AHB Alliance

Coatings Life Cycle Management Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

Auckland Harbour Bridge
PART OF THE AUCKLAND MOTORWAY ALLIANCE

Quality Assurance Statement	
Prepared by:	Hannah Barker and Raed El Sarraf
Reviewed by:	Alex Ingram
Approved for issue by:	Alex Ingram

Revision Schedule					
Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
0	02.08.18	Final	H Barker R El Sarraf	A Ingram	A Ingram

Contents

Contents

Executive Summary

This Life Cycle Management Plan outlines the philosophy, policy and approach for the maintenance of the Auckland Harbour Bridge (AHB) steelwork protective coatings, and is an update of the previous strategy*, Coatings Maintenance Strategy for the Auckland Harbour Bridge,* published in 2014.

The approach described in this plan has been used to develop a projected forecast of coatings maintenance over the next 40 years. The approach used to develop this Life Cycle Management Plan can be summarised as identification of:

- Criteria affecting the maintenance intervention point(s)
- Maintenance options and associated costs
- Protective coating systems used
- The different zones throughout the bridge which may affect the optimum maintenance option and coating system
- Feasible maintenance scenarios (coating system and maintenance option) for each zone
- The lowest Whole of Life Cost scenario through assessment of different maintenance scenarios and net present value (NPV) cost analysis, taking into account environmental compliance, resourcing and aesthetic considerations.

The key maintenance scenarios considered in the NPV analysis were:

1. Spot repair of all moderate coatings defects, followed by over coating adjacent areas as the top coat weathers.

2. Minimum repairs of structurally critical defects, followed by full removal and replacement of the coatings system when large scale breakdown occurs.

NPV analysis identified that the preferred maintenance approach for all zones except the approach viaduct and above land areas, is to spot repair and overcoat. The analysis demonstrates that there is value in protecting the underlying paint layers, thereby delaying the need for full removal and recoating for as long as possible. The spot repair and overcoat approach will also provide better aesthetics than the do minimum spot repair approach, which will be followed by the full coating replacement at some point in the future. This would allow greater deterioration and breakdown of the coatings, with a lower rust grade.

The preferred maintenance approach for the approach viaduct and above land areas is to undertake minimum repairs of structural critical defects, followed by full replacement of the coatings when large scale breakdown of the coatings occurs. This is option is favoured due to the cost of containment needed for collecting all discharges over land. The aesthetic implications of this adopting this maintenance approach need to be considered, as these areas are highly visible to the public, and the poor visual condition may not be acceptable prior to undertaking the full replacement of the coating.

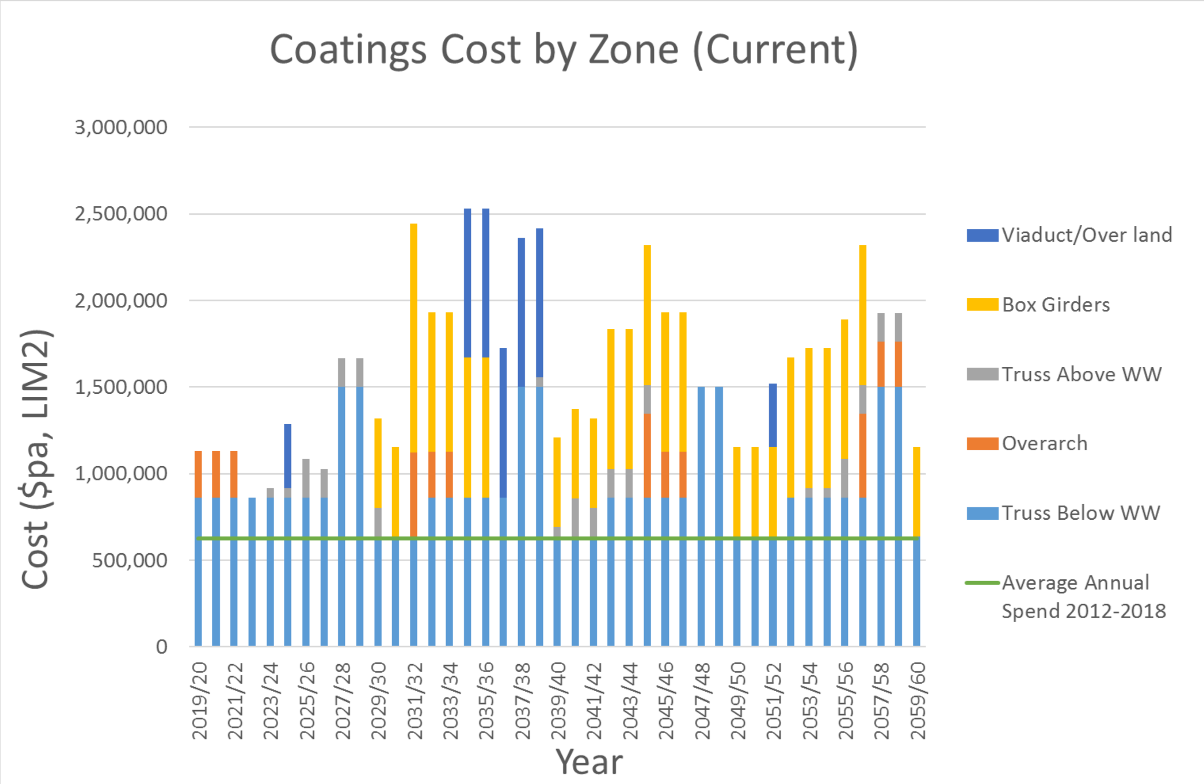


Figure 1: Long term Coatings Maintenance Forecast

The analysis in this report was based on current knowledge of the coatings performance and costs. To improve the accuracy of the maintenance approach analysis it is recommended more investigation be put into the following areas:

- Refinement of containment costs. Ventilation requirements has the potential to raise containment costs significantly (only basic ventilation system allowed for in current costs).
- Value of over coating (what extension of life this provides).
- Deterioration rate/rate of growth in failure areas.
- Investigate alternative surface preparation methods, such as vacuum blasting or laser blasting; which may assist in reducing the surface preparation and/or containment costs.

1 Introduction

The Auckland Harbour Bridge (AHB) Coatings Life Cycle Management Plan outlines the philosophy, policy and approach for the maintenance of the AHB steelwork protective coatings. The approach described in this plan has then been applied to develop a long-term forecast of coatings maintenance required over the next 40 years. The annual plans for coatings maintenance will be developed based on the approach recommended in this plan along with annual condition inspections.

The approach used in the development of this Life Cycle Management Plan can be summarised as identification of:

- Criteria affecting the maintenance intervention point(s)
- Maintenance options and associated costs
- Protective coating systems
- The different zones throughout the bridge which may affect the optimum maintenance option and coating system
- Feasible maintenance scenarios (coating system and maintenance option) for each zone
- The lowest Whole of Life Cost scenario through assessment of different maintenance scenarios and net present value (NPV) cost analysis, taking into account environmental compliance, resourcing and aesthetic considerations.

This Life Cycle Management Plan is a review and an update of the previous strategy*, Coatings Maintenance Strategy for the Auckland Harbour Bridge,* published in 2014.

The current condition of the AHB coatings is summarised in this report, further details are given in the latest annual inspection and structural inspection reports.

2 Coating Maintenance Philosophy

The main aim for the Coatings Lifecycle Management Plan is to provide the lowest whole of life cost possible, while maintaining the primary NZ Transport Agency drivers. These are summarised as follows:

- Safety.
- Efficiency.
- Resilience.
- Value for money.

Therefore, the AHB steelwork protective coatings should be maintained to ensure that the safety, efficiency and resilience of the bridge will not be affected by section loss due to corrosion of its structural steel members.

The timing and maintenance treatment of the protective coatings shall be developed and implemented to provide the least whole of life maintenance cost, given by the long-term forecast. The annual coatings programme, however, can be modified to suit the coating current condition and identified maintenance requirements for that year.

3 Intervention Considerations

When considering the maintenance intervention point for steel coatings on the AHB, the objectives include:

- To limit the impacts on the structural performance of the bridge from steel corrosion.
- To achieve environmental compliance.
- To achieve minimum aesthetic criteria.
- To achieve compliance with heritage requirements.
- To achieve least whole of life cost for maintenance of the coating.

3.1 Steel Corrosion & Structural Impacts

Based on the philosophy described in Section 2 to ensure the safety, efficiency and resilience of the bridge, the steel coatings shall be maintained to ensure that there is no loss of structural section that will reduce the live load capacity of the bridge.

This philosophy theoretically allows loss of structural section at non critical locations. The input of the structural engineer is required to fully understand the structural implications of allowing section loss and determining which locations are structurally critical and where coatings defects must be repaired urgently. It is however expected that significant loss of structural section at non critical locations will be limited by other interventions, including aesthetics and least whole of life cost.

3.2 Environmental Compliance

The current resource consent sets out discharge limits from coatings maintenance operations. Discharges from operations above land need to be collected, contained and removed from site. Discharges above water must be below the limits set out in the table below.

Table 3-1: Summary of Discharge limits and maximum treatment areas (above water) for typical coatings maintenance activities

Activity	Contaminant	Annual Discharge Limit (kg)	Maximum Treatment Area (m^2 pa)	Maximum Treatment Area (% bridge surface)
Waterblast only	Zinc[1]	223	695,000	560%[2]
Waterblast, Abrasive Blast, Typical MCU spray applied	Garnet	14679	1,979	1.6%
	Zinc[3]	223		
	Paint[4]	646		
Ferrox Overcoat (spray applied, excl. water blasting)	Paint[4]	646	36,700	24.6%

Notes to Table 3-1:

[1] May be from other sources, such as cars, not just from the coating.

[2] Maximum treatment area of water blasting only assumes the coatings are in sound condition and no paint flakes are removed.

[3] Taken as mainly being from the protective coating.

[4] Taken as being both the build and top coat (excluding the primer) of the coating.

Brush and roller paint application is taken as not causing any discharge. Whilst these application methods are time consuming when compared to spraying, the cost increase may be offset by negating the need for full containment.

The current consent also restricts the discharge of lead to a minimal quantity. Removal of historic lead coatings would require containment.

The discharge limits mean that a reasonable amount of spot repairs and over coating can be undertaken each year, for surfaces above water, without the need for containment. However, upon exceeding those limits or when full replacement of the coating system is undertaken, as well as when refurbishing the coating above land, full containment is required.

The current Coatings Maintenance Discharge Consent is valid between December 2014 and December 2039, after which there is a risk that tighter compliance standards may be required, compulsory containment throughout the bridge for example, with the next renewal.

The annual contaminant discharges in the long term programme developed in this plan have been estimated based on the specified coatings systems (refer Section 6). It should be noted however that the actual discharges reported for consent compliance are based on actual material use, and may vary from the estimated quantities. Refer to the Appendices B and C for discharge estimates.

3.3 Aesthetic Criteria

The following aesthetic intervention levels were endorsed by the AHB Alliance Leadership Team (ALT) in February 2015 (refer ALT Paper 68), to provide an acceptable level of visual condition that meets the public's expectations and to give users confidence that the bridge is being adequately maintained, see Table 3-2. The aesthetic criteria are defined as Rust Grades (percentage of visible rust) in accordance to ASTM D610-01, as shown in Figure 3-1 given for a 3"x3" unit area. The required Rust Grade varies depending on the visibility of the area to the public, as shown below.

Table 3-2: Rust grade levels of surfaces around the bridge.

Rust Grade	Location
8	Areas regular viewed by the public at close proximity e.g. southern end around the footpath and bridge climb access
7	Visible to the public from a distance e.g. overarch, box girder outer faces.
6	Areas not readily visible to the public e.g. Truss bridge above walkways.

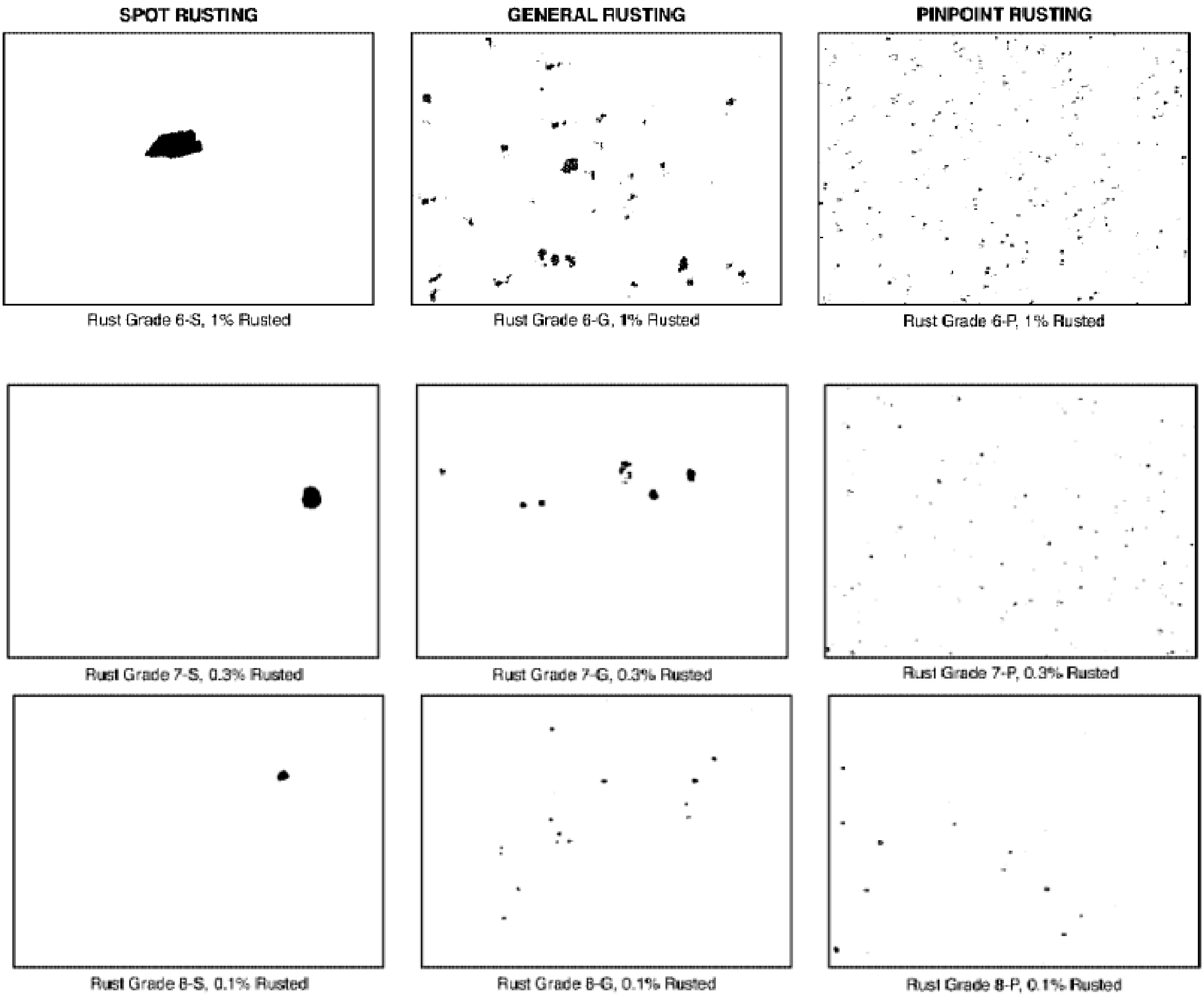


Figure 3-1: Example of rust area percentages according to ATSM D610-01.

Table 3-3: Definition of Rust Grade levels according to ASTM D610-01.

Rust Grade	% of Rusted Surface
10	≤0.01
9	>0.01 up to 0.03
8	>0.03 up to 0.1
7	>0.1 up to 0.3
6	>0.3 up to 1.0
5	>1.0 up to 3.0
4	>3.0 up to 10.0
3	>10.0 up to 16.0
2	>16.0 up to 33.0
1	>33.0 up to 50
0	>50

These aesthetic criteria are considered as guidelines only. Structural and whole of life cost considerations will have greater influence on maintenance intervention decisions.

