316b Phase II Cost Module

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 ft 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 (fps) / Water Depth (Ft) / 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 fps 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 II 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 II facilities that reported water depth data, the median water depth at the intake was 18.0 ft.

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, the median water depth value of 18 feet is multiplied by a factor of 1.5 to obtained the screen well depth (i.e., 27 feet).

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. Table 2-1 shows the range of estimated well depths that correspond to the specific well depths used for costing.

Table 2-1
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).

Table 2-2 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 Table 2-2 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

Table 2-2
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.

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.

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 Phase I, as described above the corresponding water depth, design flow, and through-screen velocities in most cases differ. As presented in Table 2-2, 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 II 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. Tables 2-3 and 2-4 present the Phase I equipment costs, adjusted for inflation to July 2002 dollars, for freshwater and saltwater environments respectively.

Table 2-3
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

Table 2-4
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 Tables 2-3 and 2-4. 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.

Table 2-5 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 II 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 Table 2-5 estimates.

Table 2-5
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 (Tables 2-3 and 2-4) included the engineering component and that installation costs (Table 2-5) 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 single10-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). Table 2-7 presents the costs for adding pumps for the added fish spray volume.

Table 2-7
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

The costs in Table 2-7 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.

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 fps, 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 (Costworks 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 (Costworks 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.dia./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-fps 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 Phase II data base, intake decks are often about half the intake water depth above the water surface, EPA has concluded in most cases there 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.

Table 2-8 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 Brayton 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 Table 2-8.

Table 2-8
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. Tables 2-9 through 2-14 (at the end of this document) 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 2-1 through 2-6, 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. Tables 2-15 and 2-16 present the estimated annual number of labor hours required to operate and maintain a "typical" traveling screen.

Table 2-15
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

Table 2-16
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. Table 2-17 presents the estimated annual labor hours for placement and removal of the fine mesh overlay screens.

Table 2-17
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 Table 2-18. 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. Tables 2-19 and 2-20 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.

Table 2-18
Screen Drive Motor Power Costs

Screen Width Ft	Well Depth Ft	Motor Power Hp	Electric Power Kw	Power Costs - Fine Mesh: Operating Hours	Annual Power Kwh	Annual Power Costs at $/Kwh of $0.04	Power Costs - Coarse Mesh: Operating Hours	Annual Power Kwh	Annual Power Costs at $/Kwh of $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

Table 2-19
Wash Water Power Costs
Traveling Screens Without Fish Handling

Screen Width ft	Flow Rate gpm	Total Head ft	Hydraulic-Hp Hp	Brake-Hp Hp	Power Requirement Kw	Fine Mesh: Annual Hours hr	Annual Power Kwh	Total Costs at $/Kwh of $0.04	Coarse Mesh: Annual Hours hr	Annual Power Kwh	Total Costs at $/Kwh of $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

Table 2-20
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 Table 2-3 and 2-4. 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

Table 2-21 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. Tables 2-22 through -27 (at the end of this document) present the O&M costs for the cost scenarios shown in Table 2-21. Figures 2-7 through 2-12 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.

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.

Table 2-21
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%

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. Table 2-28 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.

Table 2-28
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 Table 2-29 below

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

Table 2-29
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 2-5 and 2-6 (Scenario C freshwater and saltwater)

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 2-9 and 2-10 (Scenario C freshwater and saltwater).

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 estuarine/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.

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Table 2-9
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

Table 2-10
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

Table 2-11
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

Table 2-12
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

Table 2-13
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

Table 2-14
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

Table 2-22
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

Table 2-23
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

Table 2-24

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

Table 2-25

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

Table 2-26

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

Table 2-27

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