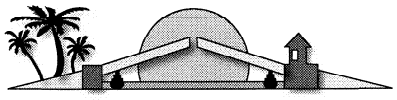
HEAVY MOVABLE STRUCTURES, INC.



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CHICAGO'S MOVABLE BRIDGES MAINTENANCE, OPERATIONS AND CAPITAL REHABILITATION STRATEGIES

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Abstract

With 37 bridges on two river systems, the Chicago Department of Transportation's (CDOT) Bureau of Bridges and Transit operates and maintains one of the largest movable bridge systems of any city in the world. The majority of these bridges date from the early part of the 20th century. Age and the harsh winter environment pose significant maintenance challenges to keep these bridges in good structural and operating condition. Many of these bridges are also designated as historic structures by the Illinois Department of Transportation (IDOT) and the Illinois Historic Preservation Agency (IHPA) which further complicates maintenance and rehabilitation. Bridge operations vary between the Calumet River, which is principally operated for commercial vessels, and the Chicago River, which is operated exclusively for recreational craft. Operating and maintaining this unique bridge inventory is reviewed with long-term strategies for capital improvements.

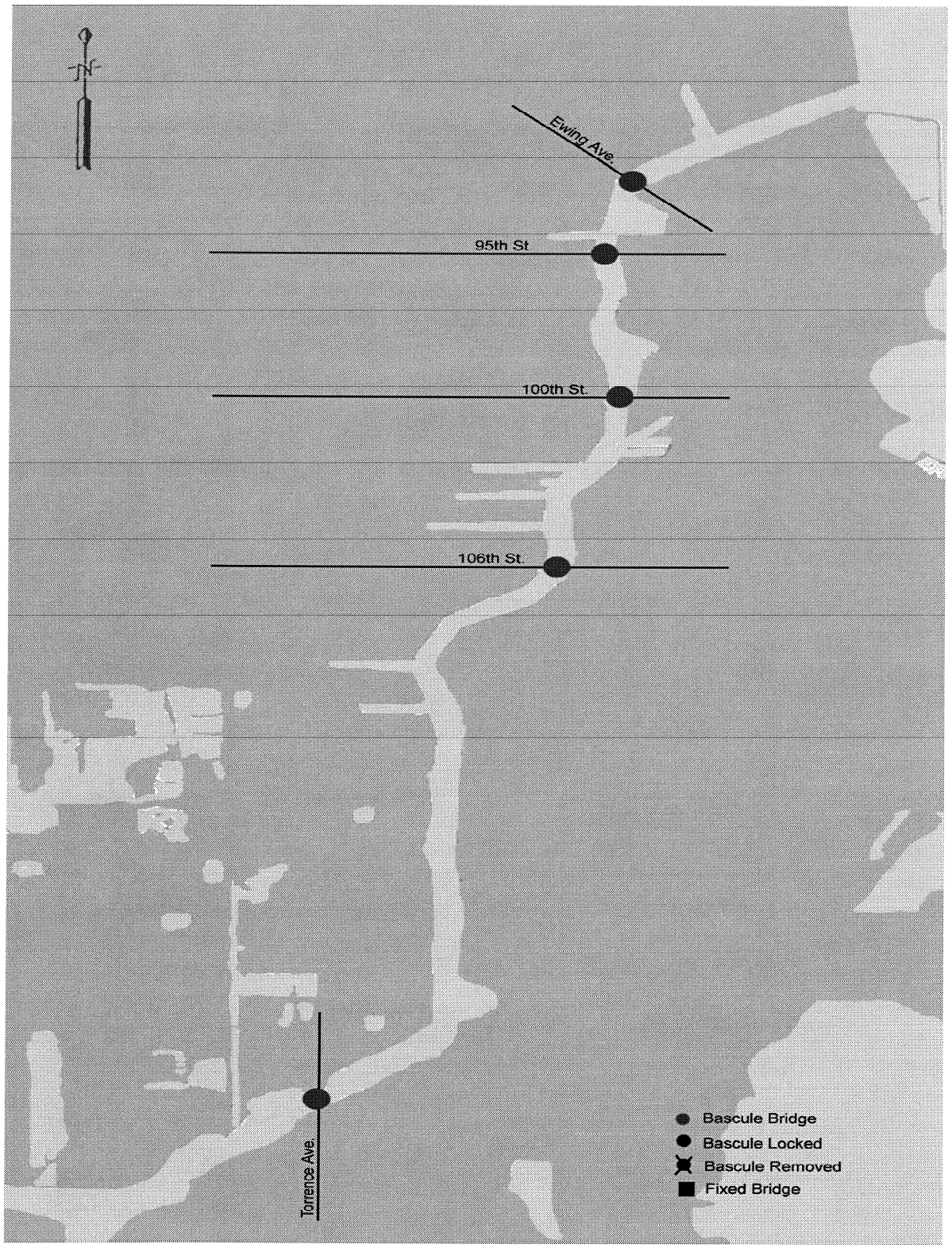
Introduction

The siting of Chicago at the mouth of the Chicago River established the historic need for – and ultimate development of – an extensive movable bridge system. The River provided the initial impetus for the growth of Chicago. As the City grew, the River became an impediment to growth. To allow ships to navigate the River and for land transportation to cross the River, a system of movable bridges evolved as the City grew.

