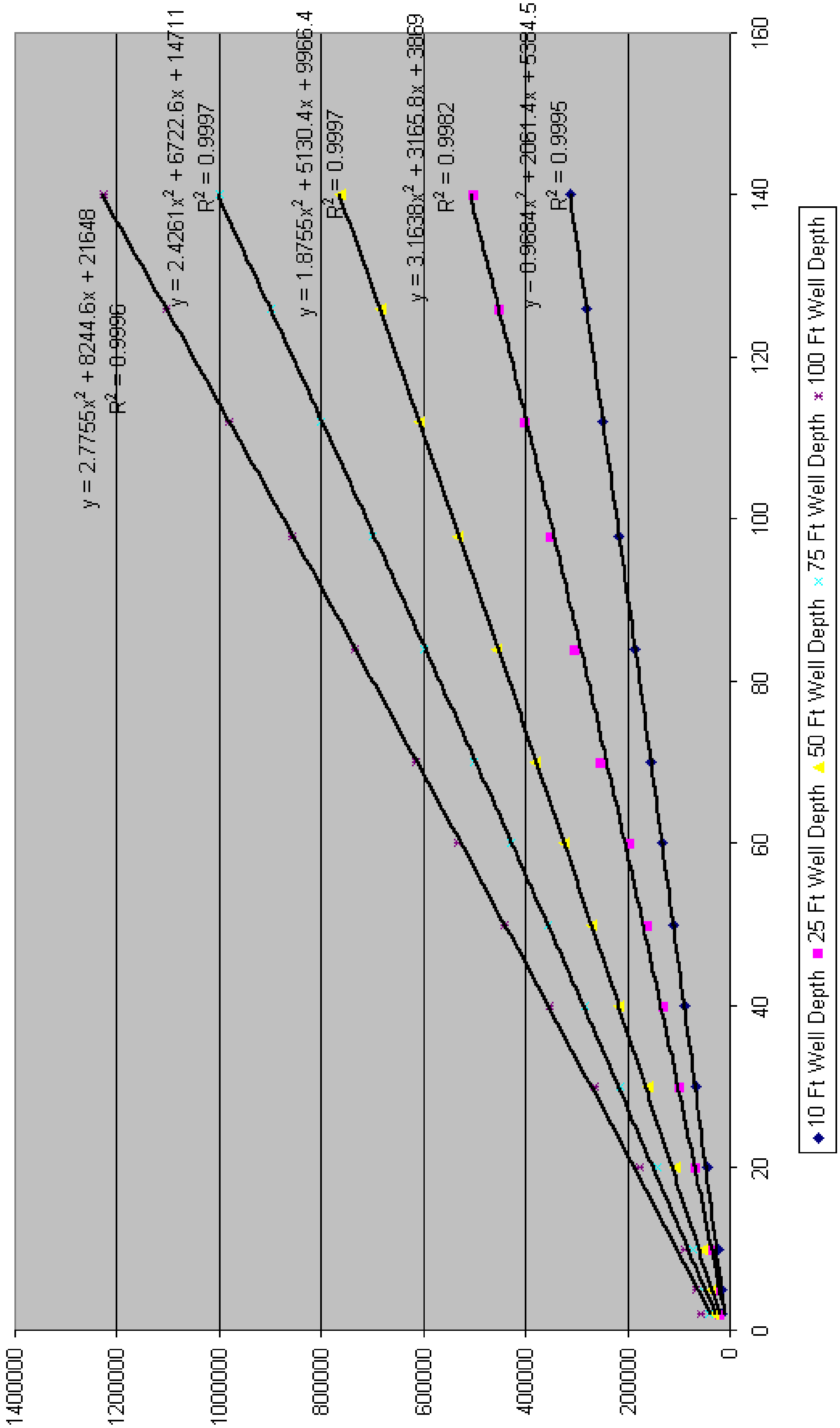


Figure 3-20. Scenario B - Capital Cost -Add Traveling Screen with Fish Handling and Return - Freshwater

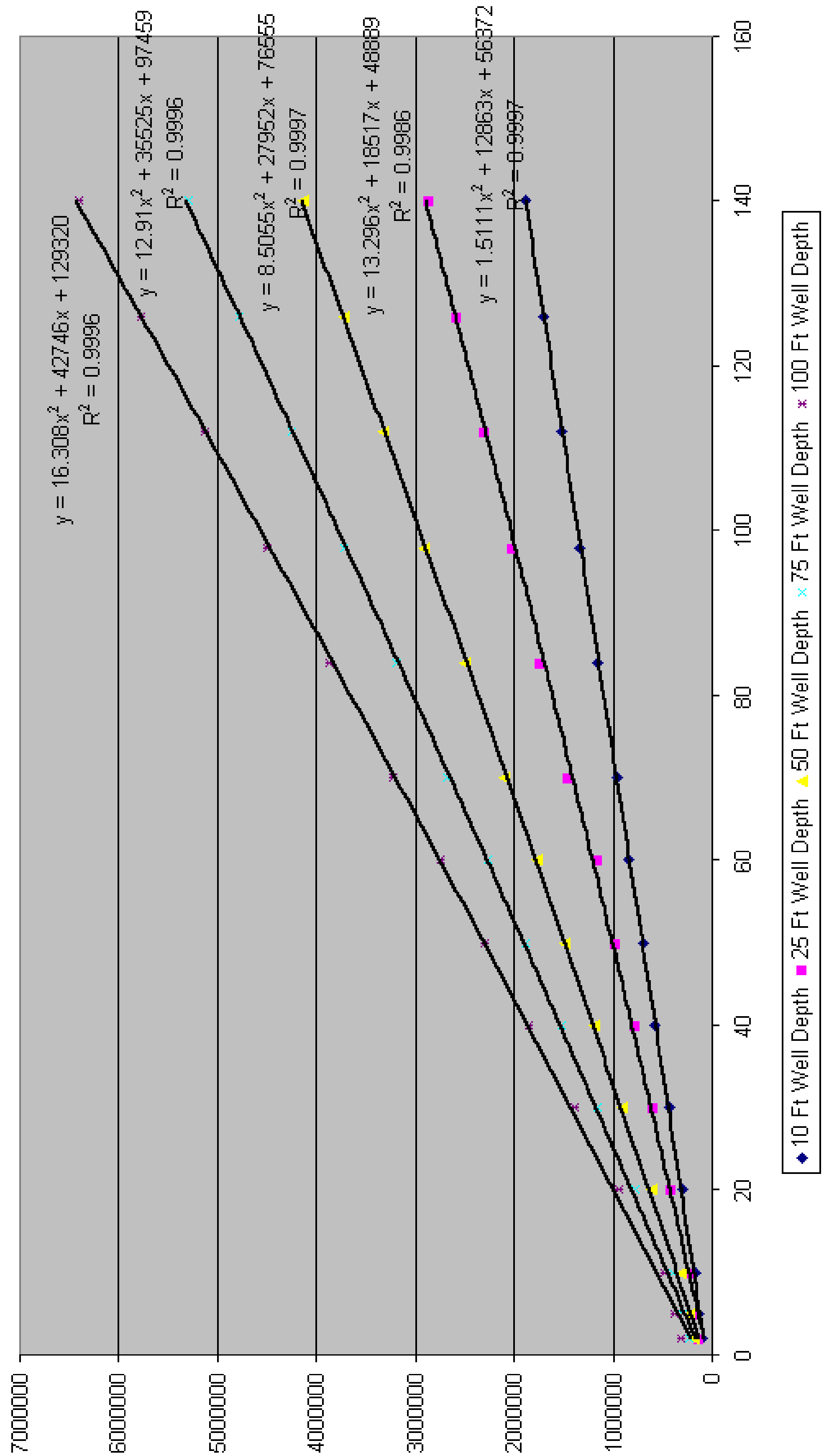


Figure 3-21. Scenario B - Capital Cost - Add Traveling Screen with Fish Handling and Return - Saltwater

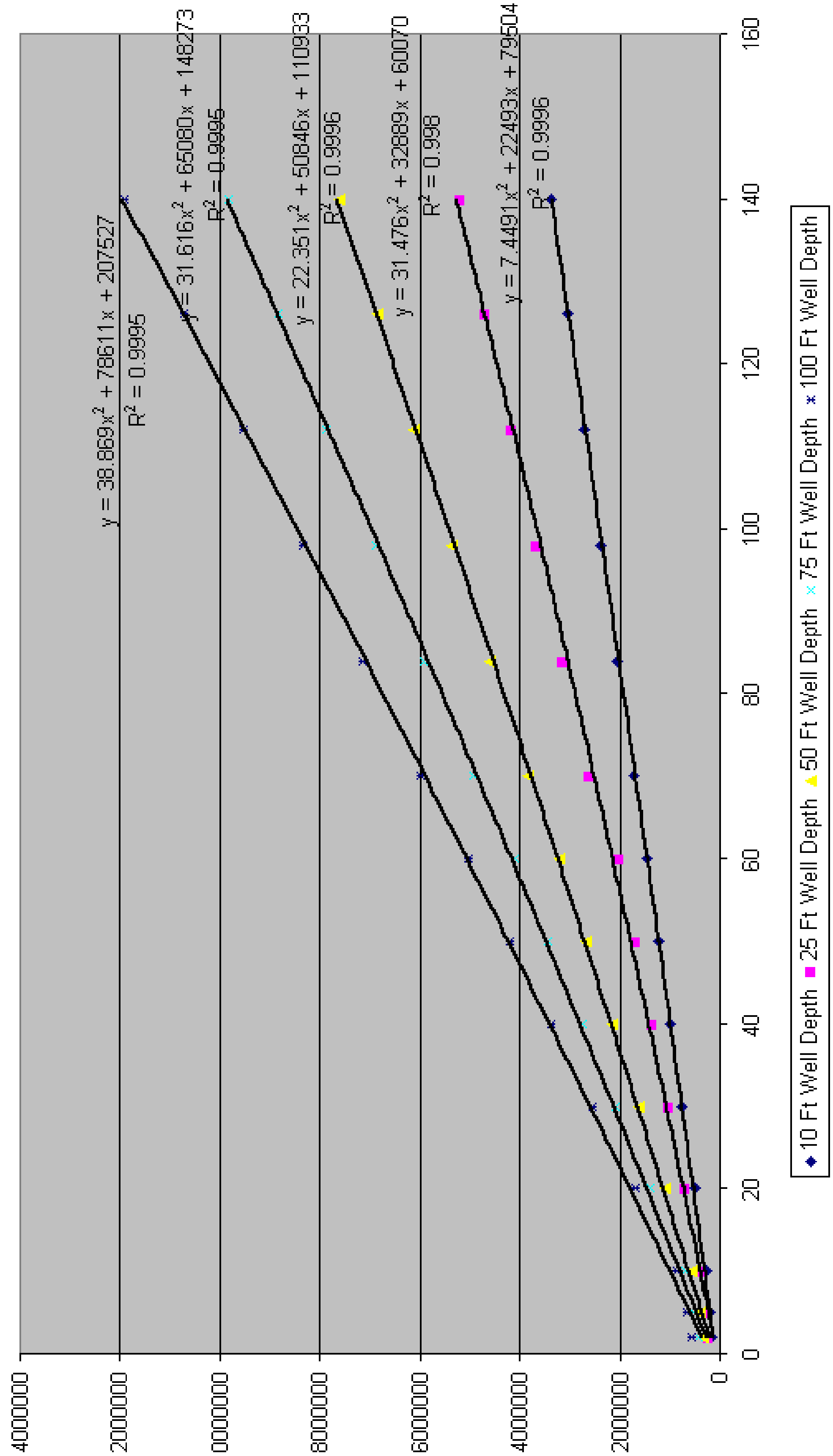


Figure 3-22. Scenario C - Capital Cost -Add Fine Mesh Traveling Screen With and Fish Handling and Return - Saltwater

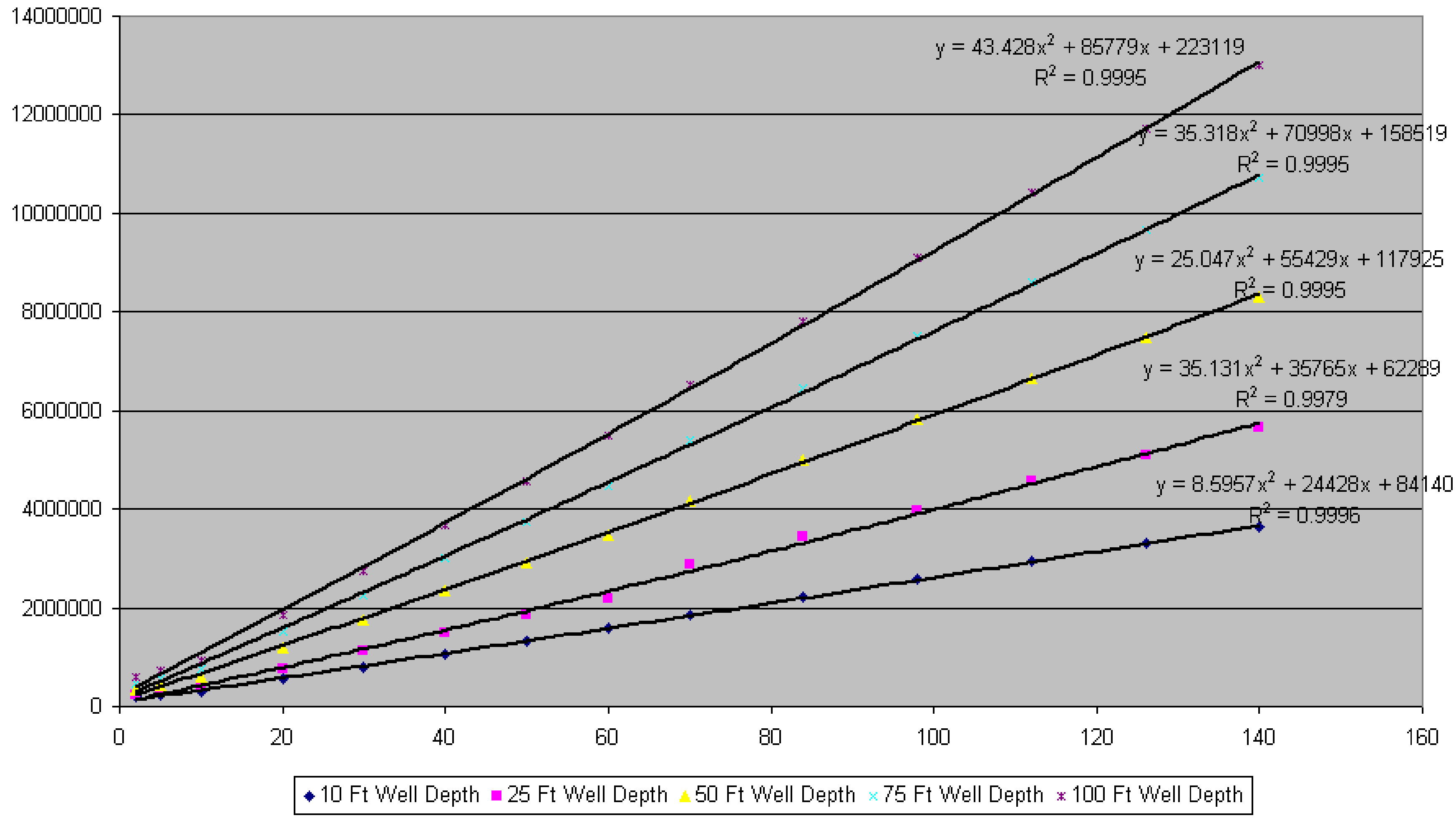


Figure 3-23. Scenario C - Capital Cost - Add Fine Mesh Traveling Screen With and Fish Handling and Return Freshwater

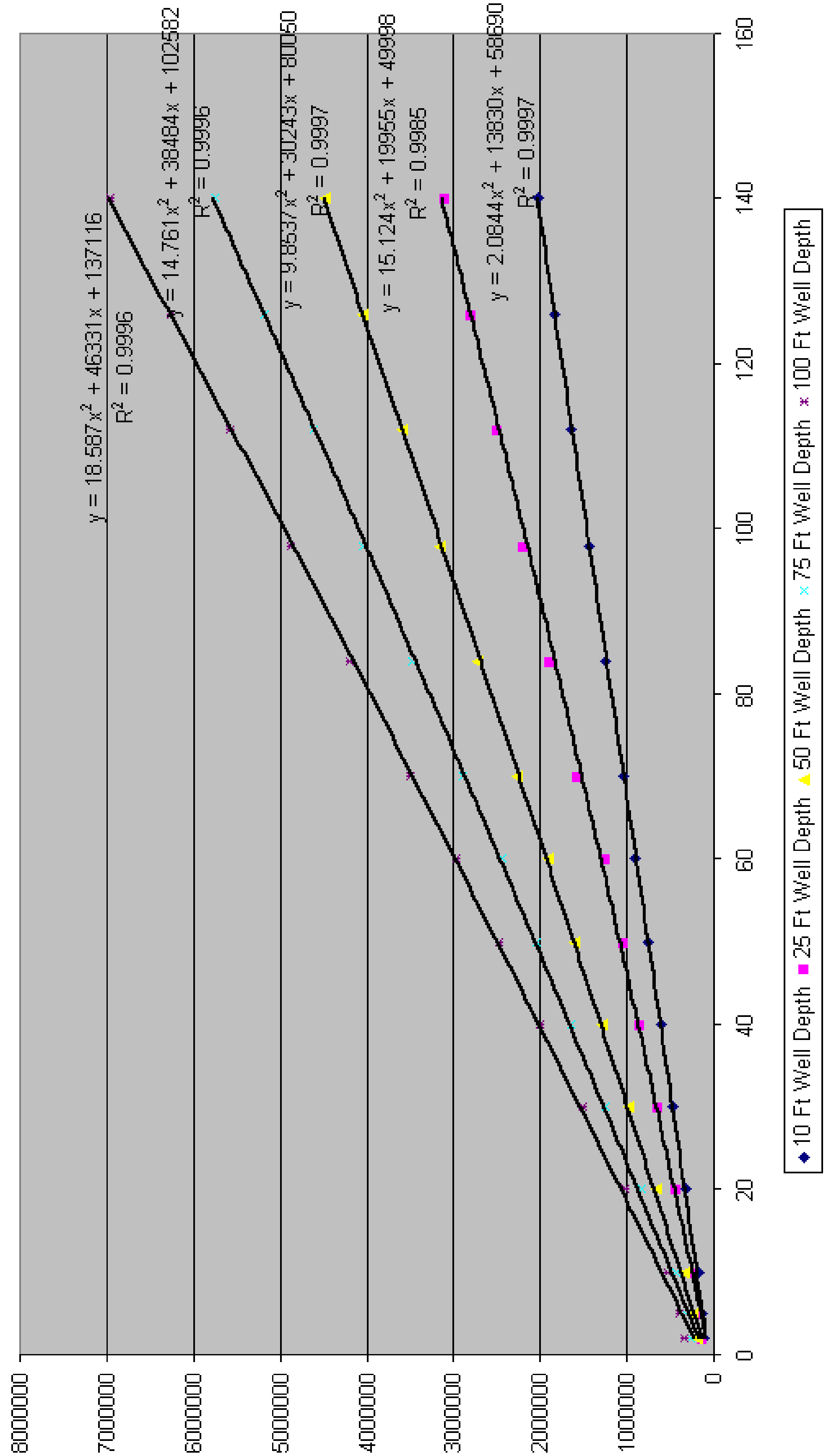


Figure 3-24. Baseline O&M Costs for Traveling Screens Without Fish Handling - Freshwater Environments

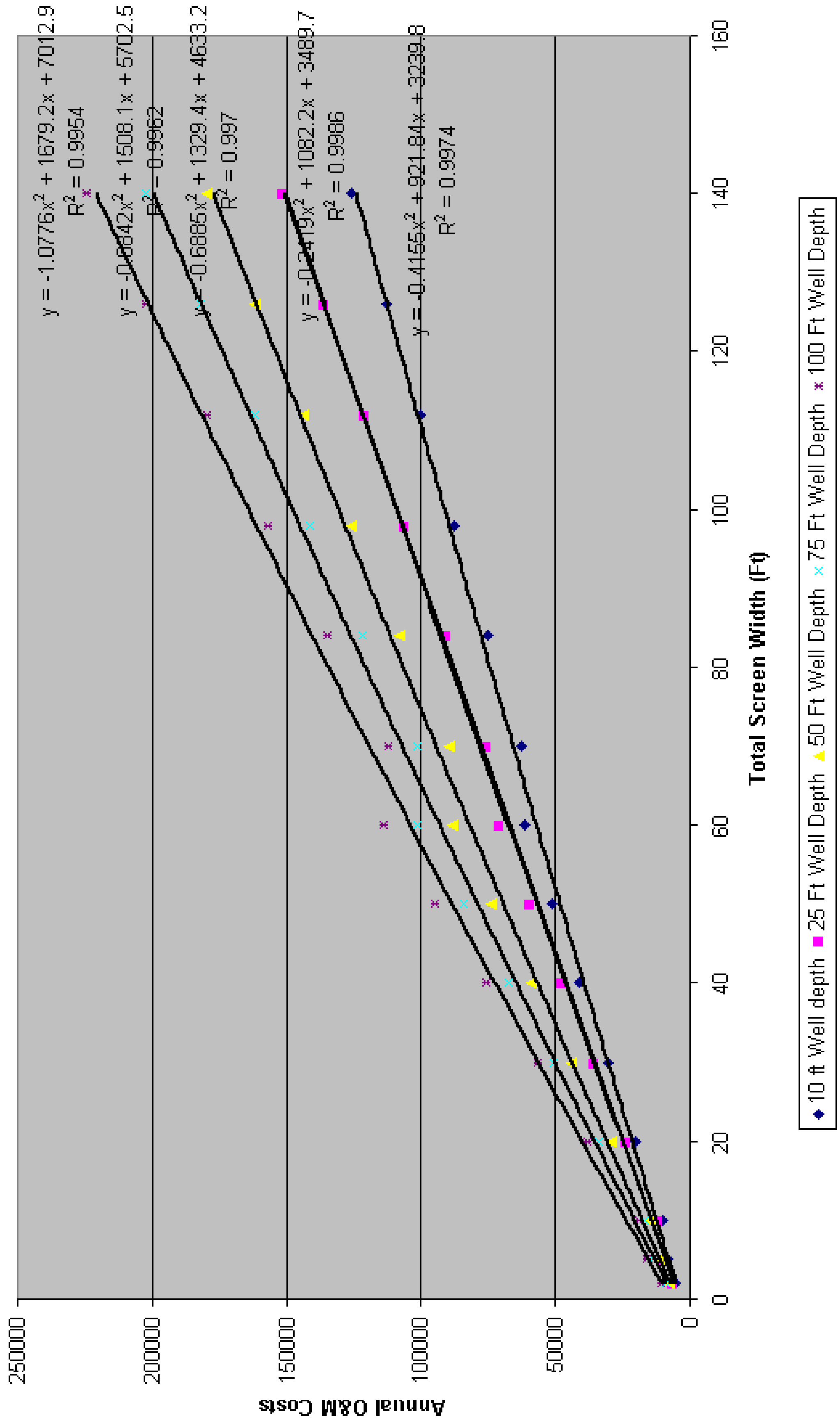


Figure 3-25. Baseline O&M Costs for Traveling Screens Without Fish Handling - Saltwater Environments

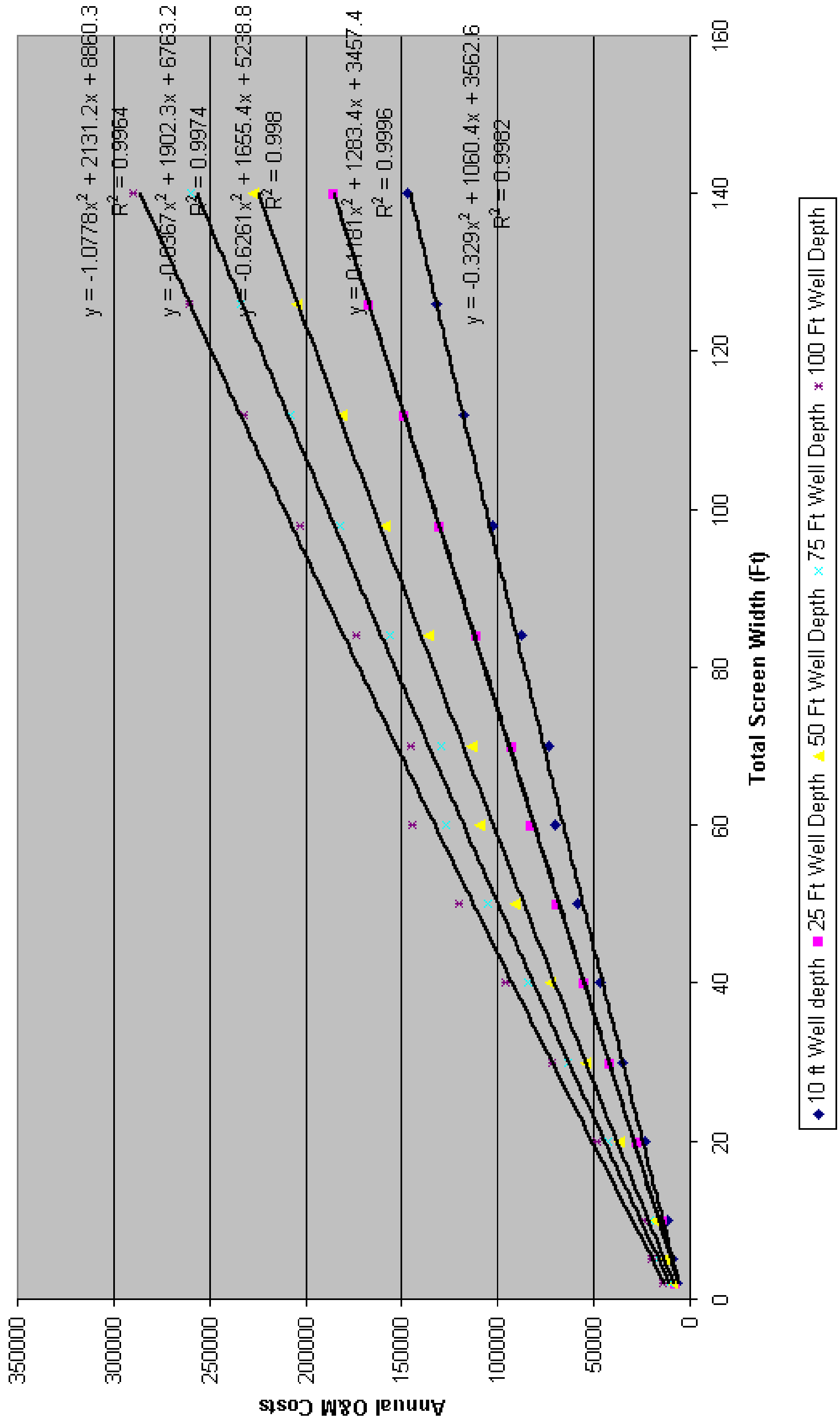


Figure 3-26. Scenarios A & C Compliance O&M Total Costs for Traveling Screens With Fish Handling Freshwater Environments

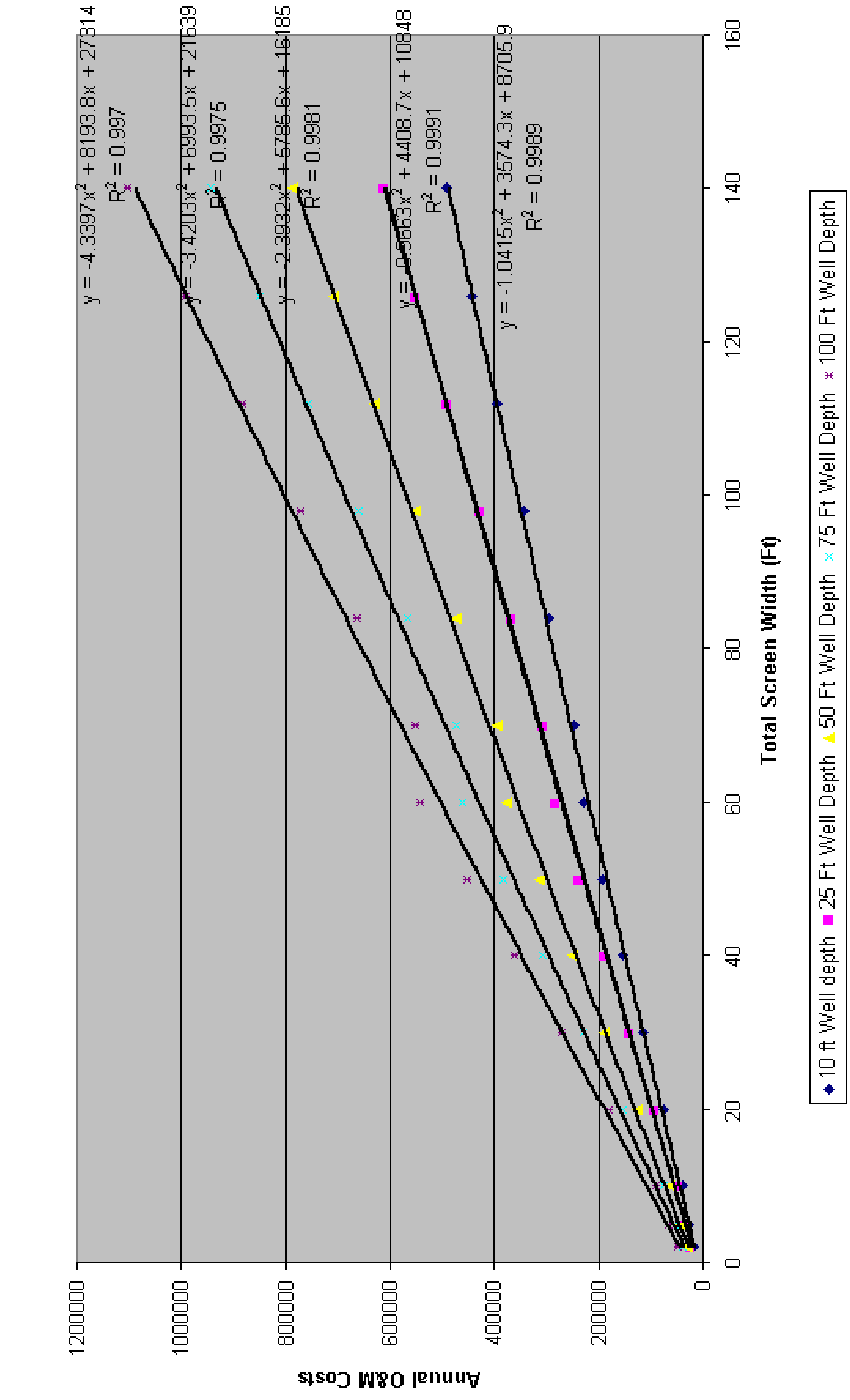


Figure 3-27. Scenarios A & C Compliance O&M Total Costs for Traveling Screens With Fish Handling - Saltwater Environments

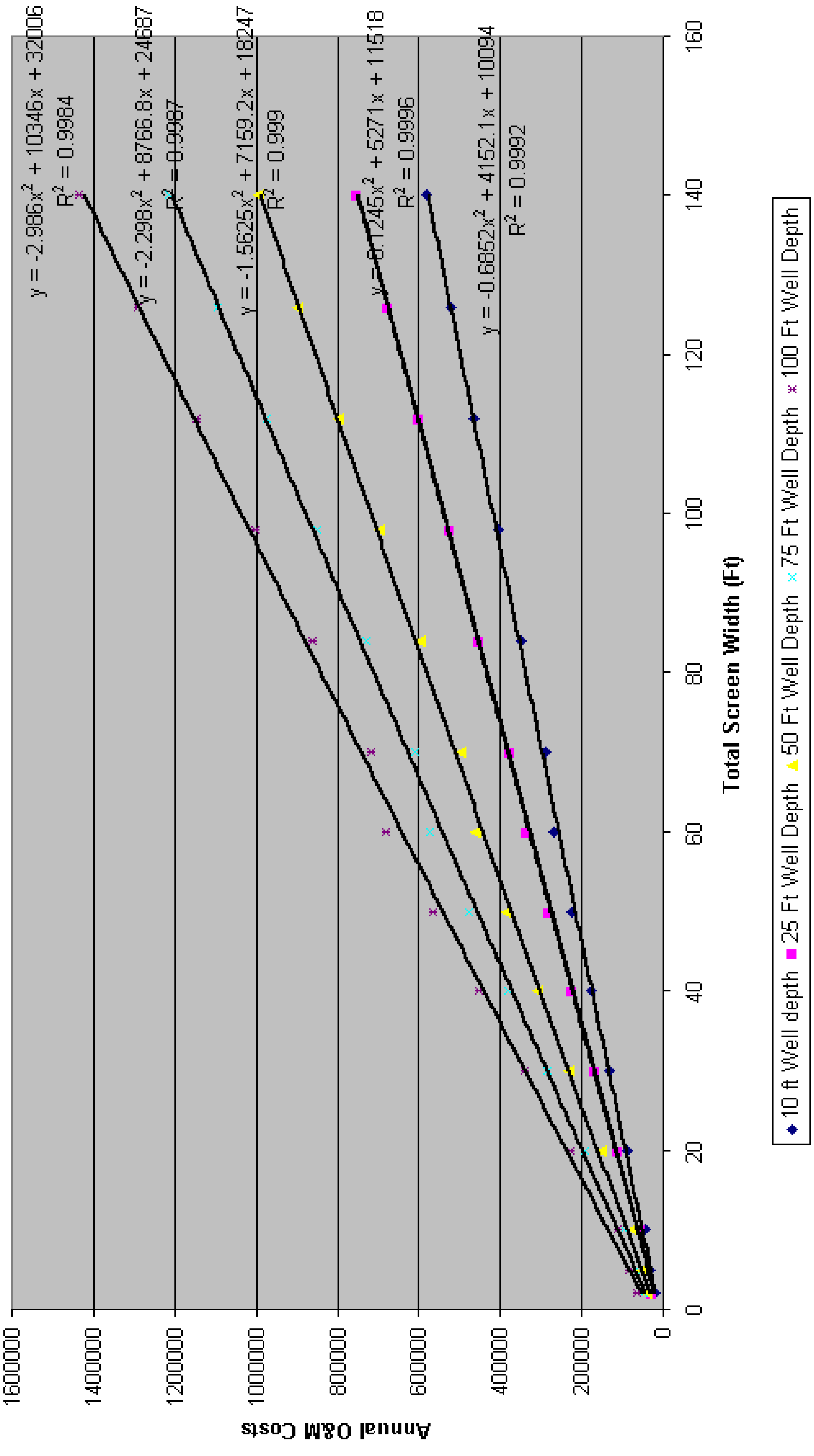


Figure 3-28. Baseline & Scenarios B Compliance O&M Total Costs for Traveling Screens With Fish Handling Freshwater Environments

