Appendix F
Estimated Cost of Alternatives

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Introduction

The U.S. Coast Guard is preparing an environmental impact statement (EIS) to support rule making for management of dry cargo residue (DCR) discharges to the Great Lakes. The purpose of this memorandum is to present estimates of cost components for the alternatives presented in the EIS. The Coast Guard will consider the economic effects of various alternatives by using the estimates contained in this memorandum and in the EIS. The alternatives include the following:

- **No Action.** The No Action alternative would allow the Interim Enforcement Policy (IEP) to end on September 30, 2008, without additional extensions. Upon termination, all laws applicable to the discharge of DCR to the Great Lakes would be enforced. DCR discharge would be prohibited, and DCR would be washed from the ship's tunnel, swept from the deck, and collected. The tunnel-washing residue and water would be transported by pump system to shoreside facilities, where it would be treated. The deck sweepings would be transported dry to either the cargo hold (during loading) or shoreside in the product storage area (for unloading).

- **Proposed Action (IEP as Coast Guard Regulation with Record Keeping).** This alternative would adopt the IEP for the Great Lakes as the basis for Coast Guard regulation, with new requirements for standardized record keeping for vessels that discharge DCR. Dry bulk cargo transport would continue, following current patterns and practices.

- **Proposed Action with Modified Exclusion Areas.** This alternative would be the Proposed Action described above *and* would modify exclusion areas to limit discharge of dry cargo residue in previously unidentified sensitive areas, to permit discharges in areas that are less sensitive than previously considered, or to limit discharge of certain types of cargoes.

- **Proposed Action with DCR Control Measures on Ships.** This alternative would be the Proposed Action described above *and* would require the use of structural and operational DCR control measures on ships.

- **Proposed Action with Shoreside DCR Control Measures.** This alternative would be the Proposed Action described above *and* would require shoreside facilities to control or eliminate dry cargo spillage during vessel loading or unloading by use of structural and management control measures. It would include new requirements for standardized record keeping by vessels that discharge DCR.

Estimated Cost Summary

Costs were developed for the DCR control measures using traditional cost-estimating techniques, coordination with Lake Carriers' Association member companies, and engineering judgment, and through direct contact with manufacturers of the control measures. The costs were separated into capital, installation, operation and maintenance, and delay costs to capture the total cost that each control measure may have on the shipping industry. Costs were estimated for U.S. ships, Canadian ships, or ports.

Capital costs include the material and manufacturing costs associated with the control measure. Installation costs include the costs associated with the installation of the control measure. Operation and maintenance costs are annual costs associated with the labor and material needed to operate and maintain the control measure. Finally, delay costs are those associated with implementing the control measures while the ship is at port, or a change in exclusion areas that require greater travel time or distance.

Traditional cost-estimating techniques were used for DCR control measures that are not specific to the shipping industry. For example, costs for tarps, brooms, and shovels were determined by researching different manufacturers and finding products that would be suitable to the needs of the ship. For more sophisticated DCR control measures, direct contact with manufacturers was used to develop the cost estimates. Estimates from manufacturers were confirmed and supplemented by the cost estimates developed by a panel of Lake Carriers' Association (LCA) members assembled to assist with the DCR control measure cost estimating. In some cases, capital costs provided by manufacturers did not include installation, operation, maintenance, or delay costs. Because the participating

LCA members have implemented the DCR control measures on some of their ships, they were able to provide costs for control measures installation, operation, maintenance, and delay. The costs provided below are estimated unit costs and will provide the basis for the Coast Guard's assessment of economic impacts associated with each alternative.

Because of the nature of DCR control measures and the uniqueness of each ship, there is no well-documented history or accepted method of developing standard costs. Also, several estimates were directly from the lake carriers and could not be independently verified. Thus, there is considerable uncertainty in the estimated costs compared to more standard engineering cost estimates, such as those for roads, buildings, or other land-based infrastructure.

No Action

Under the No Action alternative, tunnel washdown and deck sweeping would occur consistent with methods practiced by U.S. flag ships. After a ship is loaded, the deck would be swept of DCR to prevent its discharge into the water. The deck would not be washed down with water. For purposes of developing a cost estimate, it is assumed the swept DCR will be placed in the cargo hold or on shore. Consistent with current practices, deck sweeping is not expected to occur each time cargo is loaded.

After unloading, the tunnel surfaces would be washed down, and that washwater disposed of at a shoreside facility for pretreatment. Following pretreatment by a physical separation process that includes equalization and primary clarification, the washwater would be transferred to the municipal sewer authority for final treatment. The shoreside treatment facility would remove a significant amount of solids for disposal prior to discharging the pretreated washwater to the municipal sewer.

For purposes of developing a cost estimate, one of two retrofits to make pumping washwater to shore possible was assumed:

- Retrofit interior pumps and plumbing to allow for discharge of tunnel washwater to the shoreside facility by adding two new recessed discharge**s** inside of ship with a "quick" connection (one on each of the starboard and port sides), similar to that found on gasoline delivery trucks, and three new tunnel sump pumps.

- Retrofit tunnel discharge at sides (starboard and port sides) and aft of ship with a "quick" connection to allow for conveying tunnel water to a shoreside facility, using the existing plumbing on the ship but installing three new tunnel sump pumps.

Consistent with current practices, tunnel washing is unlikely to be conducted after each unloading event.