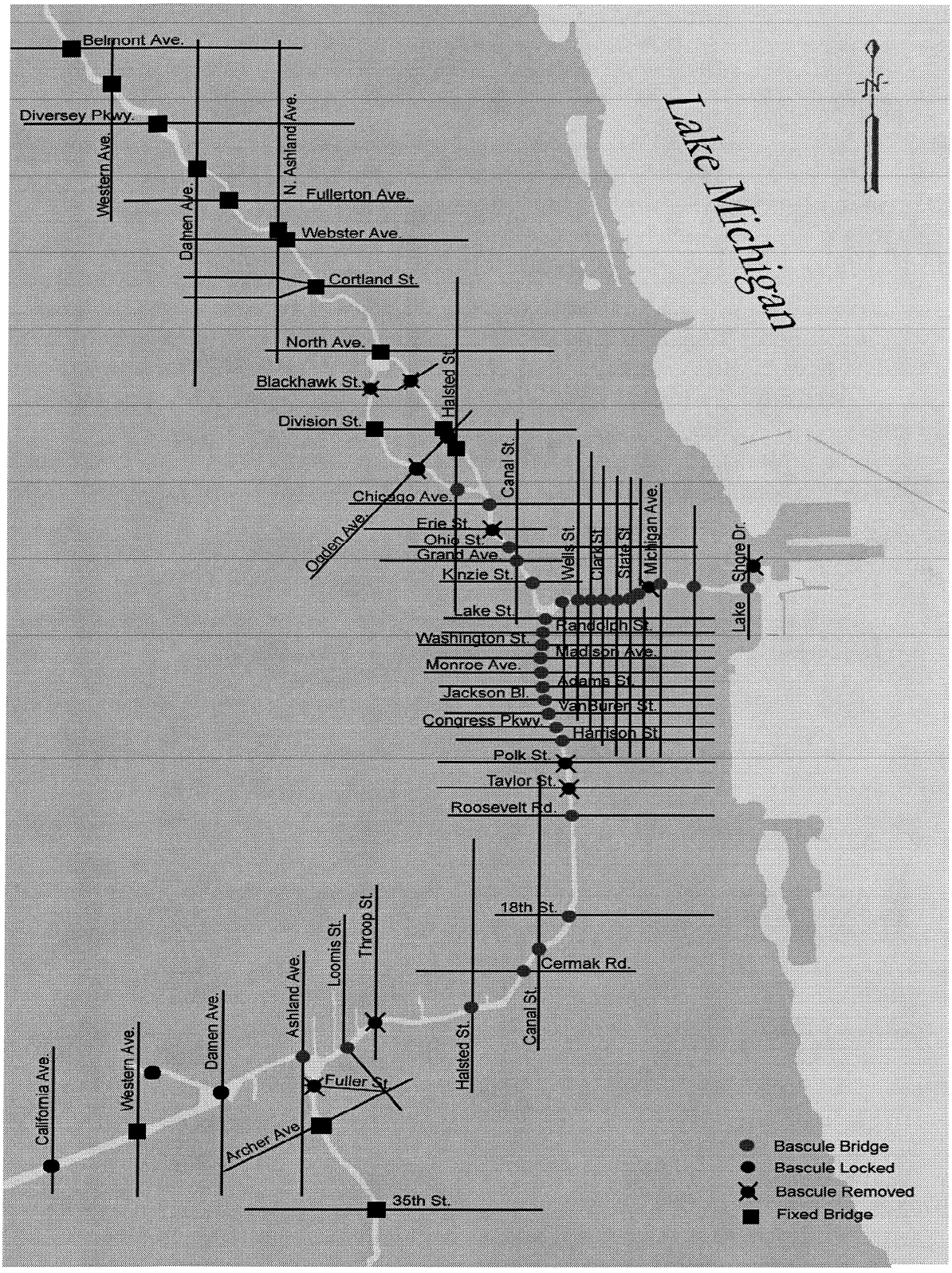
As early as 1829 there was the need to permanently link the already established town center south of the River with a growing population north of the River[1]. A ferry system was established near what is now Lake Street and in a very short time it was strained to its maximum capacity. The River became a barrier to the free movement of goods between the north and south sides of the River. In response to the problem, Chicago's first true drawbridge was constructed in 1834 near what is now Dearborn Street. The bridge was not built by the City but rather by private investors and tolls were charged for its use. The bridge was a crude wooden structure with two movable leaves and bore a resemblance to a castle drawbridge. Although needed, the bridge was not universally popular and was a constant maintenance problem. By 1839, the condition of the bridge was so poor that the City's Common Council moved to have the bridge removed. Legend has it that, upon hearing of the Council's decision, the people of Chicago turned out at dawn the next day and demolished the bridge before the Council could change its mind.

The fact that the first movable bridge was a failure did not deter original thinking entrepreneurs from trying new schemes to bridge the River. Pontoon bridges came into vogue in 1840 and in quick succession, nine bridges of this design were built. The pontoon bridges were slow to operate and impeded all river transportation since they floated on the water rather than span over it. In spite of their limitations, the pontoon bridges were inexpensive to build and operate. In 1854, the center pivot swing bridge was used for the first time in Chicago at Clark Street. Swing bridges were considered a major improvement over pontoon bridges in that they spanned above the water and allowed smaller boats to pass under them without the need to open.

It was not until 1856 that the City of Chicago agreed to undertake the construction, operation and maintenance of the first movable bridge built at its expense. That same year saw Chicago undertake the construction of the Rush Street Bridge, the first iron bridge to be built in the west[2]. By the end of the



Calumet River Bridges



Chicago River Bridges

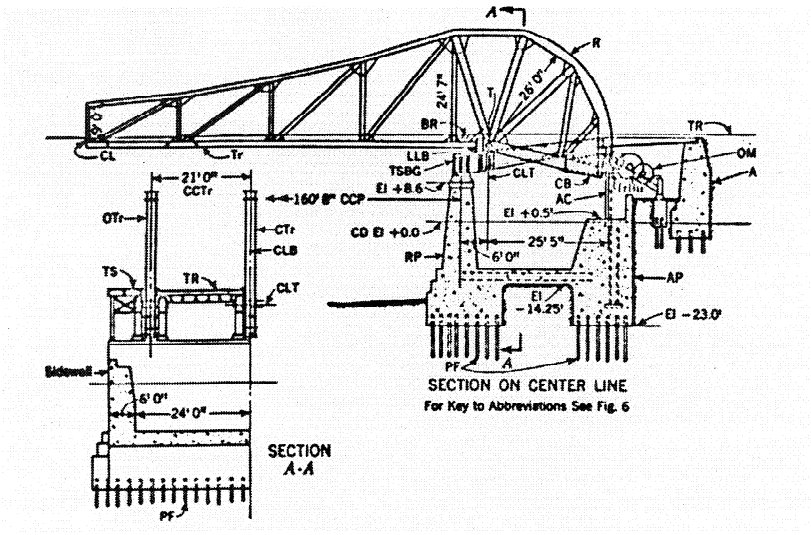
nineteenth century, over 40 swing bridges had been built over the Chicago River. By 1890, Chicago's city limits had extended south to the Calumet River and the first swing bridge was built on the Calumet River system at 95th Street. This technology endured for over 120 years with the last swing bridge being removed and replaced with a fixed span in 1970.

