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A Watershed Approach to Restoration and Mitigation Planning, Monitoring, and Assessment Based on the Wetland and Riparian Area Monitoring Plan (WRAMP)

Addendum to the Upper Pajaro River Watershed Assessment 2015

Report Prepared for the Santa Clara Valley Water District
Llagas Creek Flood Control Project

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Introduction

The Santa Clara Valley Water District (District) is leading the Llagas Creek Flood Control Project (Project) in the upper Pajaro River watershed. Mitigation for the Project involves enhancing riverine wetlands on-site and restoring riverine wetlands and enhancing depressional wetlands at Lake Silveira, in the Llagas Creek watershed.

The District is incorporating CRAM into its planning and assessment of mitigation efforts. CRAM results from the District's assessment of ambient stream conditions in the Llagas Creek watershed provide a watershed context for comparing impact and mitigation sites, consistent with USACE guidance (USACE 2015), which states:

> "A Functional or Condition Assessment Method (FCAM) should be developed and calibrated for the aquatic resource type/s and geographic area within which it is being applied. The same FCAM should be used to assess the impacts and proposed compensatory mitigation"

The District completed initial Project planning in 2013, including a Habitat Evaluation Procedure (HEP) to assess project-related impacts to fish and other wildlife resources, and to inform impact and mitigation site designs, including grading, irrigation, and re-vegetation. The District mapped the pre-construction riverine and depressional wetlands within the Project impact and at Lake Silveira. Those maps served as the sample frame for a field survey of pre-construction conditions using the California Rapid Assessment Method for wetlands (CRAM, Figure 1). The same assessment areas (AAs) were also used to estimate the future, post-construction wetland conditions of the Project and Mitigation sites (at 25 years after project completion) based on the planned flood control impacts and mitigation efforts.

The Llagas Creek watershed-wide stream condition survey was conducted under the District's Safe, Clean Water and Natural Flood Protection Program's Ecological Data Collection and Analysis Project (Priority D5), which assessed the ecological condition of streams in the whole upper Pajaro River watershed within Santa Clara County in 2015 using CRAM (Lowe et al. 2016).

The Flood Control Project's pre-construction CRAM field assessments were conducted in 2015 under the supervision of a senior member of the statewide CRAM oversight committee of the California Wetland Monitoring Workgroup (CWMW). The estimated post-construction conditions were assessed based on detailed restoration designs.

The pre- and post-construction CRAM results were: 1) overlaid on the Llagas Creek watershed wide stream condition cumulative distribution function (CDF) plot to evaluate the Project and Mitigation scores in a watershed context, and 2) compared to characterize the expected overall ecological lift in the condition of the riverine and depressional wetlands within the Project and Mitigation sites based on CRAM.

Post-construction CRAM condition scores were supplemented by a separate analysis of the expected mitigation endpoints based on Habitat Development Curves (HDCs). An HDC depicts the correlation between habitat condition and age for a large population of natural and restored sites. HDC's based on CRAM are being produced by the CWMW for the wetland types most commonly assessed using CRAM.

This memorandum demonstrates a possible watershed-based approach to evaluating mitigation sites using CRAM. A more comprehensive approach can be developed using additional data according to the 3-level framework provided by the Wetland and Riparian Area Monitoring Plan (WRAMP, CWMW 2010). WRAMP is produced by the CWMW and has been adopted by the District's D5 Project for assessments of watershed condition.