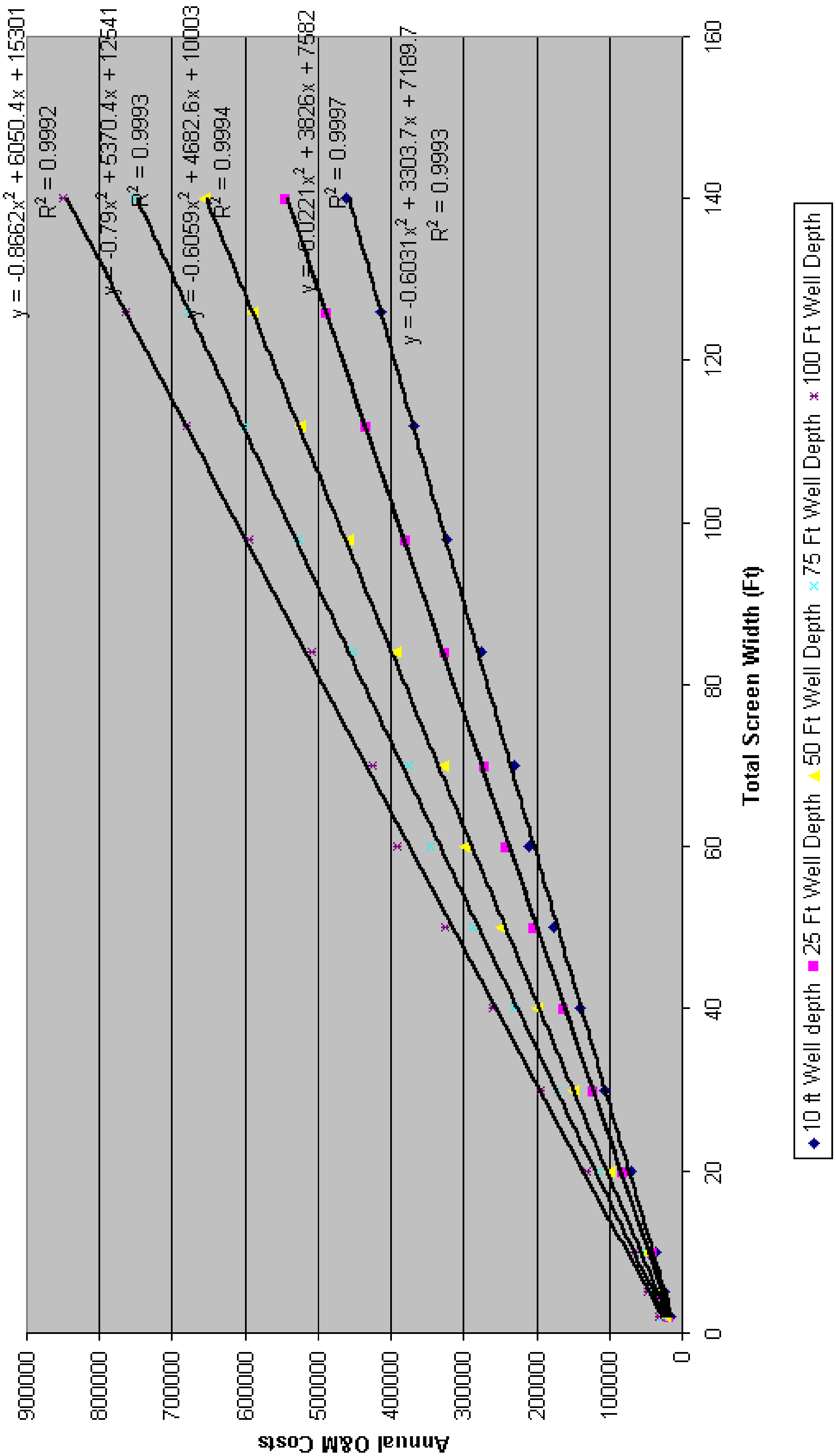


Figure 3-29. Baseline & Scenarios B Compliance O&M Total Costs for Traveling Screens With Fish Handling Saltwater Environments

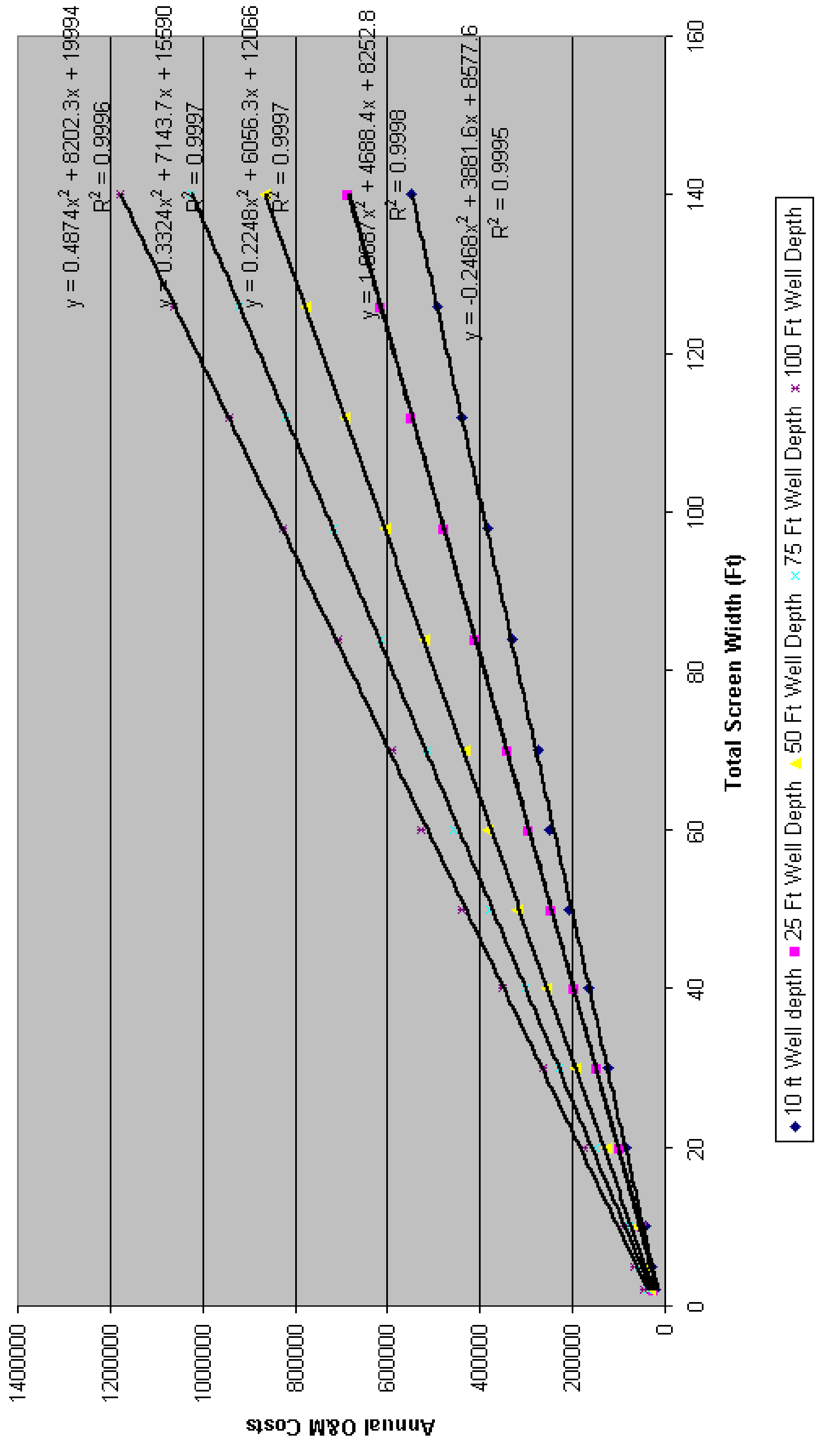
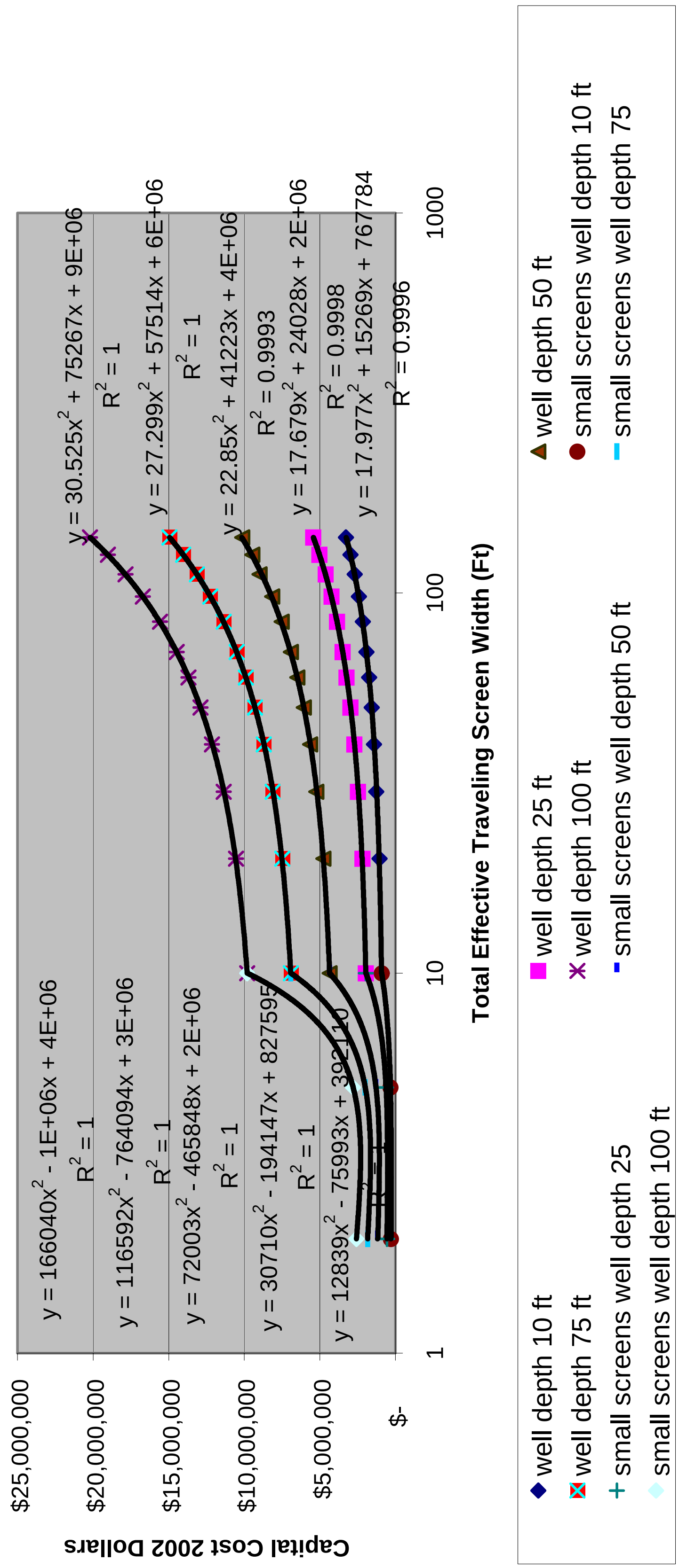


Figure 3-30. Total Capital Costs of New Larger Intake Structure



3.0 EXISTING SUBMERGED OFFSHORE INTAKES - ADD VELOCITY CAPS

Velocity caps are applicable to submerged offshore intakes. Adding velocity caps to facilities with existing or new submerged offshore intakes can provide appreciable impingement reduction. Therefore, this module may be most applicable when the compliance option only requires impingement controls and the intake requires upgrading. However depending on site-specific conditions, velocity caps could conceivably be used in conjunction with onshore screening systems tailored for entrainment reduction.

Research on velocity cap vendors identified only one vendor, which is located in Canada. (A possible reason for this scarcity in vendors is that many velocity caps are designed and fabricated on a site-specific basis, often called “intake cribs”.) This vendor manufactures a velocity cap called the “Invisihead,” and was contacted for cost information (Elarbash 2002a and 2002b). The Invisihead is designed with a final entrance velocity of 0.3 feet per second and has a curved cross-section that gradually increases the velocity as water is drawn farther into the head. The manufacturer states the gradual increase in velocity though the velocity cap minimizes entrainment of sediment and suspended matter and minimizes inlet pressure losses (Elmosa 2002). All costs presented below are in July 2002 dollars.

3.1 Capital Costs

The vendor provided information for estimating retrofit costs for velocity caps manufactured both from carbon steel and from stainless steel. Stainless steel construction is recommended for saltwater conditions to minimize corrosion. Carbon steel is recommended for freshwater systems. Due to the rather large opening, Invisihead performance is not affected by the attachment of Zebra mussels, so no special materials of construction are required where Zebra mussels are present.

Installation costs include the cost for a support vessel and divers to cut, weld and/or bolt the fitting flange for the velocity cap; make any needed minor reinforcements of the existing intake; and install the cap itself. Installation was said to take between two and seven days, depending on the size and number of heads in addition to the retrofit steps listed above. Costs also include mobilization and demobilization of the installation personnel, barge, and crane. The vendor indicated these costs included engineering and contractor overhead and profit, but did not provide break-outs or percentages for these cost components. EPA has concluded that the installation costs for adding a velocity cap on a new intake (relocated offshore) and on an existing offshore intake should be similar because most of the costs involve similar personnel and equipment. (See the “Application” section below for a discussion of new/existing submerged offshore intake cost components.)

Exhibit 3-47 presents the component (material, installation, and mobilization/demobilization) and total capital costs for stainless steel and carbon steel velocity caps provided by the vendor (Elarbash 2002a and 2002b). Data are presented for flows ranging from 5,000 gpm to 350,000 gpm. Figure 3-31 presents a plot of these data. The upper end of this flow range covers existing submerged pipes up to 15 feet in diameter at pipe velocities of approximately 5 feet per second. Second-order polynomial equations provided the best fit to the data and were used to produce cost curves. These cost curves serve as the basis for estimating capital costs for installing velocity caps on existing or new intakes submerged offshore at Phase III facilities. When applying these cost curves, if the intake flow exceeds 350,000 gpm plus 10% (385,000 gpm), the flow is divided into equal increments and these lower flows costed. The costs for these individual incremental flows are summed to estimate total capital cost. In these cases, costs are assumed to be applied to multiple intake pipes. If the intake flow is less than 5,000 gpm, the capital cost for 5,000 gpm will be used rather than extrapolating beyond the bottom end of the cost curve.

3.2 O&M Costs

For velocity caps, O&M costs generally include routine inspection and cleaning of the intake head. As noted above, biofouling does not affect velocity cap performance, so rigorous cleaning is not necessary. The vendor stated that their equipment is relatively maintenance free. However, O&M costs based on an annual inspection and cleaning of offshore intakes by divers were cited by facilities with existing offshore intakes, including some with velocity caps and especially those with bar racks at the intake. Therefore, estimated O&M costs are presented for an annual inspection and cleaning by divers because EPA believes this is common practice for submerged offshore intakes of all types.

Exhibit 3-48 presents the component and total O&M costs for the diver inspection and cleaning, for one to four days (Paroby 1999). In general, O&M costs are based on less than one day per head for inspection and cleaning of smaller intake heads and one day per head for the largest intake head. There is a minimum of one day for each inspection event. Inspection and cleaning events are assumed to occur once per year. Figure 3-32 presents the plot of the O&M costs by flow. A second-order polynomial equation provided the best fit to this data and serves as the basis for estimating the O&M costs.

Figure 3-32 also shows data for two facilities that reported actual O&M costs based on diver inspection and cleaning of submerged offshore intakes. While these two facilities use different intake technologies (passive screens for the smaller flow and bar rack type intakes for the larger flow), the inspection and cleaning effort should be similar for all three types of intakes. For both facilities, the actual reported O&M costs were less than the costs estimated using the cost curves, indicating that the estimated O&M costs should be considered as high-side estimates.

3.3 Application

As Retrofit of Existing Offshore Intake

Adding velocity caps to facilities with existing offshore intakes will provide impingement reduction only. For facilities withdrawing from saltwater/brackish waters (ocean and estuarine/tidal rivers), the capital cost curve for stainless steel caps will be applied. For the remaining facilities withdrawing freshwater (freshwater rivers/streams, reservoirs/lakes, Great Lakes), the capital cost curve for carbon steel caps will be applied. The same O&M cost curve will be used for both freshwater and saltwater systems. It is assumed that the existing intake is in a location that will provide sufficient clearance and is away from damaging wave action.

As Component of Relocating Existing Shoreline Intake to Submerged Offshore

These same velocity cap retrofit costs can be incorporated into retrofits where an existing shoreline intake is relocated to submerged offshore. In this application, some of the same equipment and personnel used in velocity cap installation may also be used to install other intake components, such as the pipe. Therefore, the mobilization/demobilization component could be reduced if these tasks are determined to occur close together in time. However, a high-side costing approach would be to cost each step separately, using the same velocity cap costs for both new and existing offshore intake pipes. In this case, the installation costs for velocity caps at existing offshore intakes (which include costs for cutting, and welding and/or bolting the velocity cap in place) are assumed to also cover costs of installing connection flanges at new offshore intakes. Costs for other components of relocating existing shoreline intakes to submerged offshore are developed as a separate cost module associated with passive screens. The compliance cost estimates did not include this scenario.

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Elarbash, M. Elmosa Canada. email correspondence with John Sunda, SAIC concerning cost and technical data for Invisihead velocity caps. August 9, 2002a

Elarbash, M. Elmosa Canada. email correspondence with John Sunda, SAIC concerning cost and technical data for Invisihead velocity caps. August 19, 2002b

Elmosa. Website at http://www.imasar.com/elmosa/invisiheaddetails.htm accessed May 9, 2002.

Paroby, Rich. Personal communication between Rich Paroby, District Sales Manager, Water Process Group and Deborah Nagle, USEPA E-mail dated May 12, 1999.

Exhibit 3-47. Velocity Cap Retrofit Capital and O&M Costs (2002 $)

Velocity Cap Retrofit Capital and O&M Costs (2002 $)

Flow (gpm)	# Heads	Material Costs - Stainless Steel /Head	Material Costs - Stainless Steel Total	Material Costs - Carbon Steel /Head	Material Costs - Carbon Steel Total	Installation	Mobilization/ Demobilization	Total Capital Costs - Stainless Steel	Total Capital Costs - Carbon Steel	Total O&M
Water Type	All	Saltwater	Saltwater	Freshwater	Freshwater	All	All	Saltwater	Freshwater	All
5,000	1	$30,000	$30,000	$22,500	$22,500	$25,000	$10,000	$65,000	$57,500	$5,260
10,000	1	$30,000	$30,000	$22,500	$22,500	$30,000	$15,000	$75,000	$67,500	$5,260
25,000	1	$40,000	$40,000	$30,000	$30,000	$35,000	$15,000	$90,000	$80,000	$5,260
50,000	2	$35,000	$70,000	$26,250	$52,500	$49,000	$25,000	$144,000	$126,500	$7,250
100,000	2	$80,000	$160,000	$60,000	$120,000	$49,000	$25,000	$234,000	$194,000	$7,250
200,000	4	$80,000	$320,000	$60,000	$240,000	$98,000	$30,000	$448,000	$368,000	$11,230
350,000	4	$106,000	$424,000	$79,500	$318,000	$98,000	$30,000	$552,000	$446,000	$11,230

Note: Vendor indicated installation took 2 to 7 days

Note: Installation includes retrofit activities such as cutting pipe and & attaching connection flange on intake inlet pipe.

Exhibit 3-48. Installation and Maintenance Diver Team Costs

Installation and Maintenance Diver Team Costs

Item	Daily Cost*	One Time Cost*	Total	Adjusted Total			
Duration			**One Day**	**One Day**	**Two Day**	**Three Day**	**Four Day**
Cost Year			**1999**	**2002**	**2002**	**2002**	**2002**
Supervisor	**$575**		$575	$627	$1,254	$1,880	**$2,507**
Tender	**$200**		$200	$218	$436	$654	**$872**
Diver	**$375**		$750	$818	$1,635	$2,453	**$3,270**
Air Packs	**$100**		$100	$109	$218	$327	**$436**
Boat	**$200**		$200	$218	$436	$654	**$872**
Mob/Demob		**$3,000**	$3,000	$3,270	$3,270	$3,270	**$3,270**
Total			**$4,825**	**$5,260**	**$7,250**	**$9,240**	**$11,230**

***Source: Paroby 1999 (cost adjusted to 2002 dollars).**

Figure 3-31. Velocity Cap Capital Costs 2002 Dollars

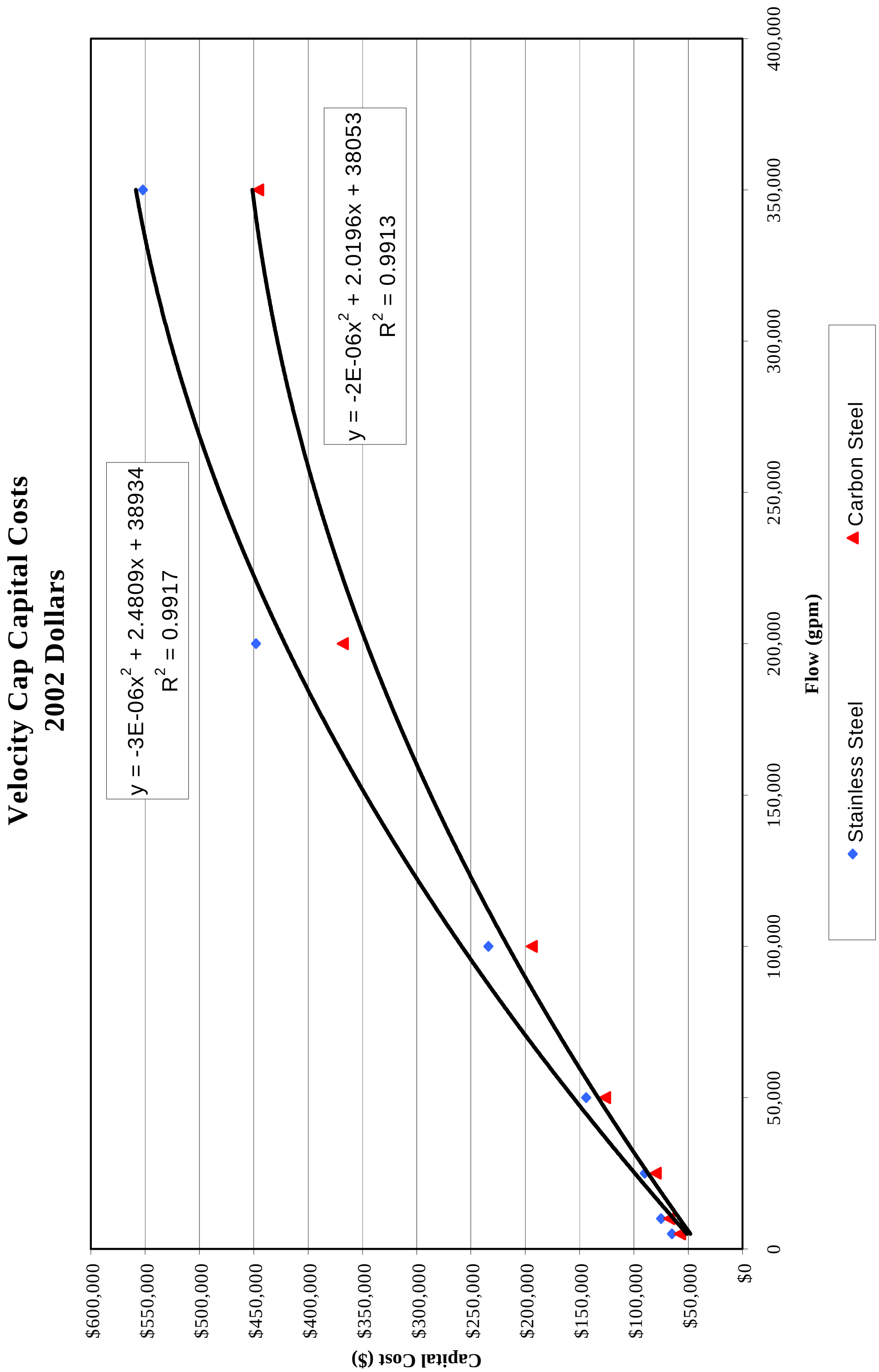
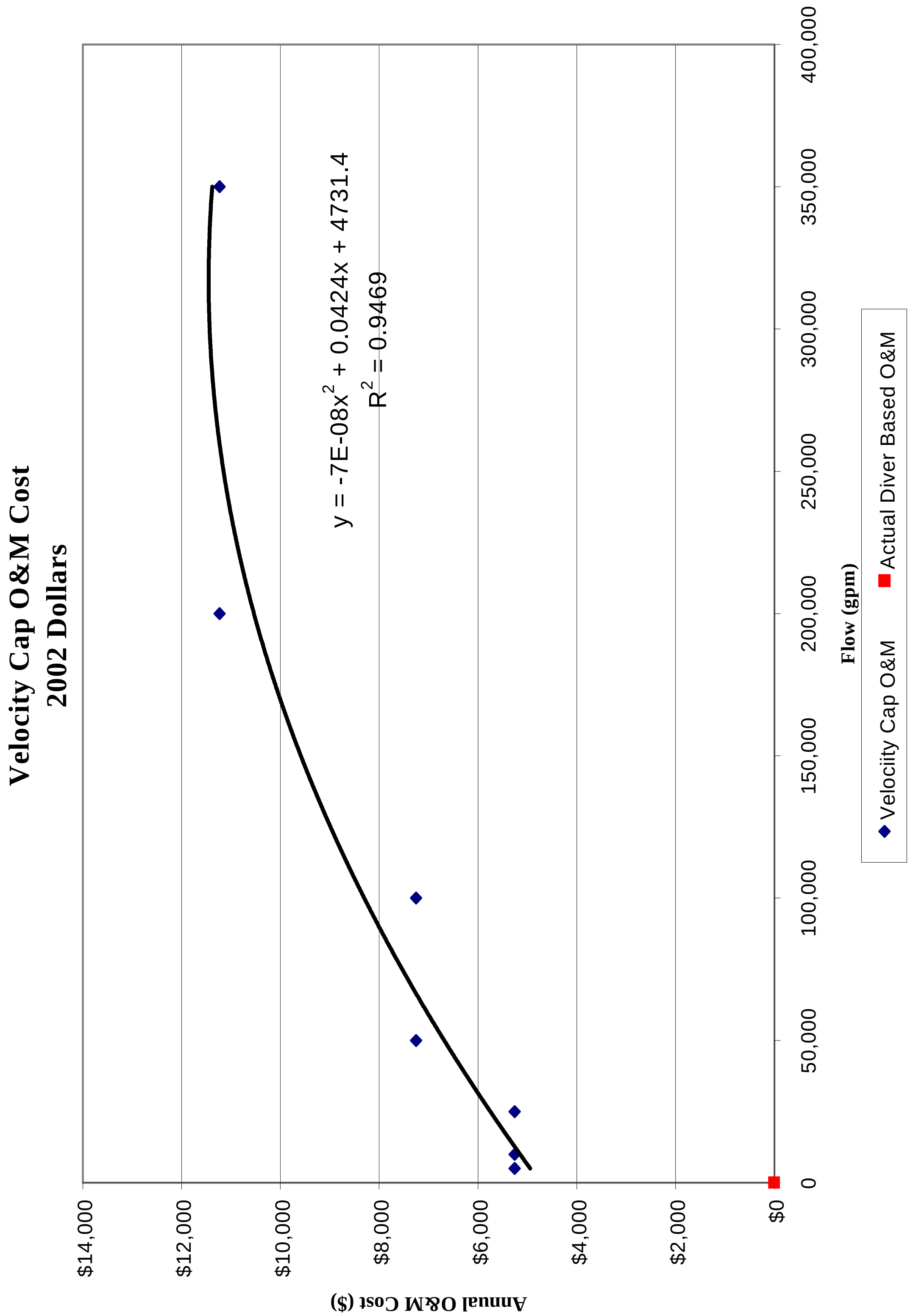


Figure 3-32. Velocity Cap O&M Cost 2002 Dollars



4.0 FISH BARRIER NETS

Fish barrier net can be used where improvements to impingement performance is needed. Because barrier nets can be installed independently of intake structures, there is no need to include any costs for modifications to the existing intake or technology employed. Costs are assumed to be the same for both new and existing facilities. Barrier nets can be installed while the facility is operating. Thus, there is no need to coordinate barrier net installation with generating unit downtime.

Fish Barrier Net Questionnaire

EPA identified seven facilities from its database that employed fish barrier nets and sent them a brief questionnaire requesting barrier net design and cost data (EPA 2002). The following four facilities received but did not submit a response:

Bethlehem Steel - Sparrows Point
Consumers Energy Co. - J.R. Whiting Plant
Exelon Corp. (formerly Commonwealth Edison) - LaSalle County Station
Southern Energy - Bowline Generating Station

The following three facilities submitted completed questionnaires:

Entergy Arkansas, Inc. - Arkansas Nuclear One
Potomac Electric Power Co. - Chalk Point
Minnesota Power - Laskin Energy Center

Net Velocity

An important design criterion for determining the size of fish barrier nets is the velocity of the water as it passes through the net. Net velocity (which is similar to the approach velocity for a traveling screen) determines how quickly debris will collect on the nets. Net velocity also determines the force exerted on the net, especially if it becomes clogged with debris. For facilities that supplied technical data, Exhibit 3-49 presents the design intake flow (estimated by EPA) and facility data reported in the Barrier Net Questionnaire. These data include net size, average daily intake flow, and calculated net velocities based on average and design flows. Note that the Chalk Point net specifications used for purchasing the net, indicated a net width of 27 ft (Langley 2002) while the Net Questionnaire reported a net width of 30 ft. A net width of 27 ft was used for estimating net velocities and unit net costs. The two larger facilities have similar design net velocity values that, based on design flow, is equal to 0.06 feet per second. This values are roughly an order of magnitude lower than compliance velocities used for rigid screens in the Phase I Rule as well as design velocities recommended for passive screens. There are two reasons for this difference. One difference is rigid screens can withstand greater pressure differentials because they are firmly held in place. The second is rigid screens can afford to collect debris at a more rapid rate because they have an active means for removing debris collected on the surface.

Based on the data presented in Exhibit 3-49, EPA has selected a net velocity of 0.06 feet per second (using the design flow) as the basis for developing compliance costs for fish barrier nets. Nets tested at a high velocity (> 1.3 feet per second) at a power plant in Monroe Michigan clogged and collapsed. Velocities higher than 0.06 feet per second may be acceptable at locations where the debris loading is low or where additional measures are taken to remove debris. While tidal locations can have significant water velocities, the periodic reversal of flow direction can help dislodge some of the debris that collects on the nets. The technology scenario described below, for tidal waterbodies, is designed to accommodate significant debris loading through the use of dual nets and frequent replacement with cleaned nets.

Exhibit 3-49. Net Velocity Data Derived from Barrier Net Questionnaire Data

Facility Owner	Facility Name	Depth*	Length*	Area	EPA Design Flow	Net Velocity at Design Flow	Average Daily Flow*	Net Velocity at Daily Flow
		Ft	Ft	sq ft	gpm	fps	gpm	fps
PEPCO	Chalk Point	27	1000	27,000	762,500	0.06	500,000	0.04
Entergy	Arkansas Nuclear One	20	1500	30,000	805,600	0.06	593,750	0.04
Minn. Power	Laskin Energy Center	16	600	9,600	101,900	0.02	94,250	0.02

* Source: 2002 EPA Fish Barrier Net Questionnaire and Langley 2002

Mesh Size

Mesh size determines the fish species and juvenile stages that will be excluded by the net. While smaller mesh size has the ability to exclude more organisms, it will plug more quickly with debris. The Chalk Point facility tried to use 0.5-inch stretch mesh netting and found that too much debris collected on the netting; it instead uses 0.75 inch stretch (0.375 inch mesh) netting (Langley 2002). Unlike rigid screens, fish nets are much more susceptible to lateral forces which can collapse the net.