Old Western Avenue Swing Bridge over West Fork of the South Branch Chicago River

The end of the 19th Century saw a blossoming in the art of movable bridge design. Material technology caught up with advances in the understanding of how bridge members performed under load and many new bridge types were developed. Chicago, faced with 55 swing bridges built between 1865 and 1890 and newly imposed federal regulations directing the Secretary of the Department of War to review all bridge plans over navigable waters with the intent of eliminating navigational hazards[3], was one of the natural places to benefit from burgeoning movable bridge technology. Commerce peaked on the Chicago River at the end of the nineteenth century and block upon block of swing bridges spent more time open than closed. The bridge center piers constricted the navigation channel making ship traversal slow and difficult.

In response to the challenge of finding a better way to span the River, many one-of-a-kind movable bridge types were developed. Engineers such as J.A.L. Waddell, John Page and William Scherzer developed designs which they hoped to patent and make a profit. Captain William Harmon, a local "designer", patented the first "jack-knife" type bascule in 1893[4]. Waddell in 1895 built his first vertical lift bridge at Halsted Street over the North Branch of the Chicago River[5]. John Page in 1902 developed a unique movable span in which the fixed approach, acting as the bridge's counterweight, was linked to the movable span serving as the counterweight to allow it to open. William Scherzer in 1895 patented his rolling lift bridge design in Chicago – a design that is still in use today[6].

In 1899, faced with the problem of growing land and river congestion and many different movable bridge types, the Chicago Department of Public Works (DPW), the predecessor agency of CDOT, commissioned a survey and critical study of the many different movable bridge types found in the United States and Europe. The goal was to find a movable bridge design suitable for the particular needs of the City of Chicago. The study showed that the trunnion style bascule, with its fixed axis, most satisfactorily met the unique requirements of Chicago "both from a scientific as well as practical and economic point of view"[7]. The bascule bridge lent itself well to solving the problem of designing a movable bridge that could at once be quickly opened without interfering with river traffic.



Chicago Style Trunnion Bascule

The trunnion bascule offered one other important advantage over all other designs – the counterweight could be placed below the bridge, out of sight, rather than above. In a city as flat as Chicago, this was a distinct advantage over having a vertical or rolling lift bridge every block, counterweights and machinery in full view of the public. The visual impact on the City would be quite different from the one seen today. To standardize the many different trunnion style bascules, DPW commissioned engineers Ralph Modjeski, E.L. Cooley and Byron Carter to select a style of bridge that best met the City's objectives[8]. The result of their efforts is the Chicago style trunnion bascule found throughout the City today.

With the standardized bridge design in hand, the period from 1900 to the Great Depression saw an unprecedented amount of bridge building in Chicago. Nearly every major span on the Chicago and Calumet River systems was reconstructed. The rebuilding was so complete that save for one Scherzer rolling leaf bridge and one vertical lift bridge, there remain no other example of the many movable bridge types found in Chicago before the start of the twentieth century.

Operational Strategies

In the mid 1960's, Chicago could claim over fifty movable bridges that required full time tending by an army of nearly 500 bridge tenders. The movable bridges on the Chicago and Calumet River systems were to be opened "on demand", 24 hours a day, seven days a week, 365 days a year. From Belmont Avenue on the North Branch of the Chicago River to Cicero Avenue on the Sanitary and Ship Canal, even along "Bubbly Creek" (the South Fork of the South Branch) to 35th Street and the long gone West Fork of South Branch, ships could ply the entire length of the navigable portions of the Chicago River system.

In spite of this impressive movable bridge infrastructure, river commerce had steadily declined on the Chicago River system since the start of the twentieth century. By the early 1970's, the heavy basic industry that once made up Chicago's economy had left the central business district and moved to other areas. Industry also became less and less dependent on the river and more and more dependent on railroads and expressways as their principal means of receiving materials and shipping goods.

Recognizing the change in river use and the need to reduce its costs, DPW sought permission from the United States Coast Guard (USCG) to change drawbridge operations on the Chicago River. The proposal was to adopt a rover bridge tender operation for all bridges on the Chicago River system except for those with restricted navigational clearances (typically less than 17'-0 clearance over mean water level). The

rover tender system recognized that the majority of commercial boats were barges that could easily clear most bridges without requiring an opening. Since the number of large vessels requiring openings was fairly limited, the rover tender system could handle the vessel's traversal without undue delay. Overnight, the number of bridges regularly tended on the Chicago River system went from over fifty to just three – Randolph Street and Cermak Road on the South Branch and Kinzie Street on the North Branch all of which had restricted navigational clearances so that even low clearance barges required the bridge to be opened to allow passage.

The reality was that many of these bridges were only opened for maintenance purposes and not for river commerce. The last commercial vessel to call on the Chicago River system, which required the routine opening of bridges, was the Medusa Challenger. The Medusa was also the largest boat ever to call on the Chicago River. At nearly 500 feet in length, it required four bridges to be opened at a time to allow it to pass. Tugs maneuvered the ship as it passed through the many twists and turns of the Chicago River between Lake Michigan and the Turning Basin near North Avenue on the North Branch of the Chicago River.

As commercial traffic decreased, recreational boaters increasingly used the River to move back and forth between their boat storage and repair yards. With the Medusa Challenger last calling on the Chicago River in the mid 1970's, the Chicago River's bascule bridges have been maintained and operated almost exclusively for recreational (masted) boating.

The rover tender system adopted was well suited for the needs of recreational boating. The sailboat owners would leave their yards to travel to the Lake in the Spring and return to their yards in the Fall, all on a fairly predictable schedule. The City was still obligated to open the bridges on demand, but was now forewarned by the boat yards that acted as the "gatekeepers" for the comings and goings of their customers.

The rover tender system is comprised of typically three teams of bridge tenders assisted by electrician and machinist support trades. The teams staff the first three bridges in the direction of the boat's travel. The first team in the direction of travel opens the bridge to allow the sail boat to pass. The next team in the direction of travel from the first team begins to lower the gates of their bridge. After the sailboat has passed through the first bridge, the first team closes their bridge and clears the gates. The second team now has its bridge fully open and the third team begins to close the gates of their bridge in anticipation of the approaching ship. The first team, now completed with its operations at the first bridge, drives ahead to the fourth bridge and begins to set up for opening while the third team has opened their bridge and the second team closes their bridge. The arrangement continues until the boat has reached its destination.

Although the rover tender system worked well and reduced staff costs, the greater problem was the fact that, in many instances, a single sailboat could still traverse the River essentially at will. Bridges were being opened during peak travel periods and several times a day to allow sailboats to traverse the River. Recognizing this fact, in 1993, CDOT again approached the USCG for changes to bridge operations on the Chicago River system.