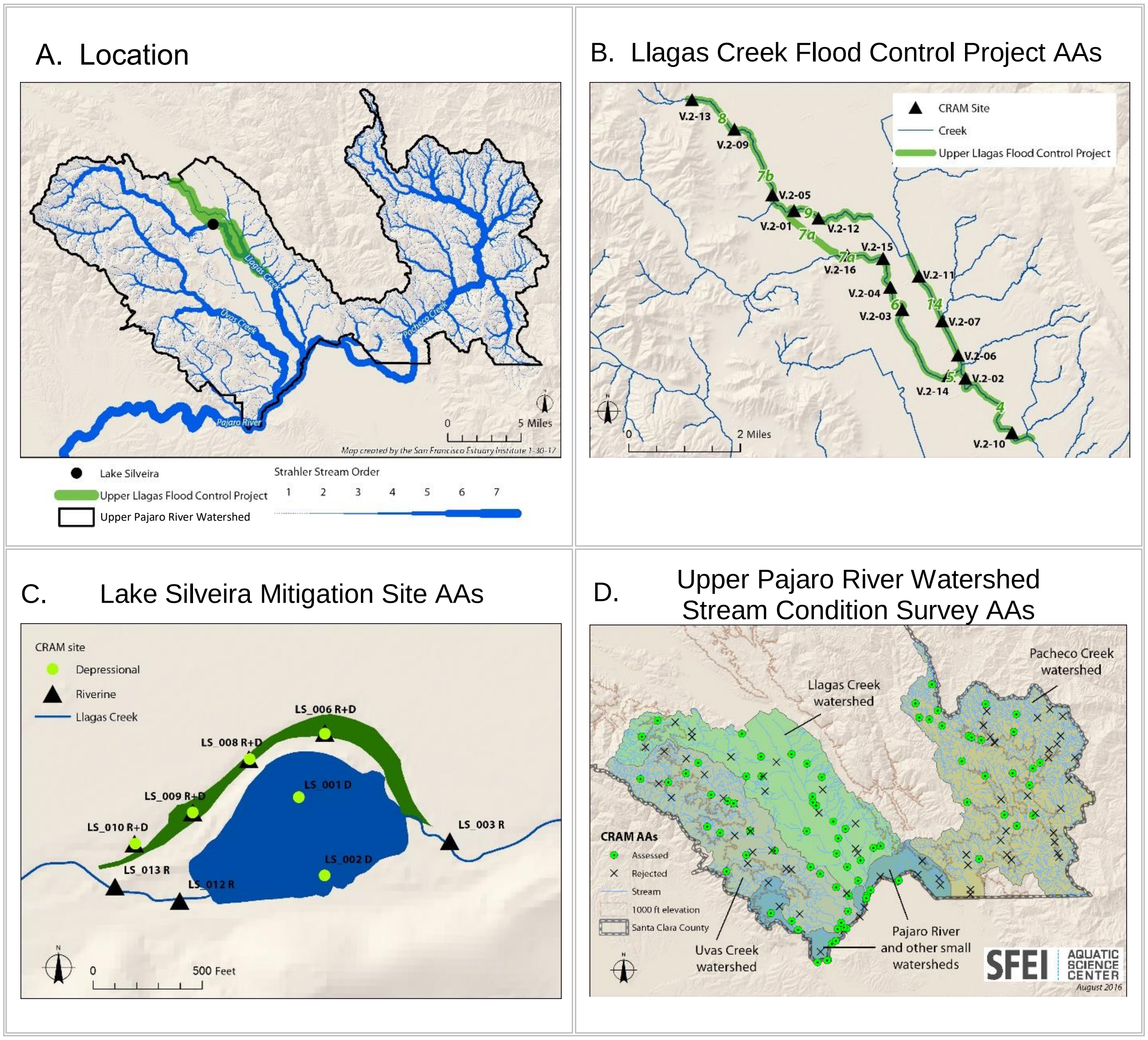


Figure 1. This figure shows (A) the location of the Llagas Creek Flood Control Project and Lake Silveira Mitigation Site along Llagas Creek in the upper Pajaro River watershed of Santa Clara County; (B) CRAM AAs within the Project Site; (C) CRAM AAs at the Lake Silveira Site; and (D) CRAM AAs for the District's Priority D5 Project's 2015 watershed wide ambient survey of stream condition in upper Pajaro River watershed and its three main watersheds.

Methods

CRAM Survey Designs

Two different survey designs were employed for the Llagas Creek Flood Control Project site and Lake Silveira Mitigation site based on the size of the two areas and the different wetland types to assess.

