EXECUTIVE SUMMARY

From December 2013 to February 2014, Halcrow performed a condition monitoring inspection of Pier 40 on the eastern shore of the Hudson River in Manhattan, New York. The scope of work included an above water and underwater inspection of the steel H-piles, concrete piles caps, pile cap beams, deck soffit, cathodic protection, and fender system, The purpose of the inspection was to provide a general condition assessment and load rating of the pier in its current condition, to evaluate and grade the condition of structural elements of the pier, and to develop repair recommendations with an associated order-of-magnitude cost estimate.

The methodology used to assign both the general condition assessment rating and the structural element grading is described in Section 1.2 of this report. Based on this methodology and the inspection results, Pier 40 is in overall **Poor** condition. The allowable uniform live load rating for the pier is significantly less than its original design live load capacity.

The repair recommendations and cost estimate contained in this report have been developed to maintain a 100 psf live load rating sufficient for public assembly use over the entire pier structure. The repair recommendations are also intended to provide enough lateral load capacity to resist ice, wind, wave, current, and mooring loads typical to this riverfront location, and to maintain sufficient structural capacity for fire truck access to the Court Yard (currently used as an athletic field) and the perimeter Pier Shed. The repair recommendations are not intended to bring the pier back to the original design live load capacity when the pier was first constructed.

As depicted in Table 1 below, the steel H-piles supporting the pier are in overall **Poor** condition with 35% graded Severe and 22% graded Major. Deterioration of the H-piles is typically due to corrosion within the splash zone and at Mean Low Water (MLW) for those piles with no prior channel repairs. In general, the condition of the steel H-piles at and below MLW, with the exception of H-piles without prior channel repairs, has little bearing on the overall pile condition rating. This is because they exhibit only minor to moderate deterioration in those areas, and appear to be adequately protected by the sacrificial anodes of the existing cathodic protection system. A full visual inspection of the underlying steel of the H-piles was not possible in

every instance as some of the piles were previously repaired with an epoxy coating, and other H-piles above the high water line were previously repaired with both welded steel plates and epoxy coating. For those H-piles that received a more intensive Level II/III inspection, the epoxy coating was removed in small sections to reveal the underlying steel. For those inspected H-piles with no prior welded steel plate repair showing rust staining through the epoxy coating, the typical condition revealed was a Severe pile section. Therefore, all H-piles that exhibited rust staining through an epoxy coating application, but which did not have a prior welded steel plate repair, were graded Severe. H-piles with visible rust staining through epoxy coating which had prior welded steel plate repair were graded Major.

A summary of the H-pile ratings are provided in Table 1.

Table 1 Summary of Pile Conditions

Location	No. of H-piles	Minor		Moderate		Major		Severe	
		No.	%	No.	%	No.	%	No.	%
Pier Shed	2,845	505	18%	669	24%	698	25%	973	34%
Court Yard	483	39	8%	255	53%	50	10%	139	29%
Finger Pier	135	8	6%	17	13%	25	19%	85	63%
Total	**3,463**	**552**	**16%**	**941**	**27%**	**773**	**22%**	**1,197**	**35%**

The concrete pile caps under the Pier Shed and Court Yard are generally in **Fair** condition with corrosion cracks on the cap soffits that extend from the flange tips of the steel H-piles to the bottom corners of the pile caps. At a number of locations, these corrosion cracks have either extended along the vertical faces of the concrete pile caps or have resulted in spalls along the bottom corners of the caps. In the Court Yard, the pile caps typically have hairline map cracks on the vertical faces with efflorescence.

The concrete pile cap beams under the Pier Shed and Court Yard are in **Fair** condition with typical rust staining and opposing longitudinal corrosion cracks that have resulted in delaminations along the beam soffits. In isolated locations, the

delaminations along the beam soffits have developed into spalls with exposed steel reinforcement.

The longitudinal concrete and transverse concrete beams at the Finger Pier Extension are in overall **Fair** condition. Similar to the beams under the Pier Shed and Court Yard, the beams exhibit rust staining and delaminations in the beam soffits with isolated spalls with exposed steel reinforcing.

The concrete underdeck at Pier 40 is in overall **Fair** condition with minor hairline cracks. There are isolated spalls up to 3 in. deep with exposed prestressing strands and reinforcing steel throughout the pier.

The Finger Pier Extension concrete underdeck is in overall **Fair** condition with areas of shallow concrete cover and spalls with exposed steel reinforcing.

The current vertical live load capacity of the pier is summarized in Table 2

Table 2 Summary of Load Ratings for Pier 40

Structure	Governing Structural Element	Current Allowable Uniform Live Load	Fire Truck Access
Pier Shed	Steel H-piles rated Severe	100 psf (with a 2% overstress)	No Restrictions
Court Yard	Concrete pile cap beam with exposed steel reinforcing and Severe piles	150 psf	No Restrictions
Finger Pier Extension	Deteriorated beams and deck	0 psf (with the possibility of ice loading)	Not Applicable
		100 psf (with no possibility of ice loading)	

The Pier Shed is capable of supporting a uniform live load of 100 psf in its existing condition, and it is also capable of supporting a fire truck with a 24 kip wheel load and a Rescue Truck with a 26 kip wheel load. The results of the analysis indicate that the design ice load, which is based on an 8 inch thick layer of ice, is very

demanding on the pier structure and is the controlling load within Load Combination 8 and Load Combination 9 (see Table 4-1).

