Plank Road/Trail Assessment and Alternatives Report

District: Metro
County: Hennepin
City: Minneapolis

Date of Assessment: 01/08/2016

Prepared for: Minneapolis Parks and Recreation Board

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EXECUTIVE SUMMARY

Background

The plank road and trails (58-foot wide and 600-ft long) were completed in 2003 at a cost of over $1 million. In 2010, the 24 foot wide roadbed portion of the plank road in West River Parkway was removed and replaced with concrete at a cost of approximately $470,000. According to City of Minneapolis data, the average daily traffic on the road is approximately 6,000 cars with 550 pedestrians and 1,000 bicyclists per day on the north trail.

Although only eleven years old, many of the planks in the trail have warped and rotted and lag bolts have loosened and popped out. Concerns about the trail are the uneven surface, trip hazards, and maintenance demands. The intent of this report is to examine the existing condition of the plank trail and propose and evaluate alternatives for their maintenance, repair and replacement.

Plank Trail Issues

Common Issues on the Trails include:

1) Timber planks
    a. cupping and warping - tripping hazards
    b. gaps and joints - tripping hazards
    c. slippery surface especially when wet
2) Anchorage systems and hardware
    a. difficult to remove planks due to countersunk holes
    b. corrosion of bolts and non-standard sizes
    c. loss of connections – stripping of holes or loss of threads in bolts
3) Drainage system
    a. hat channels undersized
    b. base materials should be sloped at a higher grade
    c. drainage system has caused cracking in roadway
4) Base materials
    a. frost heave and settlement of aggregate under north trail stringers
5) Current Maintenance Protocols
    a. snow removal on north trail is done with a plow that damages trail
    b. snow is left on the trail through winter

Semi-Common Issues include:

1) Timber planks
    a. rotting and splitting due to environment including UV light
2) Timber stringers
    a. rot and decay due to moisture and ground contact
3) Adjacent features
    a. overgrown plantings and irrigation adjacent to south trail – leading to rot and decay

Recommended Improvement Alternative

The recommended alternative has been identified as Alternative 4c (full plank and stringer replacement implemented over 10 years). This alternative has a life expectancy of 35 years and will cost approximately $66,000/year over the next 10 years, with additional maintenance costs after completion.

This alternative would use a slightly enhanced maintenance protocol over the next 10 years, with 10% of the trail area being completely replaced each year for the next 10 years. This alternative will remove the existing timber and connection components and replace with:

- New timber members (continuous and more heavily treated)
- New hardware (standard sized stainless steel)
- Upgraded connection details (making plank replacement easier)
- New features such as tar paper hats on stringers
- Upgraded base materials (compaction and slope improvements)
- Improved maintenance plans for the future (snow removal, non-skid coating, tracking costs)

1.0 INTRODUCTION

The plank road was constructed by the Minneapolis Parks and Recreation Board (MPRB) in 2003 as an interpretive feature in Mill Ruins Park. As part of the park development, construction of an approximately 600 foot long wood plank roadway surface, now known as the plank road was completed at a cost of over $1 million. The project also included accompanying pedestrian facilities, lighting, furnishings, signs, and landscaping. The plank road was built in the alignment of the original wood plank decking which once covered the main water canal powering the mills of the West Side Milling District. According to City of Minneapolis data, the average daily traffic on the road is approximately 6000 cars. The north trail sees an average of 550 pedestrians and 1,000 bicyclists per day. The south trail is primarily limited to pedestrians and no counts are available.

The plank road and trails were 58 feet wide when installed in 2003. In 2010 because of numerous complaints from local residents, the 24 foot wide roadbed portion of the plank road in West River Parkway was removed and replaced with concrete (a quieter and more resilient surface) – at a cost of approximately $470,000. A 20 foot wide plank section, which is now a pedestrian/bicycle trail along the river side (north) of the parkway remains, as does a 14 foot wide plank section for pedestrians on the inland side (south) of the parkway. In total, the remaining plank road trails are 21,000 square feet. Exposed steel rail bumpers divide the pedestrian/bicycle areas from the parkway roadbed. The north trail is a part of the Grand Round Trail System.

The remaining portions of original the plank road trail consist of 3”x10” white oak planking (untreated) with a substructure of two 2”x8” (treated) Southern Yellow Pine stringers stacked on top of each other. Below the substructure/stringers on the south side is a six inch concrete slab, while on the north side the stringers bear on 1 foot deep aggregate fill. The wooden planking is held in place with lag bolts and the pine stringers are held in place with anchor bolts to the concrete slab. Below the concrete subgrade lies the historic waterpower canal, which has been filled with sand to protect it.

Although only eleven years old, many of the planks in the trail have warped and rotted and lag bolts have loosened and popped out. The community and Minneapolis Park Board are concerned about this segment of the Grand Rounds Trail, because of its uneven surface, trip hazards, and maintenance demands. The intent of this report is to examine the existing condition of the plank trail and propose and evaluate alternatives for their maintenance, repair and replacement.

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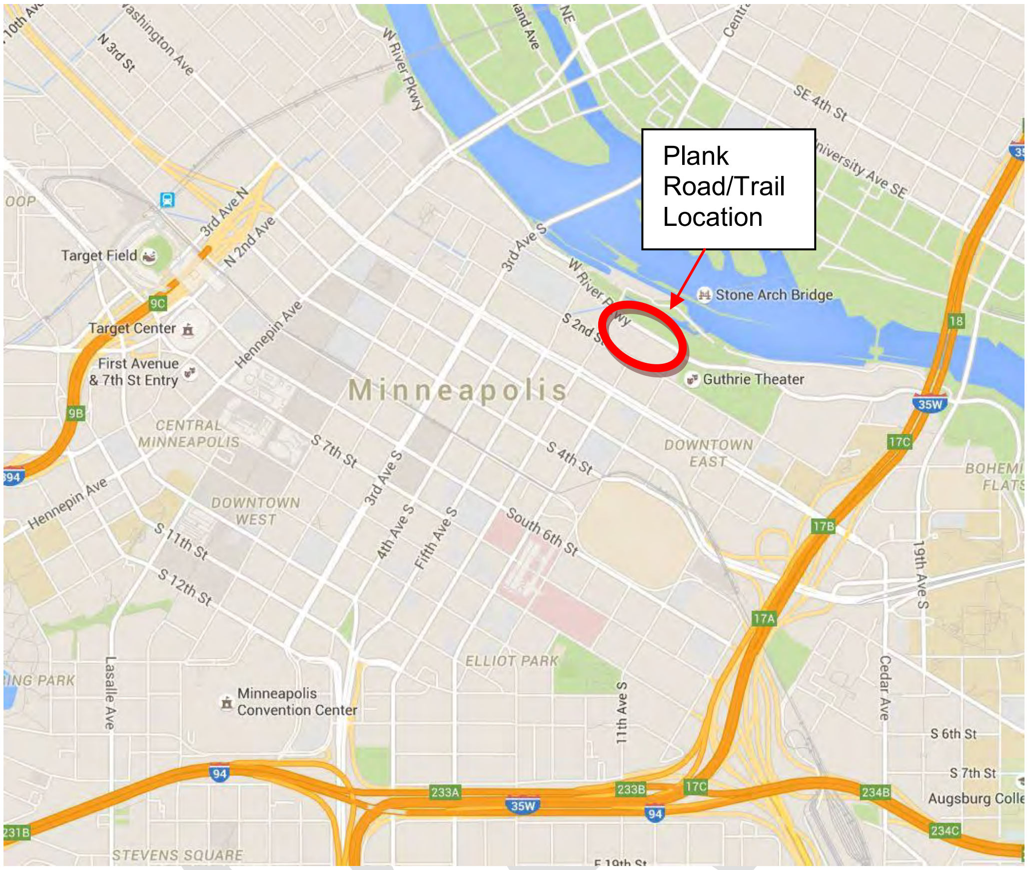