The Flood Control Project site includes 8 stream reaches and nearly 15 miles of streams and an unstratified sample design was selected to proportionally distribute CRAM AAs across the whole stream length. 15 AAs were randomly allocated across the Project extent using spatial survey design and analysis software tools for aquatic resources developed by the USEPA (Kincaid and Olsen 2016), and employed by the District's Priority D5 Project's watershed wide stream condition surveys using CRAM. Each AA represents an equal proportion of the Project or about 1 mile of the Flood Control Project extent.

The Lake Silveira Mitigation site is relatively small, encompassing about 8 acres. CRAM AAs were assigned based on guidance in the CRAM Technical Bulletin, section 5.D (CWMW 2009). Briefly, the extent of the riverine and depressional wetlands were identified on a GIS layer, and CRAM AAs were drawn to fill the entire extent of each wetland type. All the candidate AAs were then numbered sequentially. Because only 3 riverine AAs currently exist at the site, all three riverine AAs were assessed. The quarry-pond included 2 candidate AAs which were both assessed using the Depressional wetland module. The historical channel, which is currently depressional wetland and will be restored to riverine, fit 8 candidate AAs of which 4 were assessed. The final number of depressional assessments completed in the historical channel was dependent on the actual variability in its condition as observed in the field. Following guidance from the CRAM Technical Bulletin, the first 3 AAs were assessed and depending on the amount of variation between CRAM scores, additional assessments were added until the difference between the average scores of the initial assessments and the most recent assessment was <10 Index points.

CRAM Assessments

The pre-construction CRAM assessments were conducted in July 2015 by experienced CRAM Practitioners who were also conducting the District's Priority D5 upper Pajaro River watershed stream condition survey based on CRAM.

The CRAM assessments of future, post-construction conditions assumed that the planned onsite Project construction and vegetation planting efforts will be fully implemented, and that the AAs had fully matured.

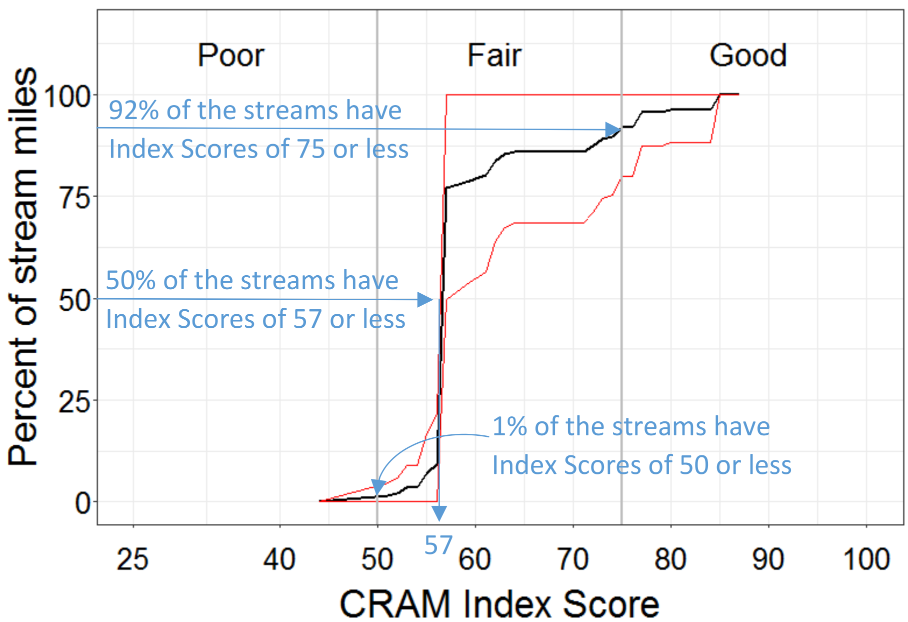
Pre- and post-construction CRAM scores were evaluated by charting them on the regional CRAM CDF plots to evaluate the overall ecological condition of the Project and Mitigation sites compared to the region and to evaluate the expected ecological lift due to wetland restoration efforts.