Capital and O&M Costs. The following capital costs are associated with the No Action alternative:

- Shoreside Pretreatment Facility = $41.80/treatment of 1,000 gallons
- Sewer Use Charge = $2.00/1,000 gallons
- Interior Piping and Pumping on Ship = $129,500 per ship, which is an average of the capital and O&M costs to retrofit ($96,000) or replace ($163,000) interior pumps and piping

Delay Hour Burden. Considerable variability exists in the frequency and duration of deck-sweeping and tunnel-washing activities. The frequency of sweeping and washing may be less if the same cargo is transported from port to port, reducing the concern for cross-contamination, or if the quantity of spilled cargo is low, reducing the potential safety hazard. Similarly, sweeping or washing frequency may be reduced if sweeping would require a detour to an area without exclusions. The total delays associated with washing and sweeping activities also will depend on the number of trips each ship makes annually.

Under the No Action alternative, a ship that completed unloading would not be allowed to discharge to the Great Lakes and would need to remain at port to washdown the tunnel and pump washwater to a shoreside pretreatment facility. Deck sweeping, which typically takes longer than tunnel washing, could occur at port during the loading process, with sweeping occurring around cargo holds that had already been filled, while loading continues at other cargo holds. As a worst-case scenario, a ship would remain at port to conduct all tunnel washdown and deck sweeping for an estimated 3.5 hours (USCG, 2005; LCA, 2007). This delay time allows for contingency and any complications associated with pumping tunnel washwater to an onshore treatment plant rather than the currently practiced over board method.

To estimate the cost of delays, each ship is estimated to make 60 trips per year (includes one loading and one unloading event) (LCA, 2007). Because deck sweeping and tunnel washing may not occur every trip, delay costs were based on an assumption that sweeping will occur 75 percent of the time. Finally, costs for the time delay were estimated using a vessel operating cost of $1,700 per hour, which is an average of industry estimates (USACE, 2002, 2005; LCA, 2007). Based on these assumptions, the cost to sweep for purpose of treating washwater is $5,950 per sweeping event, or $268,000 per ship per year. Additional details on the delay hour burden are described in Attachment 1.

Summary. For the purpose of describing the cost burden to ships versus ports, ship costs were described on the basis of a cost per gallon of washdown water. Pretreatment costs were estimated assuming that an average of three ships discharges per day at each port. The delay costs per ship were translated to a cost per 1,000 gallons based on the following assumptions:

- The average discharge per ship is 30,000 gallons.
- The annual discharge per ship is 30,000 gallons × 60 trips per year × 0.75, or 1.35 million gallons.

Direct Cost to Ships Cost (Delay & Plumbing) = $209.10/1,000 gal.
Treatment Cost (Treatment & Sewer Use Fee) = $41.80 + $2.00 = $ 43.80/1,000 gal.
Total Cost = $252.90/1,000 gal.

Proposed Action (IEP as Permanent Regulation with Record Keeping)

The alternative would replace voluntary record keeping with a requirement that each dry bulk cargo vessel maintain a discharge record book documenting the quantity of DCR discharged on each trip. The record book would be similar to the refuse discharge log provided by the Coast Guard. Entries would be made every time a ship loads or unloads cargo, as well as when it sweeps.

Capital Costs. The Coast Guard would supply the operator of a vessel with a discharge record book at no cost; consequently, there would be no capital costs with this alternative.

Operations and Maintenance. Record-keeping costs are modeled after the Coast Guard's refuse discharge log methodology (Coast Guard, 2006) and the following assumptions:

- 125 U.S. and Canadian ships operating in U.S. waters will maintain DCR discharge records.

- Each vessel makes 60 trips per year and records 2 times per trip (loading and unloading).
- Recording also would be required during sweeping events, which occur for 75 percent of the trips, resulting in a total of 2.75 recordings/trip.
- Each record takes 5 minutes to prepare.

As a result, total recording time is 1,725 hours annually. Assuming that the individual responsible for record keeping has a salary commensurate with a Coast Guard Lieutenant, the annual record-keeping cost is estimated at $ 1,100 per ship/year, or $135,000 per year. Coast Guard inspection time is expected to be negligible, as the annual inspection of the discharge record book would be incorporated into the established inspection routine. Additional detail is provided in Attachment 2.

Proposed Action with Modified Exclusion Areas

The cost of record keeping described above also applies to this alternative. The only other cost for the alternative would result if sweeping were excluded from an area where it was previous permitted. Accordingly, costs associated with the alternative result from detours in shipping routes and additional travel time rather than capital costs. Potential costs are summarized in Table 1 and detailed in the text that follows.

Exclusion Area Modification 1: Extend Lake Michigan Iron Ore Exclusion Area from 12 Statute Miles to 13.8 Statute Miles. The IEP specifies all distances in statute miles, except for the iron ore exclusion, which is stated in nautical miles. Standardizing the distance to 13.8 statute miles would address a regulatory inconsistency and formalize existing practices. As such, it would not incur a cost to the shipping industry.

Exclusion Area Modification 2: Limit the Discharge of Coal and Salt on Lake Ontario within 13.8 Statute Miles of Shore. Lake Ontario is the only lake without an official rule regarding coal or salt discharge. However, the 13.8–statute-mile limit from shore for coal and salt discharges appears to be in current practice (U.S. Coast Guard, 2006). Therefore, this modification addresses a regulatory inconsistency rather than incurs an additional cost burden to the shipping.