Figure 1: Project Location Map

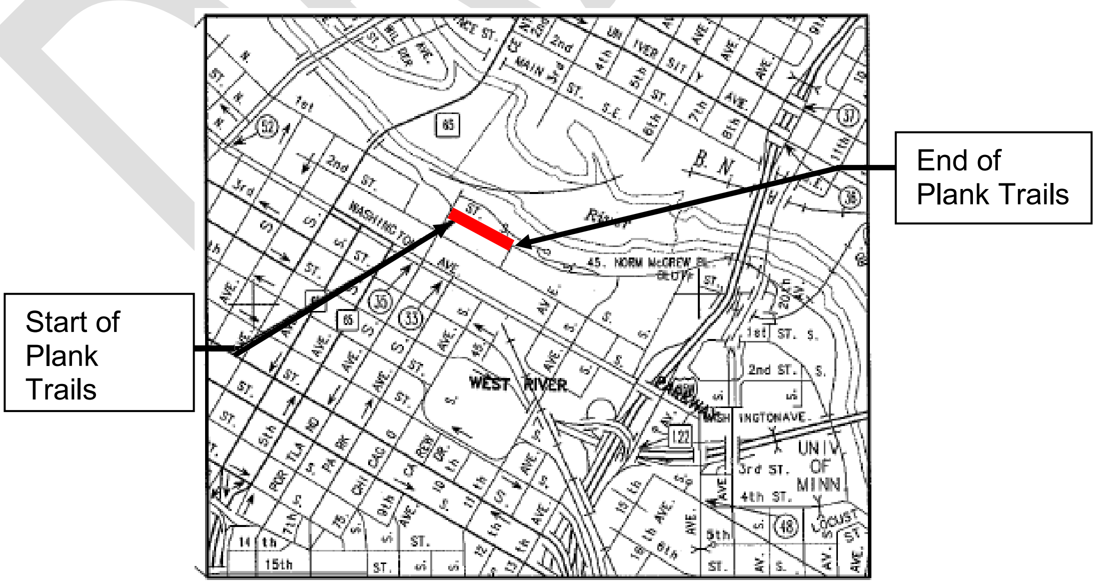


Figure 2: Project Location Map

Figure 3: Aerial View of Plank Road

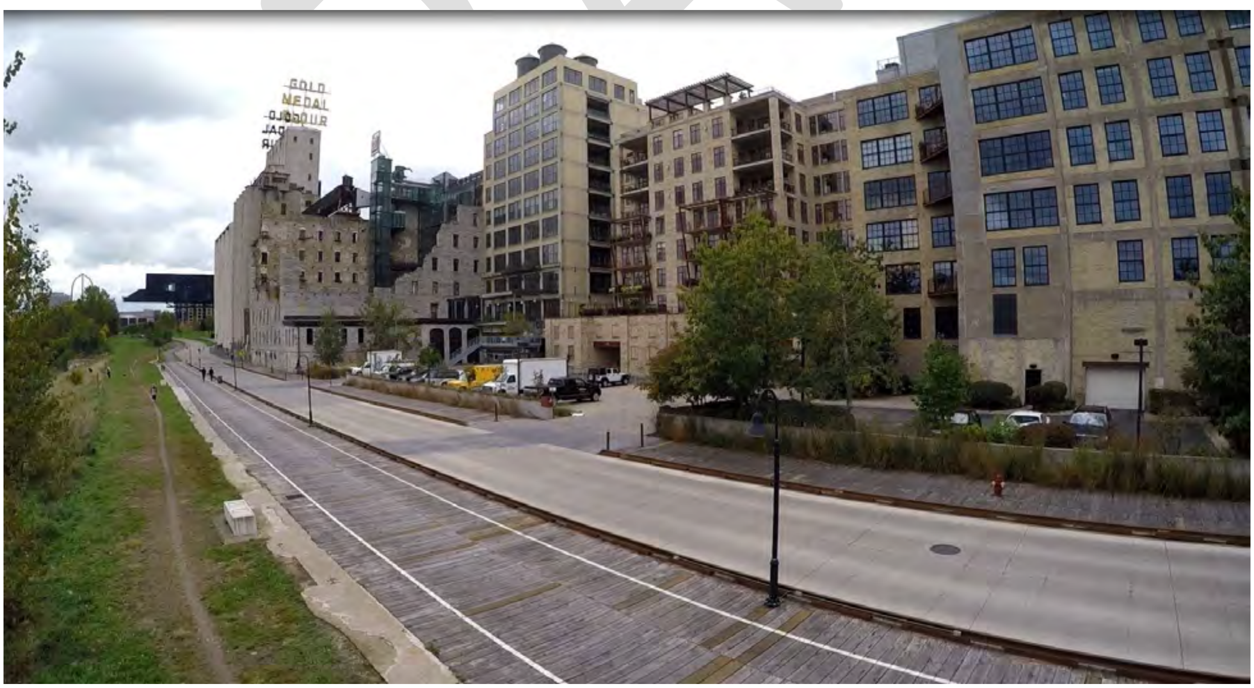


Figure 4: Plank Road/Trail Photograph (Looking East)

2.0 EXISTING CONDITIONS

2.1 Overall Site Review

WSB visited the plank road/trail on multiple occasions between August and November to collect data and make field observations. The general observations are as follows:

- The original planks have faded in color significantly and cupping/warping was observed in a number of planks.
- It was noted that each plank end attaches to a stringer with one bolt in a corner of the plank. In many locations this has resulted in bowing of the unrestrained corner which has become a tripping hazard. This can be seen in Figure 7.
- The plank seams (butt ends) are warping near the center of the north trail.
- Approximately 66 panels on the north trail have been replaced in the last 3 years.
- Approximately 20 panels on the south trail have been replaced in the last 3 years.
- The north trail appeared to be in worse condition than the south. This may be attributed to the north side experiencing more sunlight, increased traffic, event trucks parking, snow blade plowing.
- Some planks have begun to rot and deteriorate, which is not unusual for the age of the untreated lumber.
- Deterioration and rot was noted in a few of the stringers, but this is not seen as a major condition issue with the trail at this time. Over time the rot/decay of the stringers will become a more major issue, as their replacement is a tedious and expensive task.
- Some of the bolts holes in the stringers have been stripped and no longer have the ability to tightly connect the planks to the stringers. This could be remedied with an epoxy adhesive, which is a process that would make plank removal even more difficult.
- Corrosion of bolts and loss of threads has occurred and is leading to some loose planks. This corrosion is caused by rain water, treatment chemicals in the timber, and the salt used on the adjacent roadway.
- The planks are difficult to remove and replace because the bolts are countersunk. These countersunk holes fill with dirt and the sock heads MPRB crews have available to fit the bolt heads are too wide for the countersunk holes. Moreover, there is not a consistent bolt size being used throughout the trail. It takes approximately 10 to 15 minutes to remove each plank (or five minutes per bolt).
- Vegetation planted on the south side of the parkway between the trail and the adjacent parking ramp, will lead to accelerated deterioration of the timber members. This can be seen in Figure 8. Irrigation in the planted border along the south trail and the adjacent building, will also lead to accelerated deterioration of the timber members.
- The drainage was designed so the south trail stormwater flows under the roadway through “channels” and into a drain tile system under the north trail with outlets into a large concrete channel. This concrete channel takes the stormwater to the far eastern end of the road/trail and outlets into a storm sewer, which takes the stormwater back to the west and eventually into the Mississippi River.
- Visual inspection of the gutter and channel system suggests that very little stormwater is reaching the channels.
- Transverse cracks in the concrete road, corresponding with the drainage “channels” below the roadway, are present every 5 -6 ft.

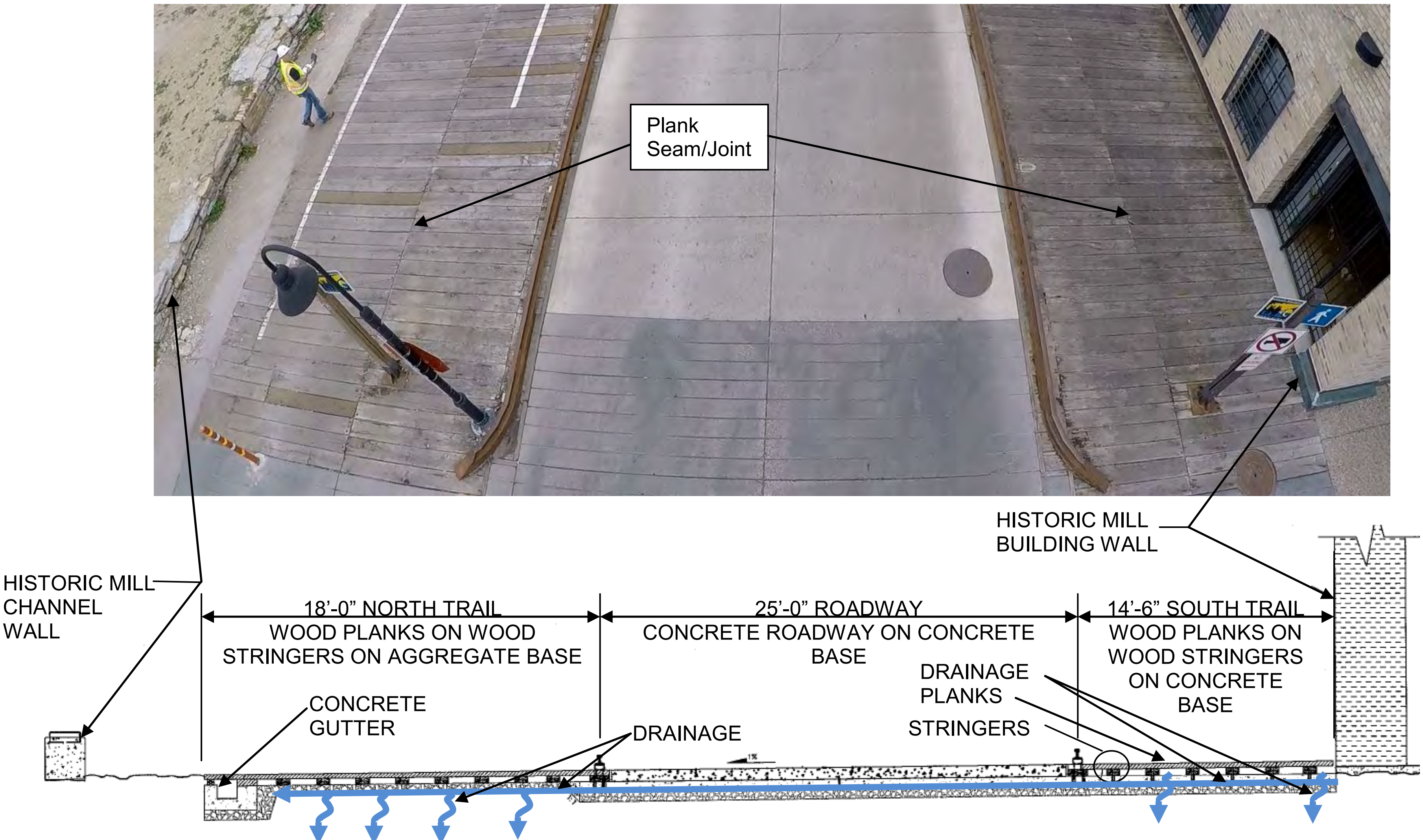
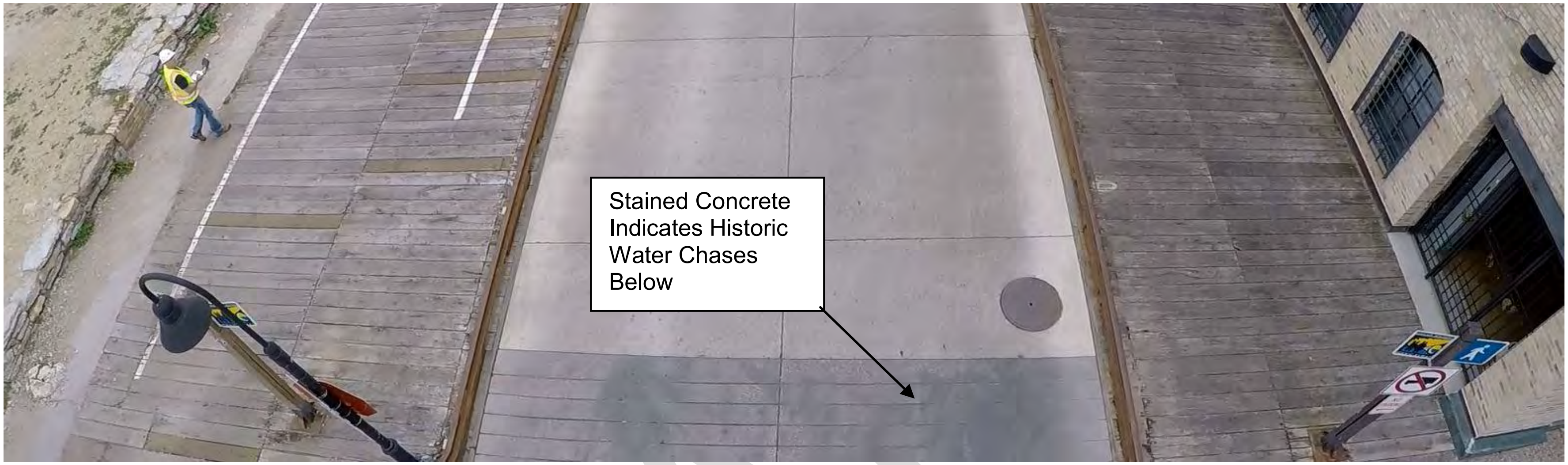


Figure 5: Plank Road/Trail Cross-Section (Looking East)



