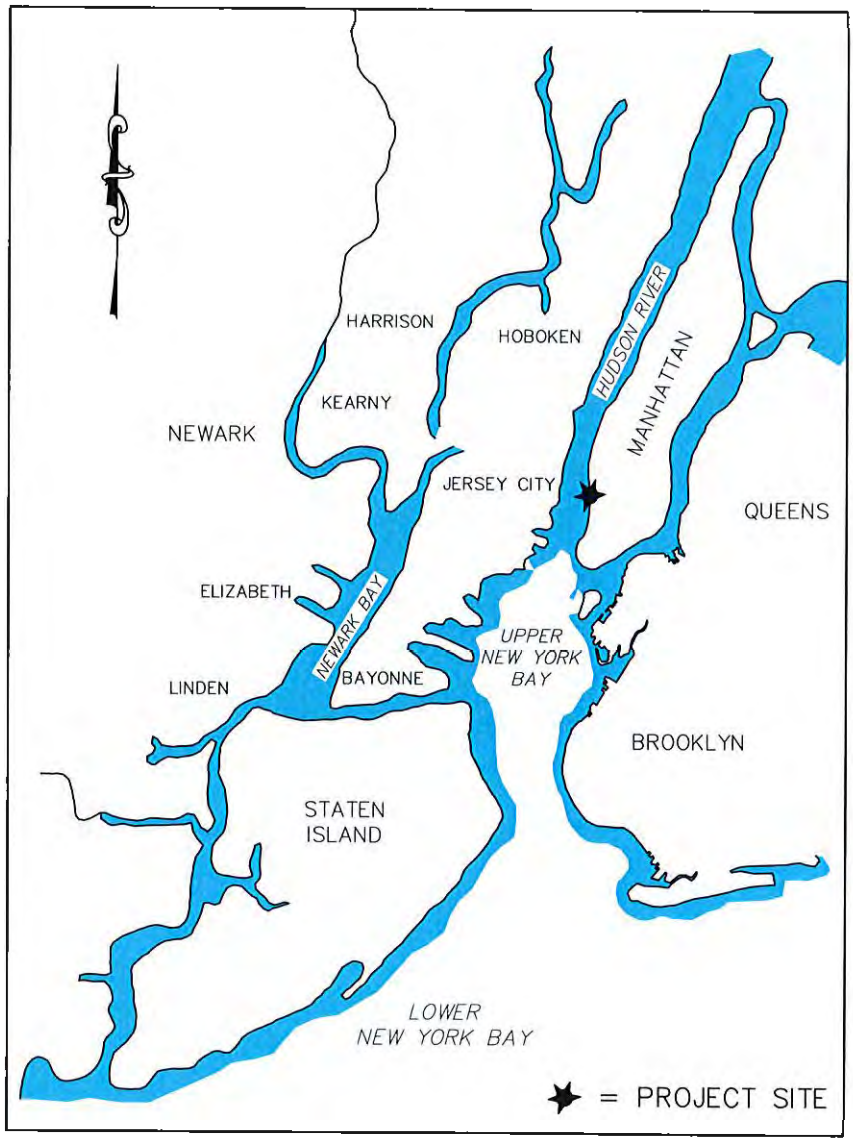
1. INTRODUCTION

From December 2013 to February 2014, at the request of the Hudson River Park Trust (Trust or HRPT), Halcrow performed a condition monitoring inspection of Pier 40 which is located at the terminus of West Houston Street, along the western shore of Manhattan in New York. A vicinity map and location plan are presented on Figures 1-1 and 1-2, respectively.

The scope of work included an above water and underwater inspection of the facility's foundation structural and non-structural components, which includes steel H-piles, concrete pile caps, pile cap beams, deck soffit, the top surface of the pier apron, 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, and to develop repair recommendations with an associated order-of-magnitude cost estimate. The repair recommendations and cost estimate were developed based upon HRPT's request for a repair plan to address all areas of deterioration without the need for future phased maintenance or repair efforts. Immediate and Priority repair recommendations were developed to maintain a 100 psf live load rating over the entire pier structure and sufficient lateral load capacity to resist, ice, wind, wave, current, and mooring loads typical to the geographical area. Considerations for fire truck loading and access to all areas within the Court Yard and the perimeter Pier Shed were also included in the repair recommendations.

A history of all previous inspections is provided in Table 1-1.