Since the implementation of the rover tender system in the 1970's, Chicago's Central Business district had undergone extensive change. An increasingly larger number of people have moved back into the City. The Central Business District has expanded westward and northward, crossing the traditional barrier

of the Chicago River. The bridges across the Chicago River have become the principal links between these new communities and the original city center. More importantly, the seemingly indiscriminate opening of the bridges on weekdays for purely recreational boating – sometimes a single boat – was felt by CDOT to be an unacceptable disruption of the transportation system. The rover tender system of "on demand" openings did not strike a balance between the needs to operate an effective land based transportation system and the purely recreational needs of the sailboat owners. Once again, the River had become a barrier to the City's continuing development.

Public hearings were held by the USCG to receive comments on the proposed regulation change. Representatives from the City and business presented the rationale for the changed regulations allowing only weekend bridge openings. The recreational boating community presented its reasons for the retention of the "on demand" openings – including the "inalienable right" of water transportation to have precedence over all other forms of transportation.

What ultimately became known nationally as the "Chicago problem" was settled through a highly unusual negotiated rule making. Representatives from the City and the recreational boating community met to hammer out regulations that ultimately were a compromise with neither side clearly "winning or losing". The USCG recommended changes to 33 CFR 117.391[9] that significantly altered the operations of the bridges of the Chicago River for the first time since bridge operations started in 1834. Although the City did not achieve its goal of limiting bridge lifts to weekend only, the regulations assured that the remaining weekly openings would be more disciplined than in the past. Limitations were established for when bridge openings would occur and, in many cases, required that a minimum number of boats be part of a flotilla before lifts would be permitted. No longer could a lone sailor arrive and expect the bridges to be opened. With the implementation of these new rules, openings on the Chicago River bridges have fallen to less than 150 per year. The regulations, applicable to all recreational craft between April 1 and December 2, provide for the following:

- Scheduled bridge openings upon six hours notice on Monday and Friday evenings after 6:30 PM, Wednesday mid-day openings, and two openings each on Saturday and Sunday mornings regardless of the number of boats.
- Additional openings scheduled with 20-hour notice and a five boat minimum flotilla.

The Calumet River system, consisting of five movable bridges, still sees the calling of commercial vessels requiring bridge openings. These five bridges see between 2,500 and 4,000 openings a year for each bridge, although this number has been falling as the character of industry on the southeast side of Chicago changes. The Calumet River bridges are the only full time staffed bridges operated by the CDOT. There are approximately 55 tenders employed to operate all bridges. These tenders are on a rotational schedule to insure coverage for the shift work on the Calumet River. The tenders are members of the International Association of Operating Engineers. As part of their recent contract with the City, all tenders are subject to random drug and alcohol testing and have accident reporting and testing requirements similar to holders of Commercial Driver Licenses (CDL).

CDOT is currently looking at how it schedules its bridge tenders with the intent of reducing costs. Since boat runs on the Chicago River take place during the day, CDOT has instituted a "power shift" where all tenders normally assigned to the Chicago River are assigned to the first shift. This avoids calling in tenders from other shifts (and paying overtime) to staff the boat runs. CDOT is also reviewing bridge tender logs for the Calumet River to determine if 24 hour staffing is required. Based upon this review, the

City may seek changes to the Calumet River operations looking to use rover bridge tenders during off peak hours.

Maintenance Strategies

The challenge CDOT faces is how best to effectively maintain an aging movable bridge infrastructure to provide operational reliability when needed for increasingly fewer openings. Through its capital program, CDOT strives to insure that the rehabilitated bridge has the longest possible life through an aggressive replacement of members and use of more durable materials. Until that rehabilitation can occur, the existing bridge spans awaiting rehabilitation must be kept in good working order and structurally sound. CDOT, through use of its Motor Fuel Tax receipts, has a program of routine and annual movable bridge related maintenance items that are performed with the intent of extending useful life.

To accomplish this maintenance, CDOT relies principally on approximately 225 in-house trades people representing 13 different unions. This staff performs routine maintenance not only on the movable bridge inventory, but also CDOT's fixed bridge inventory of over 300 bridges. This trades staff has become an effective and cost competitive performer of certain types of bridge rehabilitations – principally movable bridge rehabilitations. The more challenging projects allow this staff to refine its trades skills and insures that the routine maintenance is performed in a professional manner.

Routine Maintenance

Routine maintenance takes the form of those tasks which must be performed to keep the movable bridges in operation. CDOT's routine maintenance program for the bridges includes the following:

- **Greasing of gear trains, bearings and other movable parts.** This task is performed by small teams of machinist moving from bridge to bridge within their respective zone of the bridge system. Currently, the Chicago River is divided into four sections – one each on the Main and North Branch and two on the South Branch. There is also one team for the Calumet River. These teams move from bridge to bridge during the week and insure that the bridge lifting and locking mechanisms are properly lubricated. They also serve the function of providing a check on bridge security whenever they enter a bridge.
- **Maintaining navigation lights and aids.** For the navigable portion of the River systems, routine checks are made of all navigation lights and other aids.
- **Maintaining life preserver rings.** A hold over from the days of full time staffing of the bridge houses, all movable and most fixed spans over water are equipped with life preserver rings and boxes. Until about three years ago, these rings were a source of constant vandalism principally for the collectors value of owning a life preserver ring for your rec room or vacation home with the words "Chicago Department of Transportation". Weekly checks of all life preserver boxes are performed and the life preservers have been made less "desirable" as a collectable by painting them with safety orange paint.
- **Pit cleaning and pumping.** Through the early 1990's, routine housekeeping activities for the bridge houses were not regularly performed. Pit cleaning, one of the most onerous maintenance tasks, in most cases was not performed. The result was pits with over four or more feet of dirt and debris that contributed to the deterioration of the concrete pit walls. The water in the pits also

contributed to the deterioration of the steel superstructure since the interior of the bridge pits was constantly damp. CDOT's practice is to clean all bridge pits as part of the rehabilitation of a bridge and then keep those pits pumped dry and regularly cleaned of debris. When designed, engineers originally contemplated the pumping of the bridge pits directly into the river. With stricter environmental laws, this is no longer possible. In compliance with these laws, CDOT has initiated a program of installing triple settlement chambers at bridges which allows for the separation of oils from the water before it enters sewer system.