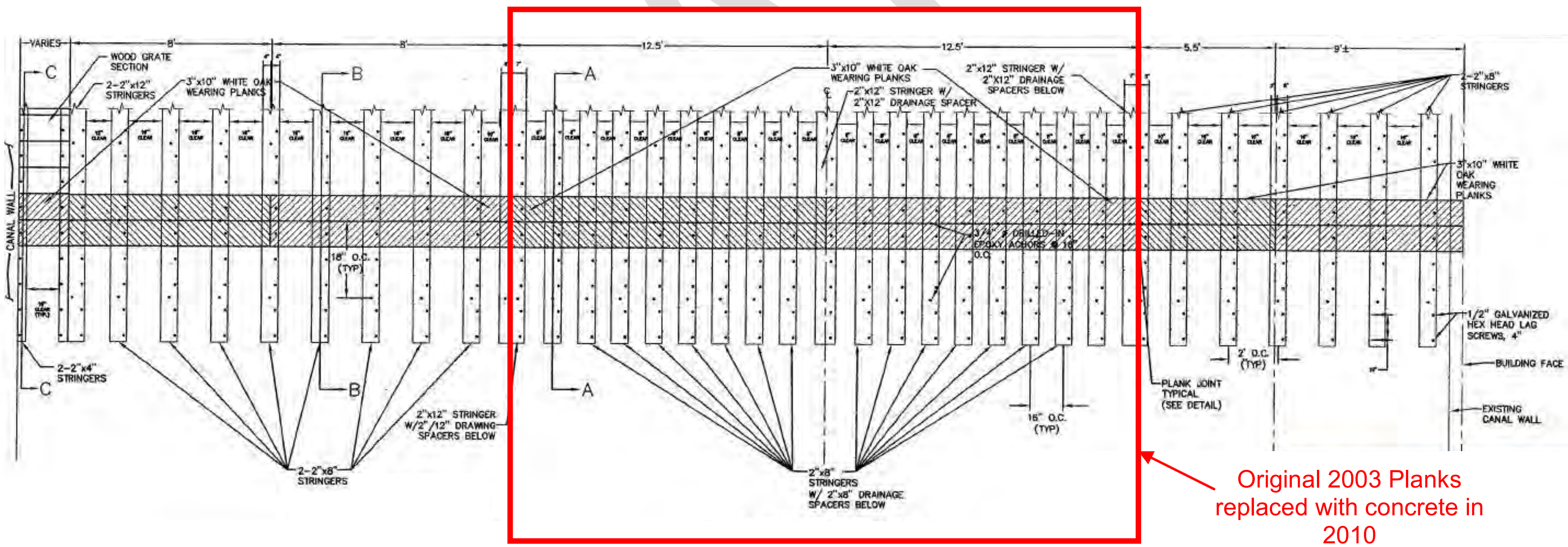


Figure 6: Plank Road/Trail Plan

2.1.1 Summary of Issues

Component	Issue	Frequency	Severity
Timber planks	Cupping and warping resulting in tripping hazards	Common	Severe – ADA compliance issue
Timber planks	Slippery - especially when wet	Common	Moderate – ADA compliance issue. Roughen boards or gritted stains would help.
Timber planks	Rot, deterioration and fading	Semi-common	Moderate –ADA and Maintenance Issue. Treated planks are recommended.
Timber planks	Gaps and warping at seams/joints	Common	Moderate - ADA compliance issue. More screws or bolts are recommended.
Anchorage hardware	Corrosion and loss of threads on bolts	Semi-common	Moderate – issue for maintenance crews.
Anchorage hardware	Loose and missing bolts	Semi-common	Moderate - ADA compliance issue
Anchorage hardware	Difficulty in removing countersunk bolts due to MPRB socket heads not fitting	Common	Moderate – issue for maintenance crews.
Timber stringers	Minor deterioration and rot	Not common	Minor – Will become a major Maintenance Issue in 10-20 years
Base aggregate	Minor settling due to free/thaw, traffic vibrations, and trucks weights	Semi-common	Minor – Settlement has ceased.
Sprinkler system and ornamental vegetation	Present along south trail, leading to premature rotting	Semi-common	Moderate – These elements will continue to deteriorate the wood elements
Drainage system	Drainage channels are undersized. May limit drainage under roadway.	Common	Minor – Drainage is occurring more through percolation into the ground.
Drainage system	Channels are sheet metal versus thicker structural metal. Likely contributed to roadway cracking	Common	Minor – Small roadway cracks could be repaired with epoxy injections
Snow removal	Current practice is to plow the north trail and blow the south trail. Plows damage the timber decking and remove bolts.	Common	Moderate – Plow blades will continue to shorten the longevity of the planks. Blowing both trails is recommended.

Table 1: Summary Plank Trail Issues

Figure 7: New Plank and Bowed Existing Plank over Butt Seam on North Trail

Figure 8: Plank Rot and Landscape Vegetation on South Trail

2.2 Plank Review

The original planks are rough-cut, untreated 3”x10” White Oak. The planks have begun to rot, deteriorate and warp. Some planks have been replaced through the years with treated timber. These newer treated planks appear to be in good condition. WSB recommends using full-length treated timber in the future. Treated timber has a substantially longer life span than untreated and full length planks (16’-0” on the north trail) will remove the nuisance butt seam/joint in the north trail. Common treatments include Alkaline Copper Quaternary (ACQ) and Ammoniacal Copper Zinc Arsenate (AZCA). **WSB recommends using 3”x10” Southern yellow pine treated with minimum 0.6 lb/ft^3 ACQ concentration.** This is recommended due to its non-toxic properties, durability, protection qualities and compatibility with Southern Yellow Pine - as compared to the other chemical treatments at this time. See Appendix A for more information on wood treatments.

Each plank end attaches to a stringer with one hex-bolt in a corner of the plank as seen in Figure 10. These bolts are oversized and should be decreased in size. In some cases the unbolted corner has cupped and bowed out of plane, causing a tripping hazard. In addition, bolts that connect the planks to the stringers below have begun to rust and some have lost their threads. Exposure to salt may have accelerated this process. In the future, bolts should be hot dip galvanized or stainless steel. Access to the bolt heads has become limited in some areas due to buildup of dirt and debris in the countersunk holes. WSB has identified that the current anchorage system appears to be tedious and will discuss this system in more detail with the Minneapolis Park Board maintenance crews. It is believed that a stainless steel round head bolts or screws at each corner of the plank may be a better detail. Only galvanized or stainless steel bolts should be used as wood treatments and road salt corrodes steel quickly.

Figure 9: Corroded Bolt that has Lost its Threads

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Figure 10: Countersunk Bolts

Figure 11: Warping at Butt Seam/Joint in the Center of the North Trail

WSB consulted with different timber suppliers in the metro area and came up with the unit lumber prices found in Table 2 below.

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Wood	Size	$	Treatment	Longevity
White Oak	3x10	$3.5/ft	None	Ten years based on current project
White Oak	2x10	$6/ft	None	Ten years based on current project
Douglas Fir	3x10	$4/ft	ACZA	20 - 40 years
Douglas Fir	2x10	$2/ft	ACZA	20 - 40 years
Southern Yellow Pine	3x10	$4.5/ft	ACQ	20 - 40 years
Southern Yellow Pine	2x10	$1.5/ft	ACQ	20 - 40 years
Composite	2x8	$9.5/ft	None	25 Years

Table 2: Typical Wood Costs in 2015 Dollars per Linear Foot

WSB recommends SYP 3x10 (or 2x10 with shims)

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2.3 Substructure Review

The substructure consists of two 2”x12” stringers stacked on top of each other, with some offsetting to allow water to drain past the stringers. The stringers are yellow pine and have been treated with ACQ. The concentration of ACQ is not known, as it was not specified in the plans. It is assumed that the ACQ concentration was 0.06 lbs/ft^3. In general the stringers have found to be in good condition. During WSB’s field investigation one stringer was found to have 1.25” to 2” of rot. This is not believed to be typical. The south trail stringers are anchored into the concrete while the north trail stringers rest on an aggregate base.

Figure 12: Deteriorated Stringer at North Trail

2.4 Drainage Review

The drainage system consists of non-galvanized 1”x1” hat channels (see Figure 19), instead of the planned 1”x4” structural channels (galvanized), under the concrete road. The hat channels are less stiff than the structural channels, so cracking has occurred in the pavement in these locations. The hat channels take the drainage from the south trail to the north trail. Under the north trail (in the aggregate layer) is a 4” perforated pipe (running perpendicular to the roadway) which collects the channels drainage and empties into a concrete channel gutter system, which runs along the entire length of the north trail (see Figure 14). All stringers have 6” drainage gaps spaced every 4’-6”. The south trail rests on a concrete slab as opposed to the drainage aggregate on the north. Transverse cracks were observed in the concrete road in 5’-0” to 6’-0” intervals. It was determined that these cracks were above the drainage hat channels.

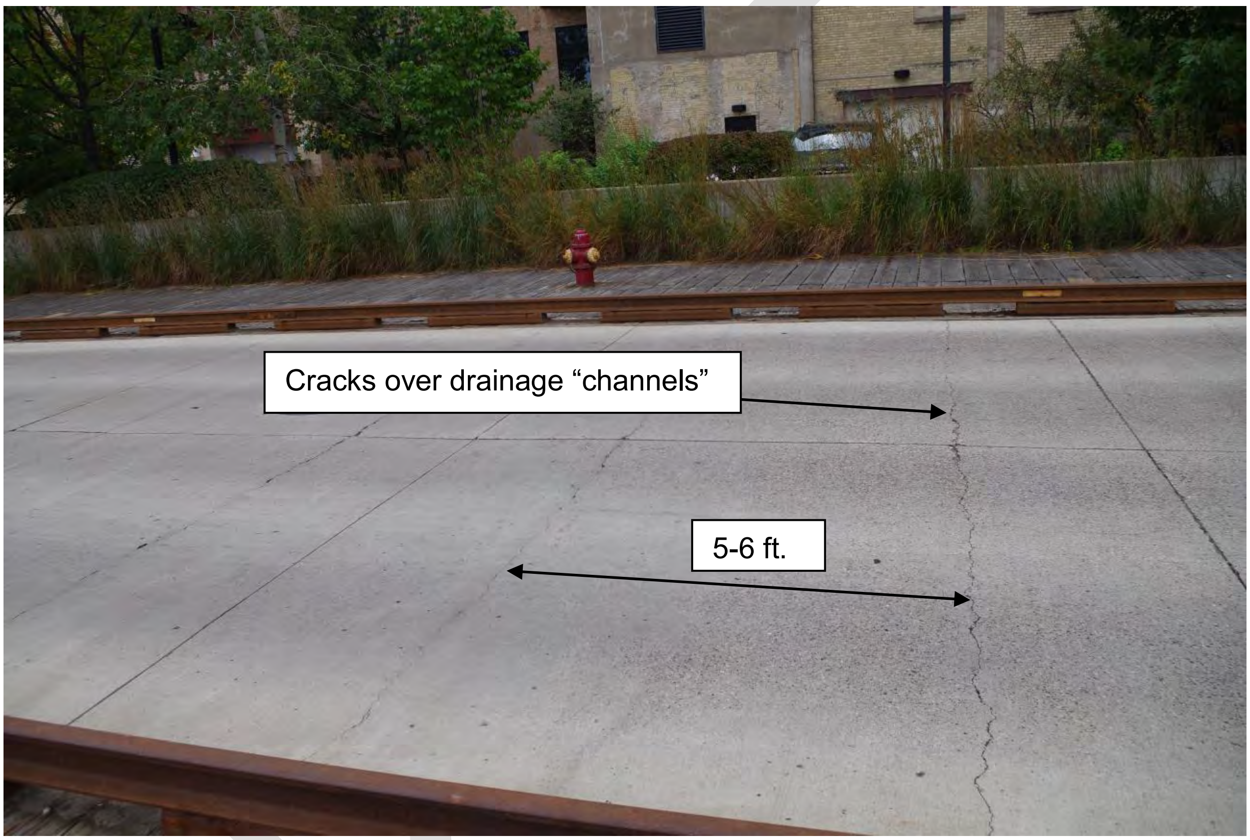

Figure 13: Transverse Roadway Cracks over “Channels” (Looking South)

The day after a rain event WSB visited the plank road and observed that the concrete gutter system along the north end of the north trail appeared to be unused. The cleanliness of the concrete gutter after 10 years is evidence that it is not being used. The storm water is likely draining directly into the groundwater through the north trail's aggregate base. Figure 14 shows the gutter one day after a rain event.