SCALE: 1"=5000'

HUDSON RIVER PARK TRUST
NEW YORK, NEW YORK
PIER 40 CONDITION MONITORING INSPECTION

VICINITY MAP

FIG 1–1

Halcrow

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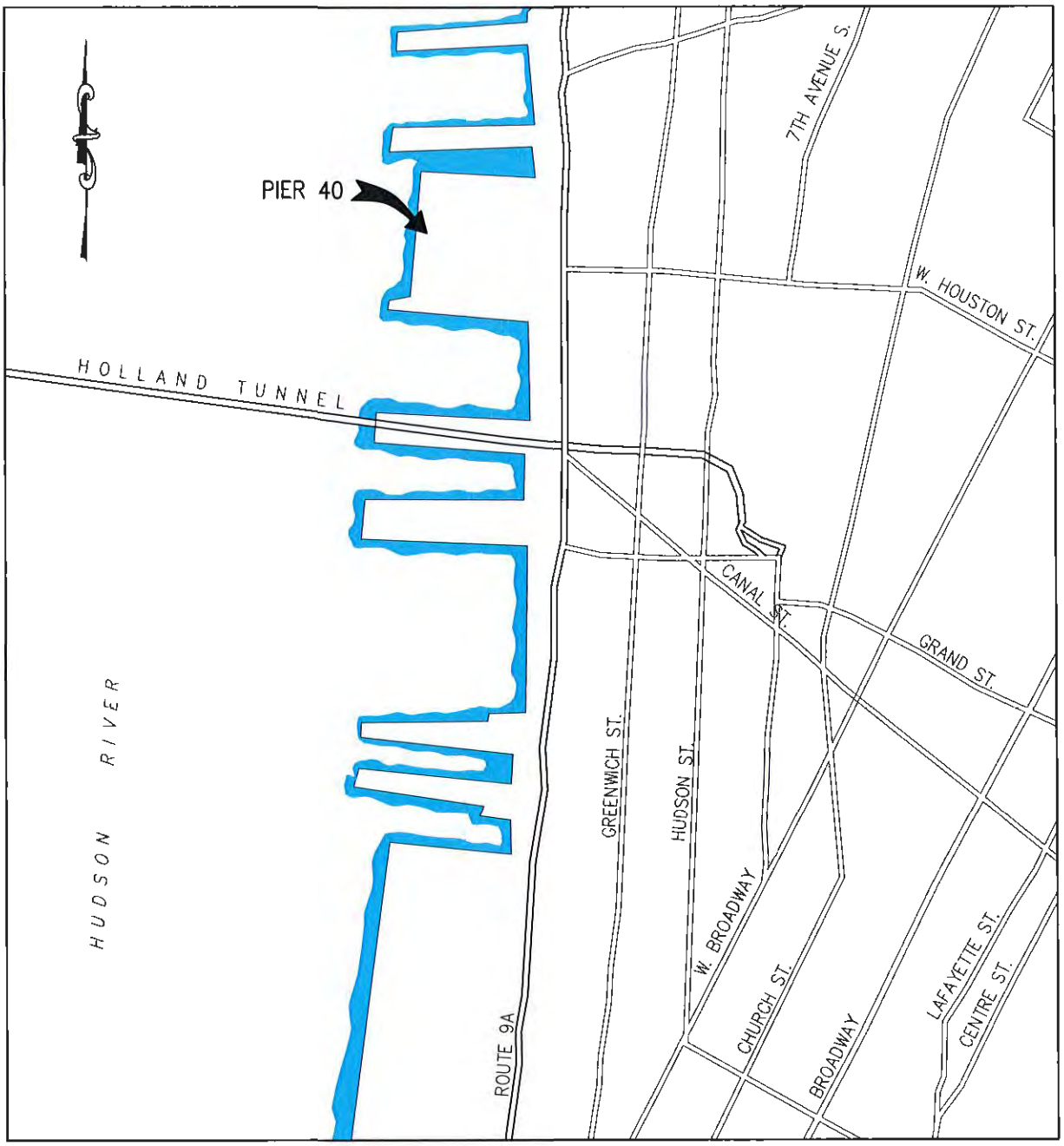

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LOCATION PLAN

FIG 1-2

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Table 1-1 Previous Inspections of Pier 40

Report Date	Inspection Date	Inspection Firm	Client
2009 Jun.	Feb. to Apr. 2009	HPA (Halcrow)	HRPT
2004 Aug.	2004 May	HPA (Halcrow)	HRPT
	2002 Dec. to Jan. 2003	HPA (Halcrow)	HRPT
2001 Jun.	1999 Apr. to 2001 Jan.	Goodkind and O'Dea	NYSDOT
1998 Dec.	1998 Apr. to Jul.	Goodkind and O'Dea	NYSDOT
1996 Aug.	1999 May to Jun.	Goodkind and O'Dea	NYSDOT
1994 Dec.	1994 Sept.	Han-Padron Associates (Halcrow)	Port Authority
1993 Aug.	1992 Sept. to Nov.	Han-Padron Associates (Halcrow)	Port Authority
1988 March	1987	Parsons Brinckerhoff, Quade and Douglas Inc.	Port Authority
1985 March	1984	Parsons Brinckerhoff, Quade and Douglas Inc.	Port Authority

1.1 Inspection and Methodology

The inspection was conducted by a three-person team lead by an engineer-diver. The underwater inspection of Pier 40 was performed using surface-supplied diving equipment staged from a van parked on the perimeter apron. The diving equipment included a Superlite 17B diving helmet, a three-part umbilical with continuous hardwire communications, and other commercial diving gear. Above water, the inspection was performed using a 12 ft aluminum boat outfitted with an outboard motor. Various hand tools, photographic equipment, and measuring devices were utilized to assess the condition of the structural components.