Pre- and post-construction CRAM scores were also summarized in simple box-and-whisker plots (boxplots) that compared the range, average, and median scores. The average scores were used to characterize the expected change in ecological conditions based on the planned wetland restoration efforts.

Application of CDFs and HDCs

The CDF plots presented in this report show the proportion of streams within a watershed or Project extent that has a specific CRAM score. Figure 2 shows the CDF plot for CRAM Index Scores of the Llagas Creek watershed stream condition survey of 2015. The black line represents the estimated percentage of stream network that has a specific corresponding CRAM score or lower. The two red lines represent the 95% confidence levels around the estimate. The blue arrows show examples of how to read across and down on the CDF to get the estimated percentage of streams with a specific CRAM Index Score. The range of possible CRAM scores has been separated into three equal-interval health classes labeled Good, Fair and Poor, as represented by CRAM scores of >75, 51-75, and ≤50, respectively.

Project AAs should achieve at least as good (or better) a CRAM Index Score than 50% of the streams within the surrounding watershed (or ecoregion) as estimated by the CDF, which is based on a probability sample or a reasonably large and spatially distributed regional sample.



Another way to summarize the overall watershed condition based on this example is to say that 8% of the streams are in Good ecological condition (>75), 91% are in Fair condition (51-75), and 1% are in Poor condition (≤50).

Figure 2. CDF plot of the CRAM Index Scores for the Llagas Creek watershed showing how to read across and down, and how to interpret the proportion of streams within the watershed that fall within the three equal-interval health classes of Poor, Fair and Good.

An HDC relates the condition of a habitat to its development stage or age. HDCs are useful for forecasting the rate of development of ecological restoration sites and have been developed for riverine wetlands in southern California coastal watersheds and for depressional wetlands statewide, using CRAM to assess condition. These HDCs can also be used in conjunction with CRAM Attribute and Metric Scores to gain insights about aspects of condition that might be improved through project design or management. Project AAs should achieve (or clearly be on a trajectory to achieve) a CRAM Index Score that is on or above the HDC.

Results

Application of Watershed Based Cumulative Distribution Function Curves

Llagas Creek Flood Control Project Site

Analysis of overall ecological condition based on CRAM Index Scores

CRAM field assessments (n=15) of pre-construction and estimated post-construction conditions for riverine wetlands in Llagas Creek Flood Control Project were plotted on the Llagas Creek CRAM Index Score CDF or streams in the Llagas Creek watershed (Figure 3).