Figure 14: Concrete Gutter System on North End of Trail

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Figure 15: 4-inch Diameter Drain Tile Outlet to Concrete Gutter

Figure 16: Drainage Hat Channel on South Edge of Trail

2.5 Geotechnical Review

Settling of the base aggregate (under the stringers) has occurred on the north trail. The settling has stabilized and is not anticipated to continue. It is unknown whether or not the aggregate was properly compacted prior to the installation of the timber stringers. Since the trail is at-grade, it is susceptible to freeze/thaw cycles which can cause heaving. WSB performed structural calculations of the bearing requirements of the subgrade and has determined that this is not an issue. If major rework is done on the north trail, it is advised to install a concrete slab subgrade, which is similar to the south trail. This will ensure a more uniform settlement in the future.

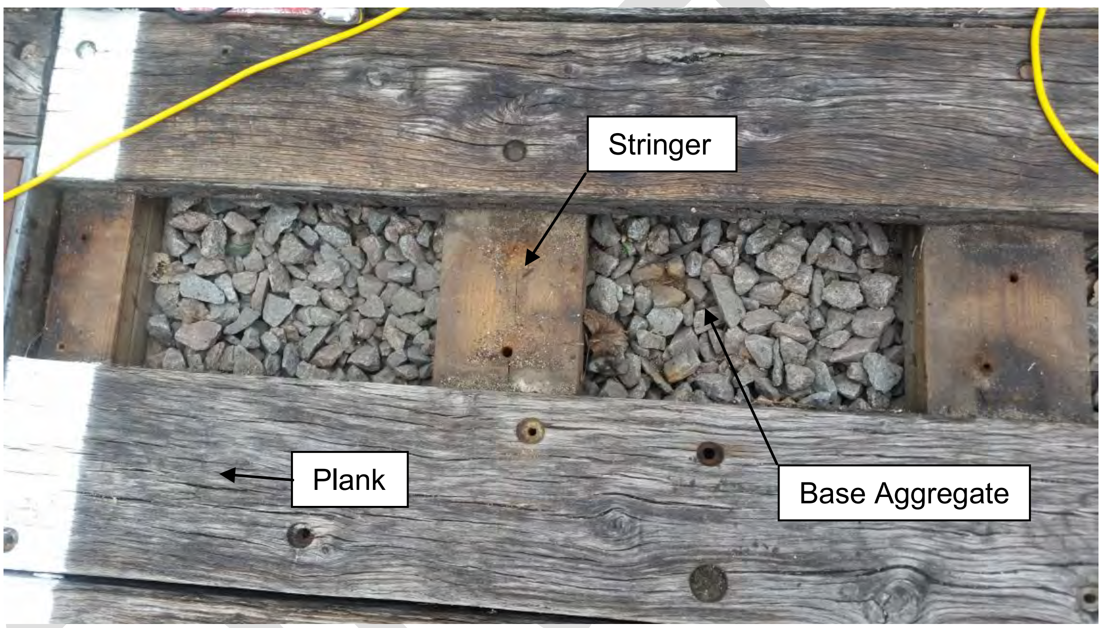

Figure 17: Base Aggregate under Stringers on North Trail

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2.6 Americans with Disabilities Act Review

Certain accessibility requirements related to the Americans with Disabilities Act (ADA) apply to the plank road trail. As of December 2015, the United States Access Board is in the process of developing new accessibility guidelines for public rights of way. Proposed guidelines for pedestrian facilities were released in 2011 and supplemented in 2013. As described in the supplemental notice, the proposed guidelines include a provision that "a pedestrian access route shall be provided for the full width of a shared use path." Essentially, this means that for the purposes of grades, cross slopes, and surfaces, the provisions for shared use paths are the same as for sidewalks (which are referred to as "pedestrian access routes" in the draft guidelines). This would mean the plank road trail would fall under this category.

While these guidelines have not yet been finalized, the proposed rule offers an interim source of guidance until the final guidelines are published and are implemented as enforceable standards by other agencies.

Surfaces: The surfaces of pedestrian access routes shall be firm, stable, and slip resistant. No numerical values are given for this requirement. The plank road trail could violate the surface Requirements, as it is slippery when wet, unstable when bolts are missing, and soft when the wood is rotted.

Vertical Alignment: Vertical alignment shall be generally planar within pedestrian access routes (including curb ramp runs, blended transitions, turning spaces, and gutter areas within pedestrian access routes) and surfaces at other elements and spaces required to comply with R302.7 that connect to pedestrian access routes. Grade breaks shall be flush. Where pedestrian access routes cross rails at grade, the pedestrian access route surface shall be level and flush with the top of rail at the outer edges of the rails, and the surface between the rails shall be aligned with the top of rail.

Vertical Surface Discontinuities: Vertical surface discontinuities shall be 13 mm (0.5 in) maximum. Vertical surface discontinuities between 6.4 mm (0.25 in) and 13 mm (0.5 in) shall be beveled with a slope not steeper than 50 percent, as shown in Figure 18. The bevel shall be applied across the entire vertical surface discontinuity. The plank road often violates the vertical surface discontinuities requirements due to the bowed nature of the planks. Figure 7 shows one instance of this. WSB would expect this condition to worsen as the planks continue to age.

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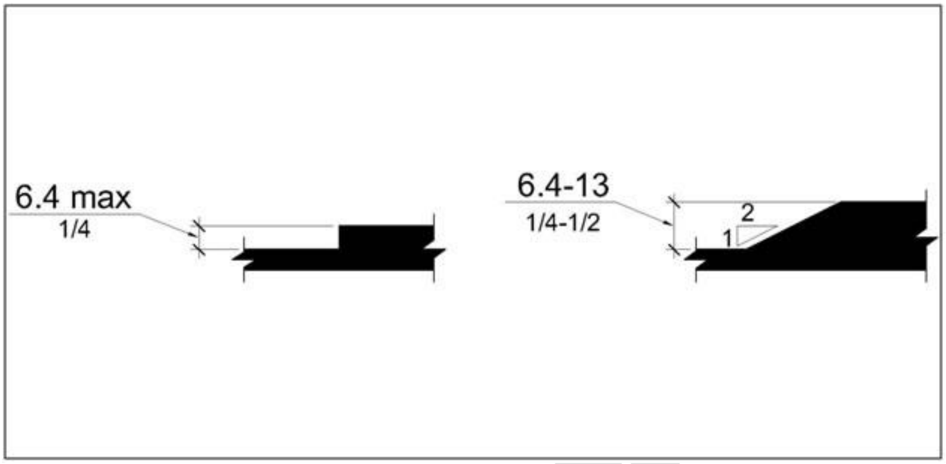

Figure 18: ADA Vertical Surface Discontinuities

Horizontal Openings: Horizontal openings in gratings and joints shall not permit passage of a sphere more than 13 mm (0.5 in) in diameter. Elongated openings in gratings shall be placed so that the long dimension is perpendicular to the dominant direction of travel. In general the plank road satisfies the horizontal opening conditions. Though, in some locations with deterioration the gap may exceed 1/2 inch especially in the areas with vegetation.

2.7 Maintenance Procedure Review

Current maintenance procedures for the plank road trail are as follows:

- Snow on the North Trail is removed by a plow with a metal blade
- Snow on the South Trail is removed with a blower
- Salt and sand are used on the trail 6-12 times a year when icy
- Obvious rotted planks (about a dozen) are replaced each year
- Obvious loose bolts are replaced or tighten once a year

WSB recommends using a blower on the North and South trails to remove snow. Due to the uneven nature of the trails, metal blade plows may damage the planks. The blades also may shear the bolts if they extend above the plank surface.

WSB also recommends applying a non-skid clear coating to the planks. This coating should be applied 1-2 years after new planks have been installed, and around one every five years after that. The coating (polyurethane type product) will minimize damage to the planks from ultraviolet light damage and moisture, while also improving traction on the surface.

The maintenance of the plank road trail should be a planned event in both the spring and fall. Damaged planks should be replaced, loose bolts should be tightened and missing bolts should be replaced. WSB recommends that all replaced timber products be heavily treated with preservatives and all metal be galvanized or stainless steel. These plank road trail maintenance efforts should be given a specific job number, so maintenance demands are more accurately tracked and forecasted.

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3.0 PRELIMINARY IMPROVEMENT OPTIONS

The following section outlines some trail improvement options for the north and south trails. Table 3 summarizes the rehabilitation and replacement alternatives for the plank road trail.

Alternative ID	Construction Cost ($ 2016)	Longevity	Life-cycle Cost * ($ 2016)	Comments
1 - Do Nothing	$0	5-10 years	$0	Complete trail closure in 10 years
2 - Partial Plank Replacement - Existing maintenance Protocol	$15,000/yr	10-20 years	$300,000 at 20 years	Existing maintenance protocol. Stringers will eventually deteriorate and limit trail lifespan
3 - Full Plank and Selective Stringer Replacement	$360,000	25 years	$515,000 at 25 years	Stringers will eventually deteriorate and limit lifespan. Trail maintenance will be less than present efforts.
4a - Full Plank and Stringer Replacement (Light Duty)	$580,000	35 years	$700,000 at 35 years	There are a range of options with this. Planks (full-length) and stringers would be treated lumber. A concrete or porous base could be added to the north trail. Limit joints.
4b - Full Plank and Stringer Replacement (Heavy Duty)	$820,000	40 years	$915,000 at 40 years	There are a range of options with this alternative. Base aggregate on north trail replaced with concrete or porous pavement. Stringers are concrete or more durable composite material. Limit joints.
4c – Combination of 4a and 2 - Full Plank and Stringer Replacement Incrementally in a 10 Year Period.	$66,000/ yr over 10 years ($660,000 total)	35 years	$705,000 at 35 years	Same as 4a, except full plank and stringer replacement would take place in 10 sections over a 10-year period (60 LF per year) with partial plank replacement as needed for the unimproved sections.
OPTIONS WITH LOSS OF HISTORIC INTERPRETIVE VALUE				
5a – Composite Decking on Existing Stringers	$550,000	20 years	$645,000 at 20 years	There are a range of options with this alternative. Perhaps the north and south trail are different. Planks would be more durable composite material. Limit joints.
5b - Asphalt	$245,000	15-20 years	$275,000 at 20 years	Typical bituminous trails and maintenance costs.
5c - Concrete	$600,000	50 years	$650,000 at 50 years	Typical concrete maintenance. Longest lasting and lowest maintenance option.
6 - Concrete and Asphalt (North Trail Only)	$160,000 for north trail only *$280,000 for both trails*	25-40 years	$200,000 at 40 years or *$350,000 for both trails at 40 years*	Typical bituminous trail and maintenance costs.
7 – Plank and Asphalt. (North Trail Only)	$400,000 for north trail only or *$700,000 for both trails*	25-35 years	$490,000 at 35 years or *$850,000 for both trails at 35 years*	Complex trail with mixed pavement and timber framing systems. Possible uneven settlement.