The colour/gloss of the top coat is expected to degrade over time, however this is not considered of significant aesthetic importance that it would drive maintenance intervention. Note that removal or overpainting of graffiti is considered part of the structure's regular maintenance programme.

3.4 Heritage Requirements

The Auckland Harbour Bridge Conservation Plan (Matthews & Matthews, 2015) includes, in its conservation policy, a requirement for the bridge to be painted to match the original St Enoch's grey/silver grey colour.

3.5 Whole of Life Cost

Identifying the least whole of life cost option requires a Net Present Value (NPV) analysis of viable coatings maintenance scenarios. The NPV analysis methodology is outlined in Section 6 of NZ Transport Agency *Protective Coatings for Steel Bridges*.

4 Coatings Condition and Breakdown Mechanisms

The optimal maintenance option depends on the type and extent of coatings failure (or breakdown) occurring. Coatings breakdown can be grouped into three basic types; Coating Weathering, Substrate Corrosion and Coating Delamination.

4.1 Coating Weathering

The top coat breaks down due to weathering effects, such as UV and/or wind abrasion. From which the underlying coating will be exposure and in turn weather as well. Examples of this type of breakdown is currently being observed on the Overarch area of the AHB, see Figure 4-1; where due to the erosion of the MCU *Ferrox A* top coat, the underlying red tinted MCU *Miomastic* is turning pink due to its exposure to the UV.

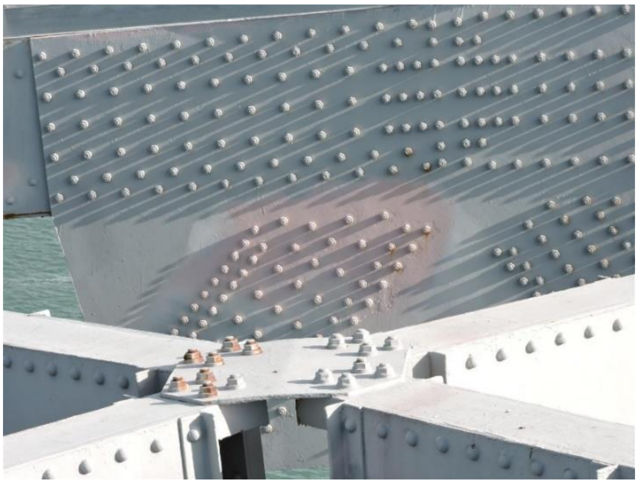


Figure 4-1: Example of coating weathering.

Repair methods for this type of breakdown include:

- Overcoat before the undercoats are compromised, with spot repair of corroded substrates when required.
- Full removal and recoat. This option is not expected to be economical, especially when the undercoats are still in good condition.

4.2 Substrate Corrosion

Corrosion of the steel substrate under the coating, often due to salt contamination prior to painting or low film build of the coating. Examples of this type of breakdown are commonly seen throughout the bridge, but especially on the more complex AHB Truss Bridge below deck, see
Figure 4-2.

Figure 4-2: Example of substrate corrosion.

Repair methods for this type of breakdown include:

- Spot repair of corroded surfaces only with the 3 coat MCU system. This could be for all breakdowns or at structural critical locations only.
- Spot repair of corroded surfaces and overcoat surrounding areas with the MCU build and top coat.
- Full removal and recoat. This may be warranted for large areas of corroded surfaces.

4.3 Coating Delamination

Loss of adhesion between the historic coating layers or cohesion in a single coating layer, resulting in the delamination of the coating, see Figure 4-3.

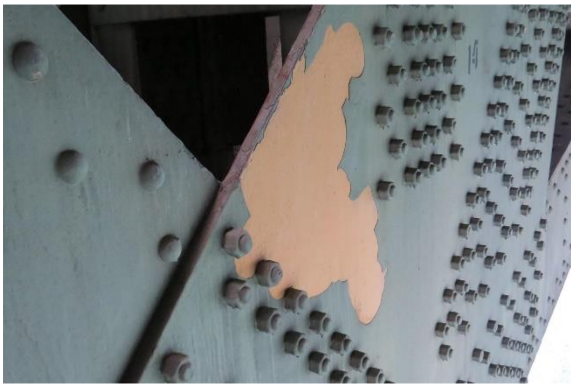


Figure 4-3: Example of coating delamination.

Investigations undertaken in 2013/2014, followed by biennial adhesion testing, indicate that the risk of widespread coating delamination is very low (Refer *AHB Alliance 2016 Biennial Coating Adhesion Strength Test Results*).

Repair methods for this type of breakdown include:

- Overcoat entire area before the undercoats are compromised, with spot repair of corroded substrates when required.
- Full removal and recoat. This is not expected to be economical given the underlying historic coatings are likely to be still in good condition.

5 Maintenance Options

To refurbish a protective coating, there are typically four maintenance options to be considered when developing a maintenance plan. These are:

5.1 Do Nothing

This option assumes that current maintenance activities are suspended and the site demobilised, after a period of time (expected to be at a maximum 5 years) the site and maintenance crew are re-established. At that point, large scale refurbishment of the coating system, in some areas requiring full removal and recoat are expected to be required.

This option was not considered further, as the demobilisation and re-establishment cost in addition to the potential for large scale refurbishment, are expected to negate any potential cost savings.

5.2 Do Minimum

This is the base option for the net present value (NPV) cost analysis.

In this case only localised structurally critical coatings defects would be repaired to prevent section loss, as advised by the Structural/Bridge Inspection Engineer. The repairs would involve spot repair of the nominated areas.

Based on current repair areas it is estimated that approximately 0.1% of the overall AHB surface area would undergo spot repair each year under this option. Noting that the do minimum repair areas of the truss bridge below walkway level are expected to be higher than other areas.

If this option was adopted, in the long term some growth in the critical repair areas would be expected, however the rate of this growth is difficult to quantify. It is also expected that large scale refurbishment would be required at some point in the future. This is estimated to range between 10 to 20 years. A risk analysis model will be required.

5.3 Spot Repair

When mobilising in one area to repair structurally critical coatings defects, all other moderate coatings defects in that area would be spot repaired regardless of the type of coating breakdown. This option is suitable for areas that are easy to access, with localised coatings defects where the surrounding coating is in satisfactory condition. The repairs would involve removal of the existing coatings and spot repair of those areas.

Spot repair has been used on the AHB since the establishment of the Auckland Harbour Bridge Alliance (AHBA) in 2012. Since then the approximate annual spot repaired surface area ranged between 1% to 1.2%/annum, i.e. around 1200m^2 to 1500m^2. To date, the annual discharges have been below the limits prescribed in the resource consent.

It is assumed that spot repairs would be programmed to be under the annual discharge limits set by the resource consent. It is not expected to be cost effective to set up containment for spot repairs.

Note that for this option, the resulting finish is likely to appear patchy.

The spot repair area quantities are expected to vary between zones, and be highest for the truss bridge below walkway level (Refer Table 8-1), particularly in spans that are closer to the water, such as Span 7.

5.4 Spot Repair and Overcoat

This option involves spot repair (as described above) and overcoat of sound adjacent coated areas. The benefit of undertaking spot repairs and over coating is the single access/setup cost, as well as refreshing the top coat of surrounding areas, thereby extending the life of the overall coating, as well as sealing over any potential defects and retarding their formation due to the reduction of the ingress of moisture vapour and oxygen. This in turn slows down the breakdown of the underlying layers, as well as restoring the aesthetics of the over coated surfaces.

Overcoating is also commonly used to encapsulate sound historic red lead primer and/or other hazardous coatings (such as zinc chromate), preferably prior to deterioration of its adhesion strength, thereby deferring the need to remove these hazardous coatings and minimising the associated health and safety risks.

It is expected that over coating could be done within the current resource consent discharge limits, and that containment would not be required other than those over land.

5.5 Full Replacement

This option involves full removal and replacement of the coating system.

Full replacement is expected to exceed annual discharge limits and require containment. Where containment is required the costs of any associated strengthening and containment set up will be included in the coatings cost.

6 Protective Coating Systems

A detailed discussion on the historic AHB protective coating systems and the different types of protective coatings that may be used as maintenance coatings, is given in the *Coatings Maintenance Strategy for the Auckland Harbour Bridge, 2014*. Based on this discussion the following protective coating systems have been considered.

6.1 Current Moisture Cured Urethane

The current maintenance coating used on the AHB is a 3-coat moisture cured urethane with a stripe coat. For spot repair only it consists of:

- 75-100 µm *MC-Zinc* spot prime
- Min 50 µm stripe coat of *MC-Miomastic* on all fasteners, welds, edges, crevices and zinc primer surfaces.
- 75-100 µm *MC-Miomastic* spot intermediate coat
- 50-100 µm *MC-Ferrox A* spot finish coat.

For surfaces that are spot repaired and over coated it consists of:

- 75-100 µm *MC-Zinc* spot prime
- Min 50 µm stripe coat of *MC-Miomastic* on all fasteners, welds, edges, crevices and zinc primer surfaces.
- 75-100 µm *MC-Miomastic* spot intermediate coat
- 40-70 µm *MC-Miomastic* full tie coat
- 50-100 µm *MC-Ferrox A* full finish coat.

This system has been used on the AHB since 1998, and the specification was last reviewed in August 2017. The experience with its performance to date is that it provides 5 – 15 years' life to first maintenance, depending on the bridge zone. For example, at the Southern Entrance in Span 7 it has provided 5 to 8 years, while on the Overarch it has provided 10+ years.

6.2 Modified MCU

As part of this review, a variation of the above MCU system is to apply an additional intermediate coat to either the spot repair and/or the spot and overcoat option.

- 100 µm *MC-Miomastic* full intermediate coat (red tint)

This modified MCU system is expected to extend the life of the coating system by 10 years, giving an expected life to first maintenance of 15 to 25 years (depending on the bridge zone). For the minor increase in application and product cost when compared to the current 3-coat MCU system, this system is recommended as the preferred option for full coatings replacement.

Note that regardless of the MCU version being considered, the top coat is still expected to start eroding/breaking down after 10 – 15 years.

6.3 Thermal Metal Spray

- 300 µm 85/15 *Zinc metal spray*
- Sealer coat

This system has a durability life expectancy of 40 years according to SNZ TS 3404:2018 and the NZTA *Protective Coatings for Steel Bridges*; however, the sealer may need to be refreshed every 10-15 years to maintain aesthetics (mainly colour).

This system would be ideal for use on the box girder extensions due to its large flat surfaces areas and ease of application at an optimal spray application angle of 90° and the reduction of overspray, when compared to the more complex shaped members of the Truss bridge.

As this system is not currently used on the bridge and/or included in the Resource Consent, further consent and environmental investigation may be warranted. However, as this system is only considered to be suitable as a full replacement coating for the box girder extensions, which would be fully contained and therefore not affect the current discharge thresholds.

6.4 Zinc rich epoxy/Epoxy/Polyurethane (PUR5)

This is a conventional 3 coat system, consisting of:

- Zinc primer (spray and brush stripe coat)
- MIO Epoxy intermediate coat
- Polyurethane top coat

This system has an expected life of 25 years, which like the modified MCU its expected life to first maintenance can be extended by the use of an additional build coat. However, its main limitation is the application environmental criteria, as it cannot be applied when the relative humidity is greater than 85%. Painting would therefore not be possible for a significant number of work days in the humid Auckland environment. As such, this option was not considered further.

7 Coatings Zones

The AHB has been split into five coatings maintenance zones with different characteristics which influence the optimal coatings selection, coatings performance, and maintenance option.

Factors considered when dividing the bridge into zones are:

- **Atmospheric Corrosivity Categories**

  The AHB has 3 recognised atmospheric corrosivity categories (ACC), which range from C5-M for Span 7 near the Southern Entrance (closer to the sea and not rain washed) to C3 on the Overarch (highest point above the sea and rain washed). The ACC is based on ISO 9223. A study is currently underway to confirm these corrosivity categories.

  According to Table 6.3 of AS/NZS 2312.1:2014, the expected life to first maintenance for moisture cured urethane system (MCU2) are given in Table 7-1, which has a total dry film thickness of 225µm. Note that while our current MCU coating is thicker, the values given below will be used to assess the return maintenance period which is a conservative approach.

Table 7-1: Expected time to first maintenance for MCU2 in different ACC.

Coating	Expected life to first maintenance for the given ACC		
	C3	C4	C5
MCU2	15-25	10-15	5-10

Having said that, for surfaces of the bridge that still contain sound historic coating, and has a total coating thickness >500µm (up to 3000µm has been measured), then the expected life to first maintenance for those areas will be in excess of the periods given above. However, the same principal for maintaining the top coat due to weathering still applies.

- **Visibility**

  How visible the area is to the public will affect the aesthetic criteria (i.e. rust grade intervention guidelines) given in Section 3.3.

- **Historic Coating Type and Condition**

  As discussed earlier, since 1998 the bridge has been maintained with a MCU system, as such all surfaces of the bridge, including the 2 panel points in Span 7 with red lead primer, have now been over coated with MCU. The current condition, total coating thickness and adhesion strength will dictate which zones can continue to be over coated or consideration for full removal; and in turn whether containment is required. Consideration also include the zone's surface area and maintenance history. Note that maintenance records prior to the formation of the Auckland Harbour Bridge Alliance in 2012 have not been fully compiled.

- **Accessibility**

  Hard to access areas are likely to require costly access provisions, which would favour a thorough maintenance approach undertaken less often. Access provisions can range from abseilers working off ropes or the use of elevated work platforms, to full fixed scaffolding.

- **Containment**

  Containment considerations include whether the area is over land or sea, whether this part of the structure can support large scale containment with or without strengthening or whether elemental containment is required, and the ease of installing containment due to the shape of the structure.

- **Structural criticality**

  Section loss at structurally critical elements will not be permitted, whereas at non-critical elements some section loss may be tolerated without reducing the overall structural capacity of the bridge. Instruction on the structural criticality and urgency of repair for any coatings defects identified would be given by the Bridge Inspection Engineer.

Based on the above characteristics the AHB has been divided into the following zones:

7.1 Zone 1: Box Girder Extensions

- **ACC:** Ranges between C4 (on Span 2) to C5-M (Span 7)
- **Visibility:** the outer faces are highly visible (RG 7), while the bottom and inner faces are less so. Hence, the inner surfaces can be taken as RG6.
- **Historic Coating Type and Condition:**
  - **Type:** Historic coating still present, but fully over coated with MCU. No red lead is known to be present.
  - **Surface Area:** Total surface area is 51,700m^2, taken as 46,530m^2 over water. The overland surface area of 5,170m^2 has been included as part of the Approach Viaduct.

  - **Maintenance History:** Last refurbished in 2009/2011 during the strengthening of the Extensions, using spot repair.
  - **Condition:** Overall the Extensions are in good condition, with minor areas of breakdown throughout. Defects include crevice corrosion, cracks in the paint (Span 7) to delamination (underside of the Western Extension on Span 6 and 7).
  - **Return Period:** Assuming minor spot repair to be undertaken within the next 10 years, followed by major refurbishment at 10 – 15 year intervals.
- **Accessibility:** easy to access via mobile gantries.
- **Containment:** easy to contain without the need for strengthening.

7.2 Zone 2: Approach Viaducts and Above Land Sections

- **ACC:** Ranges between C4 (Northern End) to C5-M (Southern End)
- **Visibility:** Highly visible, especially on the Northern End, as such taken as RG8.
- **Historic Coating Type and Condition:**
  - **Type:** Historic coating still present, but fully over coated with MCU. No red lead is known to be present.
  - **Surface Area:** Total surface area is taken as 25,170m^2, which includes the above land portions of the Truss bridge below (7,130m^2) and above walkway (5870m^2) and the Extensions (5170m^2). The approach viaducts themselves are only 7000m^2 of that area.
  - **Maintenance History:** The Approach Viaducts were last refurbished in prior to 2012, using spot and overcoat. The Box Girder Extensions (above land) were refurbished during the 2009/2011 strengthening using spot repair, and the Truss bridge in Span 1 in 2012 using spot repair only.
  - **Condition:** Overall those surfaces in good condition, with minor areas of breakdown throughout, mainly crevice corrosion, low build and misses especially over edge surfaces (such as nuts and bolts).
  - **Return Period:** It is assumed spot repairs will be required within 5 years, with major repair required at 15 year intervals.
- **Accessibility:** Depends on the area in question, the extensions can be easily accessed via mobile gantries. The Truss bridge a combination of Elevated Work Platform and scaffolding. While on the Approach Viaducts an Elevated Work Platform or scaffold will be required. Temporary Traffic Management may be required in some areas.
- **Containment:** All surfaces above land need to be contained.