- **Maintenance painting.** Under its capital program CDOT regularly schedules full sand blasting and paint removal for its lead painted bridges. This is typically scheduled once every ten to fifteen years. Interim maintenance painting is performed by CDOT crews. The bridge is fully power washed and loose paint removed with hand tools. All exposed steel is primed with an epoxy-mastic primer and the entire bridge given a top coat. Ideally, CDOT schedules an interim painting of a bridge every five years.
- **Bridge house cleaning.** Although the bridge houses are not routinely used by tenders, the houses nonetheless collect a large amount of trash and get dirty. CDOT has instituted a construction laborer crew whose job is to travel from bridge house to bridge house and perform routine cleaning.

Annual Maintenance

In addition to the routine maintenance items noted above, CDOT also has a program of annual or bi-annual maintenance for its bridges.

- **Cleaning stringers and floor beams on open deck bridges.** Chicago aggressively salts its streets in the winter months. Cars carry the road salts and dirt on to the bridge where it becomes deposited on the bridge superstructure below. Each spring, CDOT day labor trades use high pressure water and ice chippers to break up the dirt and clean the stringers and floor beams on the open deck bascule bridges. The removal of the dirt assures that the corrosive environment of the dirt and salt on the steel is mitigated to the greatest extent possible. Certain bridges see a greater amount of dirt accumulation than others. Much of this depends on the level of construction activity adjacent to the bridges.
- **Reliability testing of bridges.** Because of their relatively infrequent use, at the start and end of each bridge lift season on the Chicago River, reliability testing is scheduled for all bridges. Each bridge is closed to traffic for half a day, lifted and tested. Adjustments are made to the bridge limits to insure proper operation for opening and for center and heal locks. This procedure tends to avoid problems during the initial boat runs since the bridges have already been test lifted after being unused all winter or used relatively infrequently during the summer. Gates are repaired and checked, live load bearings cleaned and shimming checked for proper adjustment at the anchor columns. Current draw measurements are also taken as the bridge is lifted and closed to determine whether or not the bridge requires balancing. If balancing is required, it is scheduled for a time when the bridge can be closed for an extended period of time and ironworker crews are available.
- **Bridge balancing and shimming.** As the movable bridges deteriorate, they require rebalancing. CDOT rebalances and adjusts the shimming on approximately five bridges each year. Prior to 1990, little attention was paid to the proper adjustment of the bridge or its balance. Bridges are now routinely evaluated based upon operations to determine if bridge balancing is required. The

balancing procedure is relatively unsophisticated relying on current draw from the motors to gage relative balance. Engineers are assigned to the balancing operation to determine whether or not to add or remove counterweight blocks to achieve balance. Bridge shimming is critical for proper seating of the bridge when closed and under load. Again, under the direction of an engineer, the bascule bridges are shimmed to within approximately one-quarter inch of full bearing on the anchor column and "just seated" on the live load bearings under a "no live load" condition.

- **Heating of bridge houses and machinery areas.** When bridge operations on the Chicago River were changed from full time tenders to rover tenders, the heat in the bridge houses was allowed to breakdown and was no longer maintained. As a result, the bridge houses and pit areas started to deteriorate due to the freeze/thaw cycles and dampness. CDOT has instituted a program to provide heat in all bridge houses. Many pit areas were once enclosed with wooden partitions. These partitions served to separate the damp and open pit area from the controlled environment of the machinery rooms. These walls were removed over time to reduce maintenance costs. CDOT is considering the reinstallation of these enclosures as a means of reducing freeze/thaw damage to the machinery room areas and degradation of the electrical systems within these areas.
- **Maintenance of machinery and gear trains.** While rehabilitations typically address the structural and electrical systems of the bridges, many times the mechanical systems, other than centerlocks, are ignored. One reason for this is that that mechanical systems are so well built that little or no maintenance, other than lubrication, is required. CDOT has, however, instituted a policy of aggressive maintenance for its machinery gear trains. During the winter when there are no boat runs, entire drive trains are disassembled, the brass bearings cleaned of grease and dirt and checked for wear, fits verified and adjusted if necessary, caps and bearings regreased and, if necessary, the caps bolts replaced. Engineers provide the machinists with the originally specified clearances so that the gear train can be returned as much as possible back to its original configuration. Where gear teeth are damaged, they are rebuilt with weld material and ground to proper profile.
- **Snow removal.** When the bridges were operated year round, there was a need to insure that snow and ice was kept off the bridges so they could be opened. This is still true for the Calumet River bridges which are opened throughout the year. CDOT, unfortunately, continues to retain the responsibility for the removal of snow from the bridges within the Loop area on the Chicago River. This operation focuses on the removal of snow in advance of commuter traffic crossing the River. Crews are typically dispatched at 3:00 AM for light snows, earlier for heavier snows, with small plows to remove snow accumulated on the bridges and to spread salt.

Privatization of Operations and Maintenance

The operation and maintenance of the Chicago River bridges poses unique challenges from a staffing perspective. Both bridge tender and routine maintenance crews are staffed to address the needs of operating these bridges between April and December but that staff becomes superfluous during the summer months when there are few lifts and the off-peak season when there are none. This in conjunction with the reality of reduced City budgets is forcing CDOT to reevaluate how it staffs for Chicago River bridge operations.

One scenario under consideration is to privatize the operations and maintenance of the Chicago River bridges. Since the bridges open on a fairly regular schedule, the extent of the operations could be planned and effectively budgeted. All aspects of operation and routine maintenance, including snow removal in

the winter, would become the responsibility of a private contractor. The age of this infrastructure makes the predictability of the amount of maintenance required to keep the system in operation an unknown and may influence the final cost. Capital work would still be performed by City crews or crews separately contracted.

The benefit of this arrangement from the City's perspective is that the contractor is held accountable for the reliability and delivery of bridge operations and for annual maintenance items such as lubrication, cleaning and snow removal. The disadvantage of any privatization is that CDOT loses a wealth of in-house knowledge concerning the operation of these bridges. This ultimately makes the remaining crews less effective for the maintenance of the remaining bridges. Clearly, such a scenario only becomes attractive if the overall cost is less than what CDOT currently spends to maintain and operate these bridges. No final decision has been reached on whether or not to move forward with this plan.

Capital Investment Strategies

Much of CDOT's movable bridge inventory, whether still used for operations or not, is considered to be historic. Most of the Chicago-style trunnion bascules are the only examples of these bridge types in the State of Illinois and probably the United States as well. As such, the bridges are a unique picture of the evolution of this particular bridge type which makes these bridges worthy of preservation. The fact that these bridges are historic also shapes CDOT's capital improvements program in that rehabilitation, rather than replacement, is the preferred means to extend a bridge's useful life.