Mesh size is specified in one of two ways, either as a "bar" or "stretch" dimension. A "stretch" measurement refers to the distance between two opposing knots in the net openings when they are stretched apart. Thus, assuming a diamond shaped netting, when the netting is relaxed the distance between two opposing sides of an opening will be roughly ½ the stretch diameter. A "bar" measurement is the length of one of the four sides of the net opening and would be roughly equal to ½ the stretch measurement. The term "mesh size" as used in this document refers to either ½ the "stretch" measurement or is equal to the "bar" measurement

Exhibit 3-50 presents reported mesh sizes from several power plant facilities that either now or in the past employed fish barrier nets. An evaluation report of the use of barrier fish nets at the Bowline Plant in New York cited that 0.374 inch mesh was more effective than 0.5 inch mesh at reducing the number of fish entering the plant intake (Hutcheson 1988). Both fish barrier net cost scenarios described below are based on nets with a mesh size of 0.375 in. (9.5 mm) and corresponds to the median mesh size of those identified by EPA.

Exhibit 3-50. Available Barrier Net Mesh Size Data

Facility	Description	Reported Mesh Size		Type of Measurement and Source	Effective Mesh Size	
		Inch	mm		Inch	mm
Chalk Point	Inner Net	0.75	19	Stretch (1)	0.375	9.5
	Outer Net	1.25	32	Stretch (1)	0.625	15.9
Entergy Arkansas Nuclear One	Low	0.375	10	Mesh (Bar) (1)	0.375	9.5
	High (preferred)	0.5	13	Mesh (Bar) (1)	0.5	12.7
Laskin Energy		0.25	6.4	Mesh (Bar) (1)	0.25	6.4
Bowline Point	More Effective Size	0.374	9.5	Bar (3)	0.374	9.5
J.P. Pulliam		0.25	6.4	Stretch (2)	0.126	3.2
				Median	0.374	9.5

(1): 2002 EPA Fish Barrier Survey
(2):ASCE 1982
(3): Hutcheson 1988

Twine

Twine size mostly determines the strength and weight of the fish netting. Only the Chalk Point facility reported twine size data (#252) knotless nylon netting. Netting #252 is a 75-lb test braided nylon twine in which the twine joints are braided together rather than knotted (Murelle 2002). The netting used at the Bowline Power Plant was cited as multi-filament knotted nylon, chosen because of its low cost and high strength (Hutcheson 1988).

Support/Anchoring System

In general, two different types of support and anchoring systems have been identified by EPA. In the simplest system the nets are held in-place and the bottom is sealed with weights running the length of the bottom usually consisting of a chain or a lead line. The weights may be supplemented with anchors placed at intervals. Vendors indicated the requirement for anchors varies depending on the application and waterbody conditions. The nets are anchored along the shore and generally placed in a semi-circle or arc in front of the intake. The Bowline Facility net used a v-shape configuration with an anchor and buoy at the apex and additional anchors placed midway along the 91 meter length sides. In some applications anchors may not be needed at all. If the nets are moved by current or waves, they can be set back into the proper position using a boat. The nets are supported along the surface with buoys and floats. The buoys may support signs warning boaters of the presence of the net. The required spacing and size of the anchors and buoys is somewhat dependent on the size of the net and lateral water velocities. The majority of facilities investigated used this float/anchor method of installation. This net support configuration, using weights, anchors, floats, and buoys, is the basis for compliance scenario A.

A second method is to support nets between evenly spaced pilings. This method is more appropriate for water bodies with currents. The Chalk Point Power Plant uses this method in a tidal river. The Chalk Point facility uses two concentric nets. Each has a separate set of support pilings with a spacing between pilings of about 18 feet to 20 feet (Langley 2002). Nets are hung on the outside of the pilings with spikes and are weighted on the bottom with galvanized chain. During the winter top of the net is suspended below the water surface to avoid ice damage but generally thick ice does not persist during the winter months at the facility location.

Debris

Debris problems generally come in two forms. In one case large floating debris can get caught in the netting near the surface and result in tearing of the netting. In the other cases, floating and submerged debris can plug the openings in the net. This increases the hydraulic gradient across the net, resulting in net being pulled in the downstream direction. The force can become so great that it can collapse the net, and water flows over the top and/or beneath the bottom. If the net is held in place by only anchors and weights it may be moved out of place. At the Chalk Point facility, debris that catches on the nets mostly comes in the form of jellyfish and colonial hydroids (Langley 2002).

Several solutions are described for mitigating problems created by debris. At the Chalk Point Power Plant two concentric nets are deployed. The outer net has a larger mesh opening designed to capture and deflect larger debris so it does not encounter the inner net, which catches smaller debris. This configuration reduces the debris buildup on any one net extending the time period before net cleaning is required. Growth of algae and colonization with other organisms (biofouling) can also increase the drag force on the nets. Periodic removal and storage out of the water can solve this problem. At Chalk Point both nets are changed out with cleaned nets on a periodic basis. This approach is considered to be appropriate for high debris locations.

Another solution is to periodically lift the netting and manually remove debris. A solution for floating debris is to place a debris boom in front of the net (Hutcheson 1988).

Ice

During the wintertime ice can create problems in that the net can become embedded in surface ice with the net subject to tear forces when the ice breaks up or begins to move. Flowing ice can create similar problems as floating debris. Ice will also affect the ability to perform net maintenance such as debris removal. Solutions include:

- Removing the nets during winter
- Drop the upper end of the net to a submerged location; can only be used with fixed support, such as pilings and in locations where thick ice is uncommon
- Installing an air bubbler below the surface. Does not solve problems with flowing ice.

Net Deployment

EPA assumes that barrier nets will be used to augment performance of the existing shore-based intake technology such as traveling screens. The float/anchor supported nets are assumed to be deployed on a seasonal basis to reduce impingement of fish present during seasonal migration. The Arkansas Energy Arkansas Nuclear One Plant deploys their net for about 120 days during winter months. The Minnesota Power Laskin Energy Center, which is located on a lake, deploys the net when ice has broken up in spring and removes the net in the fall before ice forms. Thus, the actual deployment period will vary depending on presence of ice and seasonal migration of fish. For the compliance scenario that relies upon float/anchor supported nets, a total deployment period of eight months (240 day) is assumed. This is equal to or greater than most of the deployment periods observed by EPA.

EPA notes that the Chalk Point facility currently uses year round deployment and avoids problems with ice in the winter time by lowering the net top to a location below the surface. Prior to devising this approach, nets were remove during the winter months. This option is available because the nets are supported on pilings. Thus, the surface support rope (with floats removed) can be stretched between the pilings several feet below the surface. Therefore, a scenario where nets are supported by pilings may include year round deployment as was the case for the Chalk Point Power Plant. However, in northern climates the sustained presence of thick ice during the winter may prevent net removal and cleaning and therefore, it may still be necessary to remove the nets during this period.

4.1 Capital Cost Development

Compliance costs are developed for the two different net scenarios.

Scenario A Installation at Freshwater Lake Using Anchors and Buoys/Floats

This scenario is intended for application in freshwater waterbodies where low water velocities and low debris levels occur such as lakes and reservoirs. This scenario is modeled on the barrier net data from the Entergy Arkansas Nuclear One facility but has been modified to double the annual deployment period from 120 days to 240 days. Along with doubling the deployment period, the labor costs were increased to include an additional net removal and replacement step midpoint through this period. To facilitate the mid season net replacement, the initial net capital costs will include purchase of a replacement net.

Scenario B Installation Using Pilings.

This scenario is modeled after the system used at Chalk Point. In this case two nets are deployed in concentric semi-circles with the inner net having a smaller mesh (0.375 in) and the outer net having a larger mesh. Deployment is assumed to be year round. A marine contractor performs all O&M, which mostly involves periodically removing and the replacing both nets with nets they have cleaned. The initial capital net costs will include purchase of a set of replacement nets. This scenario is intended for application in waterbodies with low or varying currents such as tidal rivers and estuaries. Two different O&M cost estimates are developed for this scenario. In one the deployment is assumed to be year round as is the case at Chalk Point. In the second, the net is deployed for only 240 days being taken out during the winter months. This would apply to facilities northern regions where ice formation would make net maintenance difficult.

Net Costs

The capital costs for each scenario includes two components, the net and the support. The net portion includes a rope and floats spaced along the top and weights along the bottom consisting of either a “leadline”or chain. If similar netting specifications are used the cost of the netting is generally proportional to the size of the netting and can be expressed in a unitized manner such as “dollars/sq ft.” Exhibit 3-51 presents the reported net costs and calculated unit costs. While different water depths will change the general ratio of net area to length of rope/floats and bottom weights, the differences in depth also result in different float and weight requirements. For example, a shallower net will require more length of surface rope and floats and weights per unit net area but a shallower depth net will also exert less force and require smaller floats and weights.

EPA is using the cost of nets in the average depth range of 20 to 30 feet as the basis for costing. This approach is consistent with the median Phase III facility shoreline intake depth of 18 feet and median “average bay depth” of 20 feet. While nets are deployed offshore in water deeper than a shoreline intake, costs are for average depths, which include the shallow sections at the ends, and net placement can be configured to minimize depth. To see how shallower depths may affect unit costs, the costs for a shallower 10-foot net with specifications similar to the Chalk Point net (depth of 27 feet) were obtained from the facility’s net supplier. As shown in Exhibit 3-51, the unit cost per square foot for the shallower net was less than the deeper net. Therefore, EPA has concluded that the use of shallower nets does not increase unit costs and has chosen to apply the unit costs, based on the 20-foot and 30-foot depth nets, to shallower depths.

Exhibit 3-51 presents costs obtained for the net portion only from the facilities that completed the Barrier Net Questionnaire. These costs have been increased by 12% over what was reported to include shipping costs. This 12% value was obtained from the Chalk Point net supplier who confirmed that the costs reported by Chalk Point did not include shipping. (Murelle 2002) The unit net costs range from $0.17/sq ft to $0.78/sq ft. Consultation with net vendors indicates that the barrier net specifications vary considerably and that there is no standard approach. Although no net specification data (besides mesh size) was submitted with the Laskin Energy Center data, EPA has concluded that the data for this net probably represents lower strength netting which would be suitable for applications where the netting is not exposed to significant forces. Because the compliance cost scenarios will be applied to facilities with a variety net strength requirements, EPA has chosen to use the higher net costs that correspond to higher net strength requirements. As such, EPA has chosen to use the cost data for the Chalk Point and Arkansas Nuclear One facilities as the basis for each scenario.

Exhibit 3-51 Net Size and Cost Data

Facility	Depth	Length	Area	Component	Cost/net	Cost/sq ft
	ft	ft	sq ft			
Chalk Point	27	300	8,100	Replacement Net 0.675 in.*	$4,640	$0.57
	27	300	8,100	Replacement Net 0.375 in.*	$4,410	$0.54
Chalk Point (equivalent	10	300	3,000	Replacement Net*	$1,510	$0.50
Entergy Arkansas	20	250	5,000	Replacement Net*	$3,920	$0.78
Entergy Arkansas	20	1500	30,000	Net & Support Costs**	$36,620	$1.22
Laskin Energy Center	16	600	9,600	Net Costs***	$1,600	$0.17

*Costs include floats and lead line or chain and are based on replacement costs plus 12% shipping.

** Costs include replacement net components plus anchors, buoys & cable plus 12% shipping

***Cost based on reported 1980 costs adjusted to 2002 dollars plus 12% for shipping.

Scenario A Net Costs

In this scenario the net and net support components are included in the unit costs. At the Arkansas Nuclear One facility unitized costs for the net and anchors/buoys are $1.22/sq ft plus $0.78/sq ft for the replacement net, resulting in a total initial unit net costs of $2.00/sq ft for both nets. Because the data in Exhibit 3-50 indicate that, if anything, unit costs for nets may decrease with shallower depths, EPA concluded that this unit cost was representative of most of the deeper nets and may slightly overestimate the costs for shallower nets.

Scenario A Net Installation costs

Installation costs for Arkansas Nuclear One (Scenario A) were reported as $30,000 (in 1999 dollars; $32,700 when adjusted for inflation to 2002 dollars) for the 30,000 sq ft net. This included placement of anchors and cable including labor. In order to extrapolate the installation costs for different net sizes, EPA has assumed that approximately 20% ($6,540) of this installation cost represents fixed costs (e.g., mobilization/demobilization). The remainder ($26,160) divided by the net area results in an installation unit cost of $0.87/sq ft to be added to the fixed cost.

Scenario A Total Capital Costs

Exhibit 3-52 presents the component and total capital costs for Scenario A. Indirect costs are added for engineering (10%) and contingency/allowance (10%). Contractor labor and overhead are already included in the component costs. Because most of the operation occurs offshore no cost for sitework are included.

Exhibit 3-52. Capital Costs for Scenario A Fish Barrier Net With Anchors/Buoys as Support Structure

Flow (gpm)	2,000	10,000	50,000	100,000	250,000	500,000	750,000	1,000,000	1,250,000
Net Area (sq ft)	74	371	1,857	3,714	9,284	18,568	27,852	37,136	46,420
Net Costs	$149	$744	$3,722	$7,445	$18,611	$37,223	$55,834	$74,445	$93,057
Installation Costs Fixed	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540	$6,540
Installation Costs Variable	$65	$324	$1,619	$3,238	$8,096	$16,191	$24,287	$32,383	$40,478
Total Direct Capital Costs	$6,754	$7,608	$11,881	$17,223	$33,247	$59,954	$86,661	$113,368	$140,075
Indirect Costs	$1,351	$1,522	$2,376	$3,445	$6,649	$11,991	$17,332	$22,674	$28,015
Total Capital Costs	$8,104	$9,130	$14,258	$20,667	$39,896	$71,945	$103,993	$136,042	$168,090

Scenario B Net Costs

In this scenario the net costs are computed separately from the net support (pilings) costs. In this scenario there are two separate nets and an extra set of replacement nets for each. This, the unit costs for the nets will be two times the sum of the units net costs for each of the large and small mesh nets. As shown in Exhibit 3-52, the unit costs for each net was $0.57/sq ft and $0.54/sq ft resulting in a total cost for all four nets of $2.24/sq ft for the area of a single net.

Scenario B Installation Costs

Installation costs were not provided for the Chalk Point facility. Initial net installation is assumed to be performed by the O&M contractor and is assumed to be a fixed cost regardless of net size. EPA assumed the initial installation costs to be two-thirds of the contractor, single net replacement job cost of $1,400 or $933 (See O&M Costs - Scenario B).

Scenario B Piling Costs

The cost for the pilings at the Chalk Point facility were not provided. The piling costs for scenario B is based primarily on the estimated cost for installing two concentric set of treated wooden pilings with a spacing of 20 ft between pilings. To see how water depth affects piling costs, separate costs were developed at water depths of 10 feet, 20 feet, and 30 feet. Piling costs are based on the following assumptions:

- Costs for pilings is based on a unit cost of $28.50/ ft of piling (RS Means, 2001)
- Piling installation mobilization costs are equal to $2,325 based on a mobilization rate of $46.50/mile for barge mounted pile driving equipment (RS Means 2001) and an assumed distance of 50 miles
- Each pile length includes the water depth plus a 6-foot extension above the water surface plus a penetration depth (at two-thirds the water depth); the calculated length was rounded up to the next even whole number
- The two concentric nets are nearly equal in length with one pile for every 20 feet in length and one extra pile to anchor the end of each net.

Exhibit 3-53 presents the individual pile costs and intake flow for each net section between two pilings (at 0.06 feet per second).

Exhibit 3-53. Pile Costs and Net Section Flow

Water Depth	Total Pile Length	Cost Per Pile	Flow Per 20 ft Net Section	Fixed Cost Mobilization
Ft	Ft		gpm	
10	24	684	5385.6	2325
20	40	1140	10771.2	2325
30	56	1596	16156.8	2325

Exhibits 3-54, 3-55, and 3-56 present the total capital costs and cost components for the installed nets and pilings. Indirect costs are added for engineering (10%) and contingency/allowance (10%). Contractor labor and overhead are already included in the component costs. Because most of the operation occurs offshore no cost for sitework are included. The costs were derived for nets with multiple 20 ft sections. Because the net costs are derived such that the cost equations are linear with respect to flow, the maximum number of sections shown are selected so they cover a similar flow range. Values that exceed this range can use the same cost equation.

Exhibit 3-54. Capital Costs for Fish Barrier Net With Piling Support Structure for 10 Ft Deep Nets

Number of 20 ft Sections	2	4	8	12	25	50	75	100	200
Total Number of Pilings	6	10	18	26	52	102	152	202	402
Single Net Length (ft)	40	80	160	240	500	1000	1500	2000	4000
Net Area (sq ft)	400	800	1,600	2,400	5,000	10,000	15,000	20,000	40,000
Flow (gpm)	10,771	21,542	43,085	64,627	134,640	269,280	403,920	538,560	1,077,120
Total Piling Cost	$6,429	$9,165	$14,637	$20,109	$37,893	$72,093	$106,293	$140,493	$277,293
Net Costs	$1,380	$1,827	$2,721	$3,614	$6,519	$12,106	$17,692	$23,279	$45,624
Total Direct Costs	$7,809	$10,992	$17,358	$23,723	$44,412	$84,199	$123,985	$163,772	$322,917
Indirect Costs	$1,562	$2,198	$3,472	$4,745	$8,882	$16,840	$24,797	$32,754	$64,583
Total Capital Costs	$9,371	$13,190	$20,829	$28,468	$53,295	$101,039	$148,782	$196,526	$387,501

Exhibit 3-55 Capital Costs for Fish Barrier Net With Piling Support Structure for 20 Ft Deep Nets

Number of 20 ft Sections	2	4	8	12	25	50	75	100
Total Number of Pilings	6	10	18	26	52	102	152	202
Single Net Length (ft)	40	80	160	240	500	1000	1500	2000
Net Area (sq ft)	800	1600	3200	4800	10000	20000	30000	40000
Flow (gpm)	21,542	43,085	86,170	129,254	269,280	538,560	807,840	1,077,120
Total Piling Cost	$9,165	$13,725	$22,845	$31,965	$61,605	$118,605	$175,605	$232,605
Net Costs	$1,827	$2,721	$4,508	$6,296	$12,106	$23,279	$34,452	$45,624
Total Direct Costs	$10,992	$16,446	$27,353	$38,261	$73,711	$141,884	$210,057	$278,229
Indirect Costs	$2,198	$3,289	$5,471	$7,652	$14,742	$28,377	$42,011	$55,646
Total Capital Costs	$13,190	$19,735	$32,824	$45,913	$88,453	$170,260	$252,068	$333,875

Exhibit 3-56. Capital Costs for Fish Barrier Net With Piling Support Structure for 30 Ft Deep Nets

Number of 20 ft Sections	2	4	8	12	25	50	75
Total Number of Pilings	6	10	18	26	52	102	152
Single Net Length (ft)	40	80	160	240	500	1000	1500
Net Area (sq ft)	1,200	2,400	4,800	7,200	15,000	30,000	45,000
Flow (gpm)	32,314	64,627	129,254	193,882	403,920	807,840	1,211,760
Total Piling Cost	$9,576	$15,960	$28,728	$41,496	$82,992	$162,792	$242,592
Net Costs	$2,274	$3,614	$6,296	$8,977	$17,692	$34,452	$51,211
Total Direct Costs	$11,850	$19,574	$35,024	$50,473	$100,684	$197,244	$293,803
Indirect Costs	$2,370	$3,915	$7,005	$10,095	$20,137	$39,449	$58,761
Total Capital Costs	$14,220	$23,489	$42,029	$60,568	$120,821	$236,692	$352,563

Figure 3-33 presents the total capital costs for scenarios A and B from Exhibits 3-52 through 3-56, plotted against design flow. Figure 3-33 also presents the best-fit linear equations used top estimate compliance costs. EPA notes that pilings for shallower depths costed out more, due to the need for many more pilings. Scenario B costs for 10-foot deep nets will be applied wherever the intake depth is less than 12 ft. For scenario B applications in water much deeper than 12 feet, EPA will use the cost equation for 20-foot deep nets.

4.2 O&M Costs Development

Scenario A O&M Costs - Float/Anchor Supported Nets

Barrier net O&M costs generally include costs for replacement netting, labor for net inspection, repair, and cleaning, and labor for net placement and removal. The Arkansas Nuclear One facility supplied data that estimate all three components for its 1500 ft long by 20 ft deep net located on a reservoir. Net deployment, however, was for only a 120-day period. This net is installed in November and removed in March (in-place for 120 days total). Each year two 250-foot sections of the net (one-third of the total) are replaced due to normal wear and tear.

EPA assumes the labor rate is similar to the estimate for traveling screen maintenance labor ($41.10/hr). The reported Arkansas Nuclear One O&M labor requirements includes 3 hrs per day during the time the net is deployed for inspection & cleaning by personnel on a boat (calculated at $14,800). This involves lifting and partially cleaning the nets on a periodic basis. Labor to deploy and remove the net was reported at 240 hrs (calculated at $9,860). Two sections of the six total net sections were replaced annually at a cost of $7,830 total (including shipping). Total annual O&M costs are calculated to be $32,500.

Because other facilities on lakes reported longer deployment periods (generally when ice is not present), EPA chose to adjust O&M costs to account for longer deployment. EPA chose to base O&M costs for scenario A on a deployment period of 240 days (approximately double the Arkansas Nuclear One facility deployment period). EPA also added costs for an additional net removal and deployment step using the second replacement net midway through the annual deployment period. The result is a calculated annual O&M cost of $57,200.

Scenario B O&M Costs - Piling Supported Nets

Nearly all of the O&M labor for Chalk Point facility is performed by a marine contractor who charges $1,400 per job to simultaneously remove the existing net and replace it with a cleaned net. This is done with two boats where one boat removes the existing net followed quickly by the second that places the cleaned net keeping the open area between nets minimized. The contractors fee includes cleaning the removed nets between jobs. This net replacement is performed about 52 to 54 times per years. It is performed about twice per week during the summer and once every two weeks during the winter. The facility relies upon the contractor to monitor the net. Approximately one third of the nets are replaced each year, resulting in a net replacement cost of $9,050.

Using an average of 53 contractor jobs per year and a net replacement cost of $9,050 the resulting annual O&M cost was $83,250. EPA notes that some facilities that employ scenario B technology may choose to remove the nets during the winter. As such, EPA has also estimated the scenario B O&M costs based on a deployment period of approximately 240 days by reducing the estimated number of contractor jobs from 53 to 43 (deducting 10 jobs using the winter frequency of roughly 1 job every 2 weeks). The resulting O&M costs are shown in Exhibits 3-56 and 3-57.

EPA notes that other O&M costs reported in literature are often less than what is shown in Exhibit 3-56. For example, 1985 O&M cost estimates for the JP Pulliam plant ($7,500/year, adjusted to 2002 dollars) calculate to $11,800 for a design flow roughly half that of Arkansas Entergy. This suggests the scenario A and B estimates represent the high end of the range of barrier net O&M costs. Other O&M estimates, however, do not indicate the cost components that are included and may not represent all cost components.

In order to extrapolate costs for other flow rates, EPA has assumed that roughly 20% of the Scenario A and B O&M costs represent fixed costs. Exhibit 3-57 presents the fixed and unit costs based on this assumption for both scenarios.

Exhibit 3-57. Cost Basis for O&M Costs

	Deployment	Net Replacement	O&M Labor	Model Facility O&M	Fixed Cost	Variable Costs	Unit Variable O&M Costs
	Days						$/sq ft
Scenario A	240	$7,830	$49,320	$57,150	$11,430	$45,720	$1.52
Scenario B	365	$9,050	$74,200	$83,250	$16,650	$66,600	$2.47
Scenario B	240	$9,050	$60,200	$69,250	$13,850	$55,400	$2.05

Note that Unit Variable O&M Costs are based on a total net area of 30,000 sq ft (Entergy Arkansas) for scenario A and 27,000 sq ft for scenario B (Chalk Point).

Exhibit 3-58 presents the calculated O&M costs based on the cost factors in Exhibit 3-57 and Figure 3-34 presents the plotted O&M costs and the linear equations fitted to the cost estimates.

Exhibit 3-58. Annual O&M Cost Estimates

Flow (gpm)		2,000	10,000	50,000	100,000	250,000	500,000	750,000	1,000,000	1,250,000
Net Area (sq ft)		74	371	1,857	3,714	9,284	18,568	27,852	37,136	46,420
Scenario A	240 days	$11,543	$11,996	$14,260	$17,090	$25,579	$39,728	$53,877	$68,025	$82,174
Scenario B	365 days	$16,833	$17,566	$21,230	$25,810	$39,551	$62,451	$85,352	$108,252	$131,153
Scenario B	240 days	$14,002	$14,612	$17,660	$21,470	$32,899	$51,949	$70,998	$90,048	$109,097

4.3 Nuclear Facilities

Even though the scenario A costs are modeled after the barriers nets installed at a nuclear facility, the higher unit net costs cited by the Arkansas Nuclear One facility include components that are not included with the non-nuclear Chalk Point nets and thus the differences may be attributed to equipment differences and not differences between nuclear and non-nuclear facilities. In addition, the labor rates used for scenario A and B O&M were for non-nuclear facilities. Because the function of barrier nets is purely for environmental benefit, and not critical to the continued function of the cooling system (as would be technologies such as traveling screens). EPA does not believe that a much more rigorous design is warranted at nuclear facilities. However, higher labor rates plus greater paperwork and security requirements at nuclear facilities should result in higher costs. As such, EPA has concluded that the capital costs for nuclear facilities should be increased by a factor of 1.58 (lower end of range cited in passive screen section). Because O&M costs rely heavily on labor costs, EPA has concluded that the O&M costs should be increased by a factor of 1.24 (based on nuclear vs non-nuclear operator labor costs).

4.4 Application

Fish barrier net technology will augment, but not replace, the function of any existing technology. Therefore, the calculated net O&M costs will include the O&M costs described here without any deductions for reduction in existing technology O&M costs. Fish barrier nets may not be applicable in locations where they would interfere with navigation channels or boat traffic.

Fish barrier nets require low waterbody currents in order to avoid becoming plugged with debris that could collapse the net. Such conditions can be found in most lakes and reservoirs, as well as some tidal waterbodies such as tidal rivers and estuaries. Placing barrier nets in a location with sustained lateral currents in one direction may cause problems because the section of net facing the current will continually collect debris at higher rate than the remainder of the net. In this case, net maintenance cleaning efforts must be able to keep up with debris accumulation. As such, barrier nets are suitable for intake locations that are sheltered from currents, e.g., locations within an embayment, bay, or cove. On freshwater rivers and streams only those facilities within an embayment, bay, or cove will be considered as candidates for barrier nets. The sheltered area needs to be large enough for the net sizes described above. The fish barrier net designs considered here would not be suitable for waterbodies with the strong wave action typically found in ocean environments.

Scenario A is most suitable for lakes and reservoirs where water currents are low or almost nonexistent. Scenario B is more suitable for tidal waterbodies and any other location where higher quantities of debris and light or fluctuating currents may be encountered. In northern regions where formation of thick ice in winter would prevent access to the nets, and scenario B may be applied, the scenario B O&M costs for a 240-day deployment should be used. However, because this scenario results in reduced costs, EPA has chose to apply the scenario B 365 days deployment for all facilities in suitable waterbodies.

EPA notes that nets with net velocities higher than 0.07 feet per second have been successfully employed (EPRI 1985). While such nets will be smaller than those described here, they will accumulate debris at a faster rate. Because the majority of the O&M costs are related to cleaning nets, EPA expects the increase in frequency of cleaning smaller nets will be offset by the smaller net size such that the smaller nets should require similar costs to maintain.

Facilities with Canals

Most facilities with canals have in-canal velocities of between 0.5 and 1 feet per second based on average flow. These velocities are an order of magnitude greater than the design net velocity used here. If nets with mesh sizes in the range considered here were placed within the canals they will likely experience problems with debris. Therefore, if barrier nets are used at facilities with canals, the net would need to be placed in the waterbody just outside the canal entrance.

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Figure 3-33. Total Capital Costs for Fish Barrier Nets

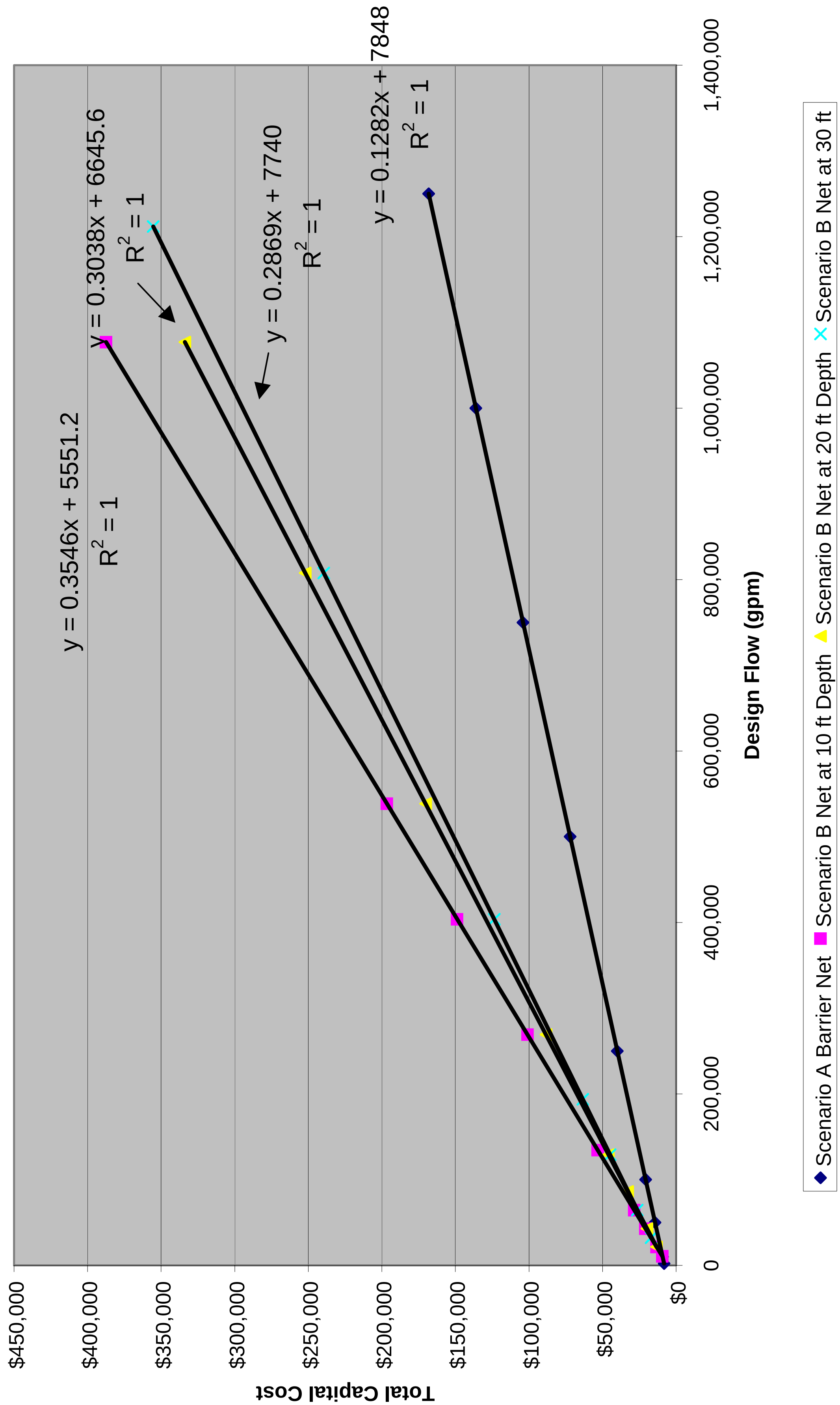
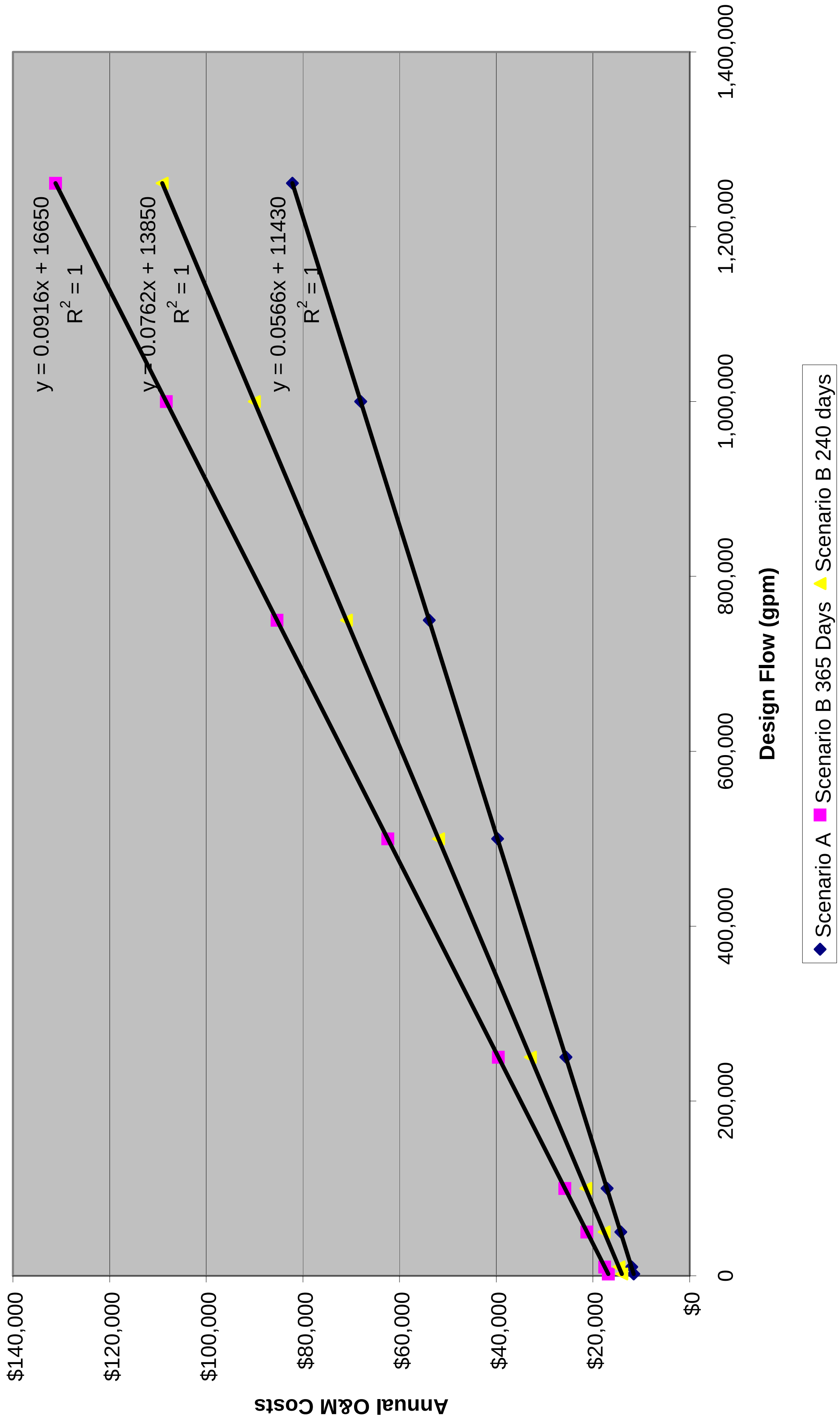


Figure 3-34. Barrier Net Annual O&M Costs



5.0 AQUATIC FILTER BARRIERS

Filter Barrier

Aquatic filter barrier systems are barriers that employ a filter fabric designed to allow passage of water into a cooling water intake structure, while excluding aquatic organisms. One company, Gunderboom, Inc., has a patented system, the Marine/Aquatic Life Exclusion System (MLES)™ that can be deployed as a full-water-depth filter curtain suspended from floating booms extending out in the waterway or supported on a fixed structure as described below. The filter fabric material is constructed of matted unwoven synthetic fibers.