TABLE 1
Summary of Annual Cost for Proposed Action with Exclusion Area Modifications

			Cost Burden per Ship ($)			Cost Burden for Industry ($)		
Modifications			**Capital**	**O&M**	**Total**	**Capital**	**O&M**	**Total**
Modification 1: Lake Michigan	Iron ore	Extend from 12 to 13.8 statute miles from shore	0	0	0	0	0	0
Modification 2: Lake Ontario	Coal and salt	Limit discharge within 13.8-statute miles of shore	0	0	0	0	0	0
Modification 3: Lakes Huron, Ontario, Michigan, and Erie	Cement	Limit discharge within 13.8-statute miles of shore	0	0	0	0	0	0
Modification based on sensitive ecological resources: all lakes	Limestone and clean stone	Limit discharge within 3-statute miles of shore	0	7,500	7,500	0	412,500	412,500
Remove or modify existing exemptions that are Inconsistent with the Intent of the IEP			0	0	0	0	0	0
Add specific unambiguous coordinates during rule-making for all exemptions			0	0	0	0	0	0
Add explanation during rule-making for all exemptions			0	0	0	0	0	0
				Total	7,500		**Total**	412,500

Exclusion Area Modification 3: Limit Cement Discharge within 13.8-Statute Miles of Shore in Lakes Huron, Ontario, Michigan, and Erie. U.S. Coast Guard (2002) provides the most comprehensive analysis of DCR discharges available to date. During winter lay-up following the 2000–2001 shipping season, ship logs were reviewed on vessels at four U.S. ports, two Canadian ports, and two Canadian shipping headquarters. Data were collected for roughly 50 percent of Canadian ships and 67 percent of U.S. ships on all five lakes. Canadian ships reported cement discharges along navigational track lines in Canadian waters. Cement is transported without residues on U.S. ships because it is consistently handled in a vacuum line. The other applicable Great Lakes DCR discharge survey was completed by the USCG (2005) but lacked information regarding cement transport. Given these data limitations, the cost analysis for this exclusion area modification alternative was based on the U.S. Coast Guard (2002) report.

Because only Canadian ships reported cement discharge, the cost of this modification focused on Canadian ships. In many cases, Canadian ships' ports of origin or termination were in Canadian waters. If they have to move through Canadian waters, by definition they are outside exclusion zones, are unaffected by the proposed exclusion area modification, and may sweep in Canadian waters without changing their course. As Canadian ships move from Canada to the U.S., they cross the center of lakes where they would be able to sweep. If the ships departed from U.S. waters after loading cement, they are likely to delay sweeping that might be needed until they reach Canadian waters, rather than detour into deeper waters. Accordingly, costs are not expected to result from this exclusion area modification.

Exclusion Area Modification: 3-Statute-Mile Limit on Limestone and Clean Stone Discharge in All Lakes Based on Sensitive Ecological Resources. Under this modification, ships would not be permitted to discharge limestone or clean stone until they were at least 3 statute miles from shore. The cost of detours to ships was based on the following assumptions:

- The total affected population is 55 U.S. vessels, as indicated from industry estimates (LeLievre, 2006; Boatnerd, 2007; Kirkbride, 2007).
- On average, each U.S. ships would carry limestone/clean stone 14 trips per year (USCG, 2005). Canadian ships were not included in the count as they would be able to sweep

when leaving Canadian waters. When leaving U.S. ports, Canadian ships would be likely to delay sweeping until they reach deeper waters, rather than detour.

- U.S. ships would be detoured a maximum of 2.5 statute miles per trip, rather than 3, given the likelihood they would normally travel away from the shoreline rather than immediately adjacent to the shoreline. If they chose to exit an exclusion area, they would not be required to travel 3 miles perpendicular to the shoreline to enter a sweeping zone. Ships would return 2.5 statute miles for a total detour of 5 statute miles.
- Sweeping events would occur for only 75 percent of the 14 annual trips per ship.
- Velocity was estimated at 12 miles per hour (LCA, 2006), resulting in a delay of 0.42 hour per sweeping event, or a 4.4-hour delay per ship per year.

Finally, assuming a vessel operating of $1,700 per hour (USACE, 2002, 2005; LCA, 2007), the total cost associated with the time delays would be approximately $7,500 per ship/year or $412,500 per year total. Additional detail is provided in Attachment 3.

Exclusion Area Modification: **Remove or Modify Existing Exemptions that are Inconsistent with the Intent of the IEP.** Three modifications to exclusion area exemptions are outlined in Table 2. None of the exemption modifications would require detours for discharge, because the carriers could still discharge along the tracks at depths greater than 12 fathoms. Therefore, there would be no additional costs for these exemption modifications.

Addition of Specific Unambiguous Coordinates for all Exemptions. The Coast Guard would incorporate coordinates in a revised Enforcement Policy, where they were not previously detailed. This will not result in an operational cost to shippers.

Explanation for Imposition of all Exemptions. This clarifying recommendation would be assumed by the Coast Guard. No operational costs would be incurred by shippers.

Proposed Action with DCR Control Measures on Ships

Table 3 summarizes order-of-magnitude costs for capital, installation, operations and maintenance, and delay components of the DCR Control Measures on Ships alternative.