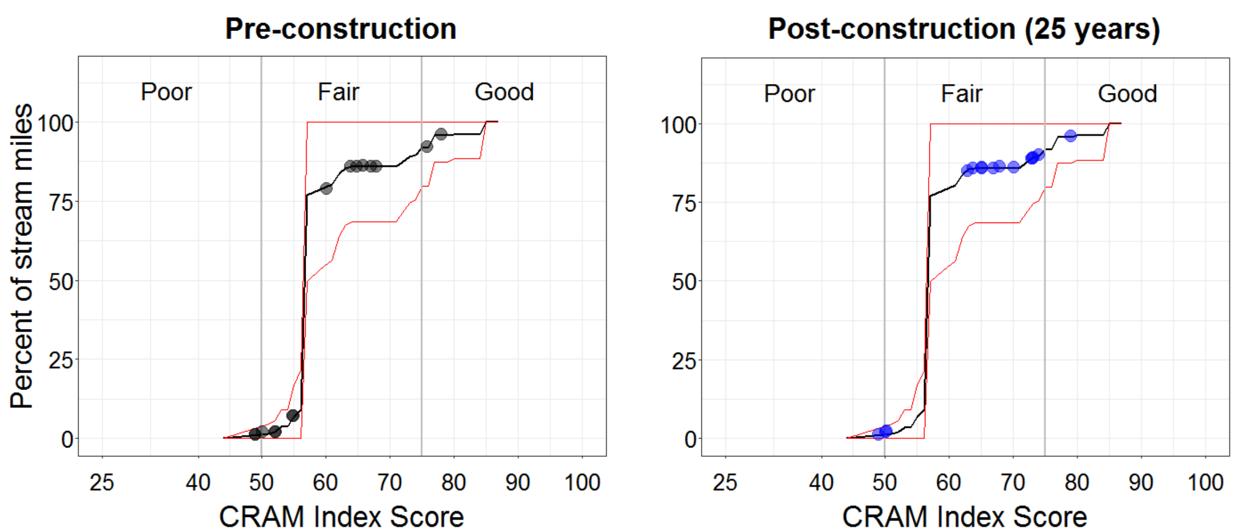


Figure 3. Existing (pre-construction) and expected future (post-construction) CRAM Index Scores for onsite Project riverine AAs plotted on the CDF profile of riverine wetlands for the Llagas Creek watershed.

The CDF indicates that streams within the Lllagas Creek watershed are mostly in Fair ecological condition. Less than 10% of the stream miles in the watershed are in Good condition, and about 1% of stream miles are in Poor condition.

7 of the 15 pre-construction onsite Project AAs had had Index Scores ≤55 and 3 of those AAs were in Poor condition (although it is difficult to see in Figure 2 since scores for three of the seven AA overlap). Those 7 low scores represent about half of the Flood Control Project's stream length and are comparable to the condition of 10% of streams in the Llagas Creek watershed. Three of the 7 AAs that were in Poor condition did not improve in the post-construction assessment because those areas have

no plans to be enhanced or restored[1]. The remaining four low-scoring pre-construction assessments are expected to increase between 9 and 15 CRAM Index points to an average Index Score of 65 - placing them well above the 50th percentile Index Score of 57 for the Llagas Creek watershed.

Whether or not the Project enhancements would significantly improve the overall Llagas Creek watershed CDF curve (shifting the curve towards the right) is largely dependent on the proportion of riverine wetlands in the Llagas Creek watershed represented by the enhancement project. This Project only effects 6% of the stream miles within the Llagas Creek watershed (14 out of 250 miles) and it is not expected to significantly change the CDF profile for the whole watershed. However, the Project is being implemented in highly modified stream channels within the valley floor region of the watershed and it will likely improve the overall ecological condition of modified stream reaches within the watershed.

When all 15 CRAM assessments completed at the Project site are included in the analysis, the average increase in overall ecological condition of the onsite streams is expected to be about 6 Index points (see the asterisks in the box-and-whisker plots presented in Figure 4). Post-construction Index Scores indicate that the Project will improve conditions for 80% of the stream miles within the Project.

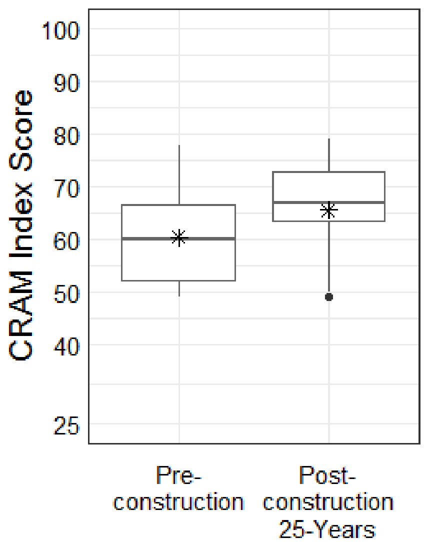


Figure 4. Boxplots[2] showing the interquartile range of CRAM Index Scores for the Llagas Creek Flood Control Project (n=15) pre- and post-construction, including the average Index Scores (shown as asterisks). There is an expected 6-point increase in the average Index Score for on-site riverine wetlands due to the Project's enhancement plans.

[1] SiteIDs: V.2-01 and V.2-12 in reach #9, and V.2-09 in reach #8.