CDOT is required, as is every other bridge owner, to perform the federally mandated National Bridge Inspection Standard (NBIS) inspections of its bridges every two years and to perform a scour inspection and analysis every five years. The inspections are performed by consultant engineering teams, led by a Licensed Structural Engineer, and who are trained in the NBIS bridge inspection program. In addition to this visual inspection, CDOT also requires its consultant inspectors to perform a defect level inspection to identify repairs requiring immediate or near term (repair within two years) actions. For movable bridges, the NBIS inspections are supplemented by an operational and visual inspection of the mechanical and electrical systems of the bridges. The three principal structural areas of the bridge – deck, superstructure and substructure – are used to establish an overall rating for the bridge. This information is used to prioritize capital investment strategies.

With respect to CDOT's movable bridge infrastructure, a three-fold capital improvements strategy has been employed. First, where bridges are not historic and no longer needed for navigation, the movable bridge structures are replaced with fixed spans. Second, where the bridges are still required to be maintained for navigation and/or have significant historical value, the bridges receive complete rehabilitations preserving their historic character. Finally, where traffic patterns and adjacent development dictates, new bridges are to be built.

Movable Bridge Declassification and Removal

With the onset of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the funding it brought, CDOT had no coherent strategy for dealing with the unused or inoperable movable bridges in its inventory. Prior to 1993, CDOT still listed 52 bridges as movable, although 15 of those had not been opened in over 20 years. These spans typically carried the requirement of being made movable upon six-

month notice by the USCG. Department policy at that time sought to retain as much of the movable bridge inventory as possible although there was no demonstrable need for its retention. As such, when unused movable bridges were to be reconstructed, no attempt was made to seek permission from the USCG to replace the bridge with a fixed span. Several bridges were ultimately reconstructed as movable, or as bridges which could be made movable, even though it was known at the time that these spans would never be operated.

CDOT has subsequently reevaluated its approach to the declassification of movable bridges. Key bridges which are in need of rehabilitation but have not opened in many years are targeted for declassification and replacement. Ideally, the key bridge should be the first non-operable span in advance of a group of spans that are also non-operational but classified as movable. This isolates the remaining bridges which, theoretically, should make declassification easier for the remaining spans. Unfortunately, the USCG still requires that a bridge permit application be made for each bridge to be declassified and that the permit be subject to public comment and review to determine if there is a potential need for movable bridge operations within the now isolated reach of the river. In spite of the resistance put forth by USCG to declassify, the strategy has met with some success and CDOT has steadily reduced the number of "movable" bridges in its inventory. At present, there are 37 movable bridges and another ten bridges which still must be maintained as "movable" but only upon six month notice from USCG. Plans are currently being prepared to replace four of those ten non-operating spans with fixed spans over the next five years.

CDOT has also embarked on a strategy to seek USCG permission to remove the mechanical and electrical systems of movable bridges that have not been opened for many years. This process still requires following USCG's permit procedures for the declassification of movable spans. The historic nature of the bridges, however, raises concerns regarding the need for preservation of the electrical and mechanical systems. The problem now becomes one of convincing IHPA that the electrical and mechanical systems that remain and have been unused for over 20 years are so deteriorated and in such poor condition that they are no longer historic. CDOT has offered to work with IHPA to preserve an historic bridge structure and its components, at an entirely new site if necessary, to gain the necessary approvals for the removal of the electrical and mechanical systems of the remaining bridges. CDOT has received assurances from the USCG that it will perform a reasonable review of the request to remove the electrical and mechanical systems of these bridges provided that all of the other historic and environmental issues can be addressed.

By the mid 1980's, the Randolph Street and Cermak Road bridges over the South Branch and the Kinzie Street bridge over the North Branch were the only remaining full time staffed bridges on the Chicago River system. An important capital improvement strategy has been to target the remaining full time staffed bridges on the Chicago River system for improved clearance over the water so that they could be converted to rover bridge tender status. The Randolph Street Bridge, originally a Scherzer rolling double leaf bridge, was replaced in the early 1980's with a Chicago style bascule with improved clearance over the River and no longer requires opening for regular navigation.

Through the 1990's, the Kinzie Street and Cermak Road Bridges remained the last bridges requiring full time staffing on the Chicago River. Due to their limited clearance over the water, the Cermak Road Bridge was opened approximately 2,000 times a year and Kinzie Street Bridge was opened over 5,000 times a year. Most of the Kinzie Street openings were for tour boats that used the bridge openings as an enticement to ride the cruise boat. In fact, the Kinzie Bridge opened more frequently in the last years of operation than it did during any other period in its history. In 1999, both bridges were raised as much as five feet which allowed all vessels except sailboats to pass. With the bridge raisings, full time bridge tender operations were eliminated bringing to an end 165 years of bridge tender staffing on the Chicago River.