* Does not include inflation or interest

Table 3: Summary of Trail Alternatives

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3.1 Alternative 1: Do nothing

The simplest option is to do nothing. The planks will continue to warp, rot and disfigure. In the next 5 years WSB would expect 100-150 more planks would need to be replaced and another 200-300 in 10 years. In other words, a majority of the planks will need to be replaced in the next 10 years. Rot and corrosion will compromise the connections between the planks and the stringers. There will be numerous tripping hazards due to the warping of the planks. The trails will become unfit for use and the trails will need to be closed.

- Pros
  - No cost
  - Money not spend on rehabilitation could be allocated towards replacement

- Cons
  - The road will fall in to disrepair and become unsafe for use
  - Community will be unhappy with trail closure

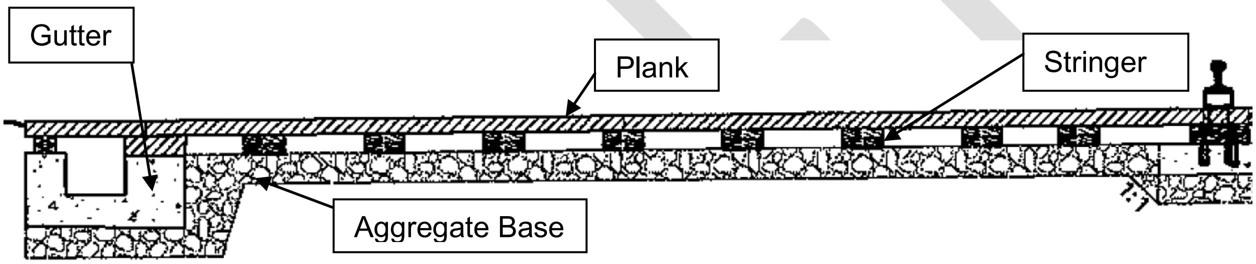

Figure 19: North Trail Typical Section

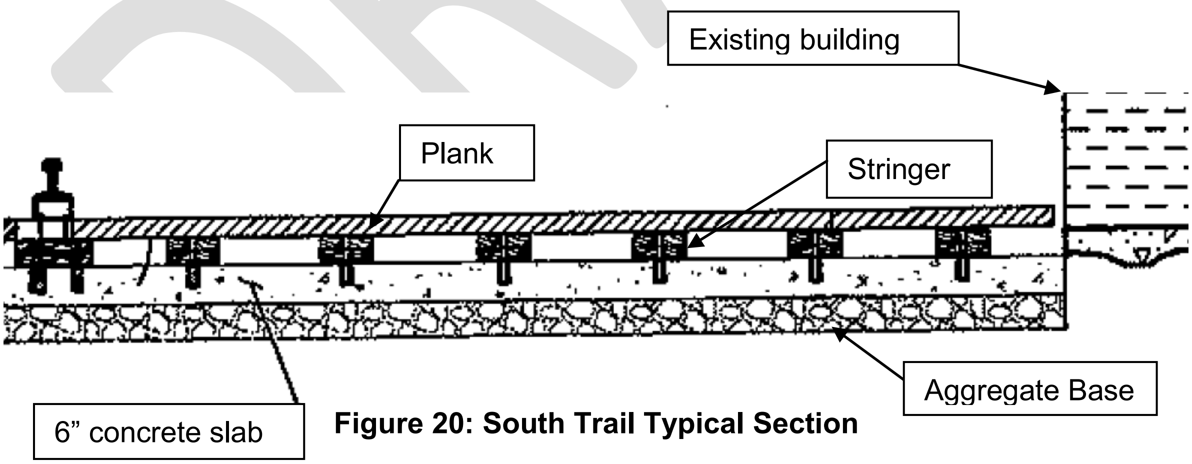

Figure 20: South Trail Typical Section

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3.2 Alternative 2: Replace Planks as Needed

One repair option is to continue to replace planks on an as needed basis, which is the existing repair procedure. The planks considered to be in the worst condition would be replaced with new full-length treated planks – improving durability and slowly removing the center seam/joint. Bolts or screws in each corner of the plank would be installed to reduce the warping of the corners. There are multiple options in terms of a replacement plank including a composite material. Table 2 shows different wood species and their cost. WSB recommends Southern Yellow Pine treated with 0.6 lb/ft^3 ACQ or Douglas-fir, treated with 0.6 lb/ft^3 ACZA or Copper Azole CA-C. This solution has a low cost but is only a temporary fix.

Other work anticipated with this option is to remove any landscaping and sprinkler system adjacent to the timber planks. These elements accelerate the deterioration of the timber.

Cost: Replacing the 50 planks in worst condition annually (split between spring and fall).

Materials:	$5,000 ($5/LFT x 800 LFT + Hardware)
Labor:	$10,000
Total:	$15,000/year

- Pros
  - Can be done as budget and time allow
  - Low cost
  - Historical context is maintained
  - Cost effective solution until stringers need replacement
  - Trails do not need to be closed for long duration

- Cons
  - Not a long term solution (roughly 10-20 years)
  - Repairs or modifications to the subgrade can't be performed
  - Will get more costly as trail continues to age

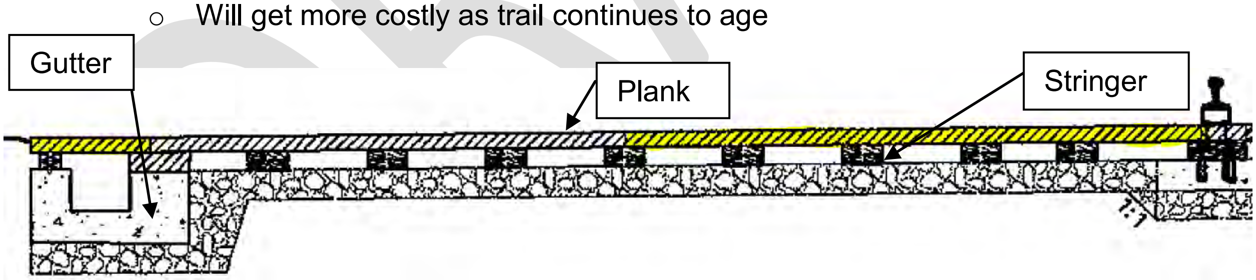

Figure 21: Typical Section Alternative 2
(Yellow highlight indicates typical areas of removal/replacement)

Figure 22: Plank with Anchorage in Each Corner

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3.3 Alternative 3: Full Plank Replacement with Selective Stringer Replacement

Another option is to completely replace the existing untreated planks with new treated planks. This option would easily allow for the use of one long plank to replace two of the old planks (16 feet long – removing the center seam/joint). New lag screws or round headed bolts in each corner of the plank would be installed to reduce the warping of the corners. This would help keep warping in the center down and reduce tripping hazards in the corners. A better anchorage system could also be implemented to reduce the difficulty and time it takes to remove the planks.

There are multiple options in terms of a replacement plank including a composite material. Table 2 shows different wood species and there cost. WSB recommends Southern Yellow Pine treated with 0.6 lb/ft^3 ACQ or Douglas-fir, treated with 0.6 lb/ft^3 ACZA or Copper Azole CA-C. The stringers would be replaced based on an as needed basis based on the level of deterioration. The stringers should also be composed of heavily treated timber. Another feature that could be utilized to prolong the life of the stringers is to use tar paper hats over all of the stringers. Some stringers could be reused with the use of an epoxy fill where the bolt holes have been stripped.

Other work anticipated with this option is to remove any landscaping and sprinkler system adjacent to the timber planks. These elements accelerate the deterioration of the timber.

Materials Cost:	$130,000 ($5/LFT X 22,000 LFT + Hardware)
Labor Cost:	$230,000
Total Cost:	$360,000

- Pros
  - Long life span
  - Improved trail performance
  - Small modifications/improvements to the substructure can be performed
  - Would allow a thorough investigation of trail substructure condition
  - Maintains the historic context
- Cons
  - High cost
  - Eventually the same condition issues will arise
  - Trail closure during construction
  - Will be replacing some planks in good condition
  - Some of the substructure will remain in place
  - Base aggregate and frost heave will still occur

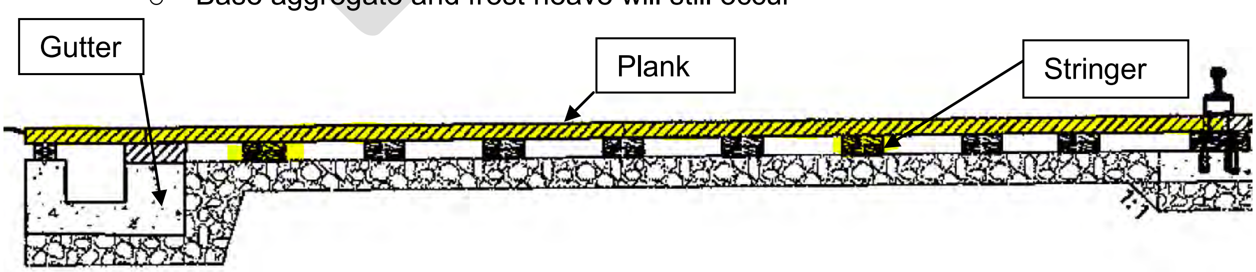

Figure 23: Typical Section of Alternative 3
(Yellow highlight indicates typical areas of removal/replacement)

3.4 Alternative 4a: Full Plank and Full Stringer Replacement (Light-Duty)

A further option is to completely replace the trails with new full-length treated planks and stringers. This option would be similar to the previous option, but with all stringers being replaced. The stringers could be heavily treated timber covered with tar paper. The planks anchorage connections should be improved for this option. Discussions with the designer, supplier, contractor and maintenance crews should take place to identify the most efficient and durable system.

This option does not appear to be warranted at this time, due to the relatively good condition of the stringers. A better time to utilize this alternative would be in approximately 20 years, when the condition of the stringers worsens and requires improvement. This option seems best suited for the south trail. Some stringers could be reused with the use of an epoxy fill where the bolt holes have been stripped.

Other work anticipated with this option is to remove any landscaping and sprinkler system adjacent to the timber planks. These elements accelerate the deterioration of the timber.