Pore Size and Surface Loading Rate

Filter fabric materials with different pore sizes can be employed depending on performance requirements. In the MLES™ system two layers of fabric are used. Because the material is a fabric and thus the openings are irregular, the measure of the mesh or pore size is determined by an ASTM method that relies on a sieve analysis of the passage of tiny glass beads. The results of this analysis is referred to as apparent opening size. The standard MLES ™ filter fabric material has an apparent opening size (AOS) of 0.15 mm. (McCusker 2003b). Gunderboom can also provides filter fabric material that has been perforated to increase the apparent opening size. Available perforation sizes range from 0.4 mm to 2.0 mm AOS. The "apparent opening size" is referred to as the "pore size" in the discussion below. While smaller pore sizes can protect a greater variety of aquatic organisms, smaller the pore sizes also increase the proportion of suspended solids collected and thus the rate at which it collects. In addition, smaller pore sizes tend to impede the flow of water through the filter fabric which becomes even more pronounced as solids collect on the surface. This impedance of flow results in an increase in the lateral forces acting on the AFB. The filter surface loading rate (gpm/ sq ft) or equivalent approach velocity (feet per second) determines both the rate at which suspended particles collect on the filter fabric and the intensity of the lateral forces pushing against the AFB. While the airburst system (see description below) is designed to help dislodge and removed such suspended particles, there are practical limits regarding pore size and surface loading rate. For filter fabric of any given pore size, decreasing the surface loading rate will reduce the rate of solids accumulation and the lateral forces acting upon the AFB. Thus, pore size is an important design parameter in that it determines the types of organisms excluded as well as contributes to the selection of an acceptable surface loading rate. The surface loading rate combined with the cooling water intake design flow determines the required AFB surface area. This total filter fabric area requirement when combined with the local bathymetry determines the area that resides within the AFB.

Since the AFB isolates and essentially restricts the function of a portion of the local ecosystem, anything that increases the AFB total surface area will also increase the size of the isolated portion of the ecosystem. As such, there is an environmental trade off between minimizing the pore size to protect small size organisms/lifestages versus minimizing the size of the area being isolated. Additionally, requirements for large AFB surface areas may preclude its use where conflicts with other waterbody uses (e.g., navigation) or where the waterbody size or configuration restricts the area that can be impacted. Vendors can employ portable test equipment or pilot scale installations to test pore size selection and performance which can aid in the selection of the optimal pore size. Acceptable design filter loading rates will vary with the pore size and the amount of sediment and debris present. An initial target loading rate of 3 to 5 gpm/sq ft have been suggested (EPA 2001). This is equivalent to approach or net face velocities of 0.007 to 0.01 feet per second which is nearly an order of magnitude lower than the 0.06 feet per second design velocity used by EPA for barrier nets. This difference is consistent with the fact that barrier net use much greater mesh sizes. Use of larger AFB pore sizes can result in greater net velocities. Since the cost estimates as presented here are based on design flow, differences in design filter loading rates will affect the size of the AFB which directly affects the costs. The range between the high and low estimates in capital and O&M costs presented below account at least in part for the differences associated with variations in pore size as well as other design variations that result from differences in site conditions.

Floating Boom

For large volume intakes such as once-through systems, an AFB supported at the top by a floating boom that extends out into the waterbody and anchored onshore at each end is the most likely design configuration to be employed because of the large surface area required. In this design, a filter fabric curtain is supported by the floating boom at the top and is held against the bottom of the waterbody by weights such as a heavy chain. The whole thing is held in place by cables attached to fixed anchor points placed at regular intervals along the bottom. The Gunderboom MLES design employ a two layer filter fabric curtain that is divided vertically into sections to allow for replacement of an individual sections when necessary. The estimated capital and O&M costs described below are for an AFB using this floating boom-type construction.

Fixed Support

The AFB vendor, Gunderboom Inc., also provides an AFB supported by rigid panels that can be placed across the opening of existing intake structures. This technology is generally applicable to existing intakes where the intake design flow has been substantially reduced such as where once-through systems are being converted to recirculating cooling towers. For other installations, Gunderboom has developed what they refer to as a cartridge-type system which consists of rigid structures surrounded by filter fabric with filtered water removed from the center (McCusker 2003). Costs for either of these rigid type of installation have not been provided.

Air Backwash

The Gunderboom MLES™ employs an automated air burst technology that periodically discharges air bubbles between the two layers of fabric at the bottom of each MLES curtain panel. The air bubbles create turbulence and vibrations that help dislodge particulates that become entrained in the filter fabric. The airburst system can be set to purge individual curtain panels on a sequential basis automatically or can be operated manually. The airburst technology is included in the both the capital and O&M costs provided by the vendor.

5.1 Capital Cost Development

Estimated capital costs were provided by the only known aquatic filter barrier manufacturer, Gunderboom, Inc. Cost estimates were provided for AFBs supported by floating booms representing a range of costs; low, high, and average that may result from differences in construction requirements that result from different site specific requirements and conditions. Such requirements can include whether sheetwall piles or other structures are needed and whether dredging is required which can result in substantial disposal costs. Costs were provided for three design intake flow values: 10,000 gpm, 104,000 gpm, and 347,000 gpm. Theses costs were provided in 1999 dollars and have been adjusted for inflation to July 2002 dollars using the ENR construction cost index. The capital costs are total project costs including installation. Figure 3-35 presents a plot of the data in Exhibit 3-59 along with the second order equation fitted to this data.

The vendor recently provided a total capital cost estimate of 8 to 10 million dollars for full scale MLES™ system at the Arthur Kill Power Station in Staten Island, NY (McCusker 2003a). The vendor is in the process of conducting a pilot study with an estimated cost of $750,000. The NYDEC reported the permitted cooling water flow rate for the Arthur Kill facility as 713 mgd or 495,000 gpm. Applying the cost equations in Figure 3-35 results in a total capital cost of $8.7, $10.1 and $12.4 million dollars for low, average and high costs, respectively. These data indicate that the inflation adjusted cost estimates are consistent with this more recent estimate provided by the vendor. Note that since the Arthur Kill intake flow exceeded the range of the cost equation input values the cost estimates presented above for this facility were derived by first dividing the flow by two and then adding the answer.

Exhibit 3-59. Capital Costs for Aquatic Filter Barrier Provided by Vendor

Flow	Floating Boom Capital Cost (2002 Dollars)		
gpm	Low	High	Average
10,000	$545,000	$980,900	$762,900
104,000	$1,961,800	$2,724,800	$2,343,300
347,000	$6,212,500	$8,501,300	$7,356,900

5.2 O&M Costs

Estimated O&M costs were also provided by Gunderboom Inc., As with the capital costs the O&M costs provided apply to floating boom type AFBs and include costs to operate an air burst system. Exhibit 3-60 presents a range of O&M costs from low to high and the average which served as the basis for cost estimates. As with the capital costs, the costs presented in Exhibit 3-60 have been adjusted for inflation to July 2002 dollars. Figure 3-35 presents a plot of the data in Exhibit 3-60 along with the second order equation fitted to this data.

Exhibit 3-60. Estimated AFB Annual O&M Costs

Flow	O&M	O&M	O&M
gpm	Low	High	Average
10,000	$109,000	$327,000	$218,000
104,000	$163,500	$327,000	$245,200
347,000	$545,000	$762,900	$653,900

5.3 Application

Aquatic filter barriers (AFBs) can be used where improvements to impingement performance is needed. Because they can be installed independently of intake structures, there is no need to include any costs for modifications to the existing intake structure or technology employed. Costs are assumed to be the same for both new and existing facilities. AFBs can be installed while the facility is operating. Thus, there is no need to coordinate AFB installation with generating unit downtime. Capital cost estimates used in the economic impact analysis used average costs.

EPA assumed that the existing screen technology would be retained as a backup following the installation of floating boom AFBs. Therefore, as with barrier nets, the O&M costs of the existing technology was not deducted from the estimated net O&M cost used in the Phase III economic impact analysis. Upon further consideration, EPA has concluded that at a minimum there should be a reduction in O&M cost of the existing intake screen technology equivalent to the variable O&M cost component estimated for that technology.

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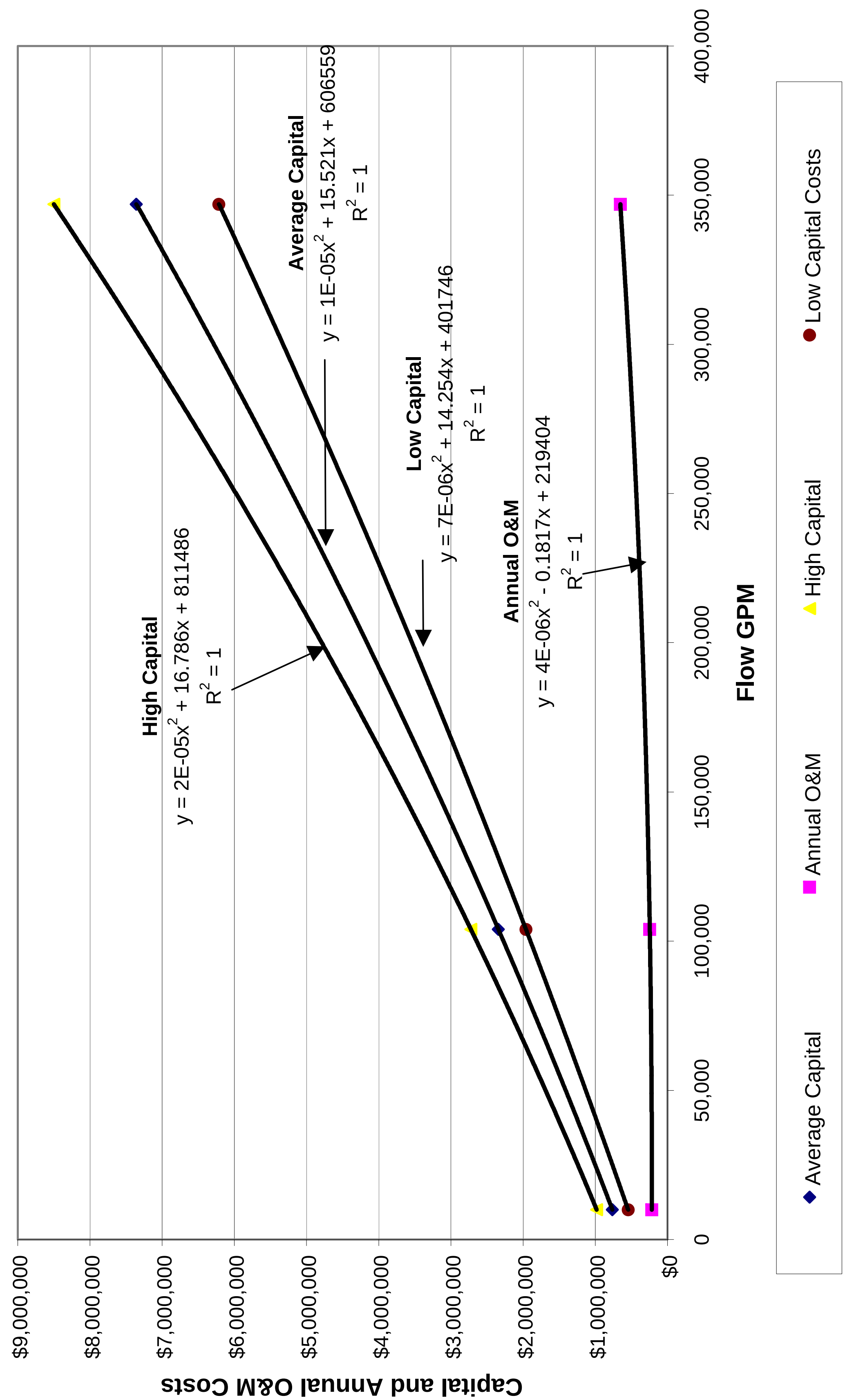
Figure 3-35. Gunderboom Capital and O&M Costs for Floating Structure in 2002 Dollars



II. TECHNOLOGY COST MODULES FOR SEAFOOD PROCESSING VESSELS

APPLICATION OF THE PROPOSED RULE

Under each of the co-proposed options, no seafood processing vessels would be subject to national performance standards.

INTRODUCTION

EPA has identified a typical 280-foot catcher-processor as an indicative vessel to assemble cost estimates for retrofitting fine mesh screens for cooling water intake structures. Information gathered during interviews with industry representatives will be used to characterize the intake structure of a typical 280-foot vessel. It is reasonable to assume that the majority of these vessels use a sea chest arrangement for cooling water intake.

Four primary fine mesh configurations have been costed:

1. Replace the existing grill with a fine mesh screen, without any other modifications;

2. Enlarge the intake structure internally to achieve 0.5 feet per second through screen velocity. Under this option, the screen will be in flush with the hull;

3. Install a fine mesh screen intake structure externally to achieve 0.5 feet per second through screen velocity. The screen protrudes outside of the hull under this option; and

4. Install a horizontal flow modifier externally to the intake structure to achieve 0.5 feet per second through screen velocity. The flow modifier protrudes outside of the hull. Cost estimates for two configurations, one for vessels with bottom sea chests and one for side sea chests are presented.

Material costs for both 316 stainless steel and copper-nickel (CuNi) alloy fine mesh screens were obtained from venders. In addition, material costs for steel fabrication and associated labor rates, including diver team costs were obtained using various vender sources. The capital costs estimated in this report are incremental costs for a facility. A 10% engineering and 10% contingency sum has been included in the cost estimates. One of the key assumptions for the development of capital costs is that the vessel is in dry dock for routine maintenance and that this work does not prolong the dry dock time for the vessel. No allowances have been made for docking fees.

Inspection frequency for fine mesh screens and horizontal flow modifiers are assumed to be one per year. This is based on typical inspection frequencies for onshore and coastal facilities. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas. It is assumed that the existing sea chests are inspected annually with the use of divers. The inspection and maintenance of the proposed enlarged intake structures will take significantly longer than current practices. An allowance of an additional day per intake has been included for these intake modification options for divers to inspect and clean the new intake structures. However, for the option where no enlargement of the intake is proposed, a lump sum cost of $100 is estimated for annual inspection and maintenance. An allowance of 6% of the capital cost has been allowed as annual replacement costs for parts. Mobilization or demobilization costs are not included in this estimate. The O & M costs estimated in this report are incremental costs for the facility.

1.0 REPLACE EXISTING GRILL WITH FINE MESH SCREEN

1.1 Capital Cost Development

In this option, the existing grill is replaced with a larger (typically 32" diameter) fine mesh screen. Costs are estimated for replacing the existing coarse grill with 316 stainless steel and Cu/Ni alloy fine mesh screens. In addition to the material cost of the screen, installation costs are included in this cost estimate.

1.2 O & M Cost Development

A lump sum cost of $100 is estimated as the annual O & M costs to inspect and clean the fine mesh screen. Exhibit 3-61 below presents the summary of incremental capital and O & M costs to replace the existing grill with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-61. Capital and O & M costs for Replacing Existing Coarse Screen with Fine Mesh Screen

Design Flow (MGD)	Stainless Steel Fine Mesh Screen		Cu/Ni Fine Mesh Screen	
	Capital Cost ($)	O & M Cost ($)	Capital Cost ($)	O & M Cost ($)
0.6	404	100	423	100
6.3	764	100	965	100
12.7	1,190	100	1,604	100

Figures 3-47 and 3-48 (at the end of this section) show the cost curves for replacing an existing grill.

2.0 ENLARGE THE INTAKE STRUCTURE INTERNALLY

2.1 Capital Cost Development

It is proposed to modify the existing 32” intake with a new intake structure that has a large enough surface area to reduce the through screen velocity to 0.5 feet per second. The primary problem with this type of intake modification is that there is typically very little room at the intake. As such, a low profile design has been developed to minimize the impacts on surrounding equipment and services of the vessel. The intake pipe suction is dispersed across the face of a large mesh using a diffuser arrangement. This type of flow modifier is often used to limit vortex problems on suction lines. It will only marginally increase the head loss through the system, as the available flow area is still large (but at right angles to the pipe flow). The similarity with a velocity cap is easily noted. This design also accounts for the structural members of the vessel’s hull. The insertion of a large intake will typically require the cutting of several hull stiffeners. The design presented is intended to transfer the loads directly through the main frame. Figures 3-36 through 3-40 present the proposed modification for the existing intake.

2.2 O & M Cost Development

The O & M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year and an allowance of 6 % of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Exhibit 3-62 below presents the summary of incremental capital and O & M costs to enlarge the intake structure internally with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-62. Capital and O & M Costs for Enlarging Intake Internally

Design Flow (MGD)	**Stainless Steel Fine Mesh Screen**		**Cu/Ni Fine Mesh Screen**	
	Capital Cost ($)	O & M Cost ($)	Capital Cost ($)	O & M Cost ($)
0.6	26,882	2,365	27,010	2,371
6.3	50,923	3,431	52,218	3,496
12.7	70,652	4,332	73,235	4,461

Figure 3-49 through 3-52 (at the end of this section) show the cost curves for enlarging an intake.

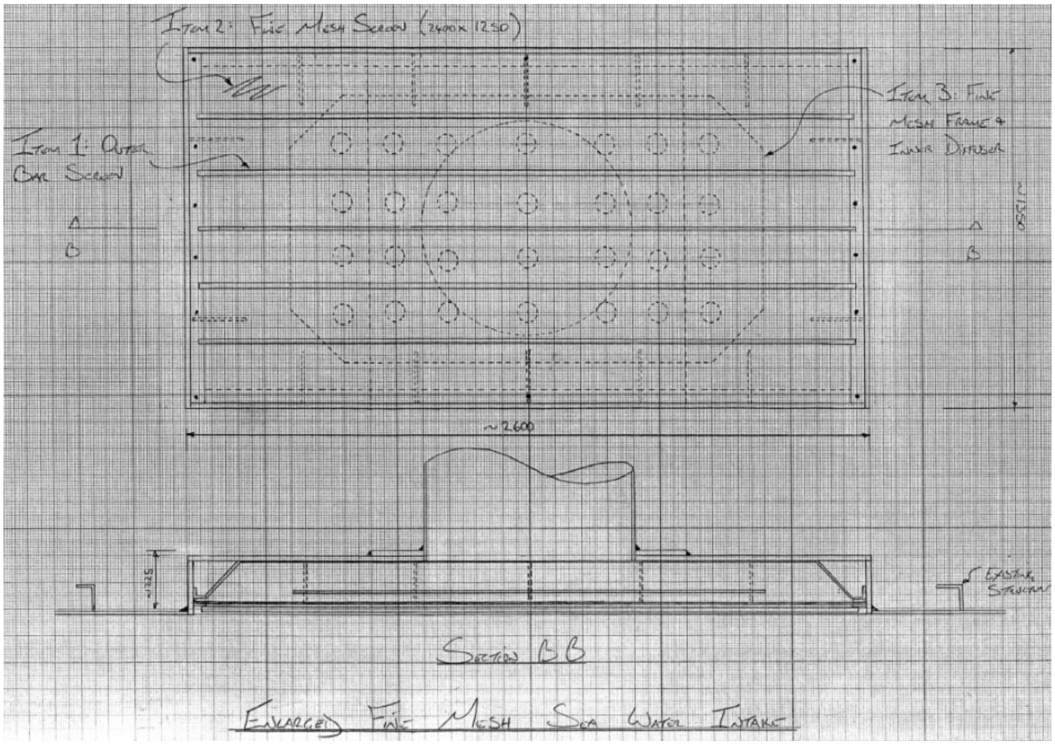


Figure 3-36. Enlarged (Internal) Fine Mesh Sea Water Intake Configuration

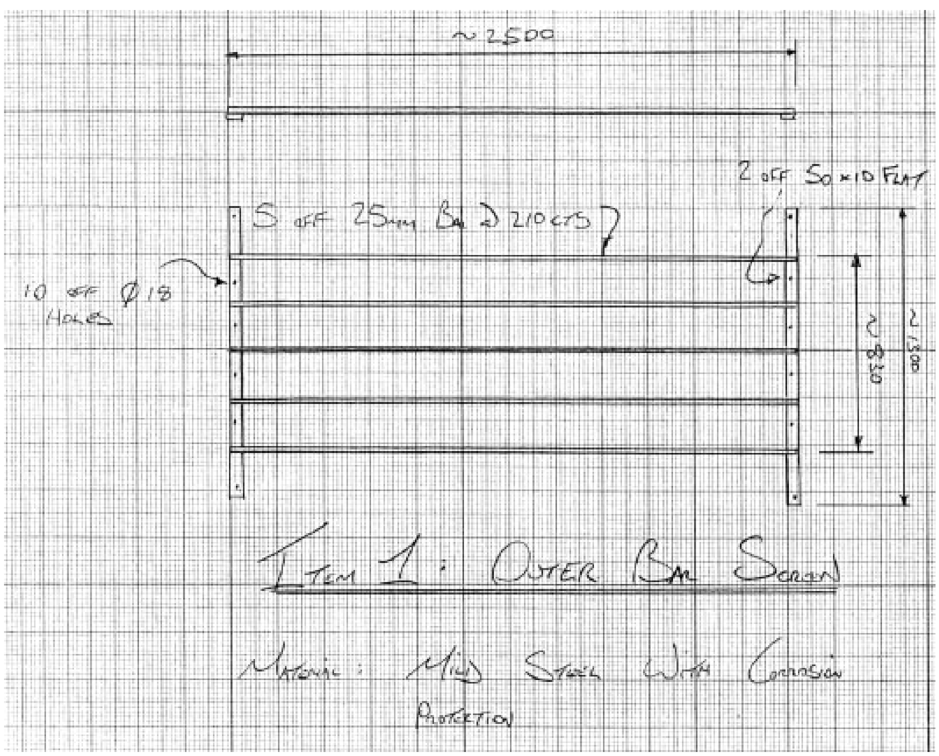


Figure 3-37. Outer Bar Screen (for Internal and External Intake Modification)

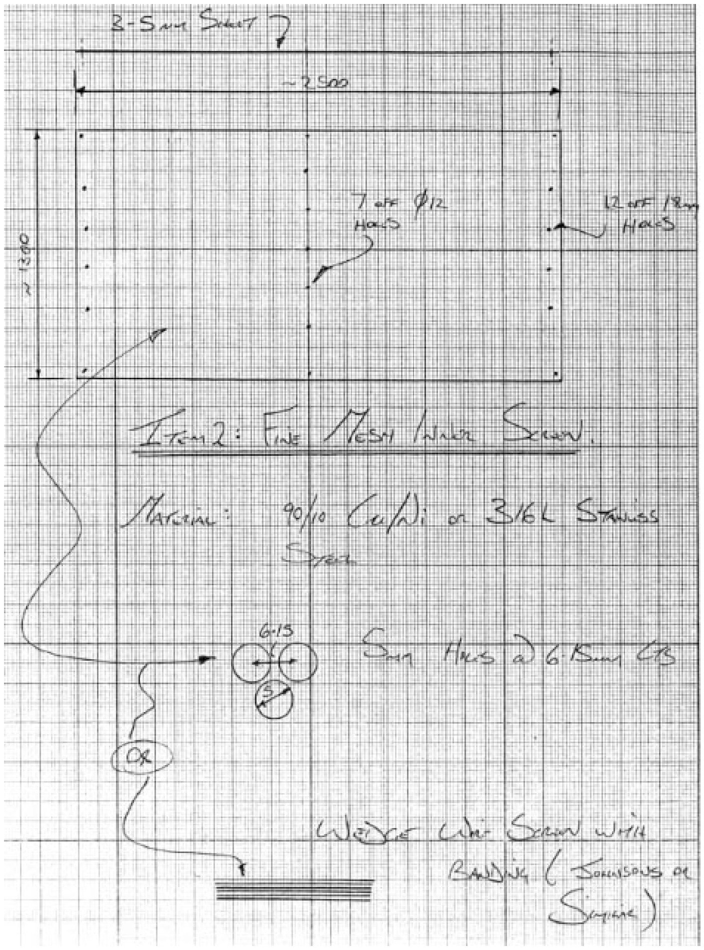


Figure 3-38. Fine Mesh Inner Screen (for Internal and External Intake Modification)

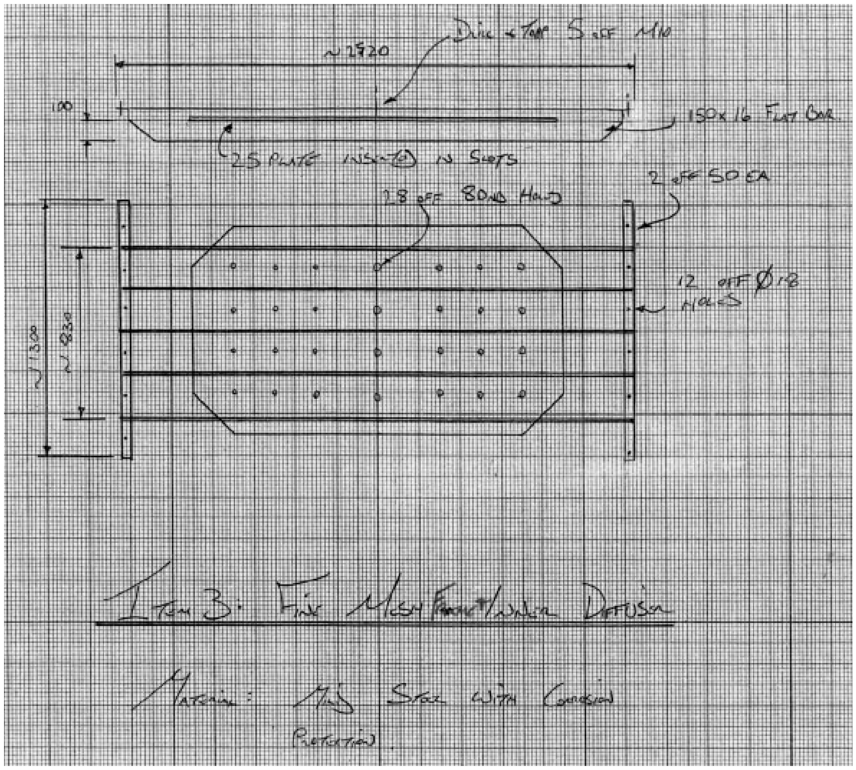


Figure 3-39. Fine Mesh Frame and Inner Diffuser (for Internal and External Intake Modification)

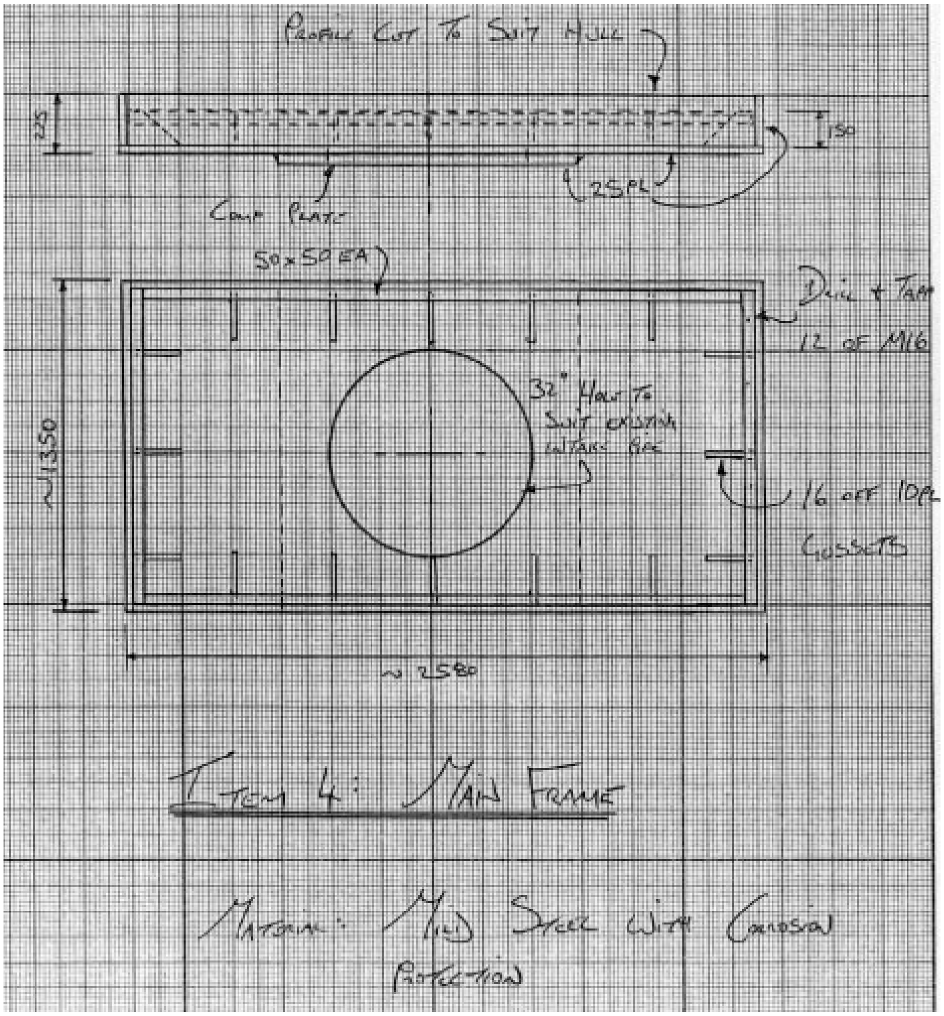


Figure 3-40. Main Frame for Internal Intake Modification

3.0 ENLARGE THE INTAKE STRUCTURE EXTERNALLY

3.1 Capital Cost Development

In this proposed modification, the existing 32" intake is replaced with a new external intake structure that has a large enough surface area to reduce the through screen velocity to 0.5 feet per second. An external intake does not affect the structure of the vessel and it is fairly simple and economical to retrofit the proposed intake to an existing vessel. However, with this type of intake modification, additional drag would be induced by its inclusion on the hull. Consequently, the low profile approach similar to the proposed internal enlargement is applicable for this configuration as well. Consultation with a naval architect confirmed that the additional drag induced by this modification would be negligible and that the cost benefit and ease of installation would likely outweigh any detrimental effects. The naval architect also confirmed that this design was reasonable for the stated purpose. Figures 3-37 through 3-39 and Figures 3-41 and 3-42 present the proposed modification to enlarge the existing intake externally.