Kinzie Street Bridge Float-in of Trusswork

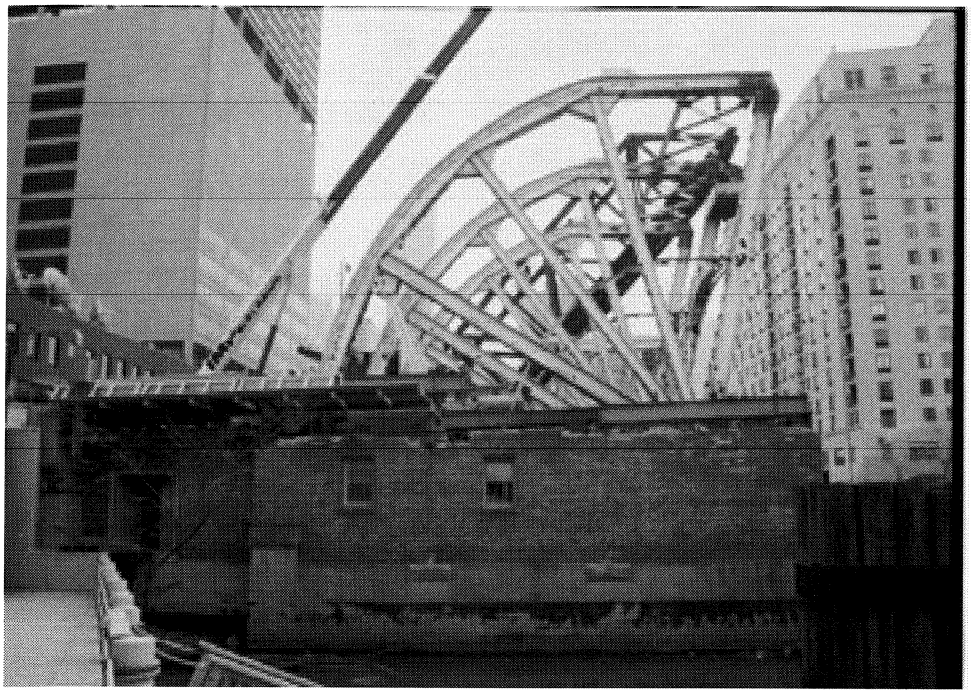
Rehabilitation versus Reconstruction

Replacement of existing movable spans with new movable bridges has not been considered a cost effective or viable option to rehabilitation. Although the existing bridge spans generally have substandard roadway geometry, the cost to either modify the existing span to increase width is cost prohibitive or there are physical constraints such as adjacent buildings that prevents widening the bridge. The historic aspect of these bridges and, more importantly, their context with the surrounding community tends to make replacement a less viable option than rehabilitation. Chicago has a keen awareness of the unique nature of its movable bridge inventory and has taken steps to preserve the bridges to the greatest extent possible. As such, rehabilitation as opposed to replacement is the preferred investment option.

Nearly all of CDOT's 37 remaining operable movable bridges, as well as its ten non-operable movable bridges, were constructed during the period from 1902 through 1930. The last major structural rehabilitation that most of these bridges received was in the 1950's when the original timber roadway decks were converted to open steel grating. This work was usually associated with the removal of the streetcar rails from the bridges. Aside from these deck replacements, relatively little in the way of structural, mechanical or electrical rehabilitation was performed on the bridges since they were first built.

CDOT has embarked on an aggressive rehabilitation program for its movable as well as its fixed bridge and viaduct structures. To date, there have been 23 movable bridges rehabilitated since 1993. Most of these rehabilitations are performed by CDOT day labor trades rather than contractor forces. CDOT is able to perform these rehabilitations using in-house labor in large part due to the level of experience its crews have acquired over time performing these rehabilitations. It has been found that, given proper supervision, CDOT trades can be as cost effective as contractor forces and are more flexible to address uncovered conditions which may not be apparent during design.

- **Member replacements.** The CDOT approach to movable bridge rehabilitation is aggressive with respect to the replacement of main truss and superstructure members and rehabilitation of systems. As a rule of thumb, if more than one quarter of any given member requires rehabilitation, replacement of the entire member is considered more economical. Similarly, if a



Kinzie Bridge showing member replacement

quarter of the members within a given truss panel require rehabilitation or replacement, then the entire truss panel is replaced. Associated floor beams, stringers and lateral systems are also completely replaced, regardless of condition, when new truss members are installed.

- **Electrical system upgrades.** The bridges received electrical system rehabilitations and upgrades in the late 1950's and early 1960's to allow single bridge tender operation. As such, the existing electrical systems are in need of full replacement. Rehabilitations include fully replacing all electrical systems to provide up to date circuitry for the bridges. The existing DC feeds are replaced with AC feeds and the power rectified to drive the DC motors. Electro-mechanical brake thrusters are installed to replace mechanically set hand brakes and pulley lines. Rehabilitation does not usually, however, extend to the control systems. CDOT's policy is to keep the controls for operations as simple and as familiar to the operator as possible.

Sophisticated "single push button" operation for the bridges has been avoided given the relatively infrequent operation of the bridges.

- **Lead paint removal.** The spans are fully painted upon completion of the rehabilitation. New steel is installed coated with an inorganic zinc rich primer applied by the fabricator. The remaining steel is given a near white metal (SP-6) blast and primed with high build aluminum mastic primer. All the steel then receives a compatible mid-coat and top-coat. To date, CDOT has not used galvanized steel for member replacement. Where the bridge steel is exposed to view, the galvanizing makes good paint adhesion difficult. Since the bridges are in the middle of downtown Chicago, appearance is critical for these spans. Consideration is being given, however, to the use of galvanized steel for under bridge members which are typically not seen.
- **Bridge and sidewalk decks.** Bridge decks are a continuing source of problems and receive special attention. The steel open deck grating typically fails much sooner than the supporting steel stringers. The original wood bridge decks were replaced with five inch open steel grating in the late 1950's. To make up the difference in thickness of the wood decks and steel gratings, small "jack beams" were installed on the existing stringers. This grating was typically fully welded to the supporting stringers or jack beams. CDOT's practice is now to bolt the grating to the stringers which simplifies later maintenance and replacement. A welded galvanized five way grating is typically used for the deck replacement. CDOT has experienced problems with weld failures on this grating and has now standardized on the welded grating design that incorporates bearing bars at tighter spacing.

  To the greatest degree possible, CDOT's policy is to use concrete filled closed grating rather than open grating for movable bridge decks. Both half and full filled grating is used depending upon weight restrictions and the ability to balance the increased bridge weight in the counterweight area. The fully enclosed deck offers a much higher level of protection to the bridge superstructure over the open grating since less road salts and debris pass through the deck. CDOT has typically used a precast grating rather than cast-in-place concrete placement since this allows the bridge to be more easily balanced. There is a concern, however, that the joints between precast grating panels tends to focus the runoff at discrete places accelerated deterioration of the steel below. CDOT will be experimenting with a integral cast-in-place curb and deck design that will channel runoff to a trough at the end of the span near the fixed approach. The concrete used to fill the deck is typically a 4,000 psi chip type mix of normal weight concrete. CDOT is now considering the use of latex modified concrete in lieu of traditional concrete as a means of providing additional protection for the grating.

  Fiberglass composite deck material is being considered in lieu of the half or fully concrete filled steel grating for the bridge roadway decks. The fiberglass composite offers the advantage of being lighter in weight than concrete which makes it easier to balance the bridge and is less susceptible to deterioration from road salts than conventional steel grating. The fiberglass deck also is more "bike friendly" than the open steel grating. Steel bridge decks are thought to pose a significant safety hazard to cyclists. The fully closed deck is the solution to this problem but this cannot always be achieved with the existing steel deck/concrete fill technology.