The underwater inspection included a 100% visual (Level I) inspection of all steel H-piles below mean low water (MLW) and a detailed (Level II/III) inspection on approximately 10% of the steel H-piles. The Level II/III detailed inspection was conducted on the same H-piles that received a Level II/III detailed inspection during the 2009 Halcrow inspection. The detailed inspection was performed by using an ultrasonic thickness (UT) gauge to collect thickness measurements (readings) of the pile webs and flanges at the mudline and at mid-pile elevations. The mid-pile readings were taken

at either above existing channel repairs on the H-piles, at the top set of bolts connecting the repairs to the H-piles, within the areas of severe deterioration at MLW, at the bottom set of bolts connecting the repairs to the H-piles, or below the channel repairs. Pile ratings were based on a combination of visual assessment and UT measurements. The presence and condition of the sacrificial anodes connected to the H-piles were also noted and assessed.

The above water inspection included a visual (Level I) inspection of the pile caps, beams, and deck soffits, and the portions of the steel H-piles above MLW. A detailed inspection of the above water portions of the same 10% of steel H-piles selected for the underwater detailed inspection was also performed. Thickness measurements of the pile web and flange were taken using the ultrasonic measuring device or by a micrometer.

1.2 Rating Criteria

The general condition assessment ratings for the entire pier and element groups are based on a six point assessment scale developed by the American Society of Civil Engineers (ASCE). The six condition ratings are:

- Good: No visible damage, or only minor damage is noted. Structural elements may show very minor deterioration, but no overstressing is observed. No repairs are required.

- Satisfactory: Limited minor to moderate defects or deterioration are observed, but no overstressing is observed. No repairs are required.

- Fair: All primary structural elements are sound, but minor to moderate defects or deterioration are observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.

- Poor: Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may be carried out with moderate urgency.

- Serious: Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.

- Critical: Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very priority basis with strong urgency.

The pile rating criteria are based on a five point assessment scale defined by average residual thickness of the pile flange and web. The ratings are listed and defined below:

- No Damage: Protective coating intact. No apparent loss of material.

- Minor: Less than 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section. Remaining thickness greater than 0.500 in. (1/2 in.).

- Moderate: Over 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section. Remaining thickness between 0.375 in. (3/8 in.) and 0.500 in. (1/2 in.).

- Major: Partial loss of flange edges or visible reduction of wall thickness on piles. Remaining thickness between 0.250 in. (1/4 in.) and 0.375 in. (3/8 in.).

- Severe: Structural bends or buckling and breakage. Remaining thickness of 0.250 in. (1/4 in.) or less.

Corrosion of steel elements is classified using the following assessment terms:

- Minor (or Light): A light surface corrosion with no apparent loss of section.

- Moderate: Corrosion that is loose and flaking with some pitting. The scaling or exfoliation can be removed with some effort by use of a scraper or chipping hammer. The element exhibits measurable but no significant loss of section.

- Severe: Heavy, stratified corrosion or corrosion scales with extensive pitting. Removal requires exerted effort and may require mechanical means. Significant loss of section.

The damage grades used to describe the concrete beams and pile caps are based on a four point assessment scale and are listed and defined below:

- No Damage: Good original surface, hard material, sound.
- Minor: Mechanical abrasion or impact dents up to 1 in. General cracks up to 1/16 in. Occasional corrosion stains but no exposed reinforcing. Small shallow pop-out spalls.
- Moderate: Structural cracks up to 1/8 in. Corrosion stains and cracks up to 1/4 in. wide and open spalls with no exposed steel reinforcing. Signs of chemical deterioration.
- Severe: Structural cracks wider than 1/8 in. or complete breakage. Complete loss of concrete cover due to corrosion of reinforcing steel with over 30 percent of diameter loss for any main reinforcing bar. Loss of concrete cover (exposed steel) due to chemical deterioration.

Chemical deterioration in the above context can include sulfate attack, alkali-silica reaction, or ettringite distress.

Cracking of concrete elements, defined as a separation into two or more parts as identified by the space between fracture surfaces, is categorized using the following assessment terms:

- Hairline - Crack width less than 1/32 in.
- Fine - Crack width between 1/32 in. and 1/16 in.
- Medium - Crack width between 1/16 in. and 1/8 in.
- Wide - Crack width greater than 1/8 in.

The types of cracks identified include overstressing, corrosion, and general cracking. An overstressing crack results from external loads which cause high internal stresses that exceed the strength of the concrete member. Corrosion cracks are the result of the expansion of chemical products generated by the corrosion of the steel reinforcement. General cracks typically include shrinkage, thermal and chemical reaction cracks caused by the expansion of concrete, which occurs during chemical reaction between concrete constituents or these constituents and the environment.