[2] The 'box' within the boxplot indicates the interquartile range (or 25th and 75th percentiles) of the CRAM Project's Index scores (n=15). The median Index score (or 50th percentile score) is represented by the bold horizontal line inside the box. The average (or mean) Index score is indicated by an asterisk. The vertical lines (or whiskers) extend 1.5 x the inter-quartile range (or the distance between the 25th and 75th percentile range). Outliers are shown as black dots.

When the three Poor condition AAs, representing stream reaches that will not be enhanced, are dropped from the analysis the remaining 12 AAs that represent enhanced reaches can be used to more exactly assess the lift due to enhancement. These 12 AAs represent 80% of the stream miles in the Project (Figures 5 and 6). The expected lift equals about 7 CRAM points.

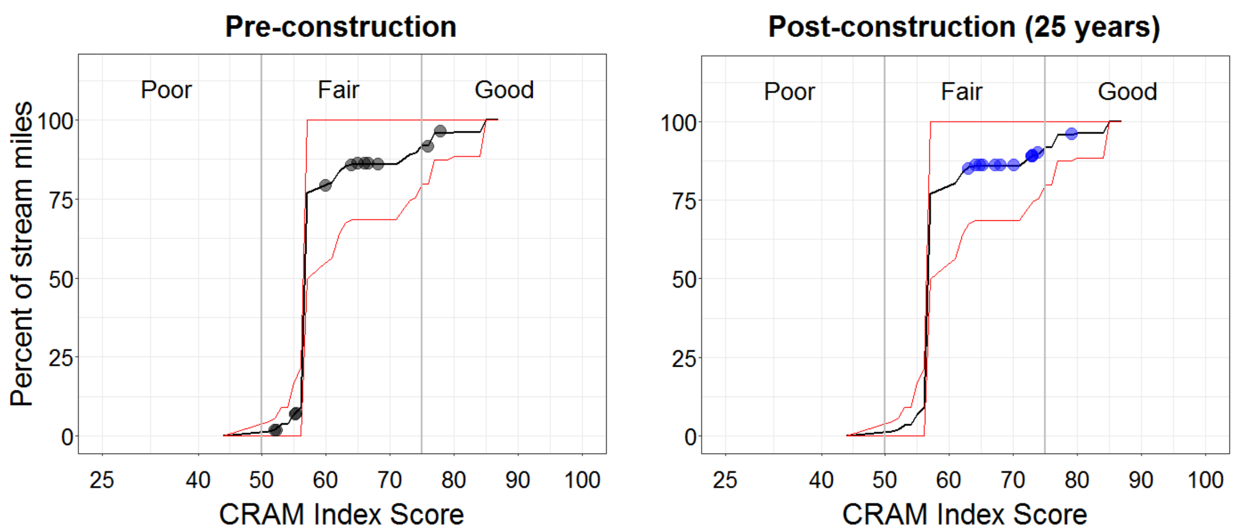


Figure 5. Pre- and post-construction CRAM Index Scores for 12 of the 15 onsite Project riverine AAs plotted on the CDF of riverine wetlands for the Llagas Creek watershed. These assessments represent areas of planned riverine wetland impacts or enhancements. This figure does not include 20% of the Project stream length represented by 3 AAs that have no planned impacts or enhancement actions.