7.3 Zone 3: Overarch

- **ACC:** C3.
- **Visibility:** Highly visible, taken as RG 8.
- **Historic Coating Type and Condition:**
  - **Type:** Historic coating still present, but fully over coated with modified MCU, i.e. 2 layers of the zinc primer and 2 layers of the intermediate coat. No red lead primer is known to be present.
  - **Surface Area:** Total surface area is 7,300m^2.

  - **Maintenance History:** Last refurbished in 2004 using spot and overcoat. Spot repairs and overcoating is programmed for 2018/19
  - **Condition:** Overall the Overarch coatings are in good condition, with minor areas of breakdown throughout. Defects include crevice corrosion, cracks in the paint, low build and misses especially over edge surfaces (such as nuts and bolts). As well as weathering of the top coat, thereby exposing the underlying intermediate coat which is likely to result in the accelerated breakdown of that layer.
  - **Return Period:** Due to the high expected access and containment cost, it was recommended (Refer Memo to AHB Technical Advisory Group, March 2016 "*Proposal – Refurbishing the AHB Overarches*") that pro-active refurbishment of the coating is undertaken between 2018 and 2022. The aim is to save the existing sound coating and prolong its life by extending the residual value of the coating. It is expected the over coating would then be required at 10 – 15 year intervals, or full replacement at intervals of 30+ years.
- **Accessibility:** Difficult, as lane closures and traffic management will be required in addition to the use of Elevated Working Platform.
- **Containment:** Difficult and costly, especially if full coating replacement is undertaken. Such maintenance activities will require long term lane closures, resulting in significant traffic disruptions that may not be allowed.

7.4 Zone 4: Truss Bridge Below Deck, Above Walkways

- **ACC:** C4, even though the coated surfaces are mostly sheltered from the benefits of rain washing, they are also sheltered from airborne salt deposition. As such, the ACC is expected to be on the lower side of C4.
- **Visibility:** Low visible, taken as RG 6.
- **Historic Coating Type and Condition:**
  - **Type:** Historic coating still present, but fully over coated with MCU. No red lead primer is known to be present.
  - **Surface Area:** Total surface area is 21,870m^2, of which 16,000m^2 is above water. The remaining 5,870m^2 has been included with the Approach Viaducts.
  - **Maintenance History:** Last refurbished in prior to 2012 using spot and overcoat. Span 3 was refurbished in 2010.
  - **Condition:** Overall the stringers and cross girders above the Truss walkway are in good condition.
  - **Return Period:** Estimated to be every 15 years, with spot repairs required within the next 5 years.
- **Accessibility:** Easy, readily accessible via the service walkways and gantries.
- **Containment:** Easy to contain, no strengthening is expected to be required.

7.5 Zone 5: Truss Bridge Below Walkways

- **ACC:** Varies, it can range from C5 at the Southern Entrance, to C4 on the Northern Entrance, and C3 on the rain-washed surfaces at the piers.
- **Visibility:** Low visible, taken as RG 6.

- **Historic Coating Type and Condition:**
  - **Type:** Historic coating still present, but fully over coated with MCU. Red lead primer is known to be present at Panel Point 4 and 5 in Span 7.
  - **Surface Area:** Total surface area is 21,870m^2, of which 16,000m^2 is above water. The remaining 5,870m^2 has been included with the Approach Viaducts.
  - **Maintenance History:** Varies depending on location. For example, Span 3 was refurbished in 2010.
  - **Condition:** The Truss Bridge is the most complex part of the AHB, with rivets, crevices, back to back angles and various sized members. Its condition varies depending on the location, with Southern Span 5 to 7 (that are closer to the water) being in poorer condition than the Northern Spans. Taken globally the overall condition of the Truss bridge is satisfactory, with minor to moderate areas of breakdown throughout. Defects are mainly due to crevice corrosion, cracks in the paint, low build and misses especially over edge surfaces (such as nuts and bolts). Some surfaces have been found with weathering of the top coat, especially on the Western prevailing wind side of the bridge.
  - **Return Period:** This will vary depending on location, ACC, its last refurbishment, access and containment. It is expected that spot repairs will be required annually in parts of this zone, with over coating required every 10 years or full replacement of coatings every 20 – 30 years.
- **Accessibility:** Varies depending on location. Access options include service walkways, scaffolding, suspended stages or rope access.
- **Containment:** Difficult and costly, as the Truss bridge is not able to support large scale containment, even with strengthening. If containment is required, it would need to be provided for individual or small groups of elements.

8 Net Present Value Analysis

Several maintenance scenarios have been selected for NPV analysis for each zone which combine the most suitable maintenance option (described in Section 5) and coatings system (described in Section 6). The scenarios considered for each zone are described below.

A 40-year period has been considered in the NPV analysis, using a 6% discount rate. Year 0 is taken as starting from 2019/2020.

Given the difficulty in accurately predicting when maintenance intervention will be required, the timings and treatment areas have been estimated from historical records and observations on the quality /performance of different ages of coatings on the AHB.

Table 8-1 Assumed Spot Repair Areas by Zone

Zone	Area (m^2)	Spot Repairs			Do Minimum Repairs		
		Repair %	Return Interval	Repair Area p.a. (m^2)	Repair %	Return Interval	Repair Area p.a. (m^2)
1. Box Girders	51700	5.00%	15	172.33	0.20%	15	6.89
2. Approach Viaducts/Above Land	7000	5.00%	15	23.33	0.20%	15	0.93
3. Overarch	7300	5.00%	12	30.42	0.20%	12	1.22
4. Truss Bridge, Above Walkways	21870	6.00%	15	87.48	0.33%	15	4.81
5. Truss Bridge, Below Walkways	37130	4.00%	1	1485.20	0.27%	1	100.25
Total	**125000**			**1799m^2 (1.44%)**			**114m^2 (0.1%)**

A sensitivity analysis has been undertaken to identify the maintenance intervals at which the preferred (least Whole of Life cost) scenario would change. It is intended that these critical intervals could be used to make judgement calls on the best maintenance option when confirming the annual coatings plans (e.g. If we expect this coating to perform satisfactorily for another 5+ years the most cost effective option may be to spot repair only. If the coating isn't expected to hold up for another 5 years, the best option may be to spot repair and overcoat).

In the first iteration of the long term programme used in the NPV analysis maintenance costs are grouped into one year for simplicity.

In the second iteration of the long term programme some maintenance tasks have been spread out over several years in order to ensure the annual discharge thresholds can be met.

Overall assumptions made in the cost analysis are:

- Do minimum and spot repair costs assume distribution and priority of repair areas are so that a quarter of the zones would be accessed each year. For example, assuming 1.5% of the bridge requires spot repair, this equates to 6% of the truss bridge surface area; for which 25% of that zone elements will require repair. This is based on the current return intervals; however, we have no way of accurately modelling the distribution of repair areas.

- Do minimum repair areas in the NPV analysis assumed no coating breakdown growth. It may be reasonable to expect exponential growth in critical repair areas if this approach was used for an extended period of time, however we have no information to quantify the rate of growth of these areas.

- Coatings costs are based on the current site establishment, with a maintenance crew being based on site permanently. If the maintenance contract arrangement were to change and a permanent crew were not based at the AHB the establishment costs for coatings maintenance would increase and may favour an approach of more thorough maintenance completed less often.

The full NPV cost analysis are given in Appendix B and C.

8.1 Zone 1: Box Girder Extensions

8.1.1 Scenario 1

Spot repair (5%) and overcoat (entire zone) every 15 years.

Assumptions:

- Access type 95% gantry, 5% suspended stage.
- No containment required (discharges are below resource consent limits).
- Overcoat would be undertaken every 15 years as this is expected to be the average length of time taken for the top coat to erode.
- Repairs would use typical MCU system, MC-Ferrox for overcoat.

8.1.2 Scenario 2

Do minimum repairs (0.2%) every 15 years, full replacement with modified MCU at year 15 (2035)

Note in the second iteration of the long term programme the repair frequency has been increased to every 10 years, allowing spot repairs to be programmed in years when spot repairs on the truss bridge are not programmed, in order to meet discharge limits.

Assumptions:

- Access type for do minimum repairs 95% gantry, 5% suspended stage.
- Access type for full replacement 100% scaffold supported off gantries, to support containment wrap.
- Do minimum repairs would use typical MCU system.

8.1.3 Scenario 3

Do minimum repairs (0.2%) every 15 years, full replacement with thermal metal spray at year 15 (2035).

Assumptions:

- Access type for do minimum repairs 95% gantry, 5% suspended stage.
- Access type for full replacement 100% scaffold supported off gantries, to support containment wrap.
- Do minimum repairs would use typical MCU system.
- Thermal metal spray site application cost estimated to be 50% higher than in shop.

8.1.4 Results & Sensitivity Analysis

Scenario 1 is the preferred option based on the NPV analysis, and is also expected to provide the best aesthetic of the three scenarios.

Scenario 1 would become more expensive than scenario 2 if over coating was required every 7 years or less.

Scenario 2 would become the preferred option if full replacement was not required until year 31, however this scenario does not allow for any growth in the do minimum repair areas. The higher application cost of thermal metal spray does not justify the extended life expectancy over the MCU system.

Scenario 1 is still preferred when the repair frequency has been increased to every 10 years, in the second iteration of the long term programme.

	Scenario 1	Scenario 2	Scenario 3
Total NPV Cost	$4,828,930	$5,518,428	$8,115,143

8.2 Zone 2: Approach Viaducts

8.2.1 Scenario 1

Spot repair (5%) and overcoat (entire zone) every 15 years. First repair programmed for year 5.

Assumptions:

- Access type 100% EWP with collection setup below work area. No local road TTM has been allowed for.
- Coatings would be removed by power tool and new coatings applied by brush and roller (no spraying).
- Overcoat would be undertaken every 15 years as this is expected to be the average length of time taken for the top coat to erode.

8.2.2 Scenario 2

Do minimum repairs (0.2%) every 15 years, full replacement with modified MCU at year 15 (2035).

Assumptions:

- Access type for do minimum repairs 100% EWP with collection setup below work area.
- For do minimum repairs coatings would be removed by power tool and new coatings applied by brush and roller (no spraying).
- Access type for full replacement 100% scaffold to support containment wrap.
- No local road TTM has been allowed for.

8.2.3 Results & Sensitivity Analysis

Scenario 2 is preferred based on the NPV analysis, however is expected to have poor aesthetic (lower rust grade) prior to the full replacement. Scenario 2 also does not allow for any growth in do minimum repair areas over time.

Scenario 1 would become the cheaper option if over coating was required less frequently than every 19 years.

Scenario 2 would become the more expensive option if full replacement was required more than once in the 40-year period.

	Scenario 1	Scenario 2
Total NPV Cost	$2,314,245	$1,938,677

8.3 Zone 3: Overarch

8.3.1 Scenario 1

Spot repair 5% (typical MCU) and overcoat (MC-Ferrox) every 12 years. Spot repairs and overcoating is already programmed for 2018/19, so the remaining treatment areas are included from year 0 of the NPV analysis period.

Assumptions:

- All works in this scenario to be undertaken during overnight lane closures.
- Access provided by EWP (no containment required).
- The first overcoat is programmed to take place at year 1 as breakdown of the top coat in this zone has been observed over the past few years.
- Current motorway traffic management costs of $3200 (L2) per overnight closure have been used for access from the road deck.

8.3.2 Scenario 2

Do minimum repairs (0.2%) every 12 years, full replacement with modified MCU at year 10.

Assumptions:

- Do minimum repairs to take place during overnight lane closures with access provided by EWP.
- Full replacement is assumed to take place during longer term lane closures with access and support for containment being provided by scaffolding. The allowance for these long term lane closures would need to be confirmed.

8.3.3 Results & Sensitivity Analysis

Scenario 1 is the preferred option based on the NPV analysis.

Scenario 2 expected to have worse aesthetic, which may not be acceptable given the high visibility of this zone to the public travelling over the bridge.

Scenario 2 may not be allowable due to the traffic impact of the long term lane closures required. We do not expect full replacement to be possible without using long term lane closures as the required containment could not be set up and dismantled during overnight closures. An alternative paint removal method such as vacuum blasting could be considered to avoid the need for containment.

	Scenario 1	Scenario 2
Total NPV Cost	$1,575,812	$2,972,925

8.4 Zone 4: Truss Bridge Below Deck, Above Walkways

8.4.1 Scenario 1

Spot repair (6%, typical MCU) and overcoat (MC-Ferrox) every 15 years. First repairs programmed for year 5 (2024).

Assumptions:

- Access type 95% walkways, 5% gantry.
- No containment required (discharges would be below resource consent limits).
- Overcoat would be undertaken every 15 years as this is expected to be the average length of time taken for the top coat to erode.

8.4.2 Scenario 2

Do minimum repairs (0.33%) every 15 years, full replacement at year 10 (modified MCU). First do minimum repairs are programmed for year 5 (2024).

Assumptions:

- Access type for do minimum repairs 95% walkways, 5% gantry.
- Access type for full replacement 100% scaffold to support containment wrap.

8.4.3 Results & Sensitivity Analysis

Scenario 1 is the preferred option based on the NPV analysis, and is also expected to provide the best aesthetic of the two scenarios.

Scenario 2 would become the preferred option if full replacement was not required until year 31, however this scenario does not allow for any growth in the do minimum repair areas.

	Scenario 1	Scenario 2
Total NPV Cost	$1,003,760	$3,385,478

8.5 Zone 5: Truss Bridge Below Walkways

8.5.1 Scenario 1

Spot repair 4% every year (typical MCU), Spot repair and overcoat with MC-Ferrox every 10 years.

Assumptions:

- Access costs based on 95% rope access, 5% scaffold.
- No containment required (discharges would be below resource consent limits).
- Spot repairs would not be required in the 3 years following overcoat.
- Overcoat would be undertaken every 10 years as this is expected to be the average length of time taken for the top coat to erode.

8.5.2 Scenario 2

Do minimum repairs (0.27%) every year with typical MCU, full replacement at year 15 with modified MCU system.

Assumptions:

- Access type for do minimum repairs 95% rope access, 5% scaffold.
- Access type for full replacement 100% scaffold to support containment wrap.
- Do minimum repairs would not be required in the 5 years following full replacement.

8.5.3 Results & Sensitivity Analysis

- Scenario 1 is the cheaper option based on the intervention times described above.
- Scenario 2 is a far more expensive option due to the high cost of elemental containment required for full replacement of the coating.
- Scenario 2 would become the cheaper option if full replacement was not required until at least year 35.
- Scenario 2 would have worse aesthetic (lower rust grade).

	Scenario 1	**Scenario 2**
Total NPV Cost	$14,748,292	$22,233,170

9 Optimum Coatings Programme

The graph below shows the combined long term coatings programme based on the preferred scenarios identified in Section 8 above as well as meeting the current discharge thresholds.

As described in Section 8 maintenance costs are grouped into one year in the NPV analysis for simplicity, resulting in the peaks in the graph below. In reality the larger maintenance tasks causing these peaks would be completed over several years, thereby “smoothing out” the annual coatings spend.