3.2 O&M Cost Development

The O&M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year, and an allowance of 6 % of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Exhibit 3-63 presents the summary of incremental capital and O & M costs to enlarge the intake structure externally with fine mesh screen. These costs are presented for three design intake flow values.

Exhibit 3-63. Capital and O&M Costs for Enlarging Intake Externally

Design Flow (MGD)	Stainless Steel Fine Mesh Screen		Cu/Ni Fine Mesh Screen	
	Capital Cost ($)	O & M Cost ($)	Capital Cost ($)	O & M Cost ($)
0.6	12541	2021	12669	2027
6.3	28862	2752	30157	2817
12.7	43444	3429	46027	3558

Figures 3-53 through 3-56 (at the end of this section) show the cost curves for enlarging an intake externally.

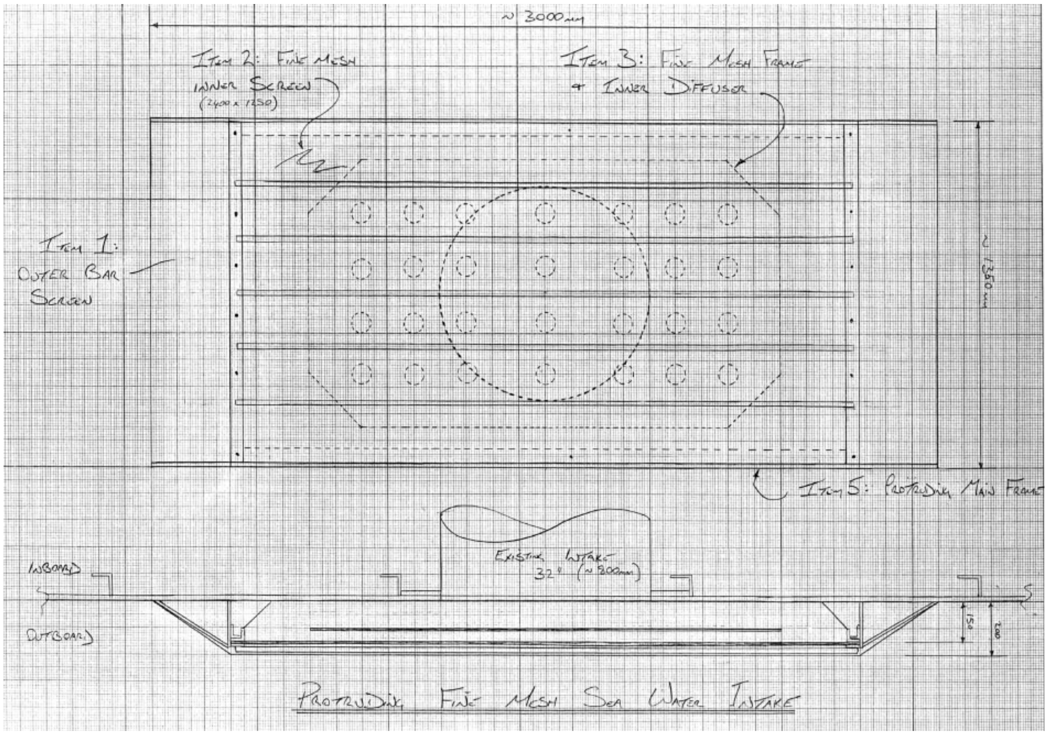


Figure 3-41. External (Protruding) Fine Mesh Sea Water Intake Configuration

Refer to Figures 3-37 through 3-39 for details of Outer Bar Screen, Fine Mesh Inner Screen and Fine Mesh Frame and Inner Diffuser, respectively

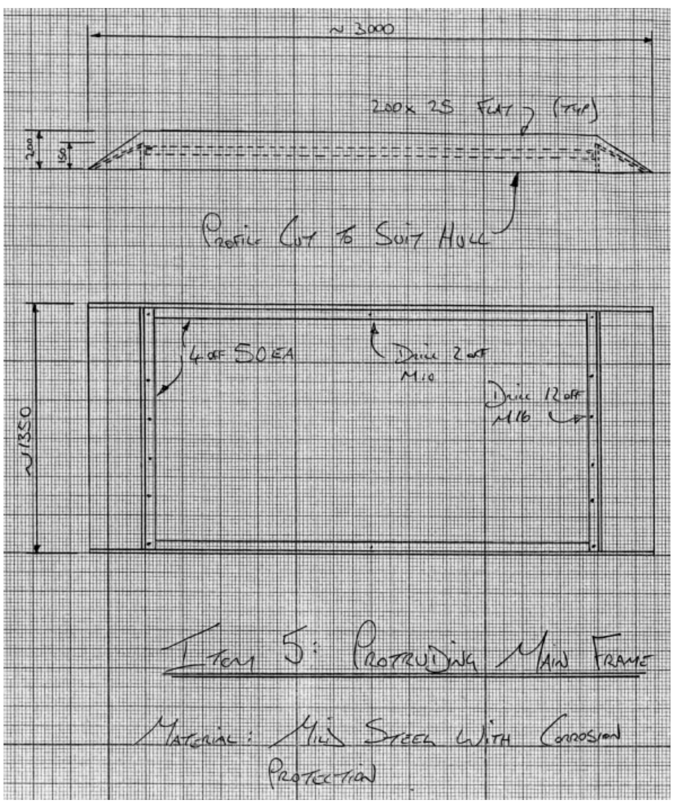


Figure 3-42. Main Frame for External (Protruding) Intake Modification

4.0 HORIZONTAL FLOW MODIFIER

4.1 Capital Cost Development

The horizontal flow modifier is a panel that ensures horizontal flow into the intake structure at a velocity of 0.5 feet per second or less. This is a derivative of the velocity cap technology.

The horizontal flow modifier option is divided up into two basic configurations: one for sea chests located on the bottom of the vessel and the other for sea chests located on the sidewalls of the vessel. The arrangement on the bottom sea chests closely resembles a standard velocity cap configuration. A plate is located over the intake opening to direct the flow in the horizontal direction between the plate and the hull. This arrangement will be suitable for hull angles up to 30˚ to the horizontal (87% of velocity will still be horizontal). For hull angles exceeding 30˚ and up to completely vertical, the side sea chest configuration will be required. This design includes a flow diffuser to spread the flow over a large area and louvres to direct the flow in the horizontal direction. Both of these designs are low profile in order to reduce any fluid dynamic effects on the hull of the vessel. The existing coarse grill over the sea chest will be retained. It is intended that the assembled horizontal flow diverter be attached using hinges to the hull to allow easy access to the existing intake structure. All materials used for the construction of this item will be mild steel coated in anti-fouling paint.

4.1.1 Vessels with Bottom Sea Chests

The proposed modification consists of a flow modifier plate that is stiffened using 4” flat bar welded to the under side. These flat bar stiffeners also assists in funneling the flow into the existing intake structure. A coarse mesh has been included around the perimeter of the new intake structure. This is to prevent larger animals (like turtles) getting trapped in the gap between the hull and the flow modifier plate (looks similar to a reef ledge to some animals). Eight brackets (4” PFC) are permanently welded to the hull as the primary attachment points. Eight legs off the flow modifier plate (1/2” plate) attach to the brackets on the hull. Three of the bracket to leg connections use hinge pins, the other 5 legs use bolts. Releasing the bolts allows the flow modifier to swing down for maintenance or cleaning of the sea chest intake. A lifting lug should be added to the hull to allow lifting equipment can be used to safely open and close this new structure. A lifting lug has been incorporated in the costs for this item. Figures 3-43 and 3-44 present the proposed configuration to modify the existing intake with horizontal flow modifiers for vessels with bottom sea chests.

4.1.2 Vessels with Side Sea Chests

The basic assembly consists of a diffuser plate nested in a number of flow louvres. The diffuser ensures that the flow is evenly distributed across the louvres and the louvres ensure that the flow is horizontal at a velocity of 0.5 feet per second or less. Two brackets (2” equal angles) are permanently welded to the hull as the primary attachment points. These run the entire width and at each end of the sea chest modification. The horizontal flow modifier is attached to the brackets on the hull by way of a hinge on one side and bolts on the other. By releasing the bolts, the horizontal flow modifier may be swung out away from the hull for access to the existing sea chest. All materials used for the construction of this item will be mild steel coated in anti-fouling paint. The direction of the flow louvres should be adjusted during the design and construction of this equipment such that they are horizontal. Figures 3-45 and 3-46 present the proposed configuration to modify the existing intake with horizontal flow modifiers for vessels with bottom sea chests.

4.2 O & M Cost Development

The O & M costs are based on the labor cost for a team of divers, including the cost of equipment and boat to inspect and clean the intake once per year and an allowance of 6 % of the capital cost for parts replacement. The estimates for inspection and cleaning frequencies are based on vendor data and data from operators of similar equipment in high marine growth areas.

Exhibits 3-64 and 3-65 below present the summary of incremental capital and O & M costs to enlarge the intake structure with flow modifier for vessels with bottom sea chests and side sea chests, respectively. These costs are presented for three design intake flow values.

Exhibit 3-64. Capital and O & M Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chests

Design Flow (MGD)	Stainless Steel Fine Mesh Screen	
	Capital Cost ($)	O & M Cost ($)
0.6	6221	1915
6.3	11437	2228
12.7	17048	2565

Exhibit 3-65. Capital and O & M Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chests

Design Flow (MGD)	Stainless Steel Fine Mesh Screen	
	Capital Cost ($)	O & M Cost ($)
0.6	5343	1863
6.3	13266	2338
12.7	22240	2876

Figures 3-57 through 3-60 (at the end of this section) show the cost curves for using a flow modifier.

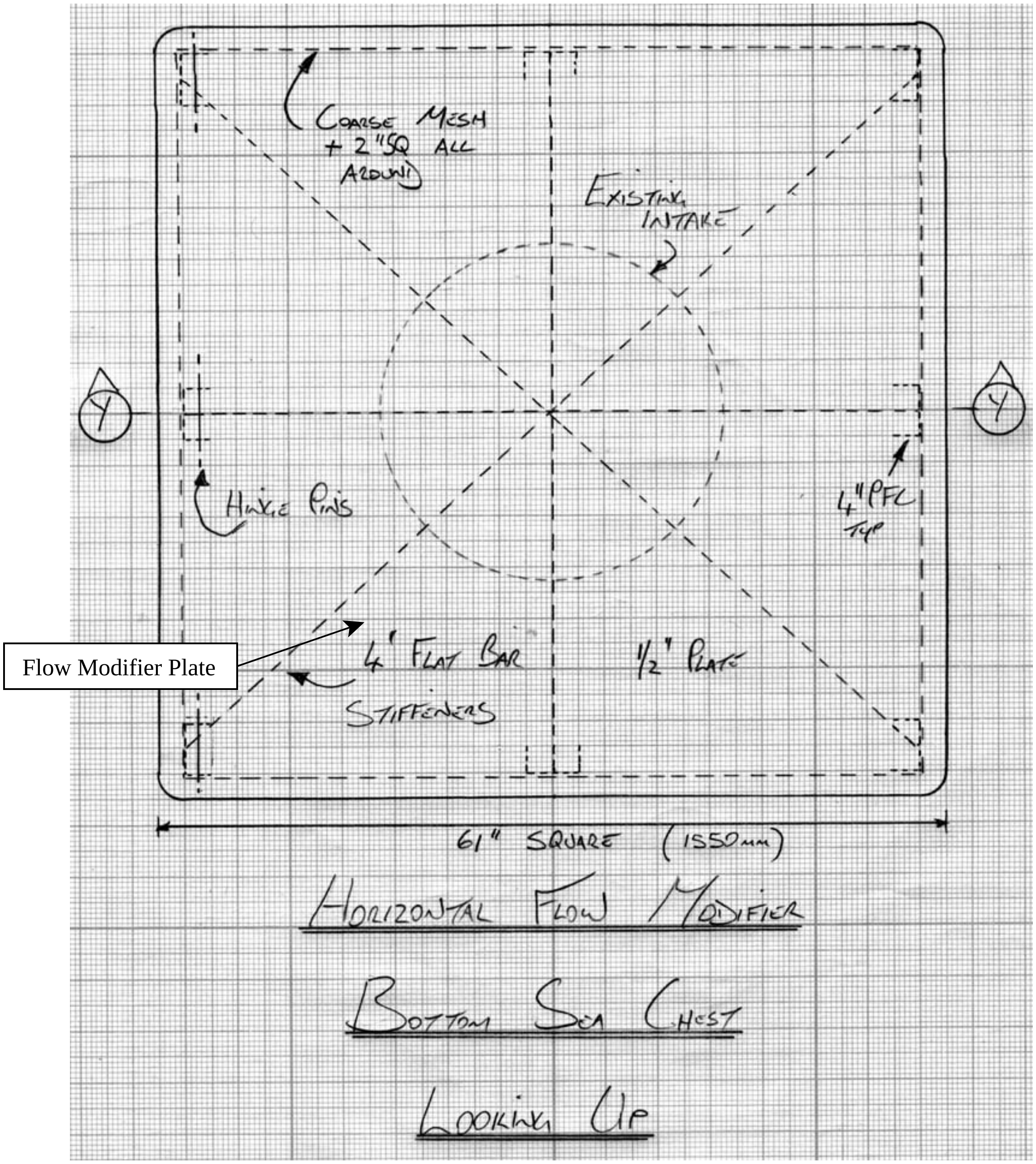


Figure 3-43. Plan View of Bottom Sea Chest Horizontal Flow Modifier

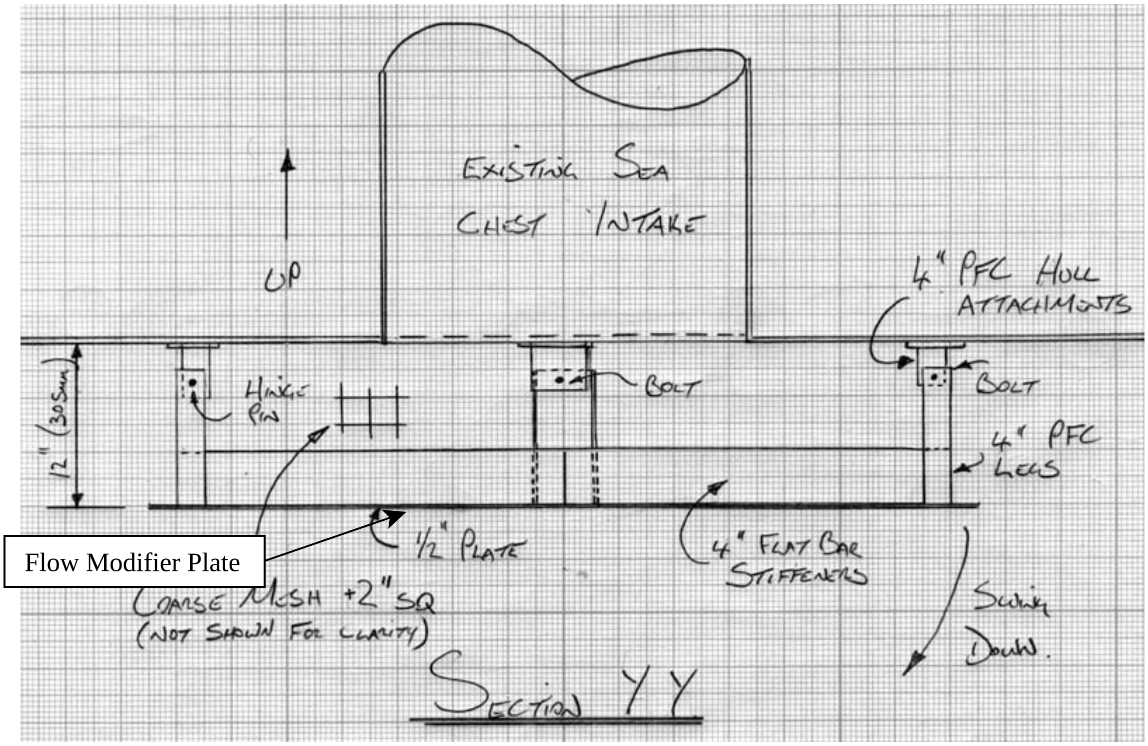


Figure 3-44. Sectional View of Bottom Sea Chest Horizontal Flow Modifier

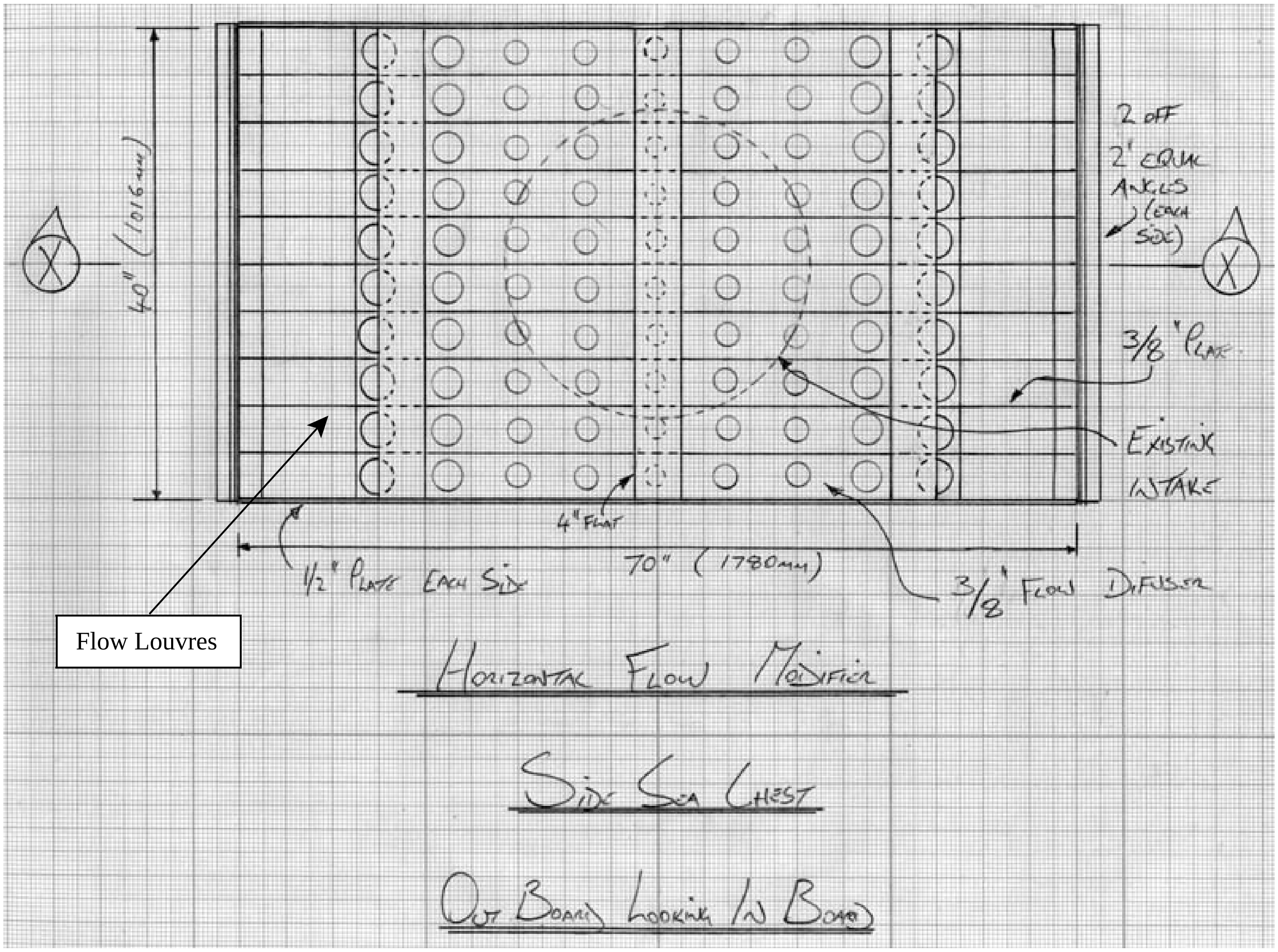


Figure 3-45. Plan View of Side Sea Chest Horizontal Flow Modifier

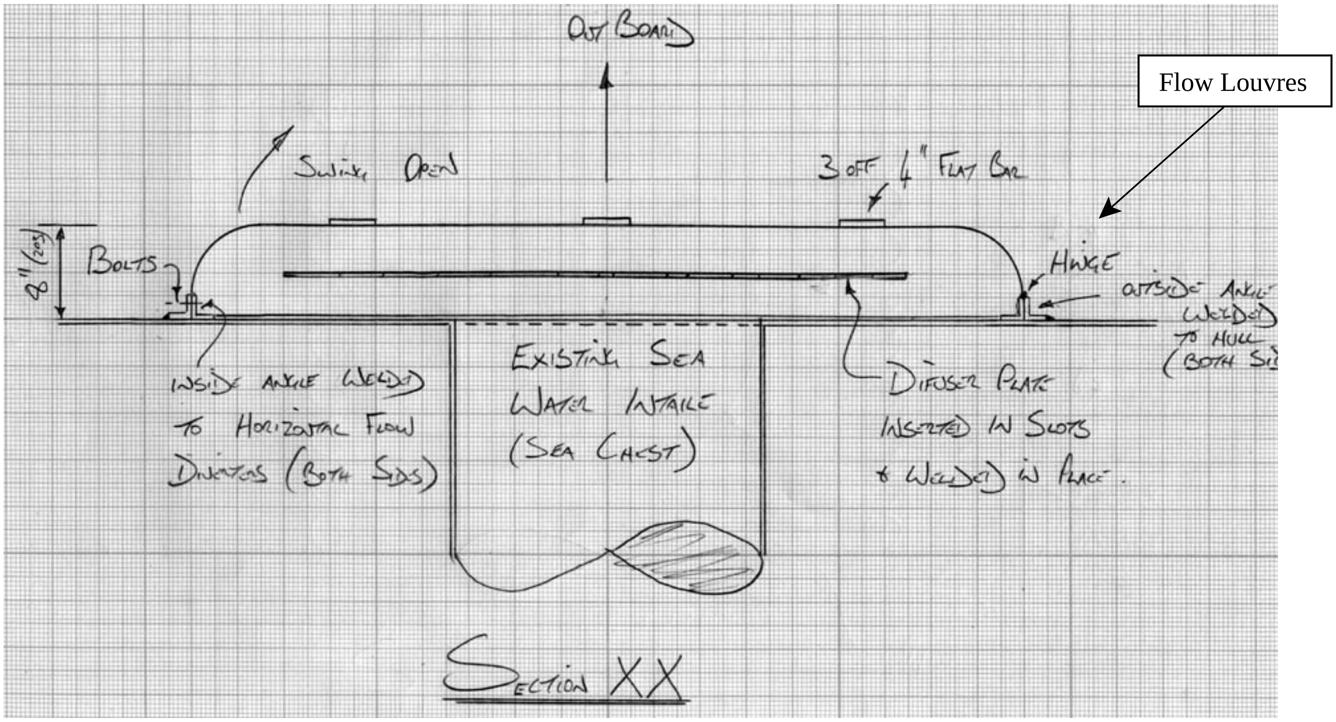


Figure 3-46. Sectional View of Side Sea Chest Horizontal Flow Modifier

Figure 3-47 Capital Cost for Replacing Existing Grill with Fine Mesh Stainless Steel Screen

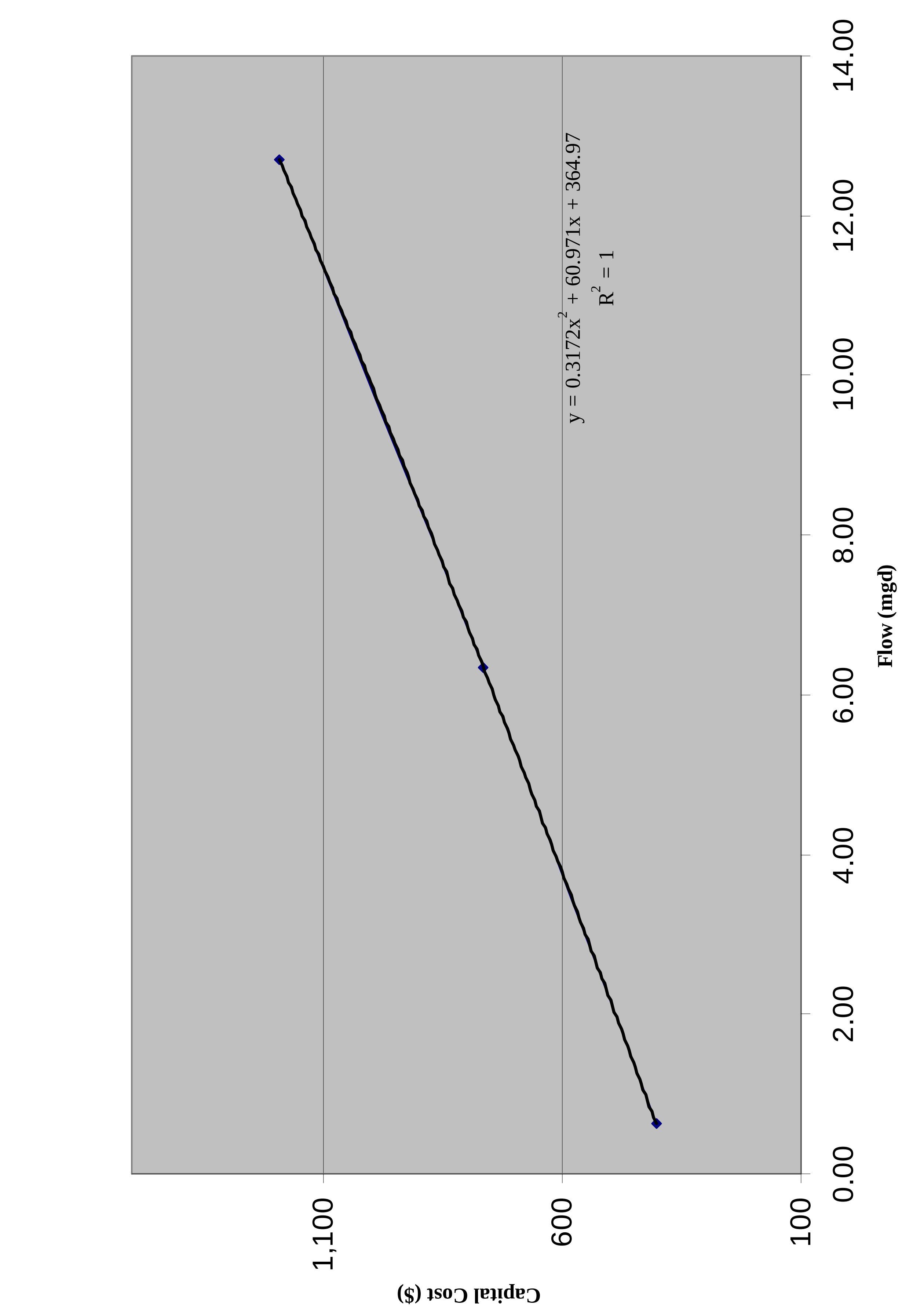
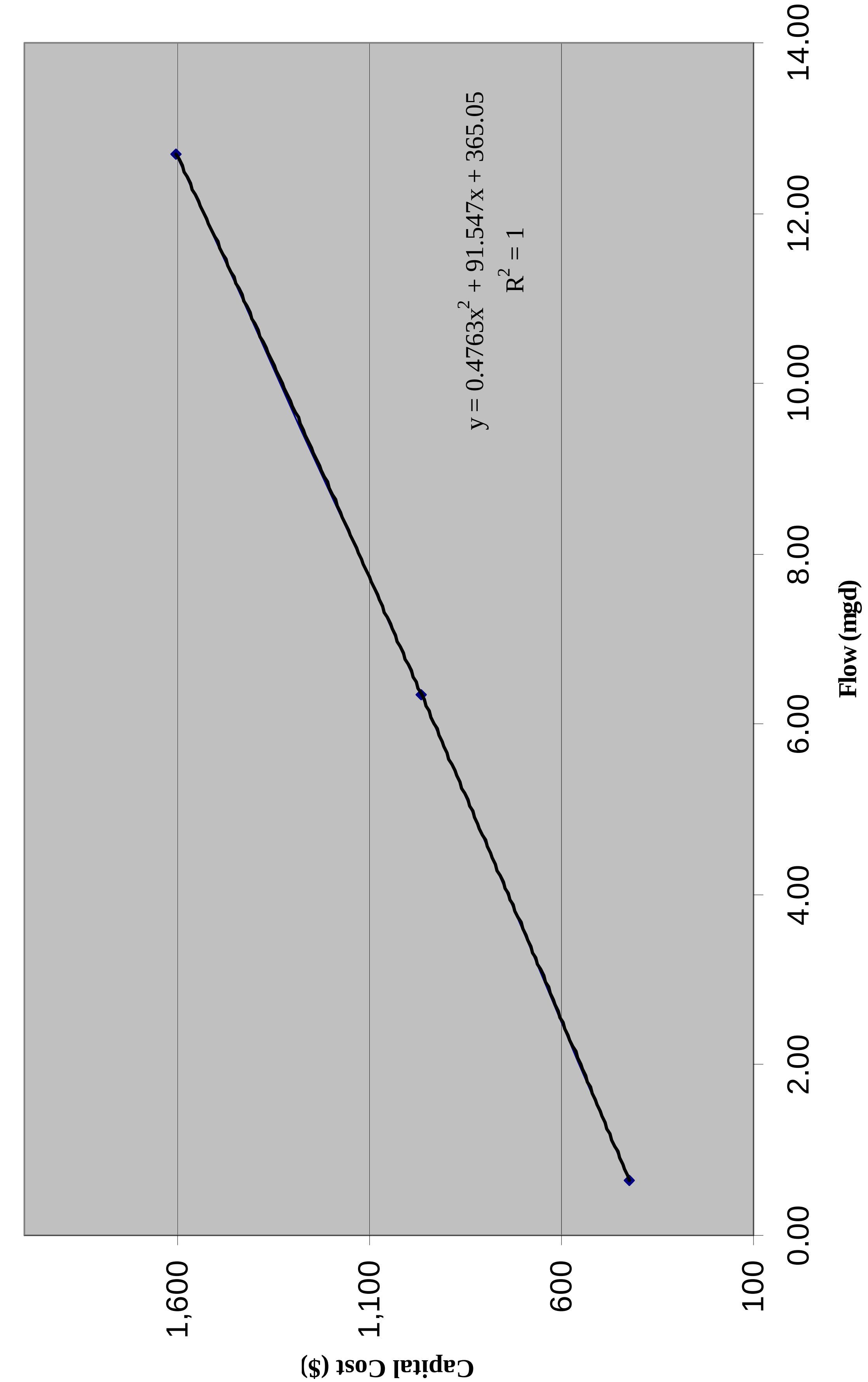


Figure 3-48. Capital Cost for Replacing Existing Grill with Fine Mesh Cu/Ni Screen



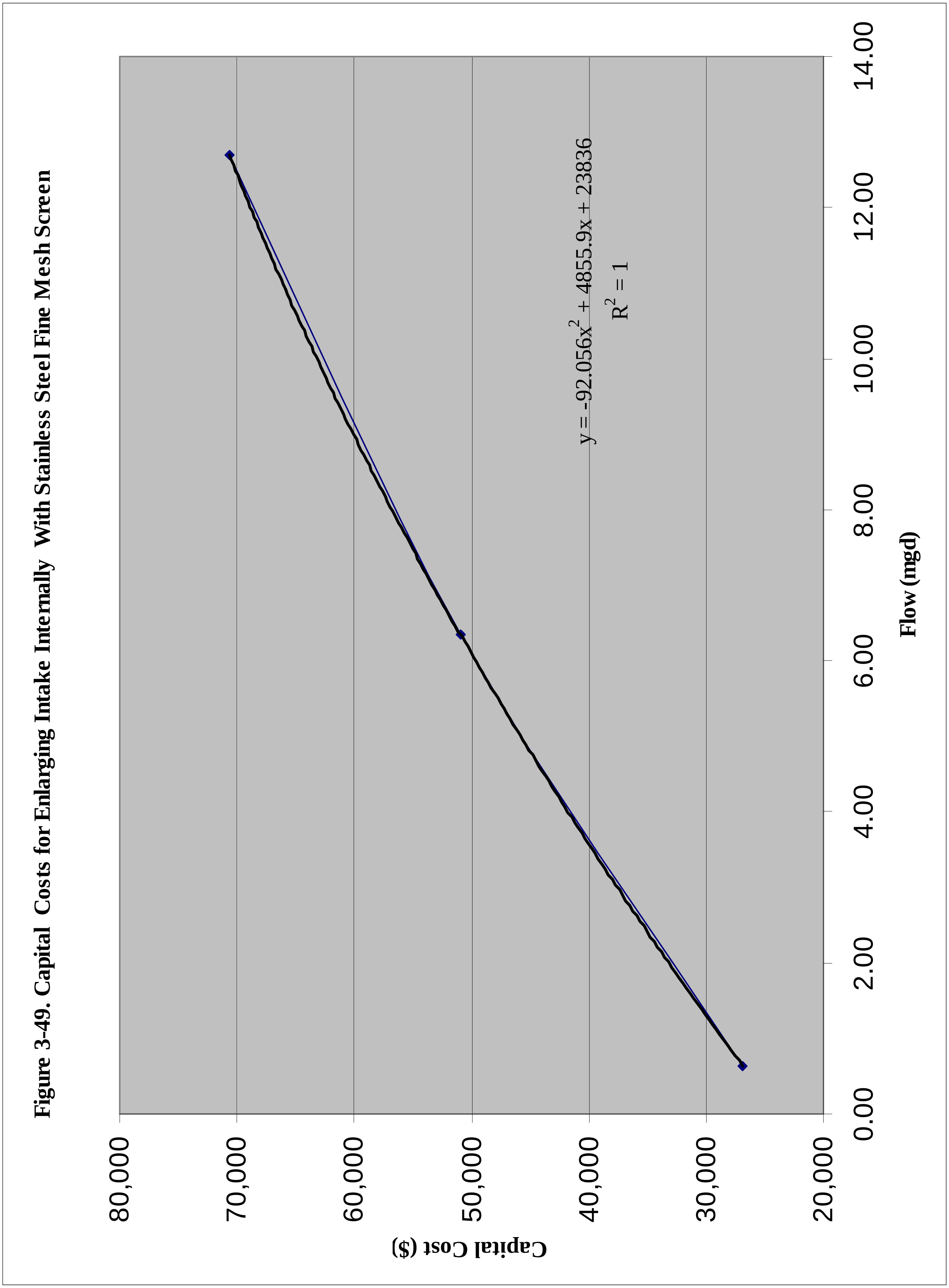


Figure 3-49. Capital Costs for Enlarging Intake Internally With Stainless Steel Fine Mesh Screen