  Bridge sidewalks are also a source of continuing concern. Thin, two inch galvanized steel concrete filled grating has been used for many bridge sidewalks. The sidewalk initially has a good walking surface, but "dimples" occur over time as salts and water pop the top layer of

concrete and make the surface uneven. Metallized steel panels have also been used as bridge sidewalks. These panels have not performed well in the field. The metallized coating debonds from the metal plate below leaving a slippery surface. Most recent bridge rehabilitations now used timber decking instead of metal or concrete panels. The timber is easily installed and can be cut to fit around the unusual shapes of the truss members. It can also be used to fully close all areas between the roadway and the walk. It is felt that the fiberglass panel system may perform the best in long service applications. The fiberglass has many of the benefits of timber in that it is relatively light in weight and can be easily cut to fit any applications. A full installation of the fiberglass panels for sidewalks is scheduled for the Madison Street Bridge.

- **Bridge centerlocks.** Bridge centerlock systems also receive special attention. The centerlocks are essential to transferring shear loads between the bridge leaves. They require constant shimming to maintain tightness and proper fit for operation. The existing locks are usually driven from a common shaft, the entire mechanism is subject to full exposure to dirt and salts and is not easily accessible. Stewart Machine Company has developed a self-adjusting lock that addresses many of the limitations of the existing centerlock systems. The lock system is designed to be mounted on the exterior of the bridge truss rather than within the truss. CDOT has worked with Stewart Machine to modify is cushion lock system so that it can be placed within the truss chord. The system has the advantage of eliminating the drive train that links both locks and is self adjusting over an extended period of time. The elimination of the shaft and large drive motors also allows for more filling of the bridge deck since the lost weight of the shaft and motors can be compensated for with filled deck.
- **Bridge House Restorations.** CDOT has also initiated a program to restore its historic bridge houses. As noted earlier, in many instances while the bridge structures themselves are considered historic, it is the bridge houses that truly make the Chicago movable bridges unique. The houses represent the styles in vogue at the time of their construction. Age and deferred maintenance have taken their toll on the exteriors and interiors of these unique buildings. Ornamental roofs leak, windows no longer operate or are rotted, terra cotta is damaged and failing, and whatever original ornamentation there was has been removed to reduce maintenance costs. CDOT now systematically performs full rehabilitations of each bridge house with new windows, new electrical and lighting, new heating,

Architectural Detail Restoration
Washington Street Bridge House

repaired or replaced roofs, historically correct colors and restoration of the features that made these houses unique. The most recent bridge house rehabilitations include historic "recreations" of the original architecture for the Kinzie Street and Grand Avenue bridge houses, restoration of the Washington Street bridge houses and soon to commence historic reconstruction of the Monroe Street bridge houses.

New Movable Bridges

The last truly new movable bridge built by the City of Chicago was the Columbus Drive bridge completed in the early 1980's. Prior to its construction, there had never been a movable span at this location on the Chicago River. During the 1970's and 1980's, movable bridges were also removed and no new bridges were installed in their places. The renewed interest in Chicago as a place to live, particularly near the City's Loop, has caused extreme pressure on the local streets system and many of the decisions to remove movable spans over the River are being called into question.

The phenomenal growth of the Near Northside centered around North Avenue has created near gridlock on the local street system. The active redevelopment of Goose Island, located between the North Branch and North Branch Canal of the Chicago River extending from Chicago Avenue on the south to North Avenue on the north, has created the need for more river crossings in this area. While this stretch of the Chicago River does not currently have movable bridges that operate, creating new points of access across the River may consider the adaptive reuse of existing historic movable spans. At least one of the locations under consideration may be used as a historic movable bridge museum where an historic bridge and its elements can be placed and used to demonstrate the evolution of movable bridge technology.

The South Loop area south of Harrison Street formerly had at least two movable bridges that spanned the South Branch of the Chicago River. The former railroad yards have been replaced by high rise and low rise developments. Access is limited between the east and west sides of the River. New crossings are under consideration for Taylor Street and 16th Street. These sites are unusual in that CDOT may consider the adaptive reuse of unused railroad bridges in lieu of the construction of entirely new bridges. The reuse of railroad bridges is appealing in that the bridges are in generally good condition and many bridges are considered historic.

Finally, the Calumet River area is also seeing a transformation from the site of basic industry to more sophisticated forms of industry relying on truck transportation. There is a long stretch of the Calumet River between 106th Street on the north and 127th Street on the south were there are no roadway crossings of the River. As this new industry grows, there is an increasing need to provide access across the River at more locations.

Conclusion

It is unlikely that the nature of traffic on the Chicago and Calumet River systems will change anytime in the foreseeable future. As such, Chicago will remain the home to the largest number of movable bridges found anywhere in the world. The challenge that CDOT continues to face is how best to maintain, operate and rehabilitate a bridge system that was conceived for high commercial river traffic volumes, but is now maintained nearly exclusively for recreational craft.

The interest in historic preservation makes these bridges even more unique since these are the only examples of this bridge type to be found anywhere in the world. In many ways, the architecture associated with these bridges is even more worth preserving for the way that it adds to the image that people have of Chicago.

CDOT is now looking at the preservation of railroad bridges, in particular movable bridges, since they also form part of the fabric of the City. Either in partnership with the railroads that still use them or independently for those bridges that are abandoned, Chicago is trying to find ways to preserve and reuse this other unique movable bridges infrastructure.

The reality remains, however, that any new bridge will in all likelihood be a refinement of the Chicago style trunnion bascule technology which has served the City of Chicago well for over 100 years.

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[1] Pihlferdt, Thomas G. (1920?). "The History and Development of the Chicago Type of Movable Bridge"
[2] Pihlferdt, Thomas G. (1920?). "The History and Development of the Chicago Type of Movable Bridge"
[3] Hess, Jeffery A., Historian (1999). Historic American Engineering Record (HAER) No. IL-111, "Chicago River Bascule Bridges, Development of Movable Bridge Technology in Chicago, 1890-1910"
[4] Department of Public Works Annual Report, 1890, 160, 162, 165; Engineering News 25 (23 May 1891) "A Folding-Floor Drawbridge"; and HAER IL-111.
[5] J.A.L. Wadell (1895). "The Halsted Street Lift-Bridge", American Society of Civil Engineers Transactions, Paper No. 742; and HAER IL-111.
[6] Schultz, Jr., John A. (1994). "Remember the Past to Inspire the Future, Historic Development of Movable Bridges"
[7] Pihlferdt, Thomas G. (1920?). "The History and Development of the Chicago Type of Movable Bridge"
[8] Chrzasc, Louis (2000). "The Movable Bridges of Chicago"
[9] Code of Federal Regulations, Title 33 "Navigation and Navigable Waters", Part 117 "Drawbridge Operation Regulations", Subpart B paragraph 117.391 "Chicago River".