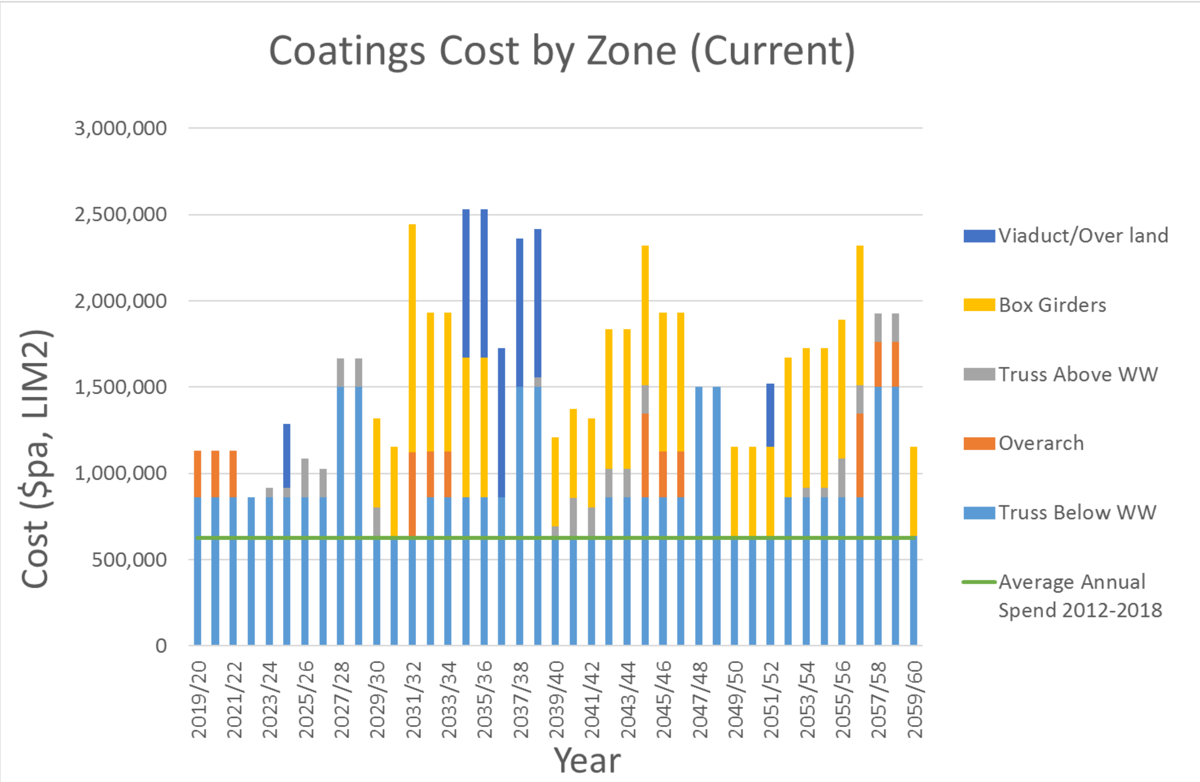


Figure 9-1: Long Term Coatings Programme: Annual Cost by Zone (Current)

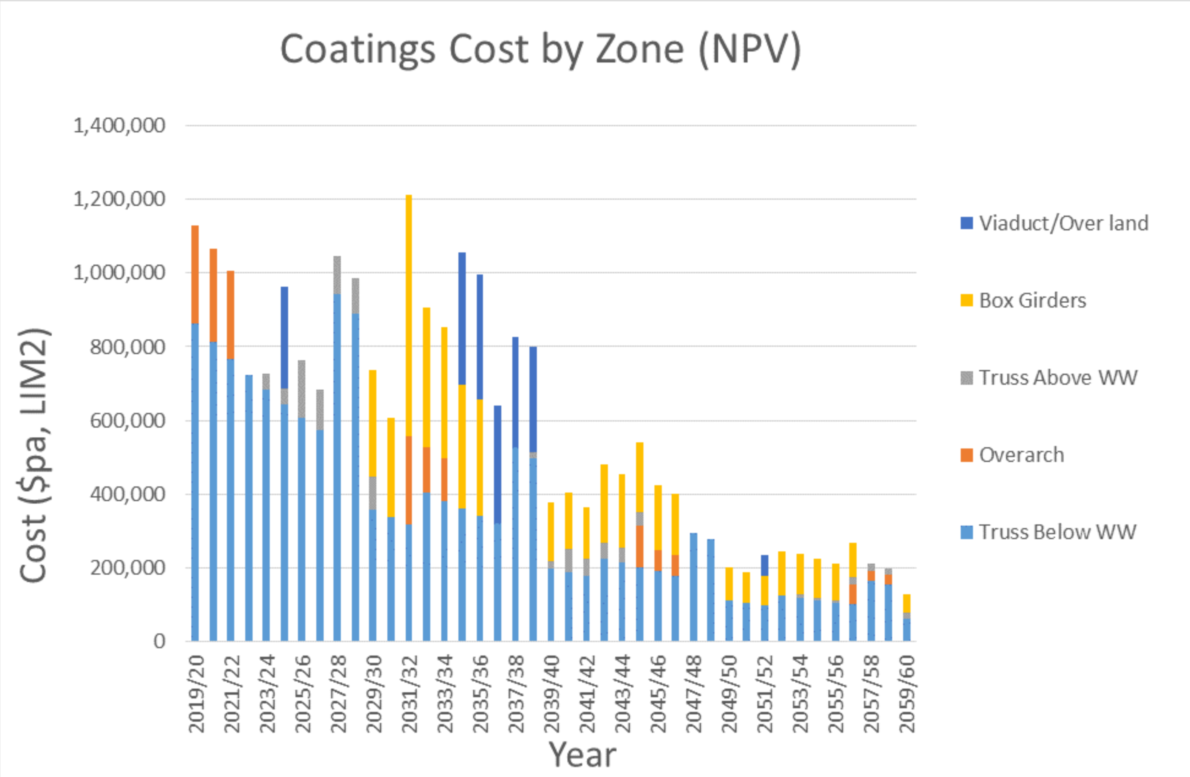


Figure 9-2: Long Term Coatings Programme: Annual Cost by Zone (NPV)

10 Risks & Opportunities

Developing technologies such as laser blasting and existing alternate methods such as vacuum blasting are being investigated. These technologies have the potential to affect the preferred maintenance options by reducing, or mitigating in some cases, the need for full containment. This could dramatically reduce the cost of full coatings replacement in some zones.

A washing study has recently commenced to investigate the value of water washing to extend the life of the coatings.

The current resource consent for maintenance discharge is due for renewal in 2039. Tightening of environmental standards at this time is a risk to the current maintenance strategy.

Sourcing of coatings products is a risk which has been identified by some asset owners. However, as there are several suppliers of the current coatings system used at the AHB this is not currently considered a risk.

The proposed SkyPath pedestrian walkway/cycleway has the potential to affect the preferred long term programme by altering the ease of access in some areas, as well as demanding a higher aesthetic standard to be maintained in areas visible to SkyPath patrons. The coatings maintenance programme should be reviewed prior to the construction of SkyPath with consideration to be given to bringing forward maintenance in areas where access will be more difficult.

The Long Term Strategy for the AHB is based on the assumption that an additional harbour crossing will be opened around 2030. The current Auckland Transport Alignment Project (ATAP) has a time frame of 2038 – 2048. At this time the use of the AHB may change significantly. This could affect the preferred coatings maintenance approach by make lane closures more available. Reduced live load on the structure could enable larger and more economic containment systems to be used.

11 Conclusion & Recommendations

The preferred maintenance approach for all zones except the approach viaduct and above land areas, is to spot repair and overcoat once weathering of the top coat occurs. The NPV cost analysis indicates that there is financial value in prolonging the life of the underlying paint layers, thereby delaying the need for full replacement for as long as possible. This is in part due to the high cost of containment required to fully remove and replace large areas of coatings, which would also exceed the current discharge limits.

The spot repair and overcoat approach will provide a better aesthetic than do minimum repair followed by full replacement, which would allow for greater visual deterioration of the coatings (i.e. a lower rust grade), prior to undertaking full replacement of the coating.

The preferred maintenance approach for the approach viaduct and above land areas is to complete Minimum repairs of critical defects followed by full replacement of the coatings when large scale breakdown of the coatings occurs. This option is favoured due to the high cost of containment needed, when containing all discharges over land. The limiting public access and aesthetic implications of adopting this maintenance approach needs to be considered, as these areas are highly visible and currently accessible to the public.

The analysis in this report was based on current knowledge of the coatings performance and costs. To improve the accuracy of the maintenance approach analysis more investigation could be put into the following areas:

- Refinement of containment costs. Ventilation requirements has the potential to raise containment costs significantly (only basic ventilation system allowed for in current costs).
- Value of over coating (what extension of life this provides).
- Deterioration rate/rate of growth in failure areas.

Appendix A – Coatings Costs

MCU **Spot repair** Coatings unit rates, based on 1.5% total area

Zone & Access Method	% Area	Interval	Set up & Access per location (50m^2)	setup/m2	WB	AB	Prime	IC	TC	Total MH	Labour total $/m^2 (L1)	TTM	Equipment Costs	product cost/m^2	Total Cost $/m^2 (L1)	Total Cost $/m^2 (L2)
Overarch - EWP	5	12	1	0.40	1	1	0.4	0.5	0.4	3.70	121.73	250.00	60	36.23	$467.96	$607.08
Box girder - gantry	5	15	30	12.00	0.3	0.5	0.3	0.4	0.3	13.80	454.02			36.23	$490.25	$636.00
Box girder - stage (span 2)	5	15	60	24.00	0.5	0.5	0.4	0.5	0.4	26.30	865.27			36.23	$901.50	$1,169.52
Approach Viaducts - EWP with collection system belo	5	15	100	40.00	1	1	0.45	0.75	0.45	43.65	1436.09		240	36.23	$1,712.32	$2,221.39
Above walkways - walkways	6	15	0.8	0.27	0.6	0.8	0.4	0.5	0.4	2.97	97.60			36.23	$133.83	$173.62
Above walkways - gantry	6	15	1	0.33	0.4	0.6	0.35	0.4	0.35	2.43	80.06			36.23	$116.29	$150.86
Below walkways - stage	4	1	30	15.00	1	1	0.5	0.6	0.5	18.60	611.94			36.23	$648.17	$840.87
Below walkways - ropes	4	1	0.6	0.30	1	0.8	0.3	0.4	0.3	3.10	101.99			36.23	$138.22	$179.31
Below walkways - scaffold	4	1	500	250.00	0.8	0.8	0.4	0.5	0.4	252.90	8320.41		120	36.23	$8,476.64	$10,996.75

MCU **Do minimum** Coatings unit rates, based on 0.1% total area

Zone & Access Method			Set up & Access per location (50m^2)	setup/m2	WB	AB	Prime	IC	TC	Total	Labour total $/m^2 (L1)	TTM	Equipment Costs	product cost/m^2	Total Cost $/m^2 (L1)	Total Cost $/m2 (L2)
Overarch - EWP	0.2	12	1	10	1	1	0.4	0.5	0.4	13.30	437.57	3125.00	750	36.23	$4,348.80	$5,641.70
Box girder - gantry	0.2	15	30	300	0.3	0.5	0.3	0.4	0.3	301.80	9929.22			36.23	$9,965.45	$12,928.18
Box girder - stage (span 2)	0.2	15	60	600	0.5	0.5	0.4	0.5	0.4	602.30	19815.67			36.23	$19,851.90	$25,753.87
Approach Viaducts - EWP with collection below	0.2	15	100	1000	1	1	0.45	0.75	0.45	1003.65	33020.09		6000	36.23	$39,056.32	$50,667.76
Above walkways - walkways	0.33	15	0.8	4.85	0.6	0.8	0.4	0.5	0.4	7.55	248.35			36.23	$284.58	$369.18
Above walkways - gantry	0.33	15	1	6.06	0.4	0.6	0.35	0.4	0.35	8.16	268.48			36.23	$304.71	$395.31
Below walkways - stage	0.27	1	30	222.22	1	1	0.5	0.6	0.5	225.82	7429.55			36.23	$7,465.78	$9,685.36
Below walkways - ropes	0.27	1	0.6	4.44	1	0.8	0.3	0.4	0.3	7.24	238.34			36.23	$274.57	$356.20
Below walkways - scaffold	0.27	1	500	3703.70	0.8	0.8	0.4	0.5	0.4	3706.60	121947.26		2222.22	36.23	$124,205.71	$161,132.07

Ferrox **Overcoat**, 100% area

Zone & Access Method	Set up & Access per location (50m^2)	setup/m2	WB	AB	Prime	IC	TC	Total	Labour total $/m^2 (L1)	TTM	Equipment Costs	product cost/m^2	Total Cost $/m^2 (L1)	Total Cost $/m2 (L2)
Overarch - EWP	1	0.02	1				0.4	1.42	46.718	25.00	6	5.31	$83.03	$107.71
Box girder - gantry	30	0.6	0.3				0.15	1.05	34.545			5.31	$39.86	$51.70
Box girder - stage (span 2)	60	1.2	0.5				0.2	1.9	62.51			5.31	$67.82	$87.98
Approach Viaducts - EWP with collection below	100	2	1				0.3	3.3	108.57		6	5.31	$119.88	$155.52
Above walkways - walkways	0.8	0.016	0.6				0.2	0.816	26.8464			5.31	$32.16	$41.72
Above walkways - gantry	1	0.02	0.4				0.175	0.595	19.5755			5.31	$24.89	$32.28
Below walkways - stage	30	0.6	1				0.25	1.85	60.865			5.31	$66.18	$85.85
Below walkways - ropes	0.6	0.012	1				0.15	1.162	38.2298			5.31	$43.54	$56.48
Below walkways - scaffold	500	10	0.8				0.2	11	361.9		3	5.31	$370.21	$480.27

MCU Modified **Full Replacement** (100% area)

Zone & Access Method	Set up & Access per location (50m^2)	setup/m2	WB	AB	Prime	ICx2	TC	Total	Labour total $/m^2 (L1)	TTM	Equipment Costs	product cost/m^2	Total Cost $/m^2 (L1)	Total Cost $/m2 (L2)
Overarch with Containment	500	10	1	1	0.2	0.5	0.2	12.9	424.41	1750000	239.7260274	43.14	$707.28	$917.55
Box Girders with Containment	90	1.8	0.5	0.5	0.2	0.5	0.2	3.7	121.73		7	43.14	$171.87	$222.97
Viaducts with Scaffold & Containment	500	10	1	0.5	0.15	0.5	0.15	12.3	404.67		7	43.14	$454.81	$590.03
Above walkways - walkways	0.8	0.016	0.4	0.6	0.2	0.5	0.2	1.916	63.0364		5	43.14	$111.18	$144.23
Above walkways - gantry	1	0.02	1	1	0.175	0.4	0.175	2.77	91.133		5	43.14	$139.27	$180.68
Above Walkways with Containment	230	4.6	0.6	0.8	0.4	0.5	0.4	7.3	240.17		7	43.14	$290.31	$376.62
Below walkways - Scaffold & Containment	1000	20	0.8	0.8	0.2	0.5	0.2	22.5	740.25		7	43.14	$790.39	$1,025.37

Thermal Metal Spray Full Replacement

Zone & Access Method	Set up & Access per location (50m^2)		WB	AB	TSM + Seal	Total	Total $/m2 (L1)	TTM	product cost/m2	Total Cost $/m2 (L1)	Total Cost $/m2 (L2)
Box Girders with Containment	90	1.8	0.3	0.5	6.08	8.679027	285.54			$285.54	$370.43

Appendix B – NPV Iteration 1

AHB Box Girder Extensions

Scenario 1

Spot repair 5% every 15 years, overcoat every 15 years

Typical MCU System

Assumes 95% gantry access, 5% stage

Spot area (m^2)	2326.5
Spot cost	$1,541,718
Overcoat area (m^2)	46530
Overcoat cost	$2,490,185

Scenario 2

Do minimum repairs (0.2%) every 15 years, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	93.06
Do min cost	$1,262,774
Full replacement area (m^2)	46530
Full replacement cost	$10,374,652

Scenario 3

Do minimum repairs (0.2%) every 10 years, Full replacement with Thermal Metal Spray at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	93.06
Do min cost	$1,235,312
Full replacement area (m^2)	46530
Full replacement cost	$17,236,156