Figure 3-50. O & M Costs for Enlarging Intake Internally With Stainless Steel Fine Mesh Screen

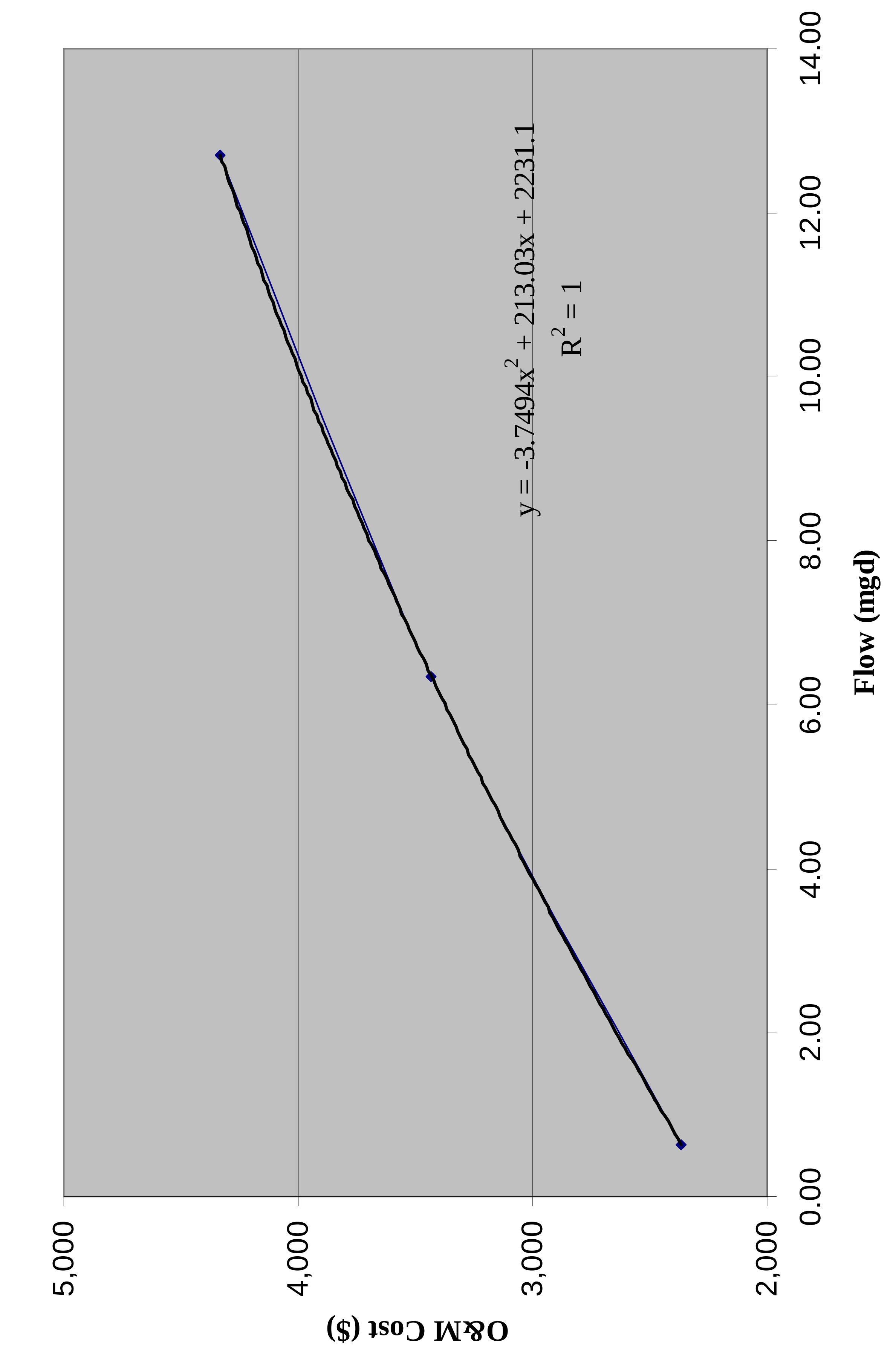


Figure 3-51. Capital Costs for Enlarging Intake Internally With CU/Ni Fine Mesh Screen

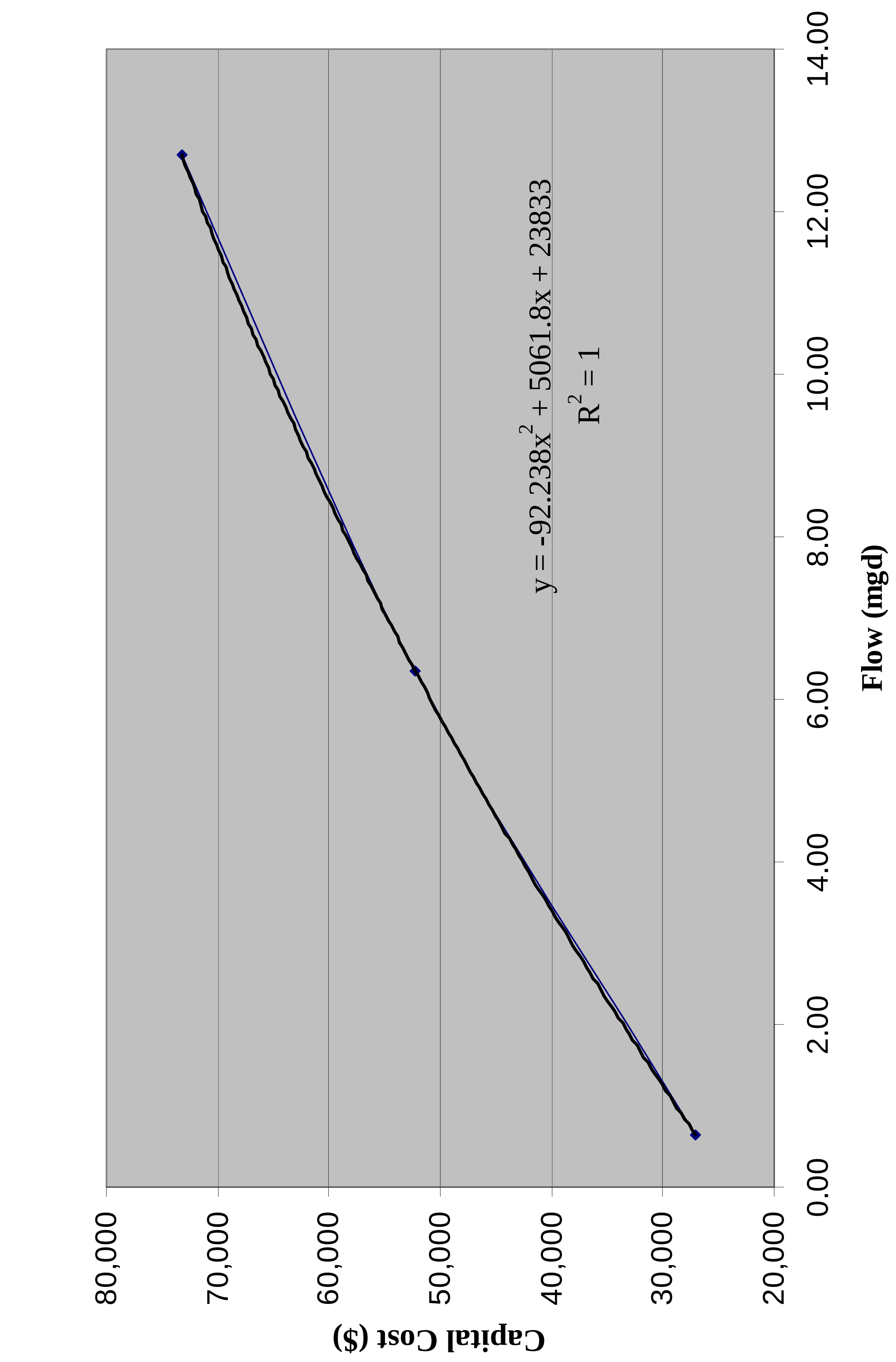
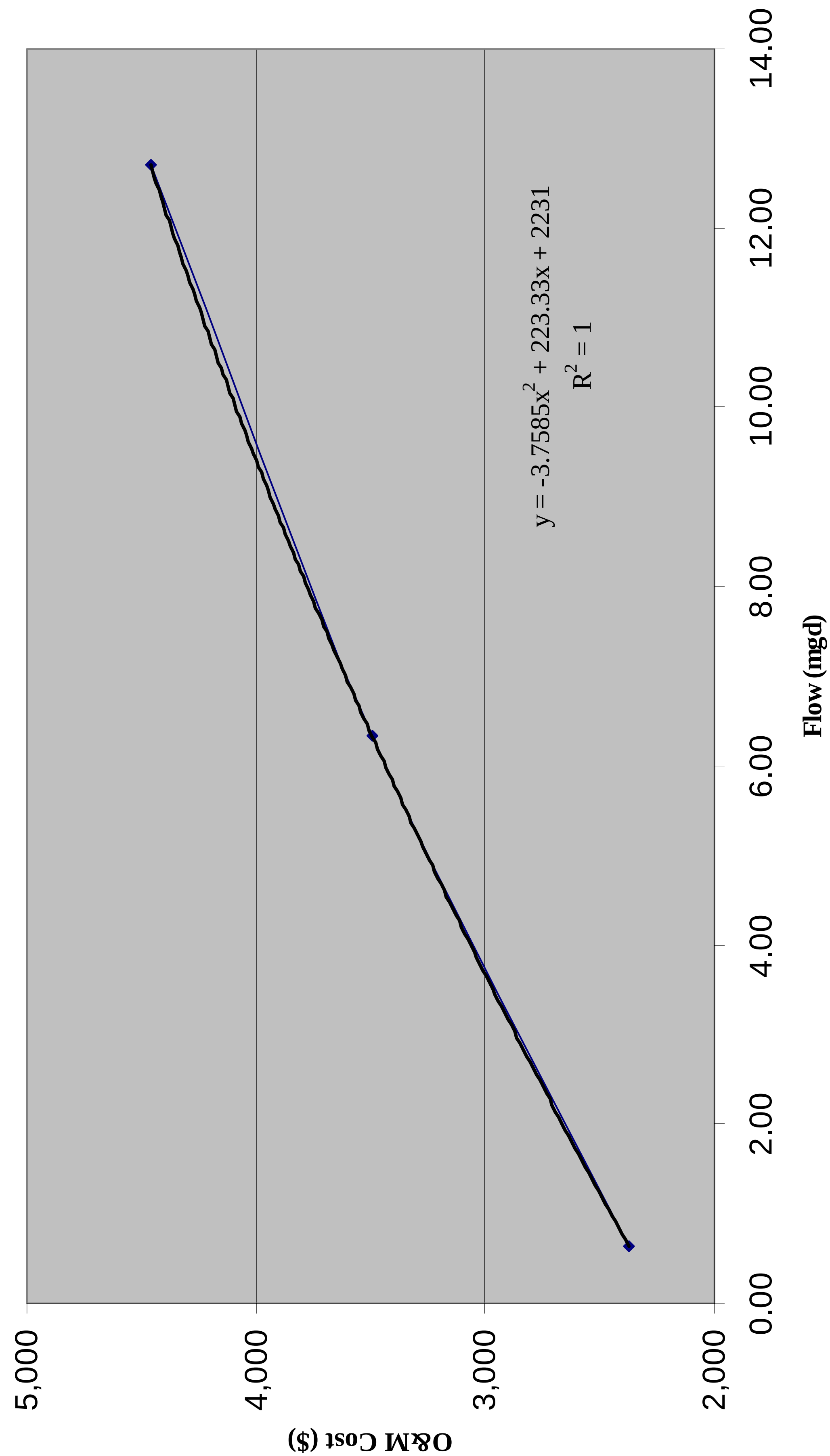


Figure 3-52. O & M Costs for Enlarging Intake Internally With CU/Ni Fine Mesh Screen



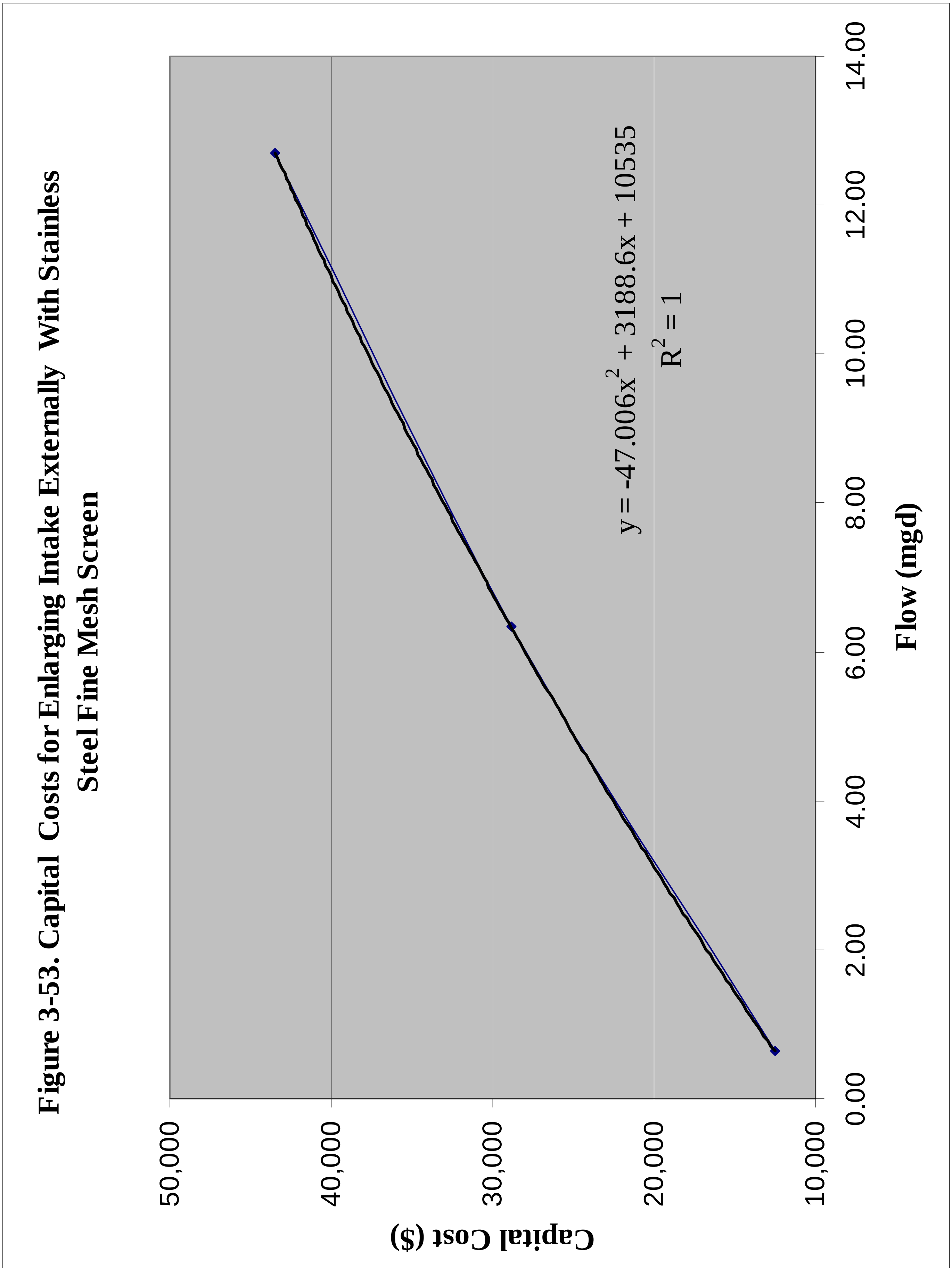
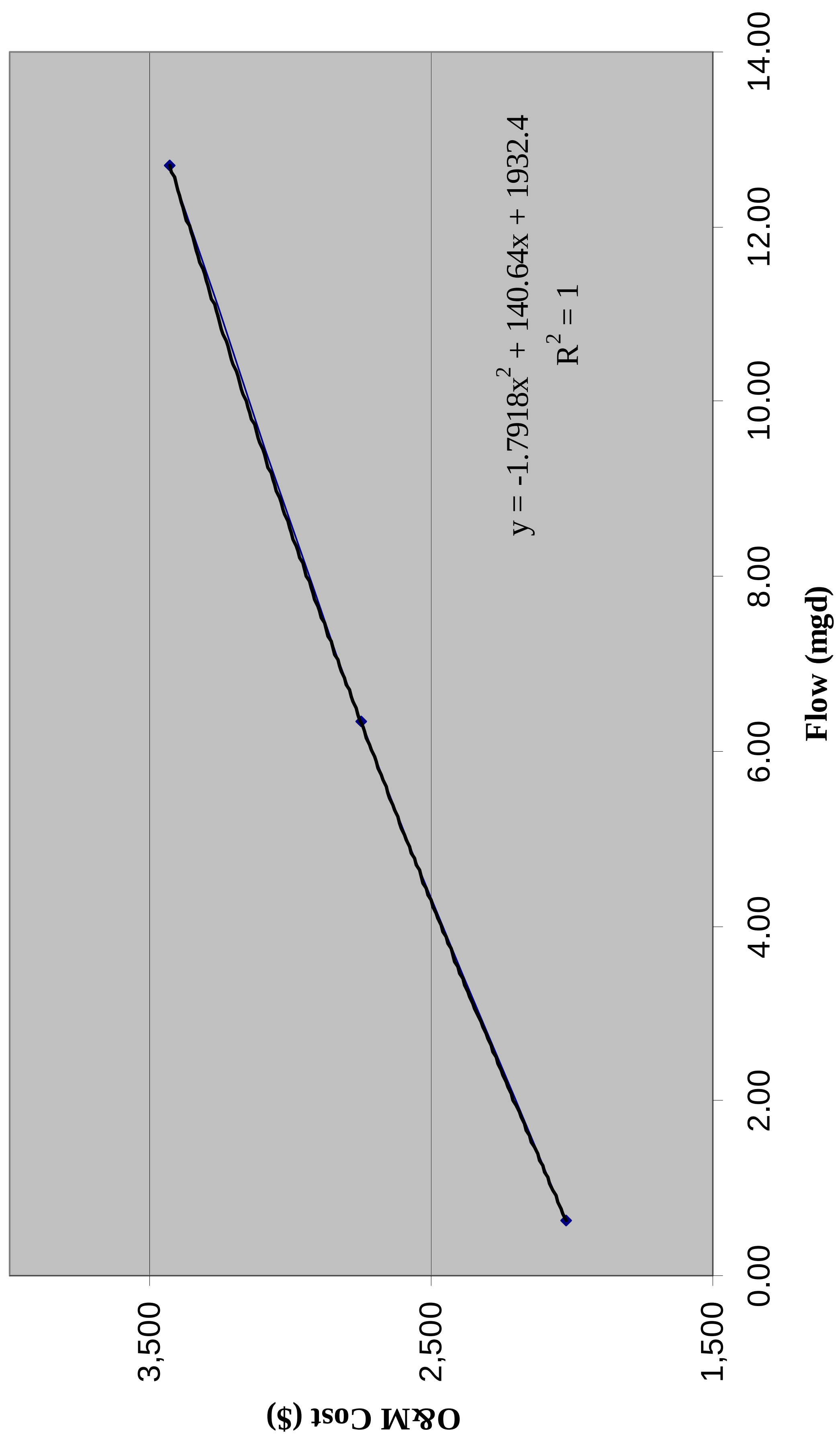


Figure 3-53. Capital Costs for Enlarging Intake Externally With Stainless Steel Fine Mesh Screen
y = -47.006x2 + 3188.6x + 10535
R2 = 1
Capital Cost ($)
50,000
40,000
30,000
20,000
10,000
Flow (mgd)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00

Figure 3-54. O & M Costs for Enlarging Intake Externally With Stainless Steel Fine Mesh Screen



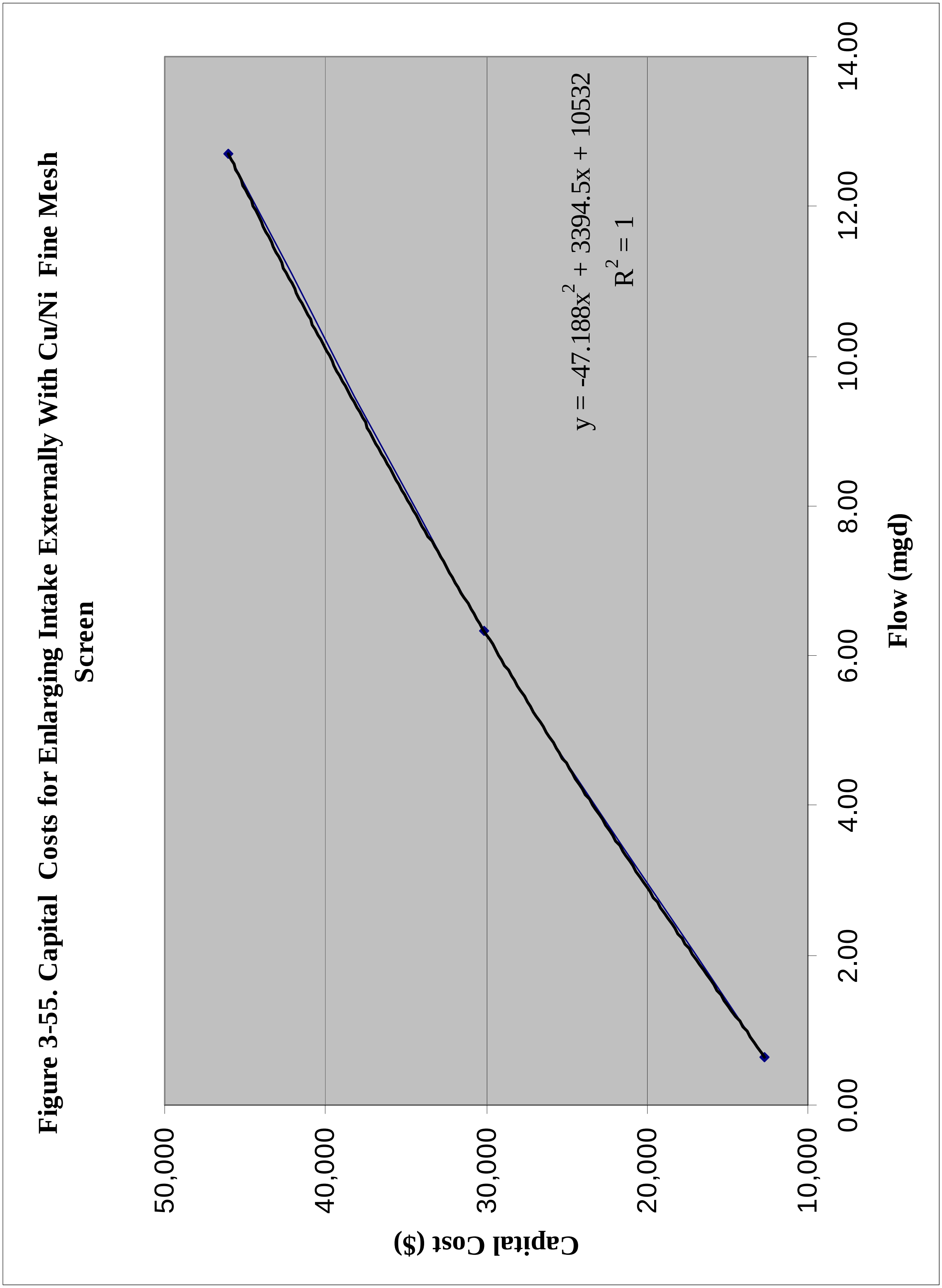


Figure 3-55. Capital Costs for Enlarging Intake Externally With Cu/Ni Fine Mesh Screen

Figure 3-56. O & M Costs for Enlarging Intake Externally With Cu/Ni Fine Mesh Screen

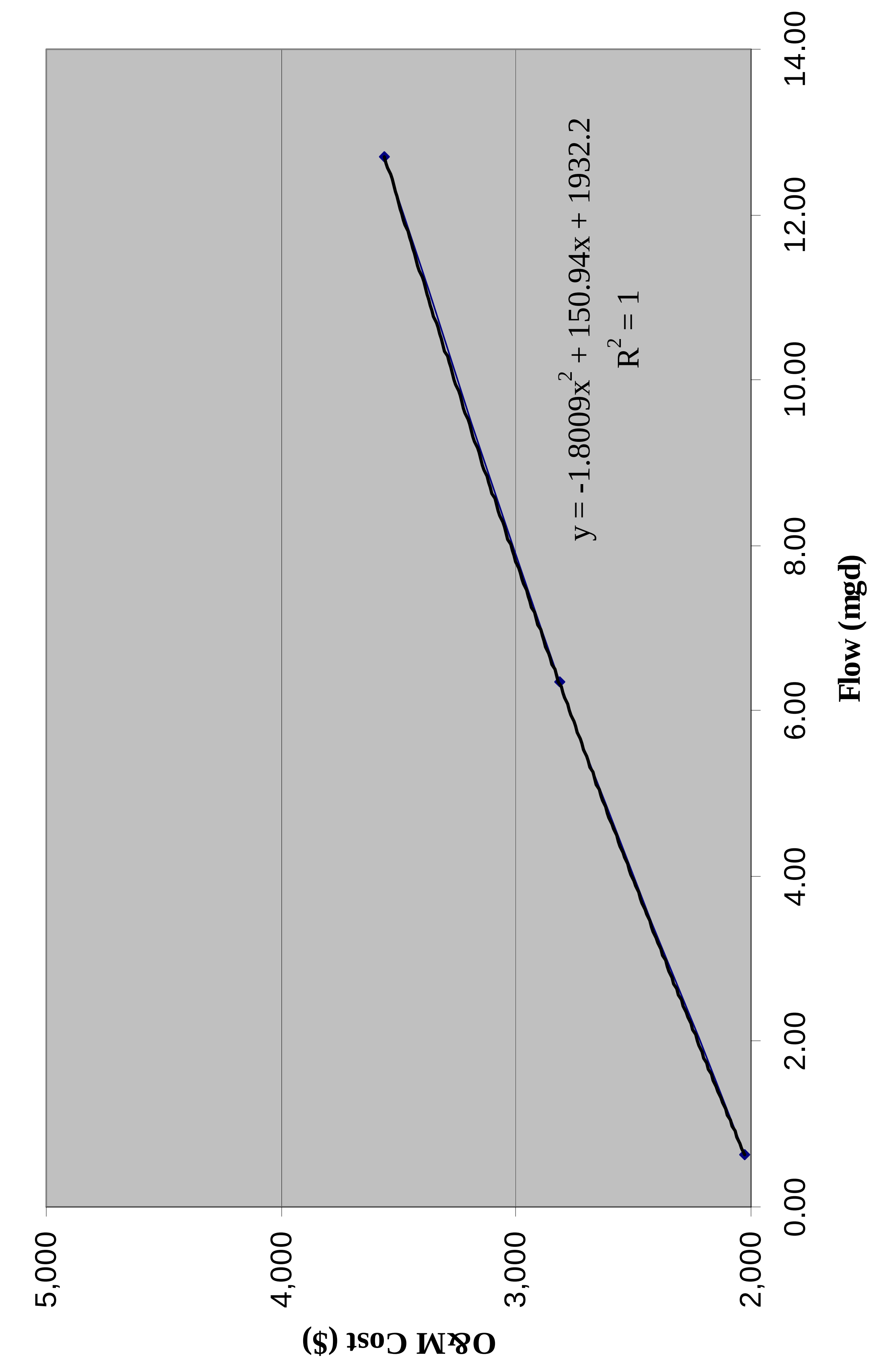


Figure 3-57. Capital Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chest

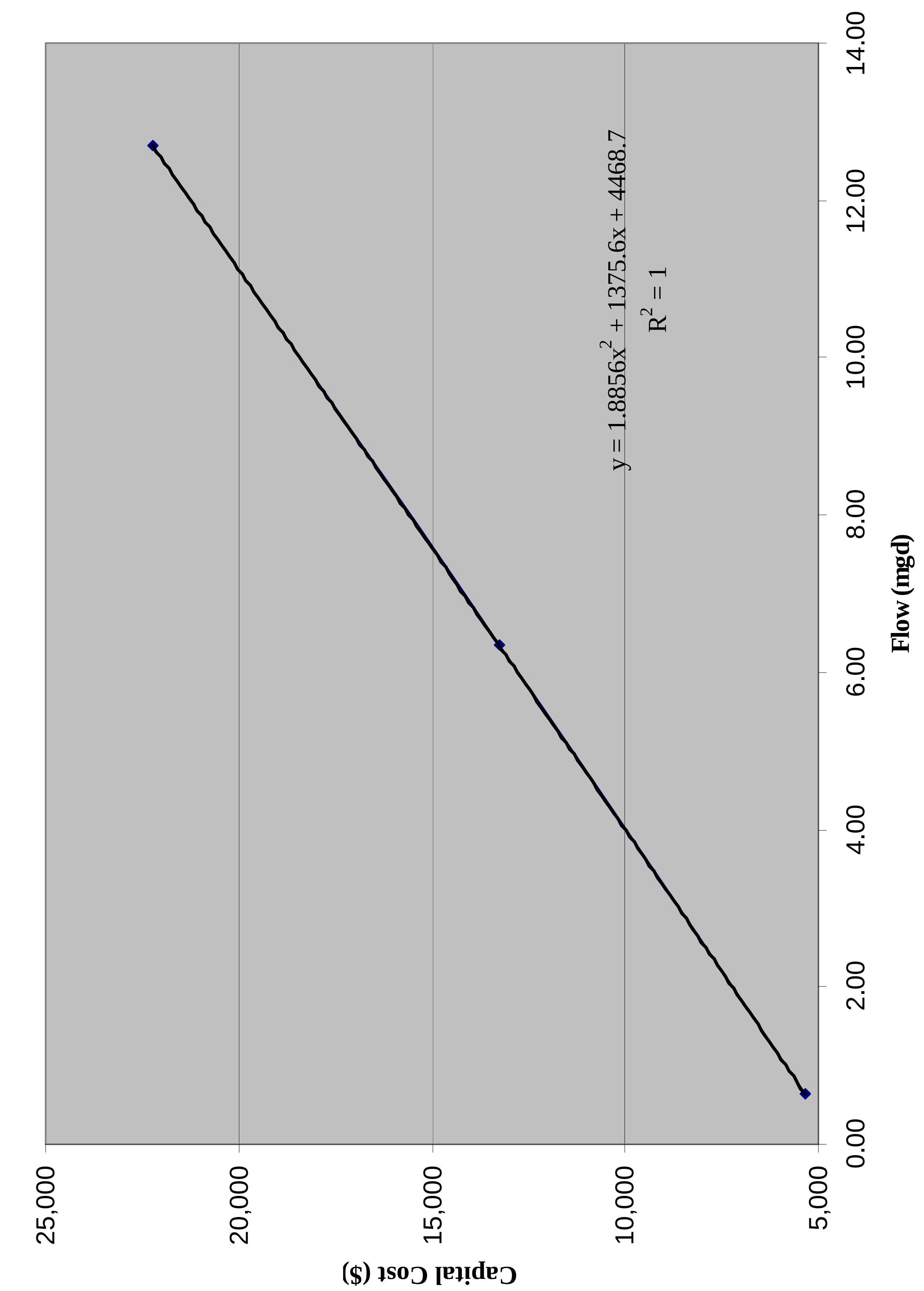


Figure 3-58. O & M Costs for Intake Modification Using Flow Modifier for Vessels with Side Sea Chest