Materials Cost:	\$200,000 (\$6/LFT X 28,000 LFT + Hardware)
Labor Cost:	\$380,000
Total Cost:	\$580,000

- Pros
  - Long life span
  - Modifications to the subgrade can be performed
  - Retains the historic context

- Cons
  - High cost
  - Many of the same condition issues will arise again
  - Replacement of some members that are in good condition
  - Trail closure during construction

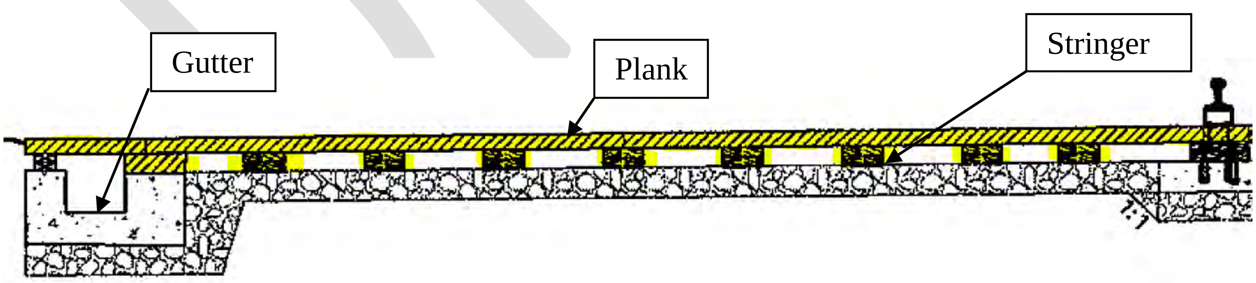

Figure 24: Typical Section of Alternative 4a
(Yellow highlight indicates typical areas of removal/replacement)

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3.5 Alternative 4b: Full Plank and Stringer Replacement – Heavy Duty

Another option is to completely replace the trails with new full-length planks, stringers and base (for the north trail). This option would be similar to the previous option but with all stringers being replaced with a more durable material. The stringers would be a durable material like concrete or plastic. The aggregate base under the north trail would be replaced with a concrete slab or porous pavement, similar to the current condition at the south trail. The planks' anchorage connections should be greatly improved for this option. Discussions with the designer, supplier, contractor and maintenance crews should take place to identify the most efficient and durable system. This alternative seems like it would be best utilized on the larger and more heavily used north trail.

This option does not appear to be warranted at this time, due to the relatively good condition of the stringers. A better time to utilize this alternative would be in approximately 20 years, when the condition of the stringers worsens and requires improvement.

Other work anticipated with this option is to remove any landscaping and sprinkler system adjacent to the timber planks. These elements accelerate the deterioration of the timber.

Materials Cost:	$420,000 ($20/ SFT Concrete/Composite Base & Stringers with Timber Planks)
Labor Cost:	$400,000
Total Cost:	$820,000

- Pros
  - Long life span
  - Modifications to the subgrade would be performed
  - Robust and durable design
  - Improved riding surface
  - Reduced noise issues

- Cons
  - High cost
  - Replacement of some members that are in good condition
  - Trail closure during construction
  - Could have loss of historical context

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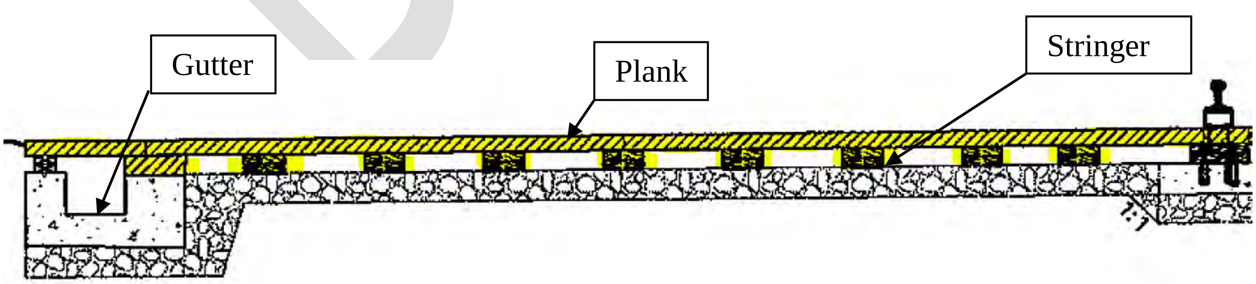

Figure 25: Typical Section of Alternative 4b
(Yellow highlight indicates typical areas of removal/replacement)

3.6 Alternative 4c: Incremental Full Plank and Full Stringer Replacement (Light-Duty)

A further option is to completely replace the trails with new full-length treated planks and stringers in an incremental timeframe. This option would be similar to Alternative 4a, but with the trail replaced in 10 section over a period of 10 years with Alternative 2 (Selective Stringer Replacement) occurring throughout the 10-year period.

This option allows the MPRB to fund the project evenly over a period of time. It also may allow for some flexibility and improvement on the design and construction techniques (best practices), which likely will occur as issues come up and are addressed.

During the maintenance task (Alternative 2) of this larger alternative is being performed, the stripped bolts could be epoxied into the stringers as they are encountered.

Other work anticipated with this option is to remove any landscaping and sprinkler system adjacent to the timber planks. These elements accelerate the deterioration of the timber.

Replacement Materials Cost:	$200,000 ($6/LFT X 28,000 LFT + Hardware) $20,000/yr over 10 years
Maintenance Materials Cost:	$30,000 ($5/LFT x 800 LFT + Hardware) per year Average $3,000/yr over 10 years
Replacement Labor Cost:	$380,000 $38,000/yr over 10 years
Maintenance Labor Cost:	$50,000 Average $5,000/yr
Total Cost:	$660,000 Average $66,000/year for 10 years

- Pros
    - Long life span
    - Modifications to the subgrade can be performed
    - Retains the historic context
    - Funding is more feasible
    - Allows for best practices to be learned and used

- Cons
    - High cost
    - Many of the same condition issues will arise again
    - Replacement of some members that are in good condition
    - Trail closure or detour during construction

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3.7 Alternative 5: Full Plank Replacement with a Non-timber Material

Other options would be to remove and replace the trails with a more conventional material or use a composite decking material on the existing timber stringers. Architectural concrete with wooden form texture could be used to simulate a timber look, or asphalt could be used for a lower cost. This alternative is not in line with the historical ambitions of the plank trail.

a) Composite Decking on Existing Stringers:

Materials:	$250,000	($10/ LFT 2x8 Composite Decking)
Labor:	$300,000	
Total:	$550,000	

b) 3" Asphalt Pavement on 6" Class 5 Base (typical Minneapolis trail)

Total Cost: $245,000 (Asphalt $95 ton)

c) 7" Concrete Pavement on 6" Class 5 Base

Total Cost: $600,000 (Conc. $550 per yd^3)

- Pros
    - Long life span
    - Low maintenance costs
    - High durability
    - Good riding surface

- Cons
    - Potential for high construction costs
    - Low historic context
    - Trail closure during construction
    - Processes for historic evaluation will be needed

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3.8 Alternative 6: North Trail Replacement with Concrete and Asphalt

Another option, from an earlier study, is to replace the planks on the north trail with a mixed asphalt and concrete configuration. Asphalt would be utilized on the bike trail and concrete would be used on the pedestrian trail and on a buffer zone between the road and the trails. In the early study, this concept was only envisioned for the north trail due to the heavy bicycle traffic here. It could be incorporated into the south trail also.

Total Cost:	$160,000	(North Trail Only)
Total Cost:	$280,000	(Both Trails)

- Pros
  - Long life span (30-40 years)
  - Low maintenance costs
  - High durability
  - Separate walking and riding paths
  - Good riding surface

- Cons
  - Low historic context
  - Potential tripping hazard due to differing settlements of asphalt and concrete
  - Trail closure during construction
  - Processes for historic evaluation may be needed

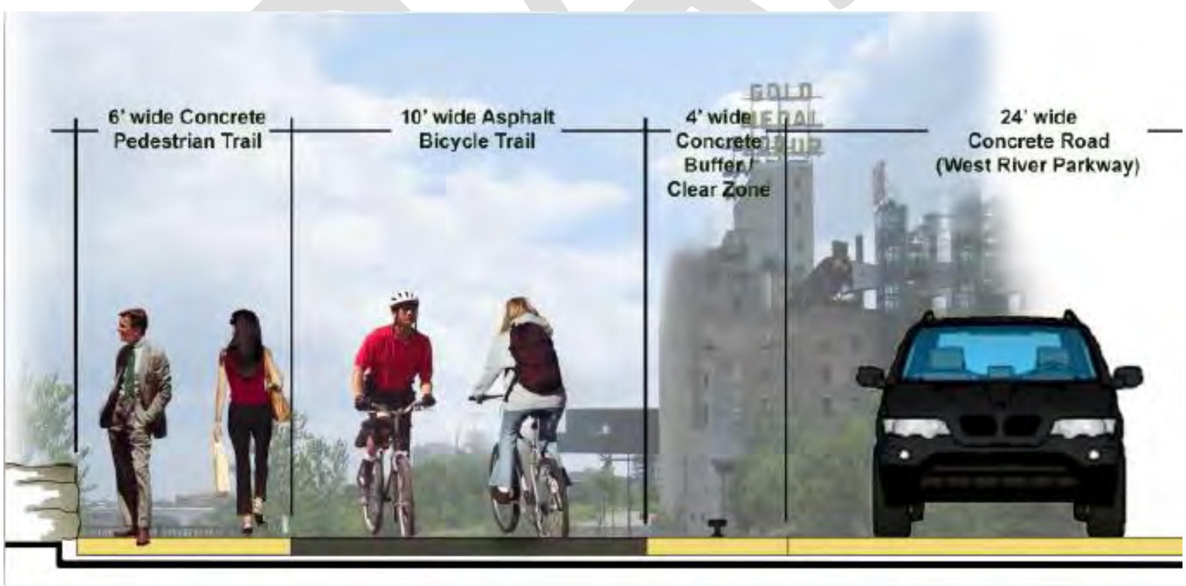

Figure 26: North Trail Replacement with Concrete and Asphalt

3.9 Alternative 7: North Trail Replacement with Wood Plank and Asphalt

The final option, from an earlier study, is to replace the planks on the north trail with asphalt and new treated timber planks. This option is similar to Alternative 6 except that the pedestrian trail and buffer zone are planks. For the timber elements (planks and stringers) many of the practices in Alternative 4a would be recommended. This would only be utilized on the North trail as it has heavy bicycle traffic, but it could also be used on the south trail.