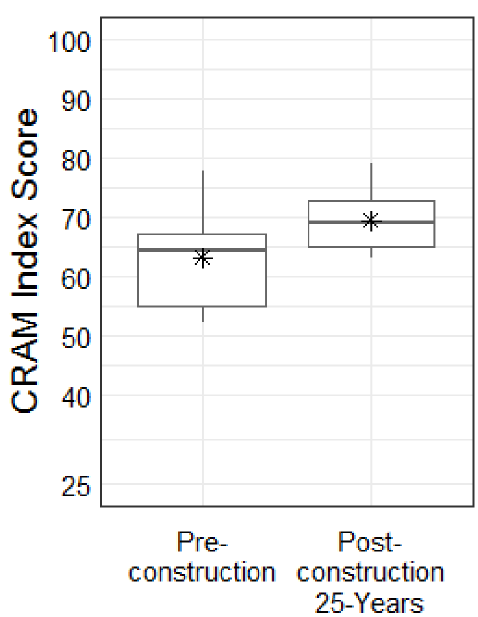


Figure 6. Boxplot showing an expected 7-point increase in the average CRAM Index Scores (asterisks) n for steams miles subject to restoration or enhancement (80% of the total stream miles). This figure does not include the 20% of the Project stream miles represented by 3 AAs that have no planned impacts or enhancement actions.

Analysis of specific ecological functions within the Project based on CRAM Attribute Scores

The following analysis characterizes of the underlying CRAM Attribute Scores that comprise the overall CRAM Index Scores presented above. CRAM Attribute Scores from pre- and post- construction assessments from the Project were plotted on the Attribute CDFs for streams in the Llagas Creek watershed, summarized visually as boxplots (Figures 7 and 8), and listed in Appendix 2. The CDF plots indicate the percent of streams in Good, Fair, or Poor condition. The Boxplots provide an additional comparison of the pre- and post-construction Project scores.

80% of streams in the Llagas Creek watershed have Good Buffer and Landscape Context Attribute Scores, but only 20% of the pre-construction streams in the Project have Good Buffer Scores (3 out of 15 AAs). The stream restoration and enhancement actions are expected to increase the proportion of Project stream miles in Good Buffer condition from 20% to 60%. Pre-construction assessments indicate that most of the Project's Buffer and Landscape Context is similar to the lowest 20th percentile of streams in the watershed. Pre-construction Buffer Scores ranged from Poor to Good condition (30 to 85) with an average score of 71 (Fair condition). The post-construction average Buffer Score is expected to increase by 3-points to 74 (compare asterisks in boxplots of Figure 7A), and 7 out of 15 AAs are expected to improve their overall Buffer conditions by 6 to 11-points.

75% of stream miles in the Llagas Creek watershed have Good Hydrology Attribute Scores, while all of the pre-construction streams are in Poor or Fair condition. The Project's pre-construction hydrologic condition, based on CRAM, falls within the lowest 25th percentile of streams in the watershed. The average post-construction Hydrology Score is expected to increase by 8-points, with 20% of the Project stream miles achieving Good Hydrology condition Scores. 2 AAs are expected to decrease in Hydrology Attribute Scores by about 9-points due to necessary flow management and unnatural engineering.

Only about 7% of stream miles in the Llagas Creek watershed have Good condition for Physical Structure Attribute; 3% have Fair condition; and 90% of the stream miles have Poor condition. . The pre-construction Project has just over half of its stream miles (8 of 15 AAs) in Poor condition for physical structure and the other half has Fair condition. The post-construction average Physical Structure Score is expected to decrease by 2-points to 50, and up to 73% of the Project is expected to have Poor Physical Structure Scores. 4 AAs are expected to decrease in Physical Structure Scores by 12 to 25-points.

12% of streams in the Llagas Creek watershed have Good Biotic Structure Attribute Scores, 8% have Fair structure Scores, and 80% of the streams have Poor Scores. 47% of the pre-construction Project streams have Poor Biotic Structure Scores, 40% have Fair Biotic Structure Scores, and 13% have Good scores. The average pre-construction Biotic Structure Score is 55 (Fair condition). The post-construction average Biotic Structure Score is expected to increase by 11-points to 66, and 20% of the Project is expected to have Good Biotic Structure Scores >75. 13 of the 15 AAs are expected to see an increase in Biotic Structure Scores by 3 to 25-points.