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	NPV Cost		Discount Factor	NPV Cost		Discount Factor	NPV Cost
2019/20	0			100.00%	$0	$0	$0		100.00%	$0		100.00%	$0
21	1			94.34%	$0	$0	$0		94.34%	$0		94.34%	$0
22	2			89.00%	$0	$0	$0		89.00%	$0		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0		83.96%	$0
24	4			79.21%	$0	$0	$0		79.21%	$0		79.21%	$0
25	5			74.73%	$0	$0	$0		74.73%	$0	$1,235,312	74.73%	$923,097
26	6			70.50%	$0	$0	$0		70.50%	$0		70.50%	$0
27	7			66.51%	$0	$0	$0		66.51%	$0		66.51%	$0
28	8			62.74%	$0	$0	$0		62.74%	$0		62.74%	$0
29	9	$1,541,718		59.19%	$912,541	$0	$912,541	$1,262,774	59.19%	$747,434		59.19%	$0
30	10			55.84%	$0	$0	$0		55.84%	$0		55.84%	$0
31	11			52.68%	$0	$0	$0		52.68%	$0		52.68%	$0
32	12		$4,031,903	49.70%	$0	$2,003,732	$2,003,732		49.70%	$0		49.70%	$0
33	13			46.88%	$0	$0	$0		46.88%	$0		46.88%	$0
34	14			44.23%	$0	$0	$0		44.23%	$0		44.23%	$0
35	15			41.73%	$0	$0	$0	$10,374,652	41.73%	$4,328,980	$17,236,156	41.73%	$7,192,046
36	16			39.36%	$0	$0	$0		39.36%	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0		35.03%	$0
39	19			33.05%	$0	$0	$0		33.05%	$0		33.05%	$0
40	20			31.18%	$0	$0	$0		31.18%	$0		31.18%	$0
41	21			29.42%	$0	$0	$0		29.42%	$0		29.42%	$0
42	22			27.75%	$0	$0	$0		27.75%	$0		27.75%	$0
43	23	$1,541,718		26.18%	$403,618	$0	$403,618		26.18%	$0		26.18%	$0
44	24			24.70%	$0	$0	$0	$1,262,774	24.70%	$311,878		24.70%	$0
45	25			23.30%	$0	$0	$0		23.30%	$0		23.30%	$0
46	26			21.98%	$0	$0	$0		21.98%	$0		21.98%	$0
47	27		$4,031,903	20.74%	$0	$836,088	$836,088		20.74%	$0		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0		18.46%	$0
50	30			17.41%	$0	$0	$0		17.41%	$0		17.41%	$0
51	31			16.43%	$0	$0	$0		16.43%	$0		16.43%	$0
52	32			15.50%	$0	$0	$0		15.50%	$0		15.50%	$0
53	33			14.62%	$0	$0	$0		14.62%	$0		14.62%	$0
54	34			13.79%	$0	$0	$0		13.79%	$0		13.79%	$0
55	35			13.01%	$0	$0	$0		13.01%	$0		13.01%	$0
56	36			12.27%	$0	$0	$0		12.27%	$0		12.27%	$0
57	37			11.58%	$0	$0	$0		11.58%	$0		11.58%	$0
58	38			10.92%	$0	$0	$0		10.92%	$0		10.92%	$0
59	39	$1,541,718		10.31%	$158,883	$0	$158,883	$1,262,774	10.31%	$130,136		10.31%	$0
2059/60	40			9.72%	$0	$0	$0		9.72%	$0		9.72%	$0
							$4,314,861			**$5,518,428**			**$8,115,143**

AHB Approach Viaducts & Over Land Areas

Scenario 1

Spot repair 5% every 15 years, overcoat every 15 years

Typical MCU System

Assumes 100% EWP access with collection set up below work area

Spot area (m^2)	365
Spot cost	$810,806
Overcoat area (m^2)	7300
Overcoat cost	$1,135,298

Scenario 2

Do minimum repairs (0.2%) every 15 years, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	7.3
Do min cost	$369,875
Full replacement area (m^2)	7300
Full replacement cost	$4,307,183

Discount 6.00%

	Year	Scenario 1	Discount Factor	NPV Cost	Do min	Replace	Discount Factor	Do min NPV	Replace NPV	Total NPV Cost
2019/20	0		100.00%	$0			100.00%	$0	$0	$0
21	1		94.34%	$0			94.34%	$0	$0	$0
22	2		89.00%	$0			89.00%	$0	$0	$0
23	3		83.96%	$0			83.96%	$0	$0	$0
24	4		79.21%	$0			79.21%	$0	$0	$0
25	5	$1,946,104	74.73%	$1,454,242	$369,875		74.73%	$276,392	$0	$276,392
26	6		70.50%	$0			70.50%	$0	$0	$0
27	7		66.51%	$0			66.51%	$0	$0	$0
28	8		62.74%	$0			62.74%	$0	$0	$0
29	9		59.19%	$0			59.19%	$0	$0	$0
30	10		55.84%	$0			55.84%	$0	$0	$0
31	11		52.68%	$0			52.68%	$0	$0	$0
32	12		49.70%	$0			49.70%	$0	$0	$0
33	13		46.88%	$0			46.88%	$0	$0	$0
34	14		44.23%	$0			44.23%	$0	$0	$0
35	15		41.73%	$0			41.73%	$0	$0	$0
36	16		39.36%	$0			39.36%	$0	$0	$0
37	17		37.14%	$0		$4,307,183	37.14%	$0	$1,599,534	$1,599,534
38	18		35.03%	$0			35.03%	$0	$0	$0
39	19		33.05%	$0			33.05%	$0	$0	$0
40	20	$1,946,104	31.18%	$606,805			31.18%	$0	$0	$0
41	21		29.42%	$0			29.42%	$0	$0	$0
42	22		27.75%	$0			27.75%	$0	$0	$0
43	23		26.18%	$0			26.18%	$0	$0	$0
44	24		24.70%	$0			24.70%	$0	$0	$0
45	25		23.30%	$0			23.30%	$0	$0	$0
46	26		21.98%	$0			21.98%	$0	$0	$0
47	27		20.74%	$0			20.74%	$0	$0	$0
48	28		19.56%	$0			19.56%	$0	$0	$0
49	29		18.46%	$0			18.46%	$0	$0	$0
50	30		17.41%	$0			17.41%	$0	$0	$0
51	31		16.43%	$0			16.43%	$0	$0	$0
52	32		15.50%	$0	$369,875		15.50%	$57,315	$0	$57,315
53	33		14.62%	$0			14.62%	$0	$0	$0
54	34		13.79%	$0			13.79%	$0	$0	$0
55	35	$1,946,104	13.01%	$253,198			13.01%	$0	$0	$0
56	36		12.27%	$0			12.27%	$0	$0	$0
57	37		11.58%	$0			11.58%	$0	$0	$0
58	38		10.92%	$0			10.92%	$0	$0	$0
59	39		10.31%	$0			10.31%	$0	$0	$0
2059/60	40		9.72%	$0			9.72%	$0	$0	$0
				$2,314,245						**$1,933,241**

AHB Overarch

Scenario 1

Spot repair 3% every 12 years, overcoat every 12 years

Typical MCU System

Assumes 100% EWP access

Spot area (m^2)	365
Spot cost	$221,586
Overcoat area (m^2)	7300
Overcoat cost	$786,299

Scenario 2

Do minimum repairs (0.2%) every 12 years, Full replacement with modified MCU at year 10

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment) during long term closures

Do min area (m^2)	14.6
Do min cost	$63,492
Full replacement area (m^2)	7300
Full replacement cost	$5,163,115

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost		Discount Factor	NPV Cost
2019/20	0	$100,169		100.00%	$100,169	$0	$100,169	$63,492	100.00%	$63,492
21	1		$700,129	94.34%	$0	$660,499	$660,499		94.34%	$0
22	2			89.00%	$0	$0	$0		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0
24	4			79.21%	$0	$0	$0		79.21%	$0
25	5			74.73%	$0	$0	$0		74.73%	$0
26	6			70.50%	$0	$0	$0		70.50%	$0
27	7			66.51%	$0	$0	$0		66.51%	$0
28	8			62.74%	$0	$0	$0		62.74%	$0
29	9			59.19%	$0	$0	$0		59.19%	$0
30	10			55.84%	$0	$0	$0	$5,163,115	55.84%	$2,883,056
31	11			52.68%	$0	$0	$0		52.68%	$0
32	12	$221,586		49.70%	$110,121	$0	$110,121		49.70%	$0
33	13		$786,299	46.88%	$0	$368,648	$368,648		46.88%	$0
34	14			44.23%	$0	$0	$0		44.23%	$0
35	15			41.73%	$0	$0	$0		41.73%	$0
36	16			39.36%	$0	$0	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0
39	19			33.05%	$0	$0	$0		33.05%	$0
40	20			31.18%	$0	$0	$0		31.18%	$0
41	21			29.42%	$0	$0	$0		29.42%	$0
42	22			27.75%	$0	$0	$0	$63,492	27.75%	$17,619
43	23			26.18%	$0	$0	$0		26.18%	$0
44	24			24.70%	$0	$0	$0		24.70%	$0
45	25	$221,586		23.30%	$51,629	$0	$51,629		23.30%	$0
46	26		$786,299	21.98%	$0	$172,836	$172,836		21.98%	$0
47	27			20.74%	$0	$0	$0		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0
50	30			17.41%	$0	$0	$0		17.41%	$0
51	31			16.43%	$0	$0	$0		16.43%	$0
52	32			15.50%	$0	$0	$0		15.50%	$0
53	33			14.62%	$0	$0	$0		14.62%	$0
54	34			13.79%	$0	$0	$0	$63,492	13.79%	$8,756
55	35			13.01%	$0	$0	$0		13.01%	$0
56	36			12.27%	$0	$0	$0		12.27%	$0
57	37	$221,586		11.58%	$25,658	$0	$25,658		11.58%	$0
58	38		$786,299	10.92%	$0	$85,894	$85,894		10.92%	$0
59	39			10.31%	$0	$0	$0		10.31%	$0
2059/60	40			9.72%	$0	$0	$0		9.72%	$0
							$1,575,456			**$2,972,925**

AHB Truss Bridge Above Walkways

Scenario 1

Spot repair 5% every 15 years, overcoat every 15 years

Typical MCU System

Assumes 95% Walkway access, 5% Gantry access

Spot area (m^2)	960
Spot cost	$165,563
Overcoat area (m^2)	15998
Overcoat cost	$659,833

Scenario 2

Do minimum repairs (0.33%) every 15 years, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	53
Do min cost	$19,559
Full replacement area (m^2)	15998
Full replacement cost	$6,025,135

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost		Discount Factor	NPV Cost
2019/20	0			100.00%	$0	$0	$0		100.00%	$0
21	1			94.34%	$0	$0	$0		94.34%	$0
22	2			89.00%	$0	$0	$0		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0
24	4			79.21%	$0	$0	$0		79.21%	$0
25	5	$165,563		74.73%	$123,718	$0	$123,718	$19,559	74.73%	$14,616
26	6			70.50%	$0	$0	$0		70.50%	$0
27	7			66.51%	$0	$0	$0		66.51%	$0
28	8		$825,397	62.74%	$0	$517,864	$517,864		62.74%	$0
29	9			59.19%	$0	$0	$0		59.19%	$0
30	10			55.84%	$0	$0	$0	$6,025,135	55.84%	$3,364,404
31	11			52.68%	$0	$0	$0		52.68%	$0
32	12			49.70%	$0	$0	$0		49.70%	$0
33	13			46.88%	$0	$0	$0		46.88%	$0
34	14			44.23%	$0	$0	$0		44.23%	$0
35	15			41.73%	$0	$0	$0		41.73%	$0
36	16			39.36%	$0	$0	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0
39	19			33.05%	$0	$0	$0		33.05%	$0
40	20	$165,563		31.18%	$51,623	$0	$51,623		31.18%	$0
41	21			29.42%	$0	$0	$0		29.42%	$0
42	22			27.75%	$0	$0	$0		27.75%	$0
43	23		$825,397	26.18%	$0	$216,087	$216,087		26.18%	$0
44	24			24.70%	$0	$0	$0		24.70%	$0
45	25			23.30%	$0	$0	$0	$19,559	23.30%	$4,557
46	26			21.98%	$0	$0	$0		21.98%	$0
47	27			20.74%	$0	$0	$0		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0
50	30			17.41%	$0	$0	$0		17.41%	$0
51	31			16.43%	$0	$0	$0		16.43%	$0
52	32			15.50%	$0	$0	$0		15.50%	$0
53	33			14.62%	$0	$0	$0		14.62%	$0
54	34			13.79%	$0	$0	$0		13.79%	$0
55	35	$165,563		13.01%	$21,541	$0	$21,541		13.01%	$2,545
56	36			12.27%	$0	$0	$0		12.27%	$0
57	37			11.58%	$0	$0	$0		11.58%	$0
58	38		$825,397	10.92%	$0	$90,165	$90,165		10.92%	$0
59	39			10.31%	$0	$0	$0		10.31%	$0
2059/60	40			9.72%	$0	$0	$0	$19,559	9.72%	$1,902
							$1,020,999			**$3,388,023**

AHB Truss Bridge Below Walkways

Scenario 1

Spot repair every year (4%pa), Spot and overcoat every 10 years

Typical MCU System

Assumes 95% rope access, 5% scaffold

Spot area (m^2)	1198
Spot cost	$862,869
Overcoat area (m^2)	29953
Overcoat cost	$2,326,563

Scenario 2

Do minimum repairs (0.27%pa) every year, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

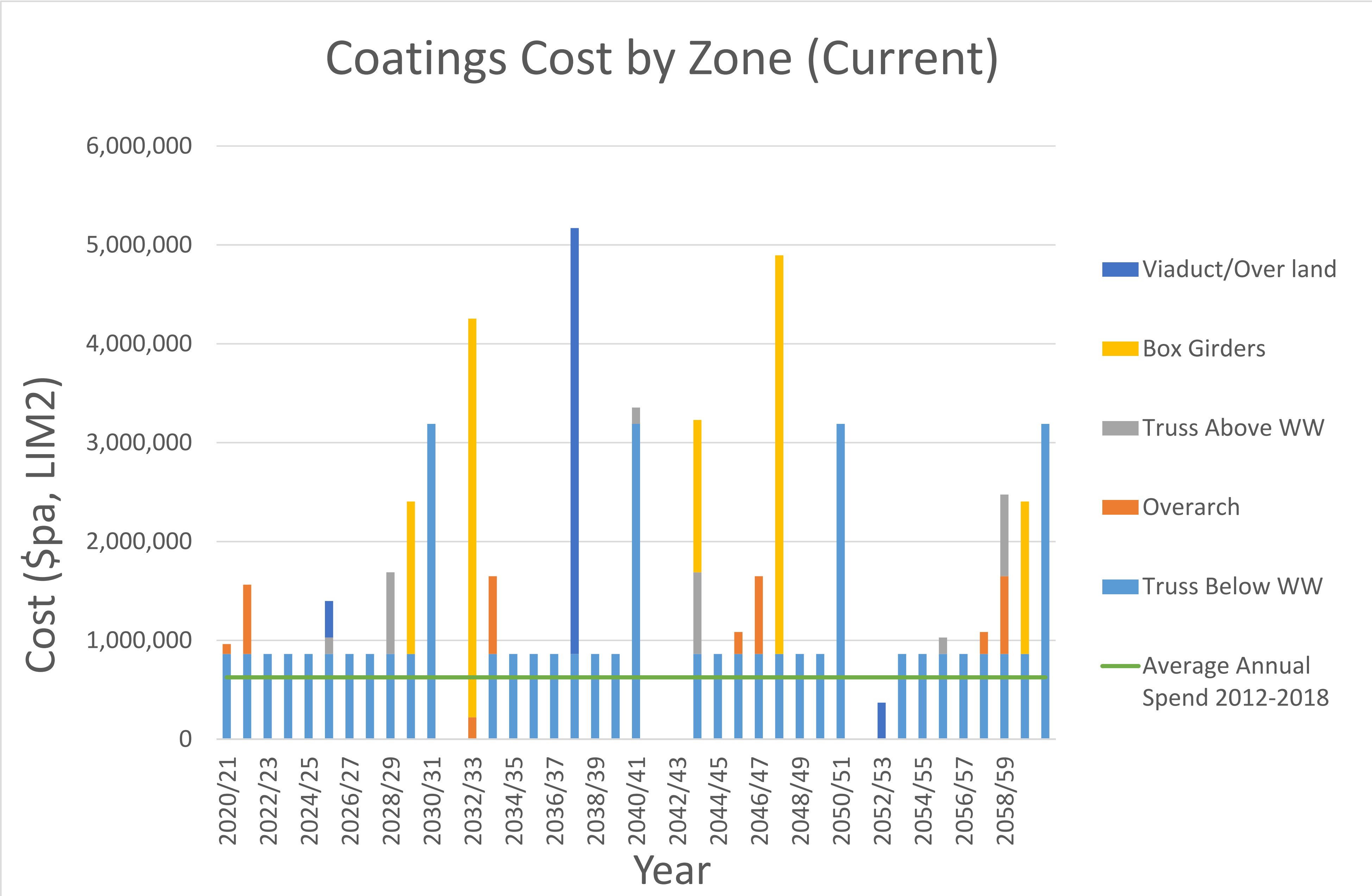
Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