TABLE 2
Exemptions to IEP Requiring Modification

NOAA Navigation Chart Heading from Indicated Port	Location	Exclusion	Exemption	Depth	Purpose	Modification to Exemption
013.5˚, 022.5˚	45˚N to Boulder Reef	No coal discharge within 13.8 miles of shore.	Coal discharge allowed along 013.5˚ LCA track line between 45˚N and Boulder Reef and along 022.5˚ LCA track line running 23.25 miles between Boulder Reef and charted position of Red Buoy #2	8–87 fathoms	To avoid unnecessary economic and energy use impacts by requiring deviation from normal transit.	Prohibit discharge near reef at north end of track line (near buoy in shallow water) at depths less than 12 fathoms to protect sensitive ecological resources. Add specific coordinates.
353˚, 247˚	Lakeport to Harbor Beach	No iron ore discharge within 6 miles of shore: no coal or salt discharge within 13.8 miles of shore	Discharge allowed for vessels carrying iron ore, coal or salt upbound along Michigan thumb: No discharge three miles from shore between 5.8 miles northeast of entrance buoys 11 and 12 to the track line turn abeam of Harbor Beach	10–17 fathoms	To avoid unnecessary economic and energy use impacts by requiring deviation from normal transit	Prohibit at depths less than 12 fathoms to protect sensitive ecological resources. Add specific coordinates
137, 138˚, 318˚, 117˚, 295˚, 100˚, 230˚, 325˚, 341˚, 189˚, 225˚, 251˚, 098˚	Alpena to ports along Michigan shore south of Forty Mile Point	No coal discharge within 13.8 miles of shore.	Discharge allowed for vessels carrying coal upbound from Alpena to ports along Michigan shore south of Forty Mile Point: as long as discharge is more than, 4 miles from shore and in greater than 10 fathoms of depth	10–66 fathoms	To avoid unnecessary economic and energy use impacts by requiring deviation from normal transit	Prohibit discharge at depths less than 12 fathoms and add specific coordinates.

Note: One fathom equals 6 feet, or 1.83 m.

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The measures include the following:

- Structural
  - Enclosed conveyor
  - Tarps
  - Troughed (U-shaped) conveyor
  - Conveyor skirts
  - Belt scrapers
  - Broom and shovel
  - Cargo hold vibrator
- Operational
  - Restrict the maximum cargo fill height of the cargo holds to below the deck elevation
  - Start/stop loading conveyor
  - Delay loading/unloading during "high" winds
  - Careful gate operation during unloading so that cargo unloaded in steady stream

Where data were available, costs were estimated using traditional methods. In some cases, costs were based on information provided by the Lake Carriers' Association. The basis for determining costs and the level of uncertainty associated with the costs are documented in Table 3.

Proposed Action with Shoreside Controls

Table 4 summarizes order-of-magnitude costs for capital, installation, operations and maintenance, and delay components of the Proposed Action with Shoreside Controls alternative. The measures include the following:

- Structural
  - Enclosed conveyor
  - Troughed (U-shaped) conveyor
  - Conveyor skirts
  - Belt scrapers
  - Loading chute
- Operational
  - Start/stop loading conveyor
  - Delay loading/unloading during high winds
  - Loading discharge point below the deck

TABLE 3
Order-of-Magnitude Cost Estimate of Ship DCR Control Measures

DCR Control Measures	Control Measure Description	Use on Deck	Use in Tunnel	Capital Cost of DCR Control Measures	Installation Cost of DCR Control Measures	O&M Annual Cost	Delay Cost	Assumptions	Comments	Cost Uncertainty
Structural Control Measures in Use										
Enclosed conveyor	Covers installed on the loading or unloading conveyors to prevent spillage	Yes	No	$95,000	$45,000	$18,000	$45,000[a] $75,000[b]	All costs based on LCA estimates. Capitol cost does not include an engineering study, which LCA suggests may increase the cost by $25,000	LCA indicated that additional costs for ABS (American Bureau of Shipping) review, approvals and fees. Delay costs are associated with additional weight added to the unloading boom as a result of the covers. This added weight, therefore, reduces the unloading rate because less cargo (i.e. less weight) can be conveyed on the conveyor. Included in alternative.	Medium uncertainty. LCA estimate without verification, but for a technology in use. LCA notes ancillary costs that are not included in estimate.
Tarps	Collects spilled cargo that may fall on the deck or between the ship and the shoreside facility. May also be installed on the loading or unloading conveyors to prevent spillage.	Yes	No	$2,000	—	$5,000	—	Assume tarps are located underneath unloading conveyor on ship deck, not needed between *each* hatch. Assume half of the tarps are replaced every year due to damage.	LCA estimated costs of $20,000 for capital, $20,000 for installation, and $5,000 for O&M. Their costs assumed tarps would be placed between *each* hatch during loading. The intent of this BMP is to use tarps on the deck surface underneath the unloading conveyor during unloading, and underneath the loading conveyor and next to the hatch being filled during loading. The capital and installation costs were not used because they did not estimate the intent of the BMP. However, the O&M costs were used to estimate potential labor cost increases. The O&M costs could be high, considering the LCA estimate assumed more significant use of tarps. Included in alternative.	Low uncertainty. LCA estimates modified based on assumptions related to reduced use of tarps.
Troughed (U-shaped) conveyor	Conveyor belts for moving dry cargo that are U-shaped to minimize spillage from the sides	Yes	Yes	$1,300,000[a] $2,500,000[b]	Included in capital cost	$65,000[a] $25,000[b]	—	All costs based on LCA estimates for converting a non-self unloading ship to a self unloader. Boom costs 30% of the cost of the tunnel conversion for a small ship. Boom costs 25% of the cost of the tunnel conversion for a large ship.	Most Great Lakes self-unloading vessels presently have a U-shaped belt configuration. For ships that require the retrofit to a self unloader, a 5% maintenance cost is assumed. It should be noted that this BMP greatly increases the efficiency of the unloading operations and has the potential to create costs savings that pay back the investment in a short period of time. This is likely the reason why nearly all of the U.S. Flag Great Lakes vessels are self unloaders. Included in alternative.	Low uncertainty. LCA estimate for a technology in use.
Conveyor skirts	Skirts installed at gate openings, along the length of conveyor belts, or at the bottom of cargo holds to reduce DCR from falling over the side of the conveyor	Yes	Yes	$36,000	$55,000	$4,000	—	All costs based on LCA estimates.	Included in alternative.	Low uncertainty. LCA estimate without verification, but for a technology in use.
Belt scrapers	Metal or synthetic scrapers that rub against the conveyor belts to dislodge cargo that may be stuck on the conveyor belt	Yes	Yes	$32,000	$32,000	$5,000	—	All costs based on LCA estimates. Capital cost similar to independently determined costs for 4 multiblade scrapers @ $8,000 ea.	Included in alternative.	Low uncertainty. LCA estimate for a technology in use. Independently verified capital cost.