Total Cost:	$400,000	(North Trail Only)
Total Cost:	$700,000	(Both Trails)

- Pros
  - Long life span (20-40 years)
  - High durability
  - Good riding surface
  - Separate walking and riding paths
  - Maintains some historical context

- Cons
  - Trail closure during construction
  - Potential tripping hazard due to differing settlements of asphalt and timber
  - High cost
  - Some maintenance issue remain
  - Processes for historic evaluation maybe needed

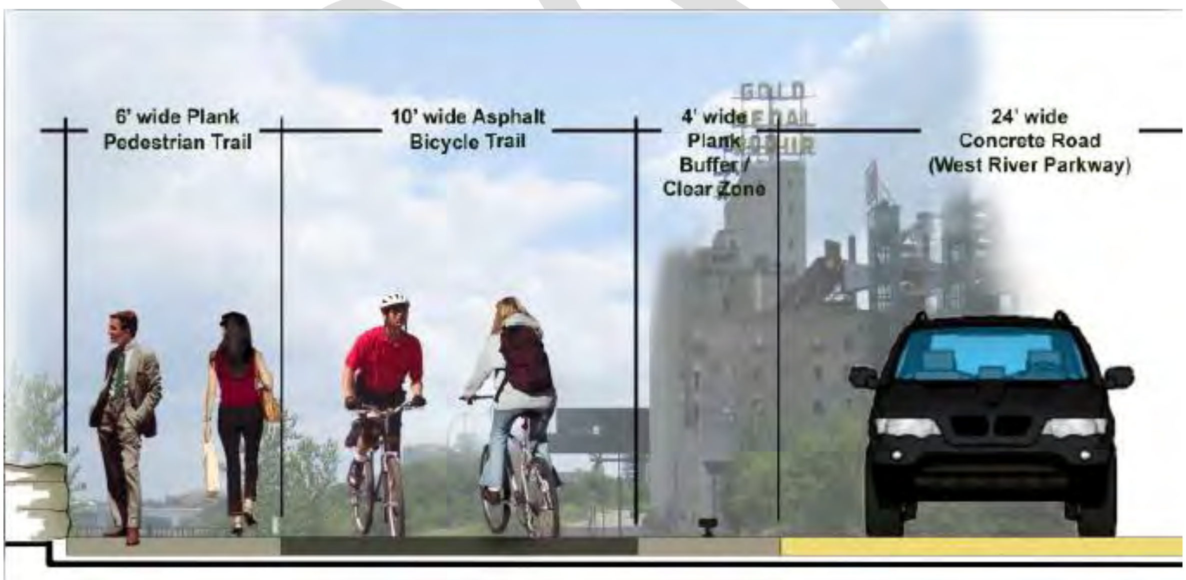

Figure 27: North Trail Replacement with Wood Plank and Asphalt

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3.10 Cost Analysis of the Improvement Alternatives.

The graphic below charts the lifecycle cost of each of the trail improvement alternatives. The life cycle costs include the initial construction cost of each alternative and the maintenance cost of each alternative. These results are in 2016 dollars and do not include any interest or inflationary adjustments.

It should be noted that the pavement alternatives (5b and 6) are the least expensive alternatives in life cycle costs.

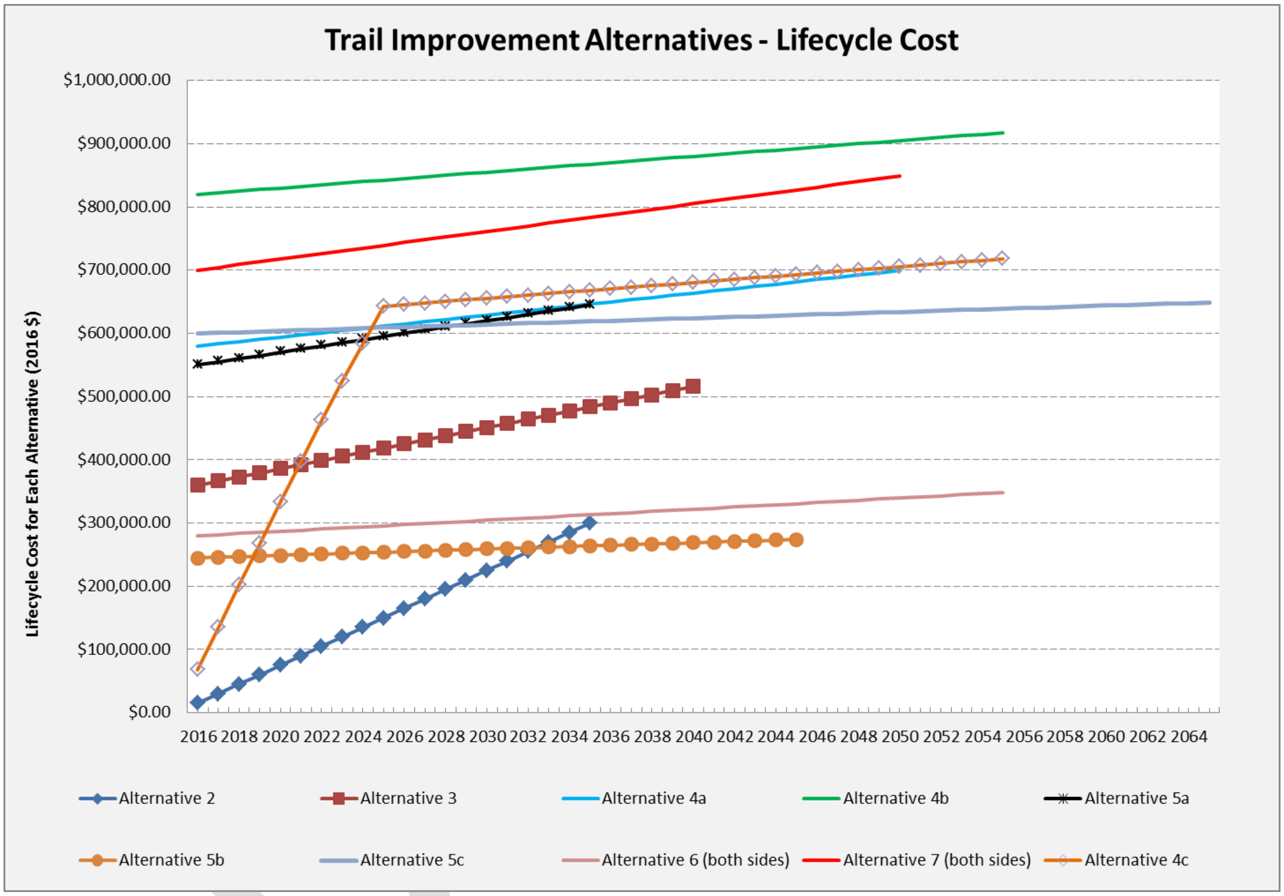

Figure 28: Graph of Lifecycle Costs for Alternatives

Amortization a process in which interest rates and inflation (combined to form effective interest rates) are applied to investments, such as a trail improvement project. For the alternatives in this report, a 2.5% yearly inflationary rate has been added to the future expenditures – such as deferred maintenance and construction. The inflationary rate essentially increases the cost of an investment as time passed, where $100 in 2016 only buys $98 in 2017. So work done in the future requires a multiplier. Interest besides inflation has not been applied to the graphs in Figure 29 and 30. Figure 29 was created to further look at the lifecycle costs of each alternative assuming 2.5% yearly inflationary rate on future investments. If MPRB utilizes a bond payment with an interest rate, then these numbers should be readjusted.

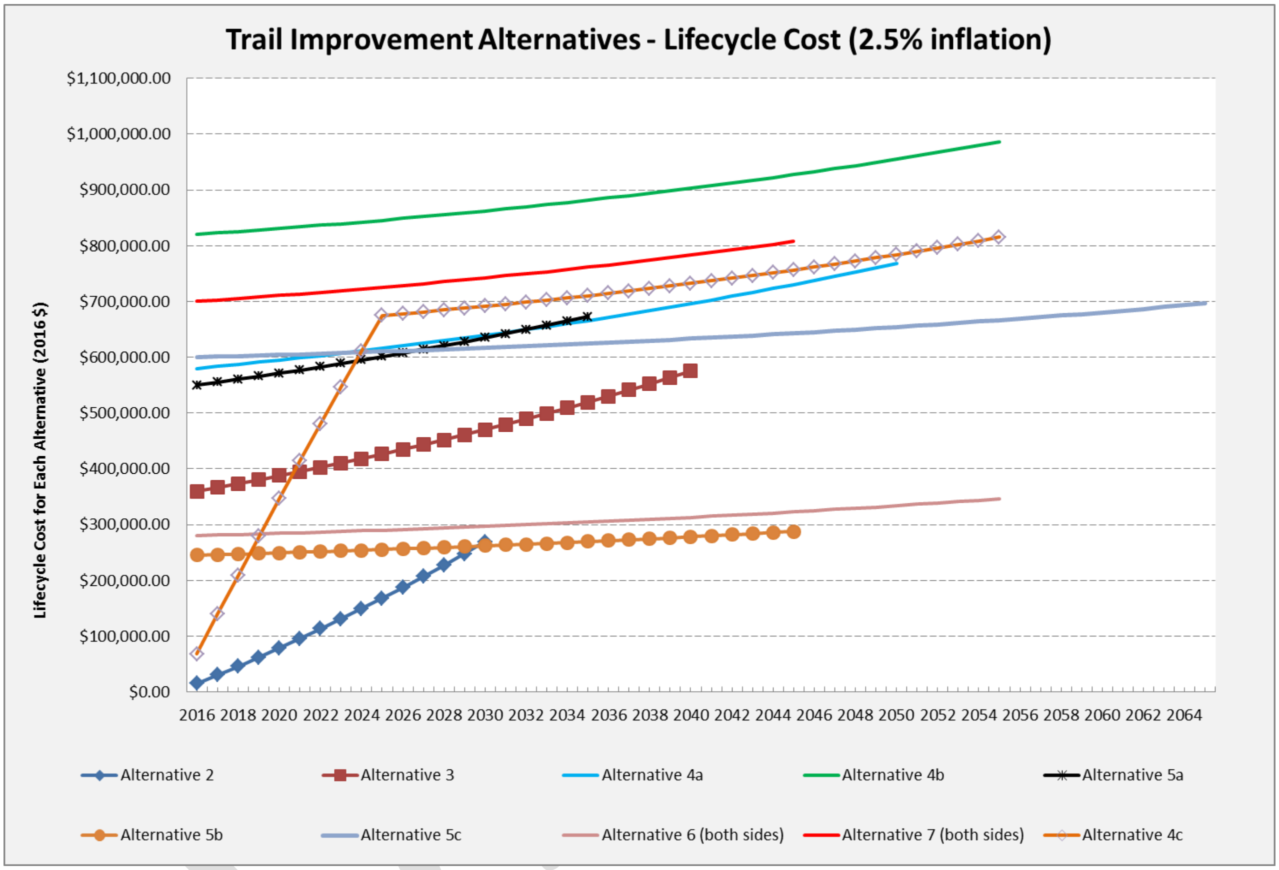

Figure 29: Graph of Lifecycle Costs for Alternatives (2.5% inflation added)

4.0 RECOMMENDATIONS

WSB was directed to determine how best to:

- increase the trails' longevity and safety,
- decrease or simplify maintenance,
- provide recommendations for phased reconstruction including substructure.