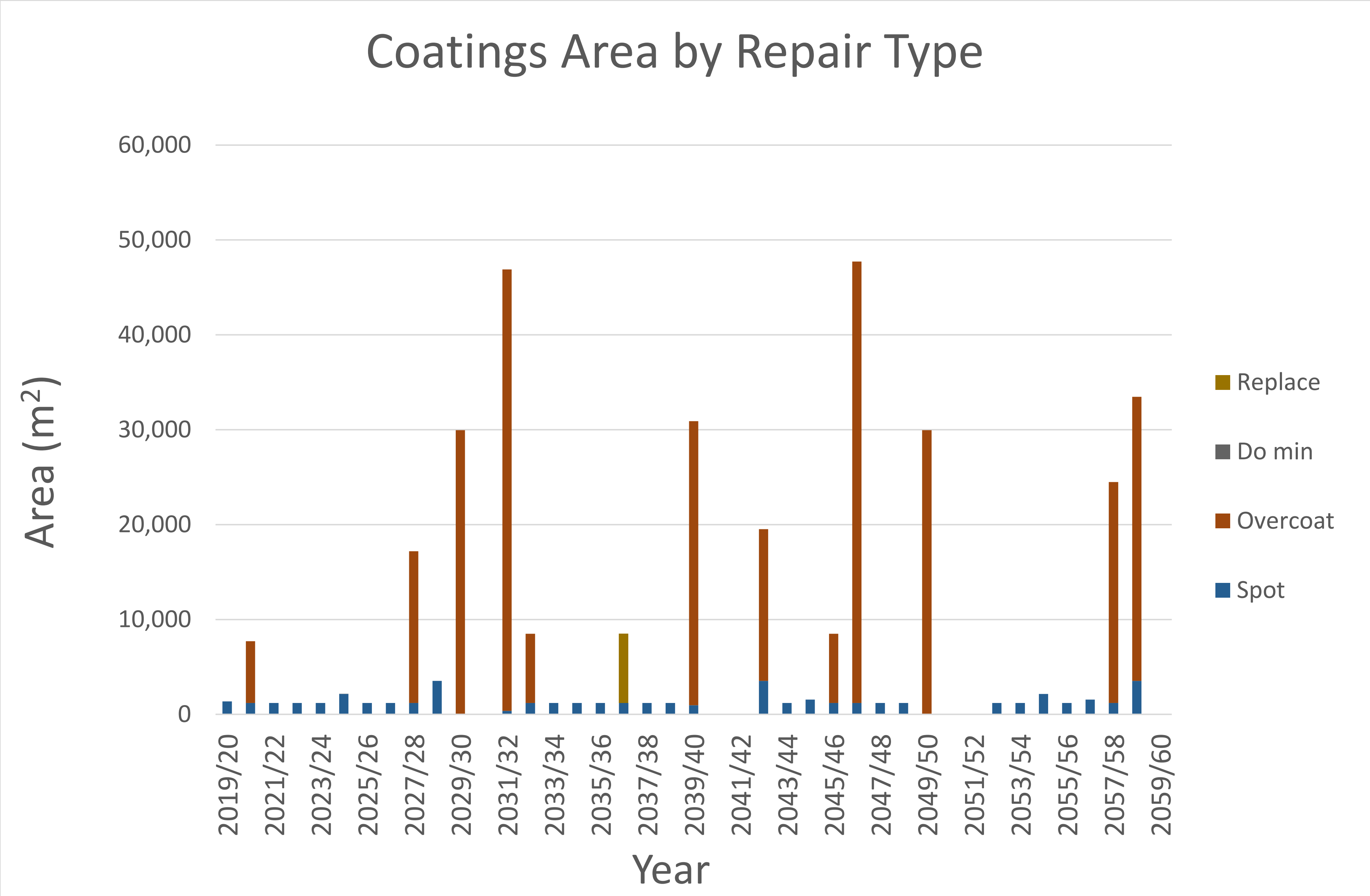
Do min area (m^2)	81
Do min cost	$678,930
Full replacement area (m^2)	29953
Full replacement cost	$30,713,047

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost	Scenario 2 Cost	Discount Factor	NPV Cost
2019/20	0	$862,869		100.00%	$862,869	$0	$862,869	$678,930	100.00%	$678,930
21	1	$862,869		94.34%	$814,027	$0	$814,027	$678,930	94.34%	$640,500
22	2	$862,869		89.00%	$767,950	$0	$767,950	$678,930	89.00%	$604,246
23	3	$862,869		83.96%	$724,481	$0	$724,481	$678,930	83.96%	$570,043
24	4	$862,869		79.21%	$683,473	$0	$683,473	$678,930	79.21%	$537,777
25	5	$862,869		74.73%	$644,786	$0	$644,786	$678,930	74.73%	$507,336
26	6	$862,869		70.50%	$608,288	$0	$608,288	$678,930	70.50%	$478,619
27	7	$862,869		66.51%	$573,857	$0	$573,857	$678,930	66.51%	$451,528
28	8	$862,869		62.74%	$541,375	$0	$541,375	$678,930	62.74%	$425,969
29	9	$862,869		59.19%	$510,731	$0	$510,731	$678,930	59.19%	$401,858
30	10		$3,189,431	55.84%	$0	$1,780,962	$1,780,962	$678,930	55.84%	$379,111
31	11			52.68%	$0	$0	$0	$678,930	52.68%	$357,652
32	12			49.70%	$0	$0	$0	$678,930	49.70%	$337,408
33	13	$862,869		46.88%	$404,547	$0	$404,547	$678,930	46.88%	$318,309
34	14	$862,869		44.23%	$381,648	$0	$381,648	$678,930	44.23%	$300,292
35	15	$862,869		41.73%	$360,045	$0	$360,045	$30,713,047	41.73%	$12,815,481
36	16	$862,869		39.36%	$339,665	$0	$339,665		39.36%	$0
37	17	$862,869		37.14%	$320,439	$0	$320,439		37.14%	$0
38	18	$862,869		35.03%	$302,301	$0	$302,301		35.03%	$0
39	19	$862,869		33.05%	$285,189	$0	$285,189		33.05%	$0
40	20		$3,189,431	31.18%	$0	$994,480	$994,480		31.18%	$0
41	21			29.42%	$0	$0	$0	$678,930	29.42%	$199,711
42	22			27.75%	$0	$0	$0	$678,930	27.75%	$188,407
43	23	$862,869		26.18%	$225,897	$0	$225,897	$678,930	26.18%	$177,742
44	24	$862,869		24.70%	$213,110	$0	$213,110	$678,930	24.70%	$167,681
45	25	$862,869		23.30%	$201,047	$0	$201,047	$678,930	23.30%	$158,190
46	26	$862,869		21.98%	$189,667	$0	$189,667	$678,930	21.98%	$149,236
47	27	$862,869		20.74%	$178,931	$0	$178,931	$678,930	20.74%	$140,788
48	28	$862,869		19.56%	$168,803	$0	$168,803	$678,930	19.56%	$132,819
49	29	$862,869		18.46%	$159,248	$0	$159,248	$678,930	18.46%	$125,301
50	30		$3,189,431	17.41%	$0	$555,312	$555,312	$678,930	17.41%	$118,209
51	31			16.43%	$0	$0	$0	$678,930	16.43%	$111,518
52	32			15.50%	$0	$0	$0	$678,930	15.50%	$105,205
53	33	$862,869		14.62%	$126,140	$0	$126,140	$678,930	14.62%	$99,250
54	34	$862,869		13.79%	$119,000	$0	$119,000	$678,930	13.79%	$93,632
55	35	$862,869		13.01%	$112,264	$0	$112,264	$678,930	13.01%	$88,332
56	36	$862,869		12.27%	$105,909	$0	$105,909	$678,930	12.27%	$83,332
57	37	$862,869		11.58%	$99,914	$0	$99,914	$678,930	11.58%	$78,616
58	38	$862,869		10.92%	$94,259	$0	$94,259	$678,930	10.92%	$74,166
59	39	$862,869		10.31%	$88,923	$0	$88,923	$678,930	10.31%	$69,968
2059/60	40		$3,189,431	9.72%	$0	$310,083	$310,083	$678,930	9.72%	$66,007
							$14,849,620			**$22,233,170**



Coatings Cost by Zone (Current)
Cost ($pa, LIM2)
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
2020/21
2022/23
2024/25
2026/27
2028/29
2030/31
2032/33
2034/35
2036/37
2038/39
2040/41
2042/43
2044/45
2046/47
2048/49
2050/51
2052/53
2054/55
2056/57
2058/59
Year
Viaduct/Over land
Box Girders
Truss Above WW
Overarch
Truss Below WW
Average Annual Spend 2012-2018



Coatings Area by Repair Type
Area (m²)
60,000
50,000
40,000
30,000
20,000
10,000
0
2019/20
2021/22
2023/24
2025/26
2027/28
2029/30
2031/32
2033/34
2035/36
2037/38
2039/40
2041/42
2043/44
2045/46
2047/48
2049/50
2051/52
2053/54
2055/56
2057/58
2059/60
Year
Replace
Do min
Overcoat
Spot

Year	Area Waterblasted (m^2)	Area Abrasive blasted (m^2)	Area Typical MCU spray, (m^2)	Area Ferrox overcoat spray, (m^2)	Water blasting, zinc (kg/m2)	Abrasive blasting, garnet (kg/m2)	Abrasive blasting, zinc (kg/m2)	Abrasive blasting, paint (kg/m2)	Typical MCU, zinc (kg/m2)	Typical MCU, paint (kg/m2)	Ferrox overcoat, paint (kg/m2)	Garnet discharged (kg)	Zinc discharged (kg)	Paint discharged (kg)
2019/20	1363	1363	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	10108	116	330
2020/21	7698	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	305
2021/22	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2022/23	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2023/24	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2024/25	2165	2158	2158	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	16003	197	549
2025/26	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2026/27	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2027/28	17196	1198	1198	15998	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	115	643
2028/29	3525	3525	3525	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	26137	322	896
2029/30	29953	0	0	29953	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	10	633
2030/31	0	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0
2031/32	46895	365	0	46530	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	2707	30	1039
2032/33	8498	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	305
2033/34	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2034/35	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2035/36	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2036/37	8498	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	305
2037/38	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2038/39	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2039/40	30913	960	960	29953	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	7118	97	877
2040/41	0	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0
2041/42	0	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0
2042/43	19523	3525	3525	15998	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	26137	327	1234
2043/44	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2044/45	1563	1563	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11592	124	361
2045/46	8498	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	305
2046/47	47728	1198	1198	46530	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	124	1287
2047/48	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2048/49	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2049/50	29953	0	0	29953	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	10	633
2050/51	0	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0
2051/52	7	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0
2052/53	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2053/54	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2054/55	2158	2158	2158	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	16003	197	549
2055/56	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305
2056/57	1563	1563	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11592	124	361
2057/58	24496	1198	1198	15998	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	117	643
2058/59	33478	3525	3525	29953	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	26137	332	1529
2059/60	0	0	0	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	0	0	0

exceeds threshold

within 10% threshold

Appendix C - NPV Iteration 2

AHB Box Girder Extensions

Scenario 1

Spot repair 5% every 15 years, overcoat every 15 years. Spot repairs are spread over 3 years and over coating over 5 years.

Typical MCU System

Assumes 95% gantry access, 5% stage

Spot area (m^2)	2326.5
Spot cost	$1,541,718
Overcoat area (m^2)	46530
Overcoat cost	$2,490,185

Scenario 2

Do minimum repairs (0.2%) every 15 years, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	93.06
Do min cost	$1,262,774
Full replacement area (m^2)	46530
Full replacement cost	$10,374,652

Scenario 3

Do minimum repairs (0.2%) every 10 years, Full replacement with Thermal Metal Spray at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	93.06
Do min cost	$1,235,312
Full replacement area (m^2)	46530
Full replacement cost	$17,236,156

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	NPV Cost		Discount Factor	NPV Cost		Discount Factor	NPV Cost
2019/20	0			100.00%	$0	$0	$0		100.00%	$0		100.00%	$0
21	1			94.34%	$0	$0	$0		94.34%	$0		94.34%	$0
22	2			89.00%	$0	$0	$0		89.00%	$0		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0		83.96%	$0
24	4			79.21%	$0	$0	$0		79.21%	$0		79.21%	$0
25	5			74.73%	$0	$0	$0		74.73%	$0	$1,235,312	74.73%	$923,097
26	6			70.50%	$0	$0	$0		70.50%	$0		70.50%	$0
27	7			66.51%	$0	$0	$0		66.51%	$0		66.51%	$0
28	8			62.74%	$0	$0	$0		62.74%	$0		62.74%	$0
29	9			59.19%	$0	$0	$0	$1,262,774	59.19%	$747,434		59.19%	$0
30	10	$513,906		55.84%	$286,962	$0	$286,962		55.84%	$0		55.84%	$0
31	11	$513,906		52.68%	$270,719	$0	$270,719		52.68%	$0		52.68%	$0
32	12	$513,906	$806,381	49.70%	$255,396	$400,746	$656,142		49.70%	$0		49.70%	$0
33	13		$806,381	46.88%	$0	$378,063	$378,063		46.88%	$0		46.88%	$0
34	14		$806,381	44.23%	$0	$356,663	$356,663		44.23%	$0		44.23%	$0
35	15		$806,381	41.73%	$0	$336,474	$336,474	$10,374,652	41.73%	$4,328,980	$17,236,156	41.73%	$7,192,046
36	16		$806,381	39.36%	$0	$317,429	$317,429		39.36%	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0		35.03%	$0
39	19			33.05%	$0	$0	$0		33.05%	$0		33.05%	$0
40	20	$513,906		31.18%	$160,238	$0	$160,238		31.18%	$0		31.18%	$0
41	21	$513,906		29.42%	$151,168	$0	$151,168		29.42%	$0		29.42%	$0
42	22	$513,906		27.75%	$142,612	$0	$142,612		27.75%	$0		27.75%	$0
43	23		$806,381	26.18%	$0	$211,108	$211,108		26.18%	$0		26.18%	$0
44	24		$806,381	24.70%	$0	$199,159	$199,159	$1,262,774	24.70%	$311,878		24.70%	$0
45	25		$806,381	23.30%	$0	$187,886	$187,886		23.30%	$0		23.30%	$0
46	26		$806,381	21.98%	$0	$177,251	$177,251		21.98%	$0		21.98%	$0
47	27		$806,381	20.74%	$0	$167,218	$167,218		20.74%	$0		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0		18.46%	$0
50	30	$513,906		17.41%	$89,476	$0	$89,476		17.41%	$0		17.41%	$0
51	31	$513,906		16.43%	$84,412	$0	$84,412		16.43%	$0		16.43%	$0
52	32	$513,906		15.50%	$79,634	$0	$79,634		15.50%	$0		15.50%	$0
53	33		$806,381	14.62%	$0	$117,882	$117,882		14.62%	$0		14.62%	$0
54	34		$806,381	13.79%	$0	$111,209	$111,209		13.79%	$0		13.79%	$0
55	35		$806,381	13.01%	$0	$104,914	$104,914		13.01%	$0		13.01%	$0
56	36		$806,381	12.27%	$0	$98,976	$98,976		12.27%	$0		12.27%	$0
57	37		$806,381	11.58%	$0	$93,373	$93,373		11.58%	$0		11.58%	$0
58	38			10.92%	$0	$0	$0		10.92%	$0		10.92%	$0
59	39			10.31%	$0	$0	$0	$1,262,774	10.31%	$130,136		10.31%	$0
2059/60	40	$513,906		9.72%	$49,963	$0	$49,963		9.72%	$0		9.72%	$0
							$4,828,930			**$5,518,428**			**$8,115,143**