TABLE 3
Order-of-Magnitude Cost Estimate of Ship DCR Control Measures

DCR Control Measures	Control Measure Description	Use on Deck	Use in Tunnel	Capital Cost of DCR Control Measures	Installation Cost of DCR Control Measures	O&M Annual Cost	Delay Cost	Assumptions	Comments	Cost Uncertainty
Broom and shovel	Collect spilled material using broom and/or shovels	Yes	Yes	$1,250	—	$1,250	$120,000[a] (loading) $360,000[b] (loading), 0 (unloading)	10 sets of brooms and shovels per ship. Replaced every year (maintenance). Assumed that only 25% of the ship's deck needs to be swept, and only swept 75% of the total number of trips (i.e.. deck and tunnel do not require sweeping for each trip and some trips between ports never leave the exclusion areas).	The delay costs assume that the deck surface is swept in one effort after loading is complete, while the ship is in port, and not allowed to leave until the deck surface is cleaned. This delay cost does not consider the potential to sweep *during* loading. Delay costs for sweeping *during* travel could be negligible. There are not expected to be delay costs associated with sweeping after unloading because only a small area (directly under the unloading conveyor) would require sweeping. Included in alternative.	Low uncertainty. Although costs may vary from ship to ship based on management practices, type of conveyors and amount of spillage, the costs are predictable.
Cargo hold vibrator	Vibrator mounted to the underside of the cargo hold to help with the a steady removal of cargo from the cargo hold.	No	Yes	$95,000	$125,000	$8,400	—	All costs based on LCA estimates for 20 vibrators per ship.	Vibrators are already in use on many ships. Included in alternative.	Low uncertainty. LCA estimate for a technology in use.
Operational Control Measures in Use										
Maximum cargo fill height below deck	Stop filling the cargo hold when the top of the cargo is at or below the deck elevation.	Yes	No	No equipment cost[c]	No installation cost[c]	$380,800 Loading and unloading time for additional trips	—	Delay costs are undetermined but expected to be zero. There may be a loss of revenue from each ship carrying coal cargo that would no longer be filled to the top. The reduced transport volume is estimated to be approximately 1.1% of the total volume of cargo. This is not expected to be an issue with limestone, taconite or other heavier cargo that cannot completely fill the hold due to limitations with maximum draft (heavier cargoes don't fill the holds because of draft limitations). Therefore, limits to fill heights will not affect overall capacity for these cargoes.	Approximately 16 additional trips by midsized ships would be needed to transport the excess coal cargo, which equals approximately $380,800 in additional loading and unloading costs (14 hours per each of 16 medium-sized ships). These costs would be distributed among the U.S. and Canadian shipping industry as a whole (carriers, suppliers, buyers) and not be restricted to individual ships. Included in alternative.	Medium Uncertainty. Uncertain of the full impact from not filling cargo hatches as high as previously filled. The extent to which draft limitations currently apply may already be limiting fill height.

TABLE 3
Order-of-Magnitude Cost Estimate of Ship DCR Control Measures

DCR Control Measures	Control Measure Description	Use on Deck	Use in Tunnel	Capital Cost of DCR Control Measures	Installation Cost of DCR Control Measures	O&M Annual Cost	Delay Cost	Assumptions	Comments	Cost Uncertainty
Start/stop loading operations	Start/stop unloading operation by stopping conveyor or other mechanism while the ship, conveyor belt, or other equipment is repositioned.	Yes	No	No equipment cost[c]	No installation cost[c]	—	Delay costs highly variable, depending on port size, cargo type, and number operations per year.	The LCA confirmed that there are no capital costs associated with the ships for this BMP. Costs may be expected for the shoreside facility.	Included in alternative.	Low Uncertainty. Although capital costs not expected, delay costs associated with starting/stopping conveyor may occur and were not predicted by LCA.
Delay loading/ unloading during "high" winds	Stop loading or unloading operations during high winds to prevent wind blown DCR.	Yes	No	No equipment cost[c]	No installation cost[c]	—	$126,000,[a] $210,000[b]	All costs based on LCA estimates. LCA assumed 10% of total annual unloading and loading times affected by high winds.	Included in alternative.	High Uncertainty. Uncertainty over definition of "high winds" and frequency of stoppage.
Careful gate operation	Carefully control the cargo gates during unloading so that the cargo is unloaded in a steady stream.	No	Yes	—	—	—	—	The LCA confirmed that there are no costs associated with the ships for this BMP. Likely to result in cost savings by minimizing spillage.	Included in alternative. Likely to result in cost savings by minimizing spillage.	Low Uncertainty.