While the steel H-piles under the Pier Shed with a pile grade of Severe are currently sufficient to support the current pier usage, the level of corrosion on the piles has reached a critical level. Any notable amount of additional section loss, especially at the tops of the piles, could result in public access restrictions on the pier because the resulting allowable live load at the Pier Shed would likely be lower than the 100 psf needed for public assembly.

The allowable uniform live load rating for the Court Yard is currently 150 psf, and is governed by the structural capacity of the concrete pile cap beams with exposed reinforcing. Although the extent of deterioration on the concrete beams varies throughout the entire Court Yard, the structure was conservatively rated based on the lowest load rating determined for the analyzed structural elements, which is 150 psf.

At the Finger Pier Extension, the steel H-piles are capable of supporting a uniform live load of 0 psf in their current condition based upon the loading combinations outlined in the HRPT Design Guide. This rating is governed by the Ice Load outlined in Load Combination 8 and Load Combination 9 (see Table 4-1). Since the controlling load is an ice load, it is recommended that access to the Finger Pier Extension be restricted whenever there is the possibility of ice loading. When there is no possibility of ice load on the Finger Pier the allowable live load remains at 100 psf.

Recommendations made in this report are grouped into the following three levels of importance. The definition of each level of importance is taken from the New York City Economic Development Corporation's (NYCEDC) Waterfront Facilities Maintenance Management System Inspection Guidelines Manual. **"Immediate"** level actions are recommended to be completed as soon as possible to prevent unsafe conditions. **"Priority"** level actions are intended to maintain the structure in a safe operating condition and/or prevent deterioration from continuing to a point where the future repairs will be significantly more costly. **"Routine"** level actions are intended to be undertaken as part of a scheduled maintenance program. They should be undertaken in accordance with good engineering and industry practice to maintain the structure and reduce future capital expenses.

A cost effective repair plan that addresses all areas of deterioration without the need for future phased repair efforts (aside from routine inspections and regular maintenance) was developed. Because of the size of the pier and complexity of the work, a single continuous design and repair effort extending over an approximately nine and one-half year period likely represents the most cost effective approach to maintaining current usage.

The order-of-magnitude cost estimate for the recommended repair is summarized in Table 3. It is assumed that a detailed design and engineering effort will take approximately 2 years and precede the physical repair work. Because of the condition of the H-piles, we recommend that this effort commence as soon as practicable.

Recommendations and assumptions regarding the timing and cost of repairs consider the extent of the repairs based on inspected conditions, the size of Pier 40 and difficulty in accessing the middle portion of the pier, environmental constraints, and lack of head room under the pier, particularly under the Court Yard, which forces more of the work to be performed underwater. Repairs specified at the interior/middle piles will therefore be significantly more labor intensive and costly than repairs specified along the pier perimeter. Environmental obstacles include pouring encasements in the winter months, which is not possible/recommended. Finally, large areas of the pier, especially under the Court Yard, have little to no headroom during some or all of the tide cycle. All of these factors contribute to the difficulty associated with a widespread and comprehensive repair effort, and, while cost effective, the recommended repair is nevertheless more costly than what would ordinarily be the case for a more typical pier structure.

Table 1 Cost Estimate for the Pier 40 Repair

Repair Importance Level	Number of Piles to Repair		Timber Fender System Replacement (LF)	Area of Beam and Deck to Repair (SF)	Cost Estimate	
	Structural Enc.	Non-Structural Enc.			Sub-Total	TOTAL
Immediate	110	0	0	0	$3.96M	$80.6M
Priority	1,671	1,124	0	0	$61.1M	
Routine	168	390	2,405	1,730	$15.46M	
Escalation to Mid-Point of Construction – 7.5 Year Construction Period						
Escalation to 2016 (2 Year Design Period)			6.09%	$4.9M		$14.9M
Escalation to 2020 (Mid-Point of Construction)			11.72%	$10M		
Total Project Construction Cost With Escalation			**$95.5M**			

Note: Owner's costs, not included in the base pricing, totals $9.1M. For detailed breakdown of costs please refer to Appendix C.

The recommended repair is a comprehensive program that encases every pile in a continuous repair program with an assumed nine and one-half year design and construction period. Fifty-six (56%) percent of the piles are recommended for structural encasement and forty-four (44%) are recommended for non-structural encasement. The resulting repaired structure should be relatively low maintenance and sufficient to support the current use requirements for the foreseeable future. In addition, any unknown deficiencies that exist now will likely be discovered and remedied during such a widespread rehabilitation effort. The $95.5 million cost estimate includes both expected contractor costs, such as insurance, overhead and profit, industry standard contingencies for design and construction, and annual escalations of 3%.

Not included in the cost estimate are typical owner costs estimated at approximately $9.1 million which would be expended during both the design and engineering phase and during construction. Owner costs include items such as design services, construction administration, diving and controlled inspections. The order-of-magnitude total for both contractor and owner costs is therefore estimated at approximately $104.6 million.