AHB Approach Viaducts & Over Land Areas

		Scenario 1			Scenario 2					
		Spot repair 5% every 15 years, overcoat every 15 years			Do minimum repairs (0.2%) every 15 years, Full replacement with modified MCU at year 15 (completed over 5 years)					
					Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat					
		Typical MCU System								
		Assumes 100% EWP access with collection set up below work area			Worse aesthetic (rust grade) as only structurally critical defects are repaired					
					For full replacement assume 100% scaffold access (to support containment)					
		Spot area (m^2)	365							
		Spot cost	$810,806		Do min area (m^2)	7.3				
		Overcoat area (m^2)	7300		Do min cost	$369,875				
		Overcoat cost	$1,135,298		Full replacement area (m^2)	7300				
					Full replacement cost	$4,307,183				
Discount	6.00%									
	Year		Discount Factor	NPV Cost	Do min	Replace	Discount Factor	Do min NPV	Replace NPV	Total NPV Cost
2019/20	0		100.00%	$0			100.00%	$0	$0	$0
21	1		94.34%	$0			94.34%	$0	$0	$0
22	2		89.00%	$0			89.00%	$0	$0	$0
23	3		83.96%	$0			83.96%	$0	$0	$0
24	4		79.21%	$0			79.21%	$0	$0	$0
25	5	$1,946,104	74.73%	$1,454,242	$369,875		74.73%	$276,392	$0	$276,392
26	6		70.50%	$0			70.50%	$0	$0	$0
27	7		66.51%	$0			66.51%	$0	$0	$0
28	8		62.74%	$0			62.74%	$0	$0	$0
29	9		59.19%	$0			59.19%	$0	$0	$0
30	10		55.84%	$0			55.84%	$0	$0	$0
31	11		52.68%	$0			52.68%	$0	$0	$0
32	12		49.70%	$0			49.70%	$0	$0	$0
33	13		46.88%	$0			46.88%	$0	$0	$0
34	14		44.23%	$0			44.23%	$0	$0	$0
35	15		41.73%	$0		$861,437	41.73%	$0	$359,447	$359,447
36	16		39.36%	$0		$861,437	39.36%	$0	$339,101	$339,101
37	17		37.14%	$0		$861,437	37.14%	$0	$319,907	$319,907
38	18		35.03%	$0		$861,437	35.03%	$0	$301,799	$301,799
39	19		33.05%	$0		$861,437	33.05%	$0	$284,716	$284,716
40	20	$1,946,104	31.18%	$606,805			31.18%	$0	$0	$0
41	21		29.42%	$0			29.42%	$0	$0	$0
42	22		27.75%	$0			27.75%	$0	$0	$0
43	23		26.18%	$0			26.18%	$0	$0	$0
44	24		24.70%	$0			24.70%	$0	$0	$0
45	25		23.30%	$0			23.30%	$0	$0	$0
46	26		21.98%	$0			21.98%	$0	$0	$0
47	27		20.74%	$0			20.74%	$0	$0	$0
48	28		19.56%	$0			19.56%	$0	$0	$0
49	29		18.46%	$0			18.46%	$0	$0	$0
50	30		17.41%	$0			17.41%	$0	$0	$0
51	31		16.43%	$0			16.43%	$0	$0	$0
52	32		15.50%	$0	$369,875		15.50%	$57,315	$0	$57,315
53	33		14.62%	$0			14.62%	$0	$0	$0
54	34		13.79%	$0			13.79%	$0	$0	$0
55	35	$1,946,104	13.01%	$253,198			13.01%	$0	$0	$0
56	36		12.27%	$0			12.27%	$0	$0	$0
57	37		11.58%	$0			11.58%	$0	$0	$0
58	38		10.92%	$0			10.92%	$0	$0	$0
59	39		10.31%	$0			10.31%	$0	$0	$0
2059/60	40		9.72%	$0			9.72%	$0	$0	$0
				$2,314,245						**$1,938,677**

AHB Overarch

Scenario 1

Spot repair 3% every 12 years, overcoat every 12 years. Over coating is spread over 3 years.

Typical MCU System

Assumes 100% EWP access

Spot area (m^2)	365
Spot cost	$221,586
Overcoat area (m^2)	7300
Overcoat cost	$786,299

Scenario 2

Do minimum repairs (0.2%) every 12 years, Full replacement with modified MCU at year 10

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment) during long term closures

Do min area (m^2)	14.6
Do min cost	$63,492
Full replacement area (m^2)	7300
Full replacement cost	$5,163,115

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost		Discount Factor	NPV Cost
2019/20	0	$51,602	$215,424	100.00%	$51,602	$215,424	$267,027	$63,492	100.00%	$63,492
21	1	$53,423	$215,424	94.34%	$50,399	$203,231	$253,630		94.34%	$0
22	2		$269,281	89.00%	$0	$239,659	$239,659		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0
24	4			79.21%	$0	$0	$0		79.21%	$0
25	5			74.73%	$0	$0	$0		74.73%	$0
26	6			70.50%	$0	$0	$0		70.50%	$0
27	7			66.51%	$0	$0	$0		66.51%	$0
28	8			62.74%	$0	$0	$0		62.74%	$0
29	9			59.19%	$0	$0	$0		59.19%	$0
30	10			55.84%	$0	$0	$0	$5,163,115	55.84%	$2,883,056
31	11			52.68%	$0	$0	$0		52.68%	$0
32	12	$221,586	$262,100	49.70%	$110,121	$130,256	$240,377		49.70%	$0
33	13		$262,100	46.88%	$0	$122,883	$122,883		46.88%	$0
34	14		$262,100	44.23%	$0	$115,927	$115,927		44.23%	$0
35	15			41.73%	$0	$0	$0		41.73%	$0
36	16			39.36%	$0	$0	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0
39	19			33.05%	$0	$0	$0		33.05%	$0
40	20			31.18%	$0	$0	$0		31.18%	$0
41	21			29.42%	$0	$0	$0		29.42%	$0
42	22			27.75%	$0	$0	$0	$63,492	27.75%	$17,619
43	23			26.18%	$0	$0	$0		26.18%	$0
44	24			24.70%	$0	$0	$0		24.70%	$0
45	25	$221,586	$262,100	23.30%	$51,629	$61,069	$112,698		23.30%	$0
46	26		$262,100	21.98%	$0	$57,612	$57,612		21.98%	$0
47	27		$262,100	20.74%	$0	$54,351	$54,351		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0
50	30			17.41%	$0	$0	$0		17.41%	$0
51	31			16.43%	$0	$0	$0		16.43%	$0
52	32			15.50%	$0	$0	$0		15.50%	$0
53	33			14.62%	$0	$0	$0		14.62%	$0
54	34			13.79%	$0	$0	$0	$63,492	13.79%	$8,756
55	35			13.01%	$0	$0	$0		13.01%	$0
56	36			12.27%	$0	$0	$0		12.27%	$0
57	37	$221,586	$262,100	11.58%	$25,658	$30,349	$56,007		11.58%	$0
58	38		$262,100	10.92%	$0	$28,631	$28,631		10.92%	$0
59	39		$262,100	10.31%	$0	$27,011	$27,011		10.31%	$0
2059/60	40			9.72%	$0	$0	$0		9.72%	$0
							$1,575,813			**$2,972,925**

AHB Truss Bridge Above Walkways

Scenario 1

Spot repair 5% every 15 years, overcoat every 15 years. Spot repairs are spread over 3 years and over coat over 5 years.

Typical MCU System

Assumes 95% Walkway access, 5% Gantry access

Spot area (m^2)	960
Spot cost	$165,563
Overcoat area (m^2)	15998
Overcoat cost	$659,833

Scenario 2

Do minimum repairs (0.33%) every 15 years, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

Do min area (m^2)	53
Do min cost	$19,559
Full replacement area (m^2)	15998
Full replacement cost	$6,025,135

Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost	Scenario 2	Discount Factor	NPV Cost
2019/20	0			100.00%	$0	$0	$0		100.00%	$0
21	1			94.34%	$0	$0	$0		94.34%	$0
22	2			89.00%	$0	$0	$0		89.00%	$0
23	3			83.96%	$0	$0	$0		83.96%	$0
24	4	$55,188		79.21%	$43,714	$0	$43,714		79.21%	$0
25	5	$55,188		74.73%	$41,239	$0	$41,239	$19,559	74.73%	$14,616
26	6	$55,188	$165,079	70.50%	$38,905	$116,374	$155,280		70.50%	$0
27	7		$165,079	66.51%	$0	$109,787	$109,787		66.51%	$0
28	8		$165,079	62.74%	$0	$103,573	$103,573		62.74%	$0
29	9		$165,079	59.19%	$0	$97,710	$97,710		59.19%	$0
30	10		$165,079	55.84%	$0	$92,179	$92,179	$6,025,135	55.84%	$3,364,404
31	11			52.68%	$0	$0	$0		52.68%	$0
32	12			49.70%	$0	$0	$0		49.70%	$0
33	13			46.88%	$0	$0	$0		46.88%	$0
34	14			44.23%	$0	$0	$0		44.23%	$0
35	15			41.73%	$0	$0	$0		41.73%	$0
36	16			39.36%	$0	$0	$0		39.36%	$0
37	17			37.14%	$0	$0	$0		37.14%	$0
38	18			35.03%	$0	$0	$0		35.03%	$0
39	19	$55,188		33.05%	$18,240	$0	$18,240		33.05%	$0
40	20	$55,188		31.18%	$17,208	$0	$17,208		31.18%	$0
41	21	$55,188	$165,079	29.42%	$16,234	$48,559	$64,793		29.42%	$0
42	22		$165,079	27.75%	$0	$45,810	$45,810		27.75%	$0
43	23		$165,079	26.18%	$0	$43,217	$43,217		26.18%	$0
44	24		$165,079	24.70%	$0	$40,771	$40,771		24.70%	$0
45	25		$165,079	23.30%	$0	$38,463	$38,463	$19,559	23.30%	$4,557
46	26			21.98%	$0	$0	$0		21.98%	$0
47	27			20.74%	$0	$0	$0		20.74%	$0
48	28			19.56%	$0	$0	$0		19.56%	$0
49	29			18.46%	$0	$0	$0		18.46%	$0
50	30			17.41%	$0	$0	$0		17.41%	$0
51	31			16.43%	$0	$0	$0		16.43%	$0
52	32			15.50%	$0	$0	$0		15.50%	$0
53	33			14.62%	$0	$0	$0		14.62%	$0
54	34	$55,188		13.79%	$7,611	$0	$7,611		13.79%	$0
55	35	$55,188		13.01%	$7,180	$0	$7,180		13.01%	$0
56	36	$55,188		12.27%	$6,774	$0	$6,774		12.27%	$0
57	37		$165,079	11.58%	$0	$19,115	$19,115		11.58%	$0
58	38		$165,079	10.92%	$0	$18,033	$18,033		10.92%	$0
59	39		$165,079	10.31%	$0	$17,012	$17,012		10.31%	$0
2059/60	40		$165,079	9.72%	$0	$16,049	$16,049	$19,559	9.72%	$1,902
							$1,003,760			**$3,385,478**

AHB Truss Bridge Below Walkways

Scenario 1

Spot repair every year (4%pa), Spot and overcoat every 10 years. Over coating is spread over 5 years.

Typical MCU System

Assumes 95% rope access, 5% scaffold

Spot area (m^2)	1198	
Spot cost	$862,869	
Overcoat area (m^2)	29953	5990.61
Overcoat cost	$2,326,563	

Scenario 2

Do minimum repairs (0.27%pa) every year, Full replacement with modified MCU at year 15

Assumes faster adhesion deterioration, therefore need for full replacement rather than overcoat

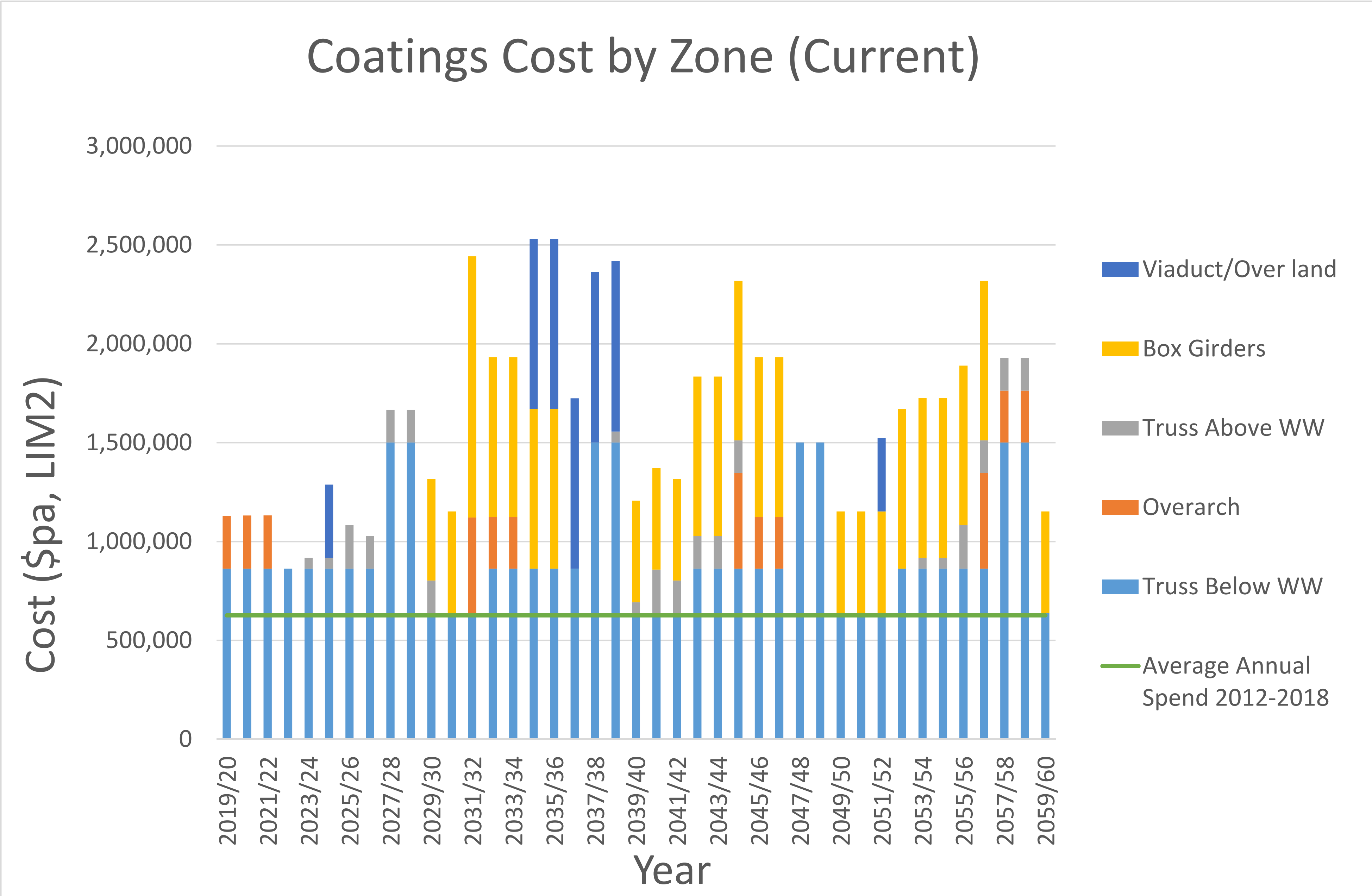
Worse aesthetic (rust grade) as only structurally critical defects are repaired

For full replacement assume 100% scaffold access (to support containment)