[a] Small ship: Classes V, VI, VII, and VIII; ~600 to 849 feet.
[b] Large ship: Classes IX and X; ~850 to 1,100 feet.
[c] The BMP may not have an associated cost. However implementing the BMP may "cost" the ship or shoreside facility money by delaying loading or unloading, ultimately reducing the efficiency of the cargo movements.
Sources.
Schultz, Bill. "Cargo Hold Vibrator Costs." Email to CH2M HILL. 10 Aug. 2007. (Chicago Vibrator Products - Costs for vibrators)
Cooper, Ron. "Scraper Cost Estimate." Email to CH2M HILL. 10 Aug. 2007. (Sterling Material Handling - Costs for scrapers)
"Midwest Rake Company, LLC." Aug. 2007 <www.midwestrake.com>. (website used for broom and shovel costs)
"United States Plastic Corporation." Aug. 2007 <www.usplastic.com>. (website used for bucket costs - for broom and shovel BMP)
"Tarps Plus." Aug. 2007 <www.tarpsplus.com>. (website used for tarp costs)
DCR Control Measures LCA Work Group Response, Final Product 10-30-07. Lake Carriers' Association.

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TABLE 4
Order-of-Magnitude Cost Estimate of Shoreside DCR Control Measures

DCR Control Measures	Control Measure Description	Capital Cost of DCR Control Measures	Installation Cost of DCR Control Measures	Operation & Maintenance Annual Cost	Delay Cost	Assumptions and Comments	Cost Uncertainty
Structural Control Measures in Use							
Enclosed conveyor	Covers installed on the loading or unloading conveyors to prevent spillage	$38,000	$18,000	$7,200	—	Used a $/ft rate from LCA estimate for ship controls for a 250-ft unloading conveyor and modified cost to reflect that of a 100-ft shoreside loading conveyor. Included in alternative.	Medium Uncertainty. Derived from an LCA estimate for ship conveyors. Not verified.
Troughed (U-shaped) conveyor	Conveyor belts for moving dry cargo that are 'U' shaped to minimize spillage from the sides	$330,000	Included in capital cost	$16,500	—	Assumed a 100-ft loading conveyor. Capital cost of $3,300/ft unit rate obtained from ThyssenKrupp Robins, Inc. for a 5-ft belt with a capacity of 4,000 tons/hr, which is similar to typical loading rates. Assumed 5% of capital and installation cost for O&M costs. Included in alternative.	Low Uncertainty. Independent cost estimate.
Conveyor skirts	Skirts installed at gate openings, along the length of conveyor belts, or at the bottom of cargo holds to reduce DCR from falling over the side of the conveyor	$ 8,800	$13,500	$1,000	—	LCA costs for conveyor skirts were estimated for approximately 410-ft of conveyor skirt for a 250-ft unloading boom and 20 4-ft gates (8-ft of skirt per gate). Shoreside conveyor skirts were assumed for the 100-ft loading conveyor. Included in alternative.	Medium Uncertainty. Derived from an LCA estimate for conveyor skirts on ship conveyors. Not verified.
Belt scrapers	Metal or synthetic scrapers that rub against the conveyor belts to dislodge cargo that may be stuck on the conveyor belt	$32,000	$32,000	$5,000	—	Cost estimate for installation and O&M costs based on LCA estimates. Assumed 4 multi-blade scrapers @ $8,000 ea. Included in alternative.	Low Uncertainty. LCA estimate for a technology in use. Independently verified capital cost.
Loading chute	Device at the end of a conveyor belt that directs cargo from the conveyor belt into the cargo hatch.	$4,000,000	$1,000,000	$200,000	—	Cost estimate provided by ThyssenKrupp Robins, Inc. Assumed a 4,000 ton per hour loading rate and telescoping loading chute. Included in alternative.	Medium Uncertainty. Independent cost estimate. Not verified

TABLE 4
Order-of-Magnitude Cost Estimate of Shoreside DCR Control Measures

DCR Control Measures	Control Measure Description	Capital Cost of DCR Control Measures	Installation Cost of DCR Control Measures	Operation & Maintenance Annual Cost	Delay Cost	Assumptions and Comments	Cost Uncertainty
Operational Control Measures in Use							
Delay loading/ unloading during "high" winds	Stop loading or unloading operations during high winds to prevent wind blown DCR.	No equipment cost[a]	No installation cost[a]	—	Delay costs highly variable, depending on port size, cargo type, and number operations per year.	Included in alternative.	High Uncertainty. Uncertainty over definition of "high winds" and frequency of stoppage.
Loading discharge point below the deck	Discharge point of loading conveyor/chute below the deck, as close as reasonably possible to the top of the cargo.	No equipment cost[a]	No installation cost[a]	—	Delay cost may include additional time to reposition discharge point. Any delay costs are shared by ships and shoreside facilities.	Assumes that shoreside facility has the capability to discharge below deck level. Included in alternative.	High Uncertainty, although costs expected to be relatively low. Uncertainty of costs because of variability of shoreside loading facilities. Uncertainty of actual delay costs associated with repositioning discharge point within each hatch.
Start/stop loading operation	Stop loading operation by stopping conveyor, closing hopper or other mechanism, while the ship, conveyor belt, or other equipment is repositioned.	Costs highly variable depending on # of loading mechanisms and extent of conveyor system replacement needed,	Costs highly variable depending on complexity of changes required.	O&M costs highly variable depending on # of loading mechanisms, the ability to start and stop during loading, and conveyor system complexity (e.g., operational changes if multiple conveyors are part of the system)..	Delay costs highly variable, depending on port size, cargo type, and number operations per year.	Included in alternative.	High Uncertainty because of highly variable costs.