The alternatives described earlier can be staggered or used in conjunction with another alternative to ensure one of the trails is open during construction. After reviewing the condition of the plank trails and the rehabilitation/replacement options, WSB recommends that the following work is planned and completed:

1) Use Alternative 2 (Partial Plank Replacement) for the next 10 years (2016-2026) on both the south and north trails, or until the replacement alternative can be funded and completed. Plank replacement will utilize: full length treated planks (slowly removing the center butt seam/joint on the north trail), stainless steel lag screws or round headed bolts and washers that are not countersunk, tar paper "hats" on stringers, and clearing of plantings and irrigation adjacent to trail. The trail substructure will slowly deteriorate, but large upfront capital expenditures will not be required. It is estimated that a 2-person maintenance crew will spend 5 full working days a year on plank replacement (and slowly decreasing as the segmental trail reconstruction takes place). Maintenance activities would best be performed in the spring and fall, as the environmental changes are greatest at this time and the trail is less used. This alternative will allow the Park Board more time to secure funding for the segmental reconstruction improvements, while maintaining the historic ambiance of the site. If reconstruction funding is not available, this alternative could be used for the next 10-20 years, which is approximately the remaining life span on the stringers.
2) Implement maintenance techniques that limit the damage to the trails. This work includes using a blower (versus plow) for removing snow, avoiding the use of salts near trail, removing vegetation and sprinkler systems adjacent to the trail, restricting trucks from using and parking on the trails and eliminating snow storage on the trails.
3) Implement Alternative 4c (Incremental Full Plank and Stringer Replacement) starting in no more than 5 years (2021). While also incorporating Alternative 2, this alternative will be broken into 10 construction seasons with approximately 60 LFT replaced each year. The sequencing of the trail replacements should be laid out in advance to allow the trail to be continuously open (ensuring either the south or north trail are open). The planks and stringers should be heavily treated lumber with an anchorage system thoroughly vetted by a designer and the maintenance crews. The plank connections should be tight to prevent noise nuisance and tripping hazards. All hardware should be stainless steel. The use of tar paper over the stringers and other simple features should also be incorporated.

   The base aggregate on the north trail could be replaced with a porous pavement, which will improve settlement and frost heave issues. The stringers could be made of concrete or a more durable composite material if funding is available. Each of these changes would improve the durability of the trail.

   Future maintenance on eh trail planks should include application of some type of non-skid protective coating such as grit enhanced polyurethane. This will improve durability and minimize the slippery surface of timber.

Table 4 on the following page outlines the recommended rehabilitation/replacement Alternative 4c and includes Alternative 2 and 4a for comparison.

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Alternative ID	Approximate Construction Cost (2016 Dollars)	Timeline of Improvements	Comments
2 - Partial Plank Replacement	$15,000/yr	2016-2025	Use the existing maintenance plan for the next 10 years. Stringers will eventually deteriorate and limit trail lifespan
4a - Full Plank and Stringer Replacement (Light Duty)	$580,000	2016-2025	Incorporate replacement of the trails with a product similar to the existing structure – only more heavy duty and with more design safeguards. All timber is heavily treated and all connections are improved and composed of stainless steel.
4c – Combination of 4a and 2 - Full Plank and Stringer Replacement Incrementally in a 10 Year Period.	$660,000 $66,000/yr	2016-2025	Combination of Alternatives 2 and 4a – replacing the trails in sections over a 10 year period while also replacing deteriorated sections of the trail.

Table 4: Summary of Recommended Alternatives

WSB recommends this alternative.

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Figure 30 depicts the lifecycle costs of a few of the alternatives with 2.5% inflation added to future expenditures. Alternative 4c, which is the preferred alternative, has a competitive cost structure. Alternative 4c allows for capital spending to be spread over a number of years instead of utilizing a large upfront

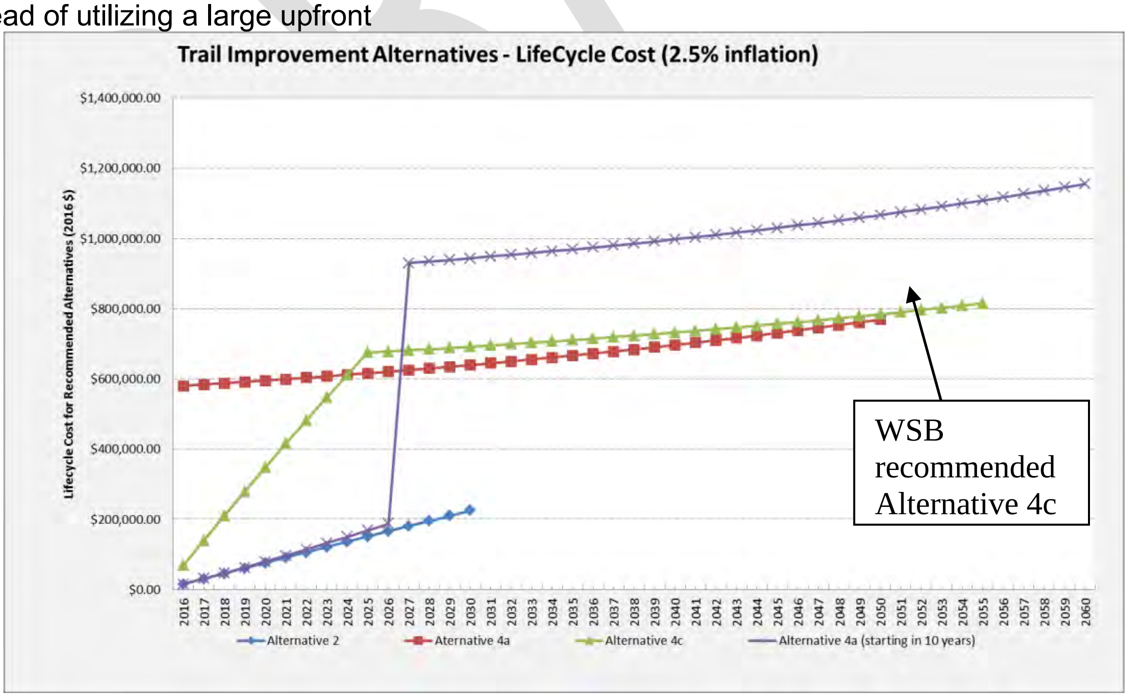

Figure 30: Graph of Amortized Lifecycle Costs for Recommended Alternatives (2.5% inflation)

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APPENDIX A: WOOD PRESERVATIVE TREATMENTS

(USDA Forest Service)

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Oil-Type Preservatives

Creosote:

- Wood is dark brown to black and has a distinct odor after use
- Effective for ground contact, water contact or above ground
- Readily Available and relatively inexpensive
- Effective for both hardwoods and softwoods
- Improves dimensional stability of treated wood
- 5-8 lbs./ft^3 (above ground use), 10 lbs./ft^3 (ground contact), 12 lbs./ft^3 (critical structural applications)
- Must be carefully handled – human contact should be avoided
- Railroad ties last about 30-35 years

Pentachlorophenol:

- Wood is brown in color with a slightly oily surface with some odor after use (Heavy solvents)
- Wood can be less oily, lighter in color and have improved paint ability with light solvents
- Properties of treated wood depend on solvent used (heavy oil is preferable for ground contact)
- Effective for ground contact, freshwater, or aboveground
- Use of a heavy oil solvent should not be used in areas with frequent contact with skin
- The effectiveness is similar to that of Creosote
- Heavier solvent: 0.4 lbs./ft^3 (aboveground), 0.5 lbs./ft^3 (critical structural applications or ground contact)
- Lighter Solvent: Above ground: 0.25-0.3 lbs./ft^3 (Red Oak), 0.4 lbs./ft^3 (Softwood Species)
- Heated Solutions can penetrate difficult to treat woods
- Readily available

Copper Naphthenate

- Effective for ground contact, water contact or aboveground use
- Bright green color that weathers to light brown – odor dissipates over time
- Not typically used for hardwood unless used for railroad ties
- 0.04 lbs./ft^3 (aboveground), 0.06 lbs./ft^3 (ground contact), 0.075 lbs./ft^3 (critical structural applications)
- If dissolved in No. 2 fuel oil – can penetrate wood that is difficult to treat.

Oxine copper

- Most effective for above ground use
- Used for controlling sapstain fungi and mold and is used to pressure-treat wood
- Greenish brown, odorless, low toxicity to humans and animals
- 0.02 lbs./ft^3 for exposed above ground applications
- Heat sensitive
- Sometimes used to treat Douglas-fir used aboveground in wooden bridges and deck railings

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Waterborne Preservatives

Chromated Copper Arsenate

- Effective for wood used in aboveground, in contact with the ground, or in contact with freshwater or seawater
- Wood treated with CCA should not be exposed to precipitation or other environment moisture until the fixation process is complete. This time period is temperature dependent
- Type C is the formulation used by nearly all treatment facilities
- 0.25 lbs./ft^3 (aboveground), 2.5 lbs./ft^3 (marine contact), 0.4 lbs./ft^3 (ground-contact), 0.6 lbs./ft^3 (critical structural applications)
- Corrosion is not as much of a concern as with other waterborne preservatives that contain copper

Ammoniacal Copper Zinc Arsenate

- Color varies from olive to bluish green
- Slight Ammonia odor until it dries
- Used to protect from decay and insect attack
- 0.25 lbs./ft^3 (above ground), 0.4 lbs./ft^3 (ground contact), 0.6 lbs./ft^3 (highway construction)
- The ammonia in the treating solution combined with steaming and extended pressure periods at higher temperatures do a better job of penetrating difficult to treat wood than any other water based preservatives
- Used frequently to treat Douglas-fir lumber and timbers
- Hot-dipped galvanized or stainless steel fasteners should be used.

Alkaline Copper Quaternary Compounds – ***RECOMMENDED with*** **0.6 lbs/ft^3**

- Dark Greenish Brown and fades to a lighter brown.
- Stakes treated with the three types of preservatives (ACQ –B,C,D) have demonstrated effectiveness against decay fungi and insects when the stakes contacted the ground
- Minimum ACQ Retentions are the same as that for Ammoniacal copper Zinc Arsenate
- Hot dipped galvanized copper or stainless steel fasteners must be used

Copper Azoles

- Type A is no longer used in the United States.
- Greenish-brown color and little to no odor
- Tests show that copper azole protects stakes in the ground from attack by decay fungi and insects.
- Used for a range of softwood species.
- Retentions are 0.10, 0.21, or 0.31 lbs./ft^3 for aboveground, ground contact or in critical structural components respectively
- Copper Azole treatments increase the rate of corrosion of metal fasteners relative to untreated wood
- Often used to treat Douglas-fir.

APPENDIX B: SITE PHOTOGRAPHS (2015)

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Figure B-1: Drainage Grate on North Trail

Figure B-2: Top View of Gutter at North Trail

Figure B-3: Plank Rot and Landscape Vegetation on South Trail

Figure B-4: Wood Rot around Fire Hydrant on South Trail

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Figure B-5: Replacement Plank at South Trail (Concrete Base)

Figure B-6: Loose Countersunk Bolts

Figure B-6: Corroded Bolt with Thread Loss

Figure B-7: Warping at Butt Seam/Joint in the Center of the North Trail

Figure B-8: Countersunk Holes Filled with Debris

Figure B-9: View from the North Trail Looking East

Figure B-10: Gas Pipeline on the South Trail

Figure B-11: Sprinkler System on the Border of the South Trail and Adjacent Building

Figure B-12: Plank Road in winter before Road was Rebuilt (Circa 2010)

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Appendix C: 2010 Plan Set

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