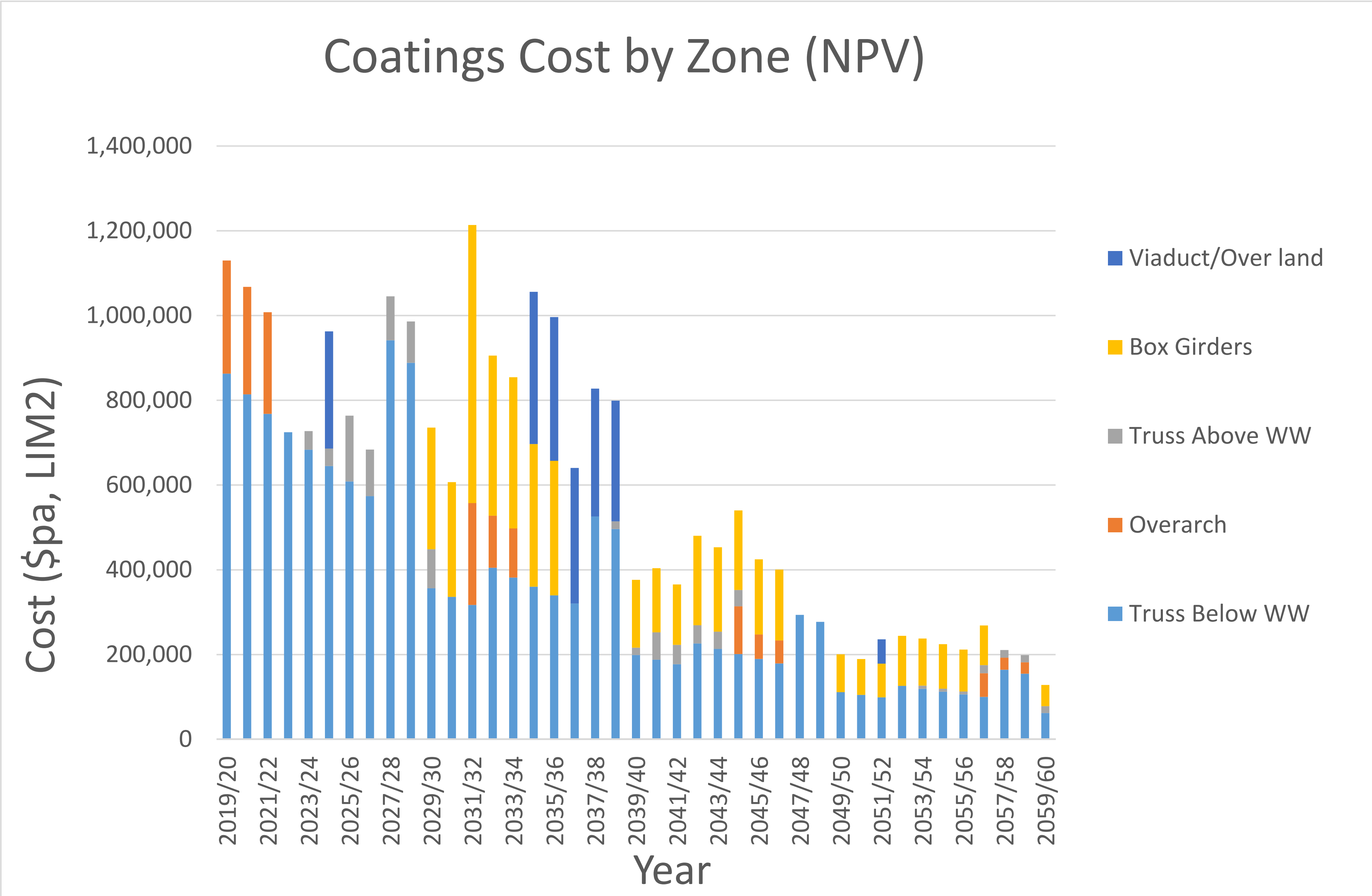
Do min area (m^2)	81
Do min cost	$678,930
Full replacement area (m^2)	29953
Full replacement cost	$30,713,047

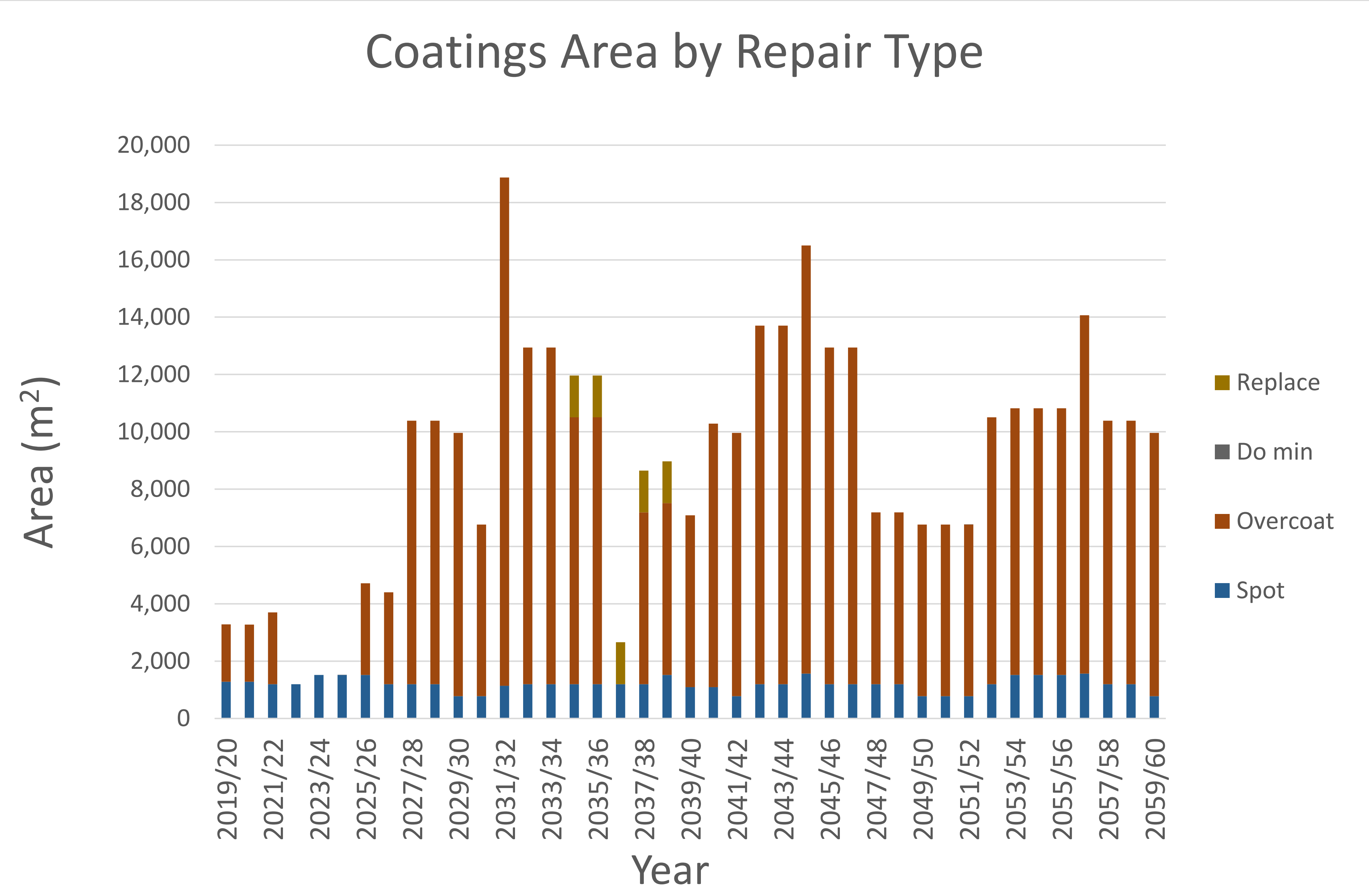
Discount 6.00%

	Year	Spot	Overcoat	Discount Factor	Spot NPV	Overcoat NPV	Total NPV Cost		Discount Factor	NPV Cost
2019/20	0	$862,869		100.00%	$862,869	$0	$862,869	$678,930	100.00%	$678,930
21	1	$862,869		94.34%	$814,027	$0	$814,027	$678,930	94.34%	$640,500
22	2	$862,869		89.00%	$767,950	$0	$767,950	$678,930	89.00%	$604,246
23	3	$862,869		83.96%	$724,481	$0	$724,481	$678,930	83.96%	$570,043
24	4	$862,869		79.21%	$683,473	$0	$683,473	$678,930	79.21%	$537,777
25	5	$862,869		74.73%	$644,786	$0	$644,786	$678,930	74.73%	$507,336
26	6	$862,869		70.50%	$608,288	$0	$608,288	$678,930	70.50%	$478,619
27	7	$862,869		66.51%	$573,857	$0	$573,857	$678,930	66.51%	$451,528
28	8	$862,869	$637,886	62.74%	$541,375	$400,218	$941,592	$678,930	62.74%	$425,969
29	9	$862,869	$637,886	59.19%	$510,731	$377,564	$888,295	$678,930	59.19%	$401,858
30	10		$637,886	55.84%	$0	$356,192	$356,192	$678,930	55.84%	$379,111
31	11		$637,886	52.68%	$0	$336,031	$336,031	$678,930	52.68%	$357,652
32	12		$637,886	49.70%	$0	$317,010	$317,010	$678,930	49.70%	$337,408
33	13	$862,869		46.88%	$404,547	$0	$404,547	$678,930	46.88%	$318,309
34	14	$862,869		44.23%	$381,648	$0	$381,648	$678,930	44.23%	$300,292
35	15	$862,869		41.73%	$360,045	$0	$360,045	$30,713,047	41.73%	$12,815,481
36	16	$862,869		39.36%	$339,665	$0	$339,665		39.36%	$0
37	17	$862,869		37.14%	$320,439	$0	$320,439		37.14%	$0
38	18	$862,869	$637,886	35.03%	$302,301	$223,479	$525,780		35.03%	$0
39	19	$862,869	$637,886	33.05%	$285,189	$210,830	$496,019		33.05%	$0
40	20		$637,886	31.18%	$0	$198,896	$198,896		31.18%	$0
41	21		$637,886	29.42%	$0	$187,638	$187,638	$678,930	29.42%	$199,711
42	22		$637,886	27.75%	$0	$177,017	$177,017	$678,930	27.75%	$188,407
43	23	$862,869		26.18%	$225,897	$0	$225,897	$678,930	26.18%	$177,742
44	24	$862,869		24.70%	$213,110	$0	$213,110	$678,930	24.70%	$167,681
45	25	$862,869		23.30%	$201,047	$0	$201,047	$678,930	23.30%	$158,190
46	26	$862,869		21.98%	$189,667	$0	$189,667	$678,930	21.98%	$149,236
47	27	$862,869		20.74%	$178,931	$0	$178,931	$678,930	20.74%	$140,788
48	28	$862,869	$637,886	19.56%	$168,803	$124,790	$293,593	$678,930	19.56%	$132,819
49	29	$862,869	$637,886	18.46%	$159,248	$117,726	$276,974	$678,930	18.46%	$125,301
50	30		$637,886	17.41%	$0	$111,062	$111,062	$678,930	17.41%	$118,209
51	31		$637,886	16.43%	$0	$104,776	$104,776	$678,930	16.43%	$111,518
52	32		$637,886	15.50%	$0	$98,845	$98,845	$678,930	15.50%	$105,205
53	33	$862,869		14.62%	$126,140	$0	$126,140	$678,930	14.62%	$99,250
54	34	$862,869		13.79%	$119,000	$0	$119,000	$678,930	13.79%	$93,632
55	35	$862,869		13.01%	$112,264	$0	$112,264	$678,930	13.01%	$88,332
56	36	$862,869		12.27%	$105,909	$0	$105,909	$678,930	12.27%	$83,332
57	37	$862,869		11.58%	$99,914	$0	$99,914	$678,930	11.58%	$78,616
58	38	$862,869	$637,886	10.92%	$94,259	$69,682	$163,941	$678,930	10.92%	$74,166
59	39	$862,869	$637,886	10.31%	$88,923	$65,738	$154,661	$678,930	10.31%	$69,968
2059/60	40		$637,886	9.72%	$0	$62,017	$62,017	$678,930	9.72%	$66,007
							$14,748,292			**$22,233,170**



Coatings Cost by Zone (Current)
Cost ($pa, LIM2)
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2019/20
2021/22
2023/24
2025/26
2027/28
2029/30
2031/32
2033/34
2035/36
2037/38
2039/40
2041/42
2043/44
2045/46
2047/48
2049/50
2051/52
2053/54
2055/56
2057/58
2059/60
Year
Viaduct/Over land
Box Girders
Truss Above WW
Overarch
Truss Below WW
Average Annual Spend 2012-2018


Coatings Cost by Zone (NPV)
Cost ($pa, LIM2)
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
2019/20
2021/22
2023/24
2025/26
2027/28
2029/30
2031/32
2033/34
2035/36
2037/38
2039/40
2041/42
2043/44
2045/46
2047/48
2049/50
2051/52
2053/54
2055/56
2057/58
2059/60
Year
Viaduct/Over land
Box Girders
Truss Above WW
Overarch
Truss Below WW



Coatings Area by Repair Type
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Area (m2)
2019/20
2021/22
2023/24
2025/26
2027/28
2029/30
2031/32
2033/34
2035/36
2037/38
2039/40
2041/42
2043/44
2045/46
2047/48
2049/50
2051/52
2053/54
2055/56
2057/58
2059/60
Year
Replace
Do min
Overcoat
Spot

Year	Area Waterblasted (m^2)	Area Abrasive blasted (m^2)	Area Typical MCU spray, (m^2)	Area Ferrox overcoat spray, (m^2)	Water blasting, zinc (kg/m2)	Abrasive blasting, garnet (kg/m2)	Abrasive blasting, zinc (kg/m2)	Abrasive blasting, paint (kg/m2)	Typical MCU, zinc (kg/m2)	Typical MCU, paint (kg/m2)	Ferrox overcoat, paint (kg/m2)	Garnet discharged (kg)	Zinc discharged (kg)	Paint discharged (kg)	
															exceeds threshold
2019/20	3283	1283	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	9515	113	318	within 10%threshold
2020/21	3278	1278	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	9478	113	317	
2021/22	3698	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	110	305	
2022/23	1198	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	109	305	
2023/24	1518	1518	1518	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	139	386	
2024/25	1525	1518	1518	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	139	386	
2025/26	4718	1518	1518	3200	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	140	454	
2026/27	4398	1198	1198	3200	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	110	372	
2027/28	10388	1198	1198	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	499	
2028/29	10388	1198	1198	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	499	
2029/30	9966	776	776	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	74	391	
2030/31	6766	776	776	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	73	324	
2031/32	18870	1141	776	15297	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8458	91	577	
2032/33	12937	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2033/34	12937	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2034/35	11964	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2035/36	11964	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2036/37	2658	1198	1198	0	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	110	305	
2037/38	8649	1198	1198	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	431	
2038/39	8969	1518	1518	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	141	513	
2039/40	7086	1095	1095	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8124	102	405	
2040/41	10286	1095	1095	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8124	103	473	
2041/42	9966	776	776	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	74	391	
2042/43	13704	1198	1198	12506	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	569	
2043/44	13704	1198	1198	12506	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	569	
2044/45	16502	1563	1198	12506	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11592	129	625	
2045/46	12937	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2046/47	12937	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	113	501	
2047/48	7189	1198	1198	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	111	431	
2048/49	7189	1198	1198	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	111	431	
2049/50	6766	776	776	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	73	324	
2050/51	6766	776	776	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	73	324	
2051/52	6773	776	776	5991	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	73	324	
2052/53	10504	1198	1198	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	501	
2053/54	10824	1518	1518	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	142	583	
2054/55	10824	1518	1518	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	142	583	
2055/56	10824	1518	1518	9306	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11258	142	583	
2056/57	14069	1563	1198	12506	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	11592	128	625	
2057/58	10388	1198	1198	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	499	
2058/59	10388	1198	1198	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	8885	112	499	
2059/60	9966	776	776	9190	0.0003	7.4156	0.0399	0.1545	0.0511	0.0998	0.0211	5751	74	391	