[a]The BMP may not have an associated cost. However implementing the BMP may "cost" the ship or shoreside facility money by delaying loading or unloading, ultimately reducing the efficiency of the cargo movements. Limiting filling to the area below the deck may reduce the quantity of cargo transferred, but it is not expect to be significant as it may only apply to coal.

Sources: Lukas, Jurgen. "Cost Estimate for Ship Loading." Email to CH2M HILL. 8 Nov. 2007. (Thyssen Krupp, Robins, Inc. - Costs for conveyor belt and Telescoping loading chute). Cooper, Ron. "Scraper Cost Estimate." Email to CH2M HILL. 10 Aug. 2007. (Sterling Material Handling - Costs for scrapers). DCR Control Measures LCA Work Group Response, Final Product 10-30-07. Lake Carriers' Association.

Where data were available, costs were estimated using traditional methods. In some cases, costs were estimated from ship-based costs provided by the Lake Carriers' Association. As with ship controls, assumptions are documented in Table 4.

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Attachment 1

Estimate of Delay Costs Associated with the No Action Alternative

It is estimated that each vessel makes 60 trips per year (LCA, 2007). Sweeping may not occur for each trip for the following reasons:

- If there were little or no spillage, there would be little or no safety hazard, therefore no sweeping
- While loading and unloading cargo creates spillage, crew members may only sweep once, after unloading the cargo.

Based on tunnel washdown and deck sweeping events not occurring every trip and observations of ship practices (CH2M HILL, 2007), ships are estimated to sweep 75 percent of the time. Costs for time delay were estimated using industry estimates and the time delay calculations discussed above. The average of industry estimates suggests vessel operating costs at $1,700 per hour (USACE, 2002, 2005; LCA, 2007).

Deck sweeping could occur at port during the loading process, with sweeping occurring around cargo holds that had already been filled, with loading continuing at other cargo holds. LCA (2007) estimates that it takes 4 people with brooms and shovels 7 hours to sweep an entire deck of a "small ship" (approximately 600 to 850 feet, Class V-VIII) and 12.5 hours for a "large ship" (approximately 850 to 1,100 feet, Class IX-X). However, only 25 percent of the deck would need to be swept. Thus the small and large decks could be swept with brooms and shovels in 1.75 hours (7 hours × 0.25) or 3.13 hours (12.5 hours × 0.25), respectively. After unloading, the tunnel surfaces would be washed down for disposal of the washwater at a shoreside facility for pretreatment.

Using a dry cargo discharges database provided by USCG (2005) for U.S. vessels during the 2004-2005 shipping season, the average tunnel washdown event using hoses took 3.12 hours (data does not indicate vessel size).

If both tunnel washdown and deck sweeping were to occur at port, completing the cleaning simultaneously would minimize delay. As a worst case scenario, a ship would remain at port to conduct all tunnel washdown and deck sweeping for an estimated at 3.5 hours. This delay time allows for contingency and any complications associated with pumping tunnel washwater to an onshore treatment plant rather than the currently

practiced over board method. Based on these assumptions, the delay cost is $5,950 per sweeping event or $268,000 per ship per year. Calculations are shown below.

Delay time burden calculations:

$$\text{Event Time Burden} = 3.5\,\frac{\text{hrs}}{\text{events}}$$

$$\text{Total Time Burden} = 3.5\,\frac{\text{hrs}}{\text{events}} \times 60\,\frac{\text{trips}}{\text{yr - ship}} \times 0.75\,\frac{\text{events}}{\text{trip}} = 157.5\,\text{hrs}/\text{ship - yr}$$

$$\text{Total Time Burden} = 157.5\,\frac{\text{hrs}}{\text{ship - yr}} \times 125\,\text{ships} = 19{,}687.5\,\text{hrs}/\text{yr}$$

Delay cost burden calculations:

$$\text{Event Cost} = 3.5\,\text{hrs}/\text{event} \times 1{,}700\,\frac{\$}{\text{hr}} = \$5{,}950\,/\text{event}$$

$$\text{Vessel Cost for Time Delay} = 157.5\,\text{hrs}/\text{ship - yr} \times 1{,}700\,\frac{\$}{\text{hr}} = \$267{,}750\,/\text{ship - yr}$$

$$\text{Total Cost for Time Delay} = 19{,}687.5\,\text{hrs}/\text{yr} \times 1{,}700\,\frac{\$}{\text{hr}} = \$33{,}468{,}750\,/\text{yr}$$

Attachment 2

Estimate of Costs Associated with Proposed Action (IEP as Permanent Regulation with Record Keeping)

The total affected population is 125 vessels, as indicated from industry estimates (LeLievre, 2006; Boatnerd, 2007; Kirkbride, 2007). It is estimated that each vessel makes 60 trips a year (LCA, 2007). Sweeping may not occur for each trip for the following reasons:

- Little or no spillage creates little or no safety hazard, therefore no sweeping.
- If trips between ports do not leave the exclusion zones, ships are not allowed to sweep.
- While loading and unloading cargo creates spillage, crew members may sweep only once, after unloading the cargo.