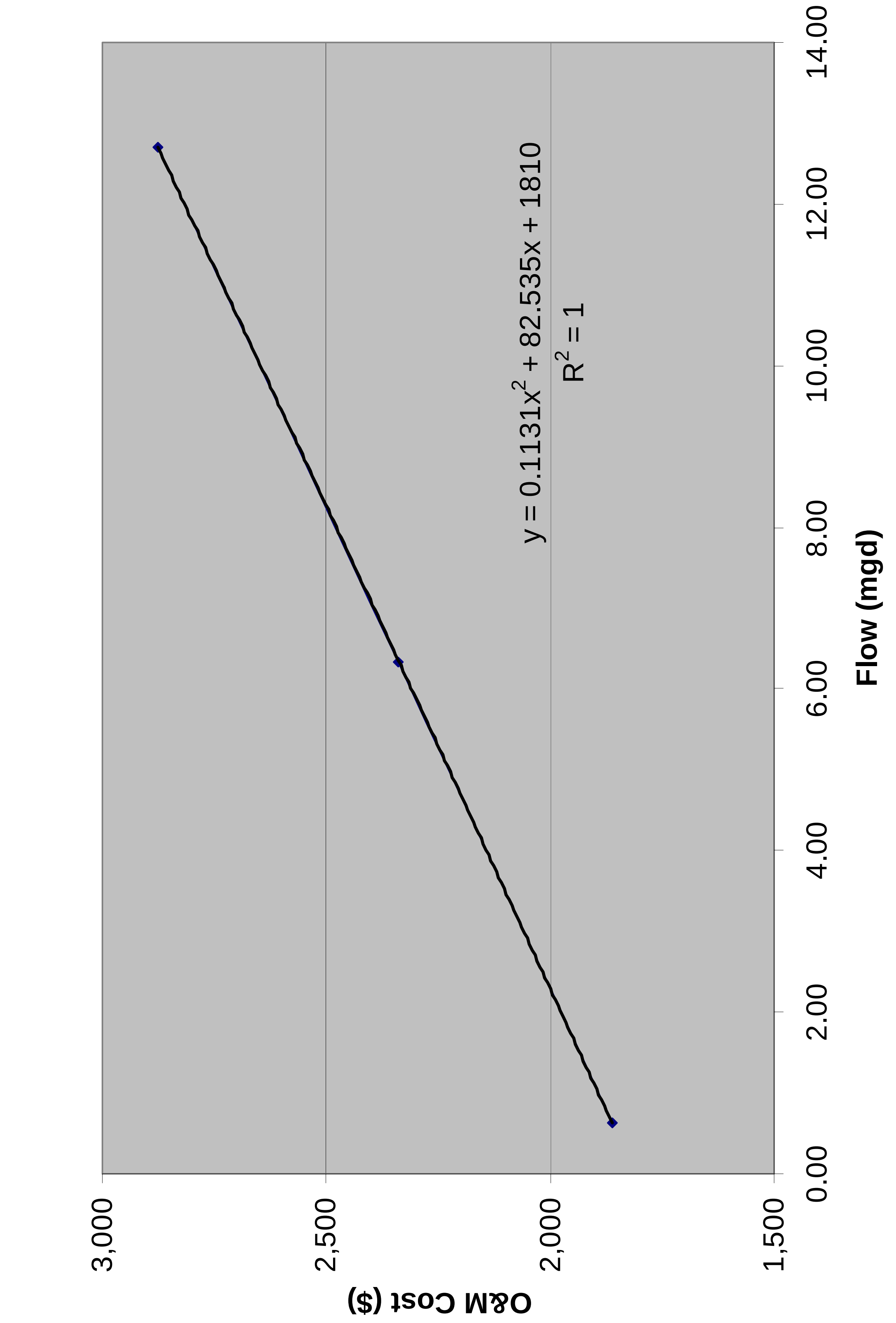
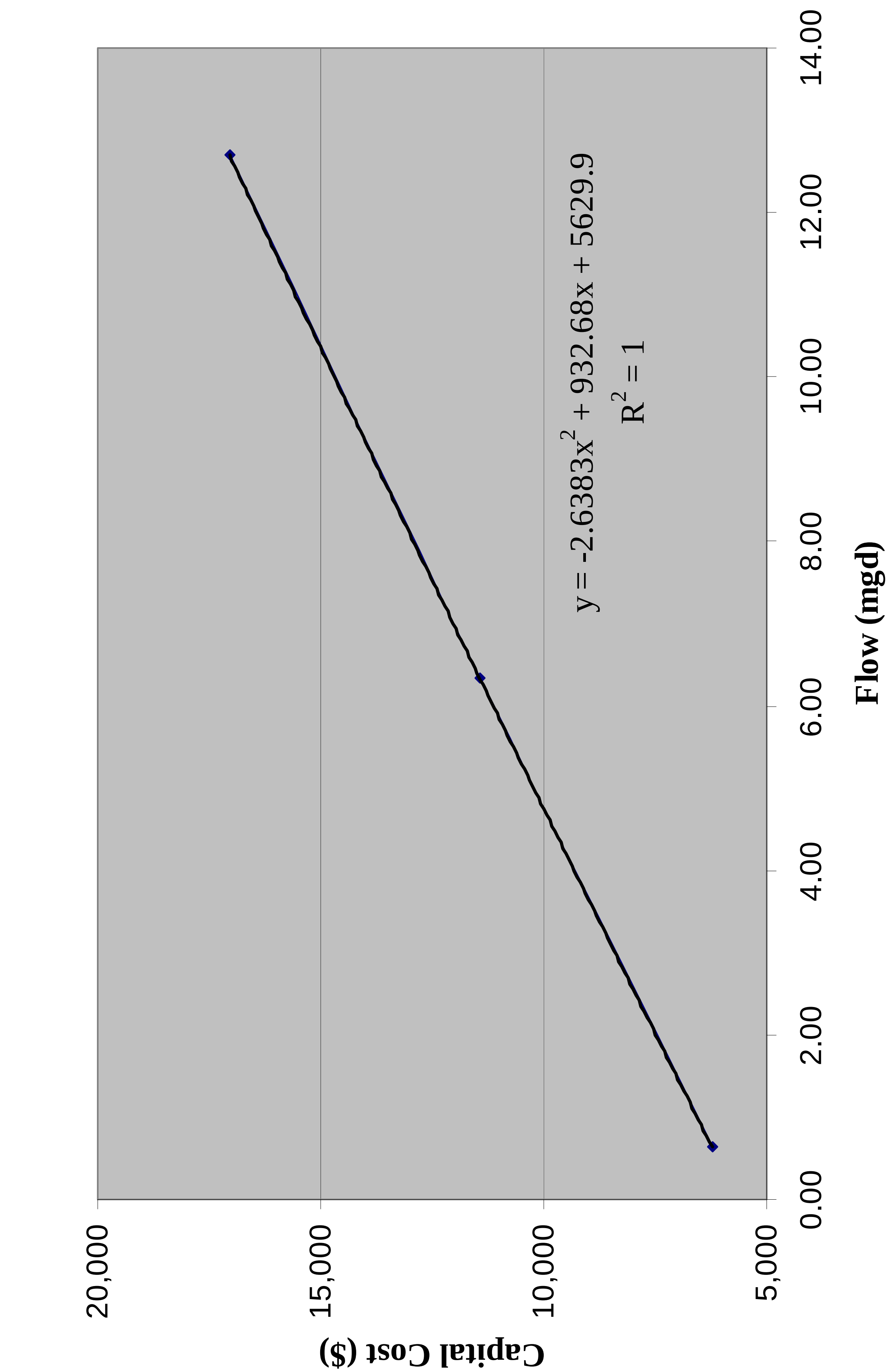


Figure 3-59. Capital Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chest



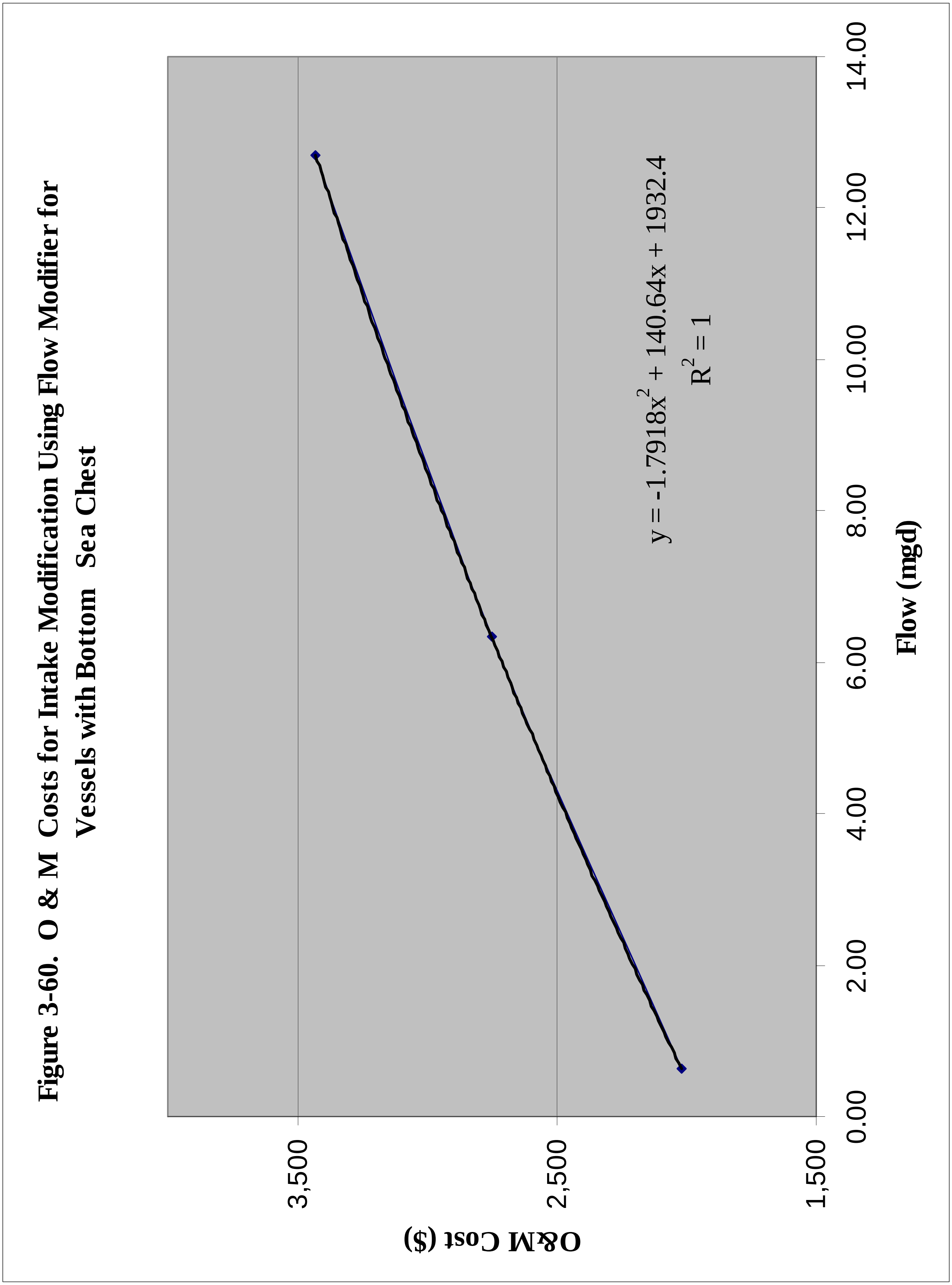


Figure 3-60. O & M Costs for Intake Modification Using Flow Modifier for Vessels with Bottom Sea Chest

III. TECHNOLOGY COST MODULES FOR OFFSHORE OIL AND GAS EXTRACTION FACILITIES

APPLICATION OF THE PROPOSED RULE

Under each of the co-proposed options, no existing oil and gas extraction facilities would be subject to national performance standards. New oil and gas extraction facilities would be subject to the proposed rule, as described in the preamble to today's rule.

INTRODUCTION

EPA did not consider new offshore oil and gas extraction facilities (the definition of "offshore" includes both coastal and offshore facilities–see the preamble for further details) in the 316(b) Phase I - New Sources rulemaking. Non-contact, once-through water is used to cool crude oil, produced water, power generators, and various other pieces of machinery at oil and gas extraction facilities.[1] The Phase I proposal and its record included no analysis of issues associated with offshore oil and gas extraction facilities (such as significant space limitations on mobile drilling platforms and ships) that could significantly increase the costs and economic impacts and affect the technical feasibility of complying with the proposed requirements for land-based industrial operations. Consequently, EPA exempted these facilities from the Phase I rule (see December 18, 2001; 66 FR 65311). As part of the Phase III rulemaking, EPA also evaluated potential 316(b) technology options for existing offshore oil and gas extraction facilities.

Since the Phase I 316(b) rulemaking, EPA collected technical and economic information associated with this industry sector. EPA also received information from industry trade associations to assist its analyses. EPA used this information to assess costs, economic impact and unique technical issues associated with various technology-based options available to control impingement and entrainment of aquatic organisms. This chapter provides an overview of the: (1) industrial sector; (2) information EPA collected and received from industry; (3) facilities in this industrial sector which EPA evaluated for the Phase III rulemaking; (4) technology options available to control impingement and entrainment of aquatic organisms; and (5) proposed technology options identified in the Phase III proposal.

1.0 INDUSTRIAL SECTOR PROFILE: OFFSHORE OIL AND GAS EXTRACTION FACILITIES

The oil and gas extraction industry drills wells at onshore, coastal, and offshore regions for the exploration and development of oil and natural gas. Various engines and brakes are employed which require some type of cooling system. The U.S. oil and gas extraction industry currently produces over 60 billion cubic feet of natural gas and approximately 5.7 million barrels of crude oil per day.[1] The U.S. Outer Continental Shelf (OCS) contributes to this energy production and the largest majority of the OCS oil and gas extraction occurs in the Gulf of Mexico (GOM). The Federal OCS generally starts three miles from shore and extends out to the outer territorial boundary (about 200 miles).[2] The U.S. Department of Interior's Mineral Management Service (MMS) is the Federal agency responsible for managing OCS mineral resources. The following are summary statistics on OCS oil and gas production:[3]

- The OCS accounts for about 25% of the Nation's domestic natural gas production and about 30% of its domestic oil production. On an energy basis (BTU), about 60 percent of the energy currently produced offshore is natural gas.
- The OCS contains about 19% of the Nation's proven natural gas reserves and 18% of its proven oil reserves. The OCS is estimated to contain more than 60% of the Nation's remaining undiscovered natural gas and oil resources.
- Since 1953, the OCS has produced about 141 trillion cubic feet of natural gas and about 13 billion barrels of oil. The Federal OCS provides the bulk—about 89%—of all U.S. offshore production. Five coastal States—Alaska, Alabama, California, Louisiana and Texas—make up the remaining 11%.

Exhibit 3-66 presents the number of wells drilled in three areas (GOM, Offshore California, and Coastal Cook Inlet, Alaska) for 1995 through 1997. The table also separates the wells into four categories: shallow water development, shallow water exploratory, deep water development, and deep water exploratory. Exploratory drilling includes those operations drilling wells to determine potential hydrocarbon reserves. Development drilling includes those operations drilling production wells once a hydrocarbon reserve has been

[1] U.S. DOE, 2004. EIA Quick Stats Pages, http://www.eia.doe.gov/neic/quickstats.html.

[2] The Federal OCS starts approximately 10 miles from the Florida and Texas shores.

[3] E-mail from James Cimato, MMS, to Carey Johnston, EPA, April 9, 2003.

discovered and delineated. Although the rigs used in exploratory and development drilling sometimes differ, the drilling process is generally the same for both types of drilling operations.

The water depth in which either exploratory or development drilling occurs may determine the operator's choice of drill rigs and drilling systems. MMS and the drilling industry classify wells as located in either deep water or shallow water, depending on whether drilling is in water depths greater than 1,000 feet or less than 1,000 feet, respectively.

Exhibit 3-66. Number of Wells Drilled Annually, 1995 - 1997, By Geographic Area

Data Source		Shallow Water (<1,000 ft)		Deep Water (≥ 1,000 ft)		Total Wells
		Development	Exploration	Development	Exploration	
Gulf of Mexico†						
MMS:	1995	557	314	32	52	975
	1996	617	348	42	73	1,080
	1997	726	403	69	104	1,302
	Average Annual	640	355	48	76	1,119
RRC		5	3	NA	NA	8
Total Gulf of Mexico		**645**	**358**	**48**	**76**	**1,127**
Offshore California						
MMS:	1995	4	0	15	0	19
	1996	15	0	16	0	31
	1997	14	0	14	0	28
	Average Annual	**11**	**0**	**15**	**0**	**26**
Coastal Cook Inlet						
AOGC:	1995	12	0	0	0	12
	1996	5	1	0	0	6
	1997	5	2	0	0	7
	Average Annual	**7**	**1**	**0**	**0**	**8**

Source: U.S. EPA, 2000, EPA-821-B-00-013.
† Note: GOM figures do not include wells within State bay and inlet waters (considered “coastal” under 40 CFR 435) and State offshore waters (0-3 miles from shore). In August 2001 there were 1 and 23 drilling rigs in State bay and inlet waters of Texas and Louisiana, respectively. There were also 19 and 112 drilling rigs in State offshore waters (0-3 miles from shore), respectively.

Deepwater oil and gas activity in the Gulf of Mexico has dramatically increased from 1992 to 1999. In fact, in late 1999, oil production from deepwater wells surpassed that produced from shallow water wells for the first time in the history of oil production in the Gulf of Mexico. As shown in Exhibit 3-66, 1,127 wells were drilled in the Gulf of Mexico, on average, from 1995 to 1997, compared to 26 wells in California and 8 wells in Cook Inlet. In the Gulf of Mexico, over the last few years, there has been high growth in the number of wells drilled in deep water, defined as water greater than 1,000 feet deep. For example, in 1995, 84 wells were drilled in deep water, or 8.6 percent of all Gulf of Mexico wells drilled that year. By 1997, that number increased to 173 wells drilled, or over 13 percent of all Gulf of Mexico wells drilled. Nearly all exploration and development activities in the Gulf are taking place in the Western Gulf of Mexico, that is, the regions off the Texas and Louisiana shores.

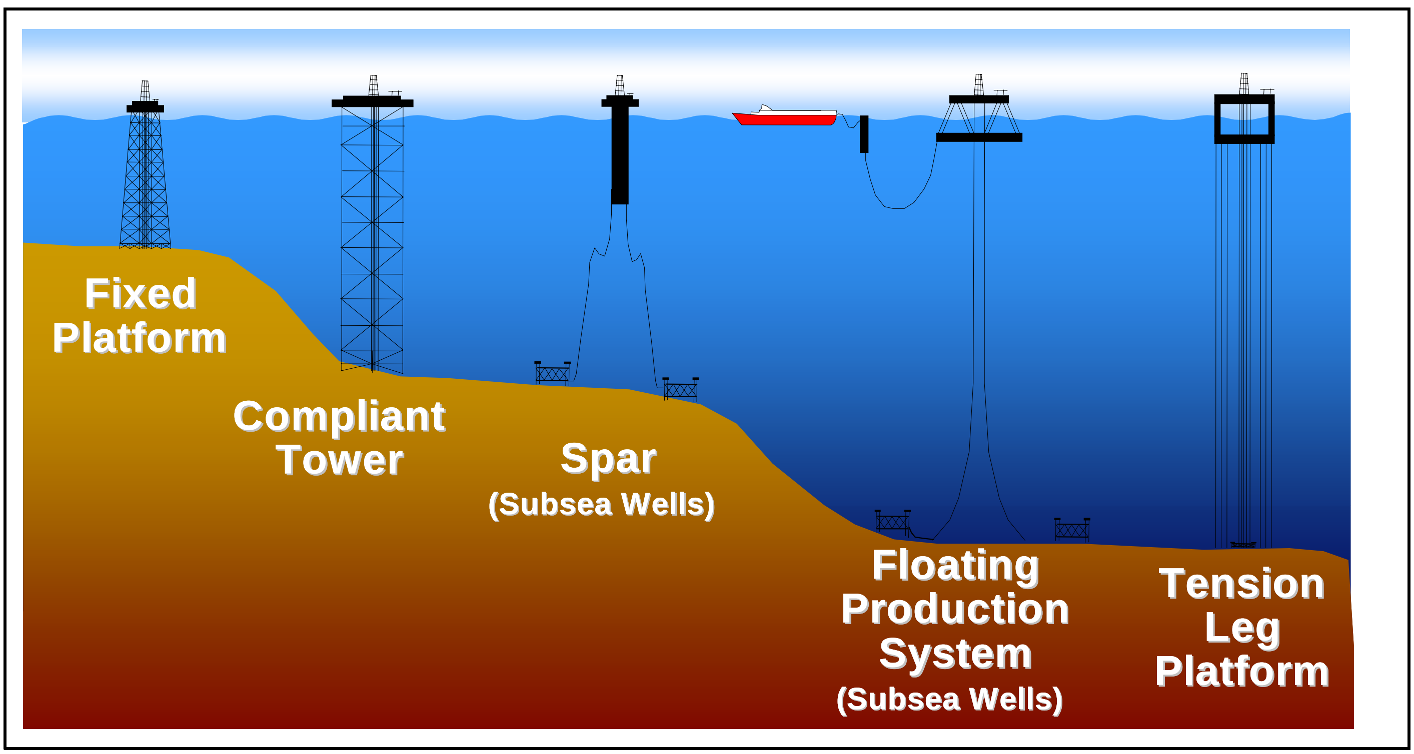
There are numerous different types of offshore oil extraction facilities. Some facilities are fixed for development drilling while other facilities are mobile for both exploration and development drilling. Previous EPA estimates of non-contact cooling water for offshore oil and gas extraction facilities showed a wide range of cooling water demands (294 - 5,208,000 gal/day).[4]

1.1 Fixed Oil and Gas Extraction Facilities

Most of these structures (Figure 3-61) use a pipe with a passive screens (strainers) to convey cooling water. There are a number of cooling water intake structure (CWIS) configurations for fixed facilities including sea chests (Figure 3-62), simple pipe (Figures 3-63 and 3-64), and caisson (Figures 3-66, 3-67, and 3-68). Perforated caissons or simple pipes have been used on some fixed platforms. For example, the Marathon platform at South Ewing Bank (OCS Block 873) has a design intake flow of 4 MGD and uses a 24 inch outer diameter simple pipe with square grid 0.5 inch perforations at the intake which translates to an intake velocity of 1 feet per second. The Aera Energy Ellen (Beta) platform in offshore California withdraws 3.5 MGD and has two cooling water intakes structures each with a through screen of 0.5 feet per second. This platform uses a simple 20 inch pipe with a 2 inch cone screen with approximately 0.5 inch openings. This intake uses a 90/10 Cu/Ni alloy pipe for controlling biofouling.

Non-contact, once-through water is used to cool crude oil, produced water, power generators and various other pieces of machinery (e.g., drawworks brakes). Due to the number of oil and gas extraction facilities in the GOM in relation to other OCS regions, EPA estimated the number of fixed active platforms in the Federal OCS region of the Gulf of Mexico using the MMS 2003 Deepwater Production Summary by Year. Abandoned platforms and platforms without production equipment were eliminated from the platform count. The platforms were then categorized by deepwater and shallow water, and 20+ wells and < 20 wells. The counts are presented in Exhibit 3-66. As the table shows, about 90 percent of platforms in the GOM are small platforms operating in shallow water. Only a limited number of structures (generally not the typical fixed platforms) are found in the deepwater regions of the GOM. Currently (2003 data) only 26 are considered build and operational in the MMS database.

Figure 3-61. Fixed Oil and Gas Extraction Facilities



[4] U.S. EPA, Development Document for Effluent Limitations and Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and Gas Extraction Point Source Category, EPA-821-R-93-003, January 1993.

Figure 3-62. Offshore Seachest Cooling Water Intake Structure Design

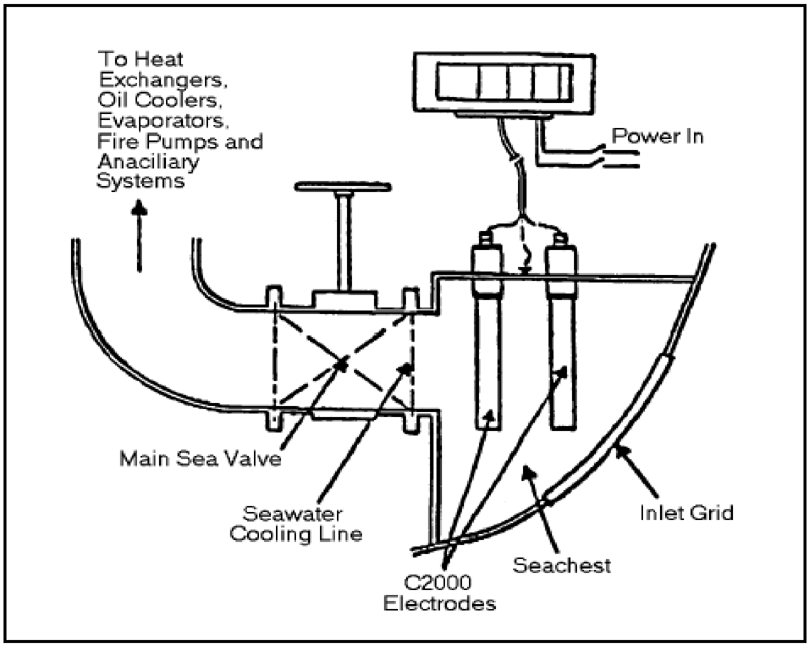


Figure 3-63. Offshore Simple Pipe Cooling Water Intake Structure Design (Schematic)

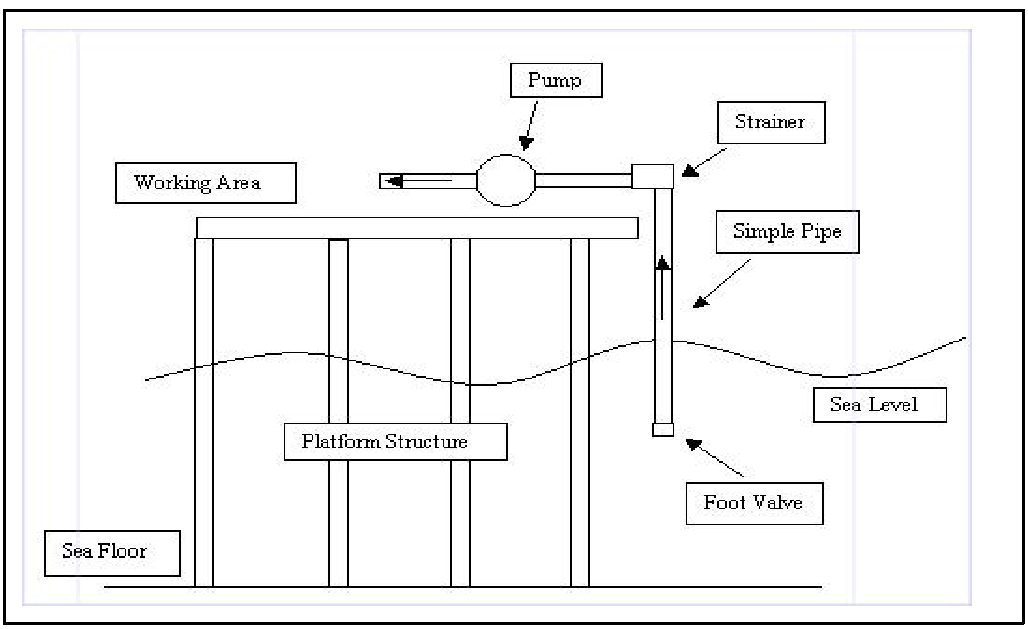
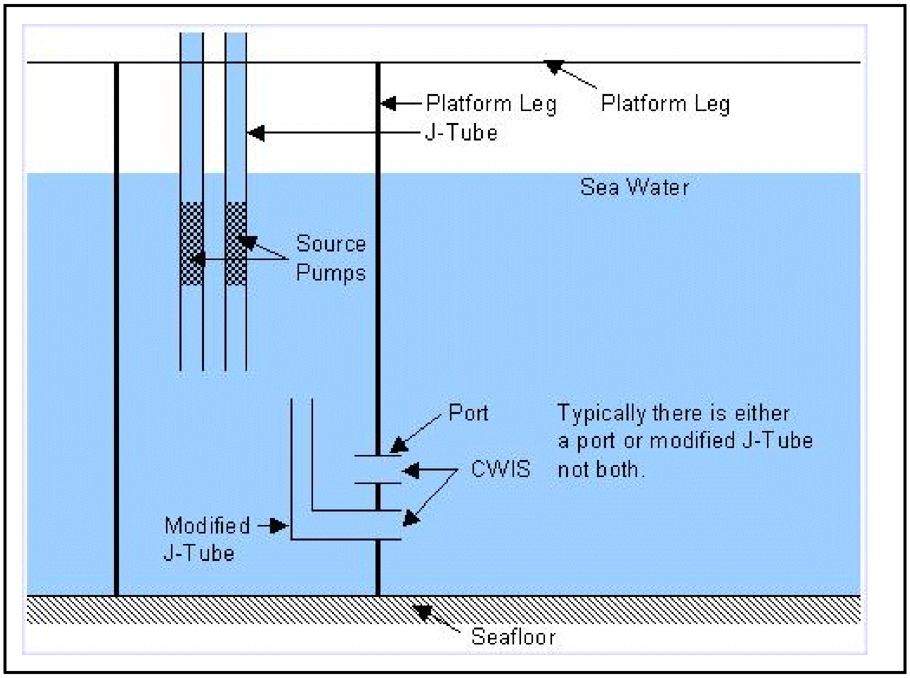


Figure 3-64. Offshore Simple Pipe Cooling Water Intake Structure Design - Wet Leg



Note: Another configuration, the "J" Tube configuration, also uses simple pipes as a cooling water intake structure but with no seawater in the platform leg.

Figure 3-65. Offshore Caisson Cooling Water Intake Structure Design (Thompson Culvert Company)

Figure 3-66. Offshore Caisson Cooling Water Intake Structure Design - Leg Mounted Well Tower

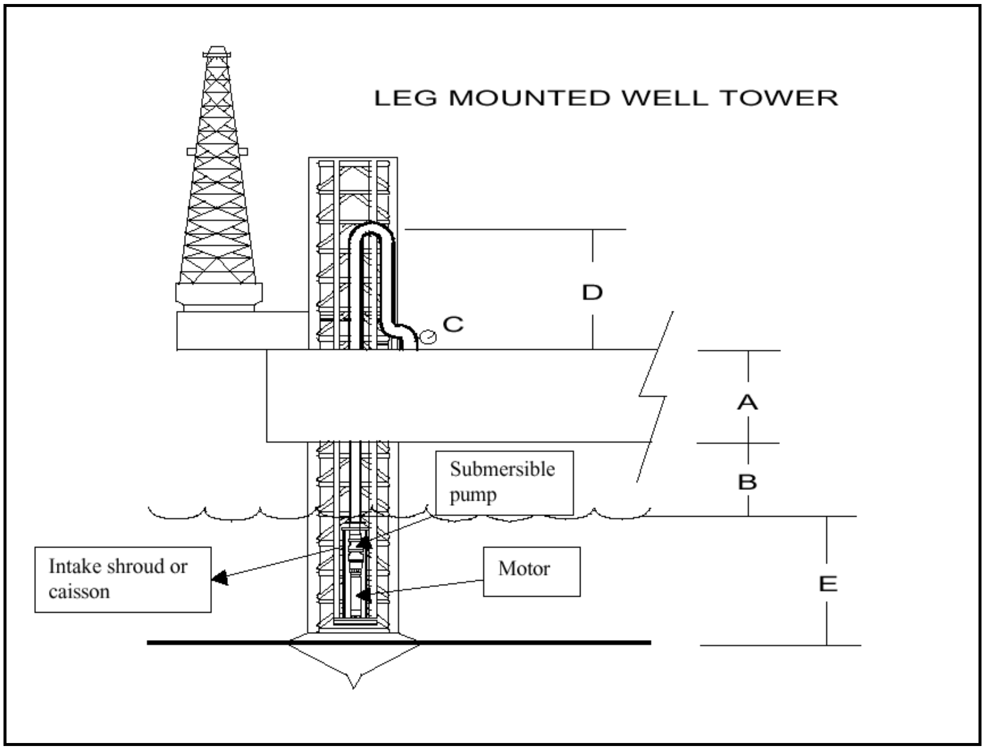


Figure 3-67. Offshore Caisson Cooling Water Intake Structure Design - Conventional Well Tower

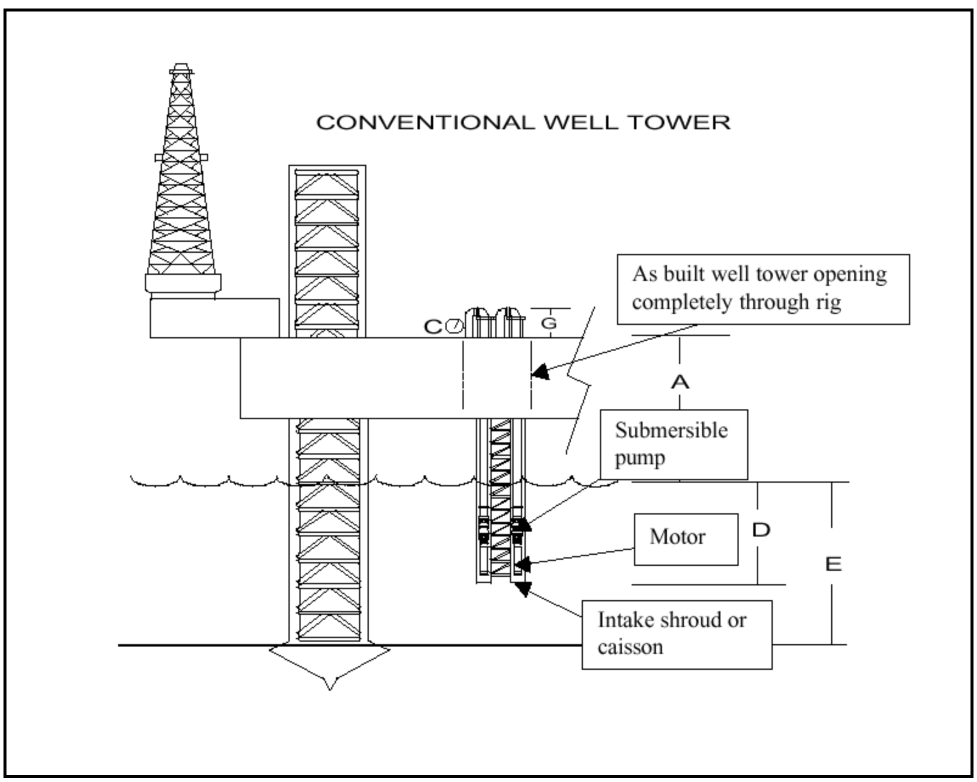


Exhibit 3-67. Identification of Structures in the Gulf of Mexico OCS

Category	Count
Total Number of Platforms	6,266
Removed Platforms	2,229
Abandoned Platforms	21
Platforms without Production Equipment	1,587
Producing Platforms - Deepwater	26
Producing Platforms - Shallow water + 20 slots	209
Producing Platforms - Shallow water < 20 slots	2,194
Total Producing Platforms	2,429

Source: MMS. 2003. Deepwater production summary by year. U.S. Department of the Interior. Mineral Management Service.