However, as discussed for the No Action alternative, it is estimated that ships sweep cargo only 75 percent of the time. Therefore, the cost estimate includes 2.75 entries per trip per ship, 1 entry for loading, 1 entry for unloading (regardless of whether sweeping occurred), and 0.75 entry (1 entry × 75 percent occurrence).

Because the standardized forms will be similar to the Coast Guard refuse discharge log, entries in the discharge record book should take less than 5 minutes (0.083 hour) to make (Tenney, 2007).

$$\text{Trip Time Burden} = 2.75\,\frac{\text{entry}}{\text{trip}} \times 0.083\,\frac{\text{hrs}}{\text{entry}} = 0.23\,{}^{\text{hrs}}\!/_{\text{trip}}$$

$$\text{Ship Time Burden} = 60\,\frac{\text{trips}}{\text{yr - ship}} \times 0.23\,\frac{\text{hrs}}{\text{trip}} = 13.8\,{}^{\text{hrs}}\!/_{\text{ship - yr}}$$

$$\text{Total Time Burden} = 125\,\text{ship} \times 13.8\,\frac{\text{hrs}}{\text{ship - yr}} = 1725\,{}^{\text{hrs}}\!/_{\text{yr}}$$

The responsibility of the individual making the log entry is commensurate with that of a Coast Guard Lieutenant (O-3). The Lieutenant (O-3) age rate is $78 per hour in accordance with the current edition of COMDTINST 7310.1K (Coast Guard, 2007).

$$\text{Trip Labor Costs} = 0.23\,\frac{\text{hrs}}{\text{ship - yr}} \times \frac{\$78}{\text{hr}} \approx \$18\,{}^{}\!/_{\text{trip}}$$

$$\text{Ship Labor Cost} = 13.8\,\frac{\text{hrs}}{\text{ship - yr}} \times \frac{\$78}{\text{hr}} \approx \$1{,}076\,{}^{}\!/_{\text{ship - yr}}$$

$$\text{Total Labor Cost} = 1725\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$78}{\text{hr}} \approx \$134{,}550\,{}^{}\!/_{\text{yr}}$$

Note that $134,550/yr is rounded to $135,000 in the main text of this document.

The annual inspection of the DCR Discharge Record Book will incorporated into the established Coast Guard inspections so added inspection time should be negligible.

Attachment 3

Estimate of Delay Cost Associated with Exclusion Area Modification: 3-Statute Mile Limit on Limestone and Clean Stone Discharge in All Lakes, Based on Sensitive Ecological Resources

The total affected population is 55 U.S. vessels, based on industry estimates (LeLievre, 2006; Boatnerd, 2007; Kirkbride, 2007). Using U.S. vessel cargo data provided by USCG (2005) for the 2004–2005 shipping season, each U.S. vessel was estimated as carrying limestone or clean stone for an average of 24 percent of their trips. Based on LCA input that each ship makes 60 trips per year, the number of trips carrying limestone or clean stone would be 14 trips per year. However, as discussed for the No-Action Alternative, it is estimated that ships sweep cargo only 75 percent of the time.

The detour distance was estimated conservatively based on ships that would otherwise not leave the imposed exclusion area during transport, assuming they would have to travel a maximum of 2.5 statute miles to exit the exclusion area to discharge, then travel 2.5 statute miles to return to their course within the exclusion area, with a total detour of 5 statute miles. Velocity estimates were based on 12 miles per hour as provided by industry (LCA, 2006).

$$\text{Sweeping Time Delay} = \frac{5\dfrac{\text{statute mile detour}}{\text{limestone/stone sweeping event}}}{12\dfrac{\text{statute miles}}{\text{hr}}} = 0.42\frac{\text{hrs}}{\text{sweeping event}}$$

$$\text{Vessel Time Delay} = 14\frac{\text{limestone trips}}{\text{yr - ship}} \times 0.75\frac{\text{sweeping events}}{\text{trip}} \times 0.42\frac{\text{hrs}}{\text{sweeping event}} = 4.4\frac{\text{hrs}}{\text{ship - yr}}$$

$$\text{Total Time Delay} = 55\ \text{U.S. ships} \times 4.4\frac{\text{hrs}}{\text{ship - yr}} = 242\ {}^{\text{hrs}}\!/_{\text{yr}}$$

Costs for the time delay were estimated using industry estimates and the time delay calculations discussed above. The average of industry estimates suggests vessel operating costs at $1,700 per hour (USACE, 2002, 2005; LCA, 2007).

$$\text{Event Cost} = 0.42\ {}^{\text{hrs}}\!/_{\text{sweeping event}} \times 1{,}700\frac{\$}{\text{hr}} = \$714\ /_{\text{sweeping event}}$$

$$\text{Ship Cost for Time Delay} = 4.4\ {}^{\text{hrs}}\!/_{\text{yr}} \times 1{,}700\frac{\$}{\text{hr}} = \$7{,}480\ /_{\text{yr}}$$

$$\text{Total Cost for Time Delay} = 242\ {}^{\text{hrs}}\!/_{\text{yr}} \times 1{,}700\frac{\$}{\text{hr}} = \$411{,}400\ /_{\text{yr}}$$

Note that $7,480/yr is rounded to $7,500/yr in the main text of this document. Also, $411,400/yr is represented as $412,500 in the main text of this document to remain consistent with this rounding (i.e., $7,500/yr x 55 ships = $412,500 per year).