The Offshore Operators Committee (OOC) and the National Oceans Industries Association (NOIA) also noted in their comments to the 316(b) Phase I NODA (see May 25, 2001; 66 FR 28853) that a typical platform rig for a Tension Leg Platform[5] will require 10 - 15 MM Btu/hr heat removal for its engines and 3 - 6 MM Btu/hr heat removal for the drawworks brake. The total heat removal (cooling capacity required) is 13 - 21 MM Btu/hr. Assuming continuous once through cooling and a seawater temperature increase of 10 ºC between intake and discharge, the volume of seawater required for cooling these engines at a Tension Leg Platform can roughly be estimated between 2.0 to 3.3 MGD (see DCN 7-3645).

OOC/NOIA also estimated that approximately 200 production facilities have seawater intake requirements that exceed 2 MGD. OOC/NOIA estimate that these facilities have seawater intake requirements ranging from 2 - 10 MGD with one-third or more of the volume needed for cooling water. Other seawater intake requirements include firewater and ballasting. The firewater system on offshore platforms must maintain a positive pressure at all times and therefore requires the firewater pumps in the deep well casings to run continuously. Ballasting water for floating facilities may not be a continuous flow but is an essential intake to maintain the stability of the facility.

1.2 Mobile Oil and Gas Extraction Facilities

EPA also estimated the number of mobile offshore drilling units (MODUs) currently in operation (see Figure 3-68 for examples). These numbers change in response to market demands. Over the past five years the total number of mobile offshore drilling units (MODUs) operating at one time in areas under U.S. jurisdiction has ranged from less than 100 to more than 200. There are five main types of MODUs operating in areas under U.S. jurisdiction: drillships, semi-submersibles, jack-ups, submersibles and drilling barges. Exhibit 3-67 gives a brief summary of each MODU. EPA and MMS could not identify any cases where the environmental impacts of a MODU cooling water intake structure were considered.

[5] A Tension Leg Platform (TLP) is a fixed production facilities in deepwater environments (> 1,000 ft).

Figure 3-68. Mobile Oil and Gas Extraction Facilities

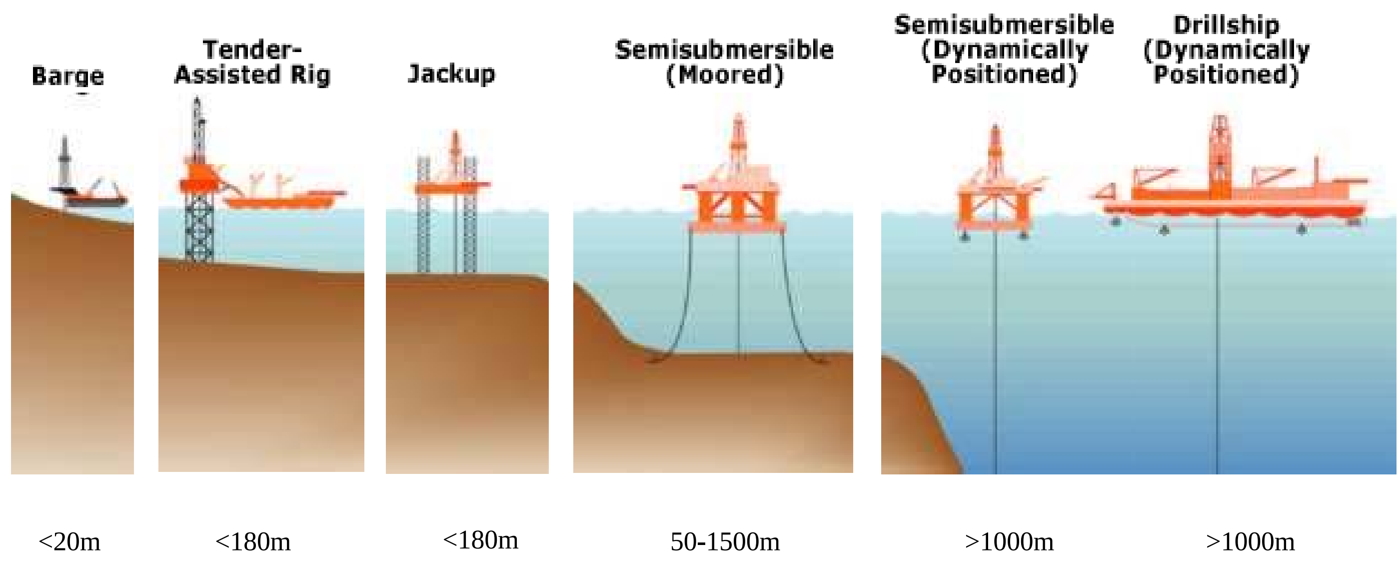


Exhibit 3-68. Description of Mobile Offshore Drilling Units and Their Cooling Water Intake Structures

MODU Type	Water Intake* and Design	Water Depth	Estimate of the Number of Existing MODUs**
Drill Ships	16 - 20 MGD Seachest	Greater than 400 ft	11
Semi-submersibles	2 - 15+ MGD Seachest	Greater than 400 ft	63
Jack-ups	2 - 10+ MGD Intake Pipe	Less than 400 ft	192
Submersibles	< 2 MGD Intake Pipe	Shallow Water (Bays and Inlet Waters)	47
Drill Barges	< 2 MGD Intake Pipe	Shallow Water (Bays and Inlet Waters)	70

Sources: 1) Johnston, Carey A. U.S. EPA, Memo to File, Notes from April 4, 2001 Meeting with US Coast Guard. April 23, 2001, DCN 2–012A. 2) ODS-Petrodata Group, Offshore Rig Locator, Houston, Texas, Vol. 28, No. 4, April 4, 2001. 3) Spackman, Alan, International Association of Drilling Contractors, Comments on Phase I 316(b) Proposed Rule, Comment Number 316bNFR.004.001. 4) Spackman, Alan, International Association of Drilling Contractors, Memo to Carey Johnston, U.S. EPA, 316(b), May 8, 2001.
* Approximately 80% of the water intake is used for cooling water with the remainder being used for hotel loads, fire water testing, cleaning, and ballast water.[6]
** MODU count from DCN 7-3657, Record Section 1.1.3.

[6]Johnston, Carey A. U.S. EPA, Memo to File, Notes from April 4, 2001 Meeting with US Coast Guard. April 23, 2001, DCN 2–012A.

The particular type of MODU selected for operation at a specific location is governed primarily by water depth (which may be controlling), anticipated environmental conditions, and the design (depth, wellbore diameter, and pressure) of the well in relation to the units equipment. In general, deeper water depths or deeper wells demand units with a higher peak power-generation and drawworks brake cooling capacities, and this directly impacts the demand for cooling water.[7]

a. Drillships and Semi-Submersibles MODUs

Drill ships and semi-submersibles use a "sea chest" as a cooling water intake structure.[8] In general there are three pipes for each sea chest (these include cooling water intake structures and fire pumps). One of the three intake pipes is always set aside for use solely for emergency fire fighting operations. These pipes are usually back on the flush line of the sea chest. The sea chest is a cavity in the hull or pontoon of the MODU and is exposed to the ocean with a passive screen (strainer) often set along the flush line of the sea chest. These passive screens or weirs generally have a maximum opening of 1 inch (Comment Number 316bNFR.004.001). There are generally two sea chests for each drill ship or semi-submersible (port and starboard) for redundancy and ship stability considerations. In general, only one seachest is required at any given time for drilling operations (DCN 2–012A).

While engaged in drilling operations most drillships and one-third of semi-submersibles maintain their position over the well by means of "dynamic positioning" thrusters which counter the effects of wind and current. Additional power is required to operate the drilling and associated industrial machinery, which is most often powered electrically from the same diesel generators that supply propulsion power. While the equipment powered by the ship's electrical generating system changes, the total power requirements for drillships are similar to those while in transit. Thus, during drilling operations the total seawater intake on a drillship is approximately the same as while underway. The majority of semi-submersibles are not self- propelled, and thus require the assistance of towing vessels to move from location to location. For example, the Transocean Deepwater Horizon semi-submersible MODU withdraws 16.0 MGD and has eight cooling water intakes structures each with a through screen velocity of 0.5 feet per second. This MODU uses sea chests openings of 24.4 inch by 28.7 inch with single simplex strainers in the sea chest. The sea chest screens are simple passive strainers with a one inch grid opening. The Transocean Cajun Express semi-submersible MODU withdraws 6.1 MGD and has six cooling water intakes structures each with a through screen of 0.23 feet per second. This MODU uses sea chests openings of 32 inches in diameter with 14 inch by 8 inch corrugated basket strainers in the sea chest. The sea chest screens are simple passive strainers with a one inch grid opening.

Information from the U.S. Coast Guard indicates that when semi-submersibles are drilling their sea chests are 80 to 100 feet below the water surface and are less than 20 feet below water when the pontoons are raised for transit or screen cleaning operations (DCN 2–012A). Drill ships have their sea chests on the bottom of their hulls and are typically 20 to 40 feet below water at all times.

The International Association of Drilling Contractors (IADC) notes that one of the earlier semi-submersible designs still in use is the "victory" class unit (Spackman, May 8, 2001). This unit is provided with two seawater-cooling pumps, each with a design capacity of 2.3 MGD with a 300 head. At operating draft the center of the inlet, measuring approximately 4 feet by 6 feet, is located 80 feet below the sea surface and is covered by an inlet screen. In the original design this screen had 3024 holes of 15mm diameter. The approximate inlet velocity is therefore 0.9 feet per second.

The more recent semi-submersible designs typically have higher installed power to meet the challenges of operating in deeper water, harsher environmental conditions, or for propulsion or positioning. IADC notes that a newly-built unit, of a new design, has a seawater intake capacity of 34.8 MGD, which includes salt water service pumps and ballast pumps, and averages 10.7 MGD of seawater intake of which 7.4 MGD is for cooling water.

b. Jack-up MODUs

Jack-up, submersibles, and drill barges use intake pipes for cooling water intake structures. These facilities basically use a pipe with a passive screens (strainers) to convey cooling water. Non-contact, once-through water is used to cool crude oil, produced water, power generators and various other pieces of machinery on these facilities (e.g., drawworks brakes).

[7] Spackman, Alan, International Association of Drilling Contractors, Memo to Carey Johnston, U.S. EPA, 316(b), May 8, 2001.

[8] A sea chest is an underwater compartment within the vessel's hull through which sea water is drawn in or discharged. A passive screen (strainer) is set along the flush line of the sea chest. Pumps draw seawater from open pipes in the sea chest cavity.

The jack-up is the most numerous type of MODU. These vessels are rarely self- propelled and must be towed from location to location. Once on location, their legs are lowered to the seabed, and the hull is raised (jacked-up) above the sea surface to an elevation that prevents wave impingement with the hull. Although all of these ships do use seawater cooling for some purposes (e.g., desalinators), as with the semi-submersibles a few use air-cooled diesel-electric generators because of the height of the machinery above the sea surface (Comment Number 316bNFR.004.001). Seawater is drawn from deep-well or submersible pumps that are lowered far enough below the sea surface to assure that suction is not lost through wave action. Total seawater intake of these ships varies considerably and ranges from less than 2 MGD to more than 10 MGD. Jack-ups are limited to operating in water depths of less than 500 feet, and may rarely operate in water depths of less than 20 feet.

The most widely used of the jack-up unit designs is the Marathon Letourneau 116-C (Spackman May 8, 2001). For these types of jack-ups typically one pump is used during rig operations with a 6" diameter suction at 20 to 50 feet below water level which delivers cooling water intake rates of 1.73 MGD at an inlet velocity of 13.33 feet per second (Spackman May 8, 2001). Additionally, pre-loading involves the use of two or three pumps in sequence. Pre-loading is not a cooling water procedure, but a ballast water (which is later discharged).[9] Each pump is fitted with its own passive screen (strainer) at the suction point which provides for primary protection against foreign materials entering the system.

In their early configurations, these jack-up MODUs were typically outfitted with either 5 diesel generator units, each rated at about 1,200 horsepower, or three diesel generator units, each rated at about 2,200 horsepower (Spackman May 8, 2001). In subsequent configurations of this design or re-powering of these units, more installed power has generally been provided, as it has in more recent designs. With more installed power, there is a demand for more cooling water. IADC reports that a newly-built jack-up, of a new design, typically requires 3.17 MGD of cooling water for its drawworks brakes and cooling of six diesel generator units, each rated at 1,845 horsepower (Spackman May 8, 2001). In this case one pump is typically used during rig operations with a 10" diameter suction at 20 to 50 feet below water level, delivering the cooling water at 3.2 MGD.

c. Submersibles and Drill Barge MODUs

The submersible MODU is used most often in very shallow waters of bays and inlet waters. These MODUs are not self-propelled. Most are powered by air-cooled diesel-electric generators, but require seawater intake for cooling of other equipment, desalinators, and for other purposes. Total seawater intake varies considerably with most below 2 MGD.

There are approximately 50 drilling barges available for operation in areas under U.S. jurisdiction, although the number currently in operation is less than 20. These ships operate in shallow bays and inlets along the Gulf Coast, and occasionally in shallow offshore areas. Many are powered by air-cooled diesel-electric generators. While they have some water intake for sanitary and some cooling purposes, water intake is generally below 2 MGD.

2.0 PHASE III INFORMATION COLLECTION FOR OIL AND GAS EXTRACTION FACILITIES

Numerous researchers and State and Federal regulatory agencies have studied and controlled the discharges from oil and gas extraction facilities for decades. The technology-based standards for the discharges from these facilities are located in 40 CFR 435. Conversely, there has been little work done to investigate the environmental impacts or evaluation of the location, design, construction, and capacity characteristics of cooling water intake structures for offshore oil and gas extraction facilities.

In developing the Phase III proposal, EPA used a variety of sources to identify data on the current status of the oil and gas extraction industry and the cooling water intake structures associated with these facilities. Sources of data included; consultations with the two main regulatory entities of this industrial sector (i.e., USCG, MMS), an EPA survey of the industry which collected both economic and technical data, technical data submittals from industry which were provided either directly or through various trade associations, and information available from the internet. Each of these sources of information are described in more detail below.

2.1 Consultations with USCG and MMS

The U.S. Coast Guard (USCG) and the Department of Interior's Mineral Management Services (MMS) agency identified no specific regulatory requirements for this industrial sector with respect to potential environmental impacts associated with cooling water intake structures. The USCG does not investigate potential environmental impacts of MODU cooling water intake structures but does require

[9] Vlahos, G., Martin, C.M., Cassidy, M.J., 2001. Experimental Investigation of a Model Jack-Up Unit on Clay, Proceedings of the Eleventh (2001) International Offshore and Polar Engineering Conference, Stavanger; Norway, June 17-22, 2001.

operators to inspect sea chests twice in every five year period and conduct at least one cleaning to prevent blockages of firewater lines. EPA met with Mr. James Magill of USCG, Vessel and Facility Operating Standards Division to collection information on MODU operations and cooling water intake systems.[10]

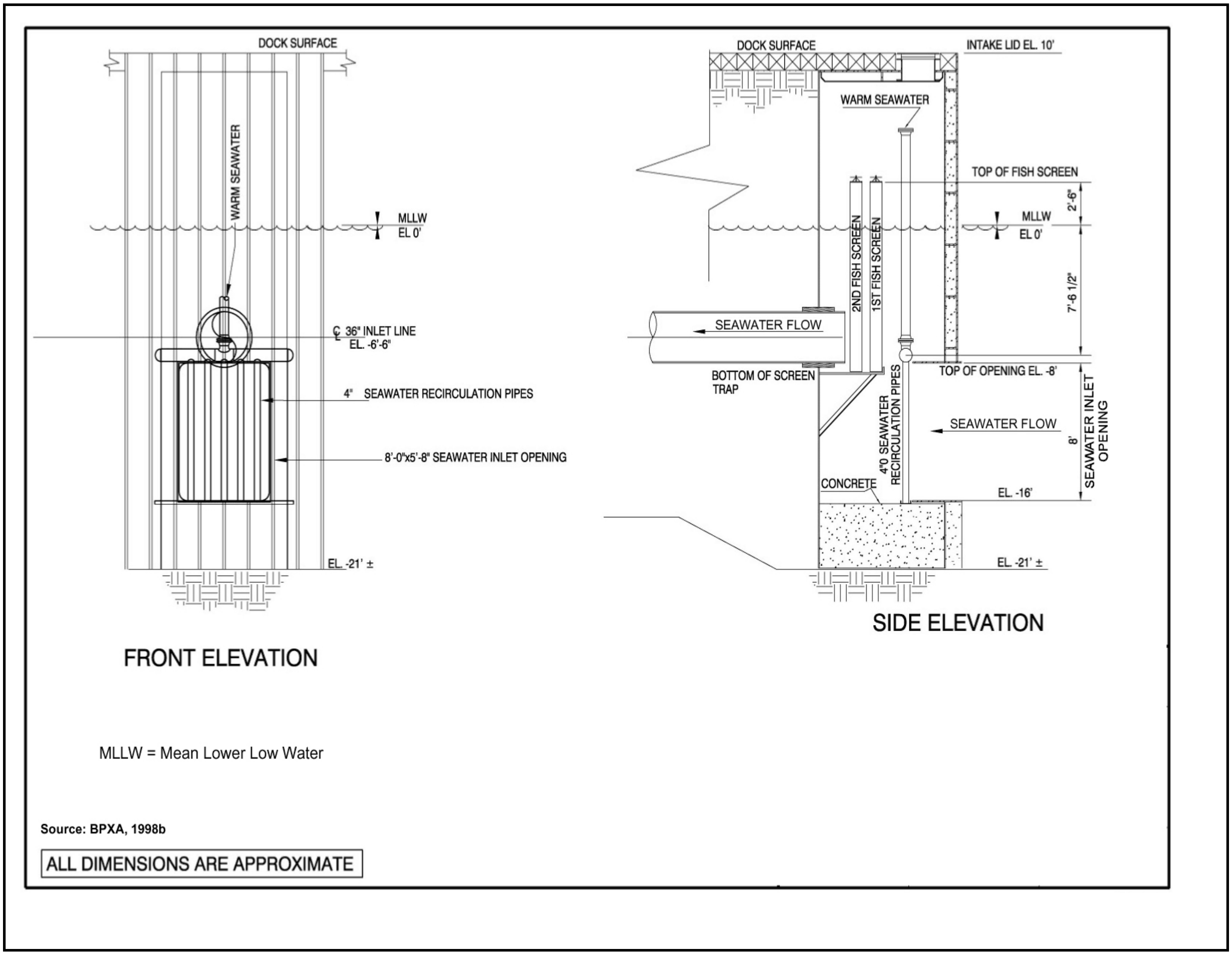
MMS is the Federal agency responsible for managing Outer Continental Shelf (OCS) mineral resources. MMS has authority for leasing in OCS and therefore has current lists of owner-operators and lessees. EPA used the MMS website, MMS Platform Inspection System, Complex/Structure database, Lessees/Operators financial information, MMS's environmental impact statements, environmental assessments, and other MMS sponsored studies to collect information to support the Phase III proposal.

Specifically, EPA used the MMS databases to estimate the number of fixed OCS platforms in the Gulf of Mexico. EPA also used facility information from the Alaska OCS Region office to determine the number of facilities in the OCS. The Pacific OCS Region website provided general information on oil and gas production facilities in the Pacific OCS Region. No information on the number of facilities in State waters and Coastal waters were found. EPA used the MMS environmental impact statements, environmental assessments, and other MMS sponsored studies to evaluate impact on marine organism assemblages from offshore oil and gas exploration and production. In general, MMS did not have information on cooling water intake structures for oil and gas extraction facilities.

EPA identified one case in the MMS files where they evaluated potential environmental impacts from an oil and gas extraction facility cooling water intake structure as part of their NEPA analyses. This analysis was conducted as part of BP Exploration Inc. (BPXA) plans to locate a vertical intake pipe for a seawater-treatment plant on the south side of Liberty Island, Beaufort Sea, Alaska. Figure 3-69 depicts the cooling water intake structure planned for the BPXA sea-water treatment plant. The pipe would have an opening 8 feet by 5.67 feet and would be located approximately 7.5 feet below the mean low-water level. The discharge from the continuous flush system consists of the seawater that would be continuously pumped through the process-water system to prevent ice formation and blockage. Recirculation pipes located just inside the opening would help keep large fish, other animals, and debris out of the intake. Two vertically parallel screens (6 inches apart) would be located in the intake pipe above the intake opening. They would have a mesh size of 1 inch by 1/4 inch. Maximum water velocity would be 0.29 feet per second at the first screen and 0.33 feet per second at the second screen. These velocities typically would occur only for a few hours each week while testing the fire-control water system. At other times, the velocities would be considerably lower. Periodically, the screens would be removed, cleaned, and replaced.

[10]Memorandum: Notes from April 4, 2001 Meeting with U.S. Coast Guard. From: Carey A. Johnston, USEPA/OW/OST, To: File, May 7, 2001.

Figure 3-69. Liberty Island Cooling Water Intake Structure



MMS states in the Liberty Island Draft Environmental Impact Statement that the proposed seawater-intake structure will likely harm or kill some young-of-the-year arctic cisco during the summer migration period and some eggs and fry of other species in the immediate vicinity of the intake. However, MMS estimates that less than 1% of the arctic cisco in the Liberty Island area are likely to be harmed or killed by the intake structure. Further, MMS concludes that: (1) the intake structure is not expected to have a measurable effect on young-of-the-year arctic cisco in the migration corridor; and (2) the intake structure is not expected to have a measurable effect on other fishes populations because of the wide distribution/low density of their eggs and fry. However, essential fish habitat for salmon will be adversely affected according to MMS because it is expected that prey species of zooplankton and fish in their early life stages (juveniles, eggs, and larvae) could be killed in the intake.

More recently, MMS assisted EPA by providing an initial annotated bibliography on all available research reported in marine and coastal waters concerning the impingement and entrainment of estuarine and marine organisms by cooling-water intake systems.[11] Most of the results obtained through this search were references about studies on fish impingement or entrainment by cooling-water intakes of nuclear or thermoelectric power plants located on estuarine or marine environments. MMS did not identify any references specific to fish impingement or entrainment by cooling-water intakes of oil and gas extraction facilities. MMS concluded that studies

[11]MMS, 2003. "Marine and Coastal Fishes Subject to Impingement by Cooling-Water Intake Systems in the Northern Gulf of Mexico: An Annotated Bibliography," MMS 2003-040, August 2003.

of impingement or entrainment by cooling-water intakes of oil and gas extraction facilities are generally unavailable through the searched databases.

2.2 EPA 316(b) Phase III Survey

In September 2003, EPA sent out a 316(b) Phase III survey to oil and gas extraction facilities to collect technical and economic data related to these types of facilities and their cooling water intake structures. EPA surveyed 90 facilities as part of this effort and received responses from 78 facilities. Exhibit 3-69 presents a breakout of the number of surveys mailed and responses by type of survey.

Exhibit 3-69. 316(b) Phase III Survey Statistics

Industry/Type of Survey	No. of Surveys Mailed	No. of Survey Responses
Oil & Gas Platforms (Technical and Economic Survey)	55	52
Oil & Gas Platforms (Economic Survey only)	5	3
MODU's (Economic Survey only)	30	23
Total	90	78

Source: Phase III Technical Questionnaire Tracking Report, From: Kelly Meadows, TetraTech, Date: 3/12/2004 (revised 3/23/2004).

EPA identified companies to survey based on a sampling frame of facilities expected to be in-scope. When a facility's eligibility was unknown, it was retained in the sampling frame. The sampling design selected by EPA included stratification of facilities based on the type of structure and its location. The stratification categories used in the survey included:

1. Gulf of Mexico Platforms - Deep Water
2. Gulf of Mexico Platforms - More than 20 Slots
3. Gulf of Mexico Platforms - Shallow Waters
4. California Platforms
5. Alaska Platforms
6. MODUs

These strata were chosen because they were expected to correspond to major differences in economic variables and also in the technology costs of implementing controls on impingement and entrainment. The survey samples were selected from lists for each of the subpopulations. A systematic sample with a random start was taken.

Exhibit 3-70 presents the number of facilities estimated to be in-scope in each of these strata and the number that were sampled in the survey.

Exhibit 3-70. Number of In-Scope Facilities and Number Sampled by Frame

Sampling Stratification Frame	Number of Facilities Estimated to be In-Scope	Number of Facilities Sampled
Gulf of Mexico Platforms - Deep Water	24	4
Gulf of Mexico Platforms - More than 20 Slots	206	33
Gulf of Mexico Platforms - Shallow Waters	2,194	18
California Platforms	20	3
Alaska Platforms	19	2
MODUs	404	30
All Frames	2,867	90

Source: Memorandum: Sampling Selection for Offshore Oil & Gas - TD#W040917a dated September 17, 2003, From: G. Hussain Choudhry and Inho Park, Westat, To: John Fox, EPA, Date: October 7, 2003.

Economic and technical data submitted as part of the responses were used by EPA in the economic and costing analyses conducted as part of the Phase III proposal.

2.3 Technical Data Submittals from Industry

EPA received the majority of its technical cooling water intake structure data from industry either directly or through industry trade associations. The trade associations supporting and providing data submittals included the:

- International Association of Drilling Contractors (IADC)
- Offshore Operators Committee (OOC)
- Western States Petroleum Association (WSPA)
- Louisiana Mid-Continent Oil and Gas Association (LMOGA)

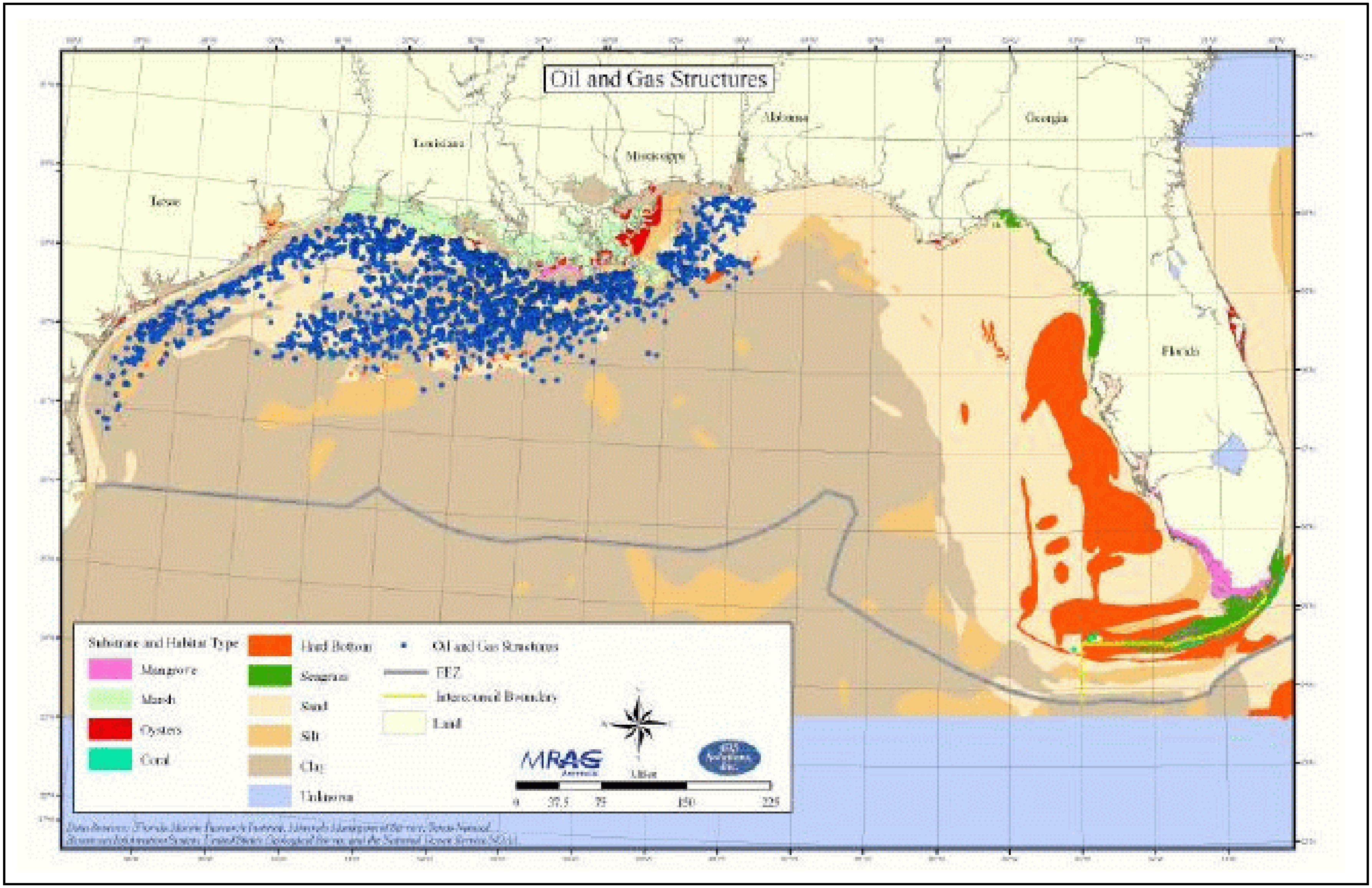
IADC provided cooling water intake structures information, solicited from its members, for over 140 mobile offshore drilling units operating in or marketed for operations in areas under the jurisdiction of the U.S. In addition, the 2002 IADC membership directory listed companies that represent a significant portion of the world's exploration and production activity. The directory information included, names of key personnel, addresses of both headquarter and branch locations, telephone and fax numbers, and internet addresses. The contractor directory also provided an alphabetical listing of drilling contractors who own and operate the vast majority of the world's land and offshore drilling units. That listing included the names of key personnel, addresses of both headquarter and branch locations, telephone and fax numbers, internet addresses, the size of each firm's rig fleet and operating theaters, and for offshore units, the rig type. The IADC submittals and directories did not include any economic information.

The OOC provided information, compiled on behalf of its members, on cooling water intake structures for offshore oil and gas extraction facilities in the Gulf of Mexico. Cooling water intake structure data were provided for 21 fixed platforms and no economic information were included. EPA was able to identify that 16 of the 2,429 fixed facilities and 87 of the 383 MODUs in the GOM withdrew more than 2 MGD of seawater with more than 25% used for cooling (see Figures 3-70 and 3-71 for display of fixed facilities).

Operators in Cook Inlet, Alaska, also provided information to EPA on cooling water intake structures for Cook Inlet platforms. The oil and gas fields in Cook Inlet are considered mature and since 1995 production in the Trading Bay Field, Granite Point Field, Middle Ground Field, and Tyonek platform declined from 17 to 92 percent. Consequently, fewer wells are being drilled in Cook Inlet and this means less equipment requires cooling. For example, the Spark and Spurr platforms have not operated their cooling water systems in over 7 years. These two cooling water system were decommissioned by their operator. Currently these two platforms are unmanned, remotely operated, gas production facilities without drilling, compression, or fire water suppression systems. Using industry data EPA was able to identify that five of the 16 fixed platforms in Cook Inlet withdrew more than 2 MGD of seawater with more than 25% used for cooling (see Figure 3-72).

The WSPA provided information, compiled on behalf of its members, on cooling water intake structures for offshore oil and gas extraction facilities off the coast of California. Cooling water intake structure data were provided for 18 fixed platforms and no economic information were included. Using this data EPA was able to identify that six of the 32 fixed platforms withdrew more than 2 MGD of seawater with more than 25% used for cooling (see Figure 3-72).

Figure 3-70. Gulf of Mexico Oil and Gas Extraction Facilities



Source: Final Environmental Impact Statement for the Generic Essential Fish Habitat, Gulf of Mexico Fishery Management Council, March 2004.