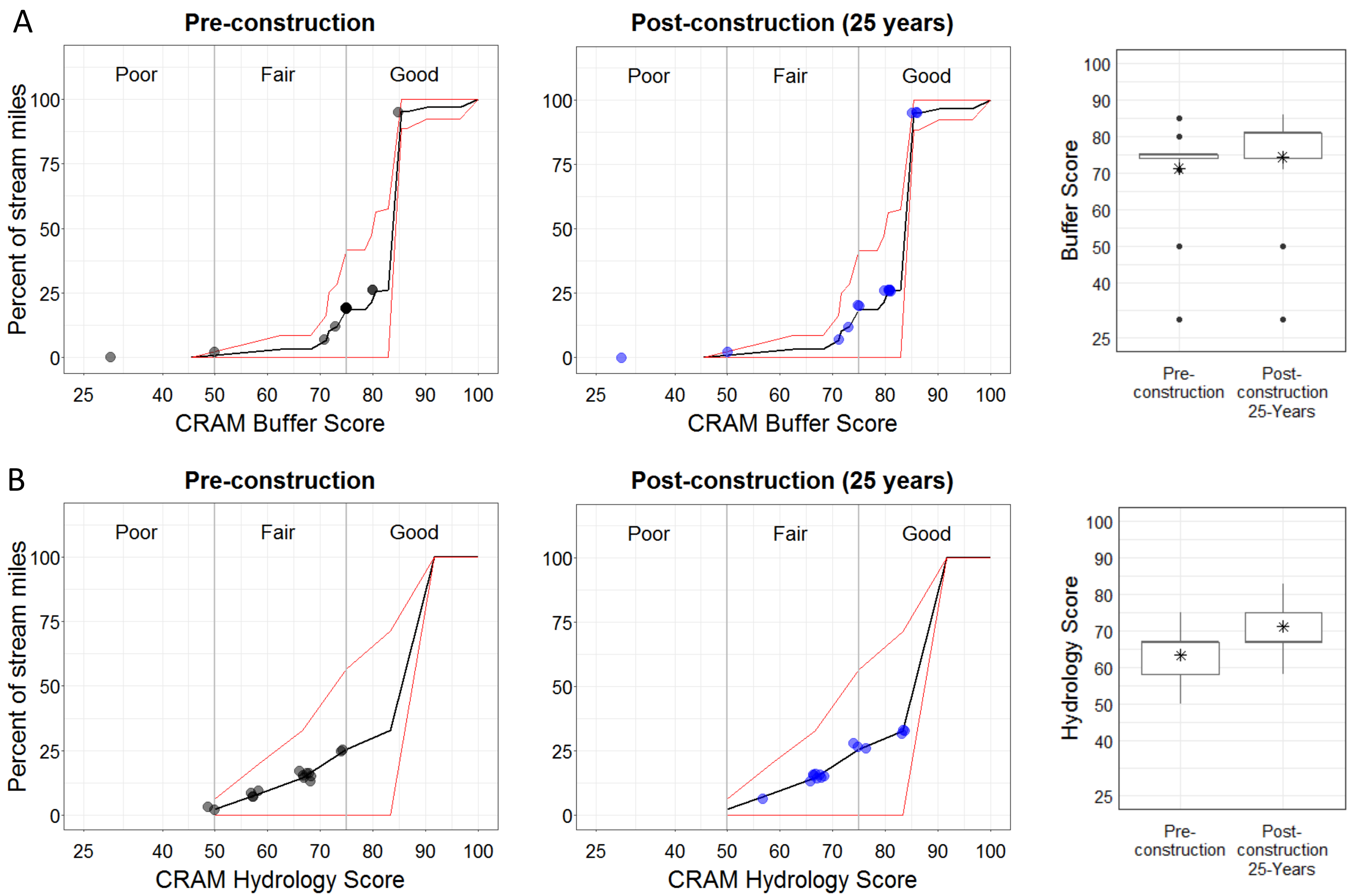


Figure 7. CRAM Buffer and Landscape Context (A) and Hydrology (B) Attribute Scores from the Flood Control Project's onsite pre- and post-construction riverine assessments (n=15) plotted on the corresponding Llagas Creek watershed CDF, along with boxplots that visually summarize the distribution of the onsite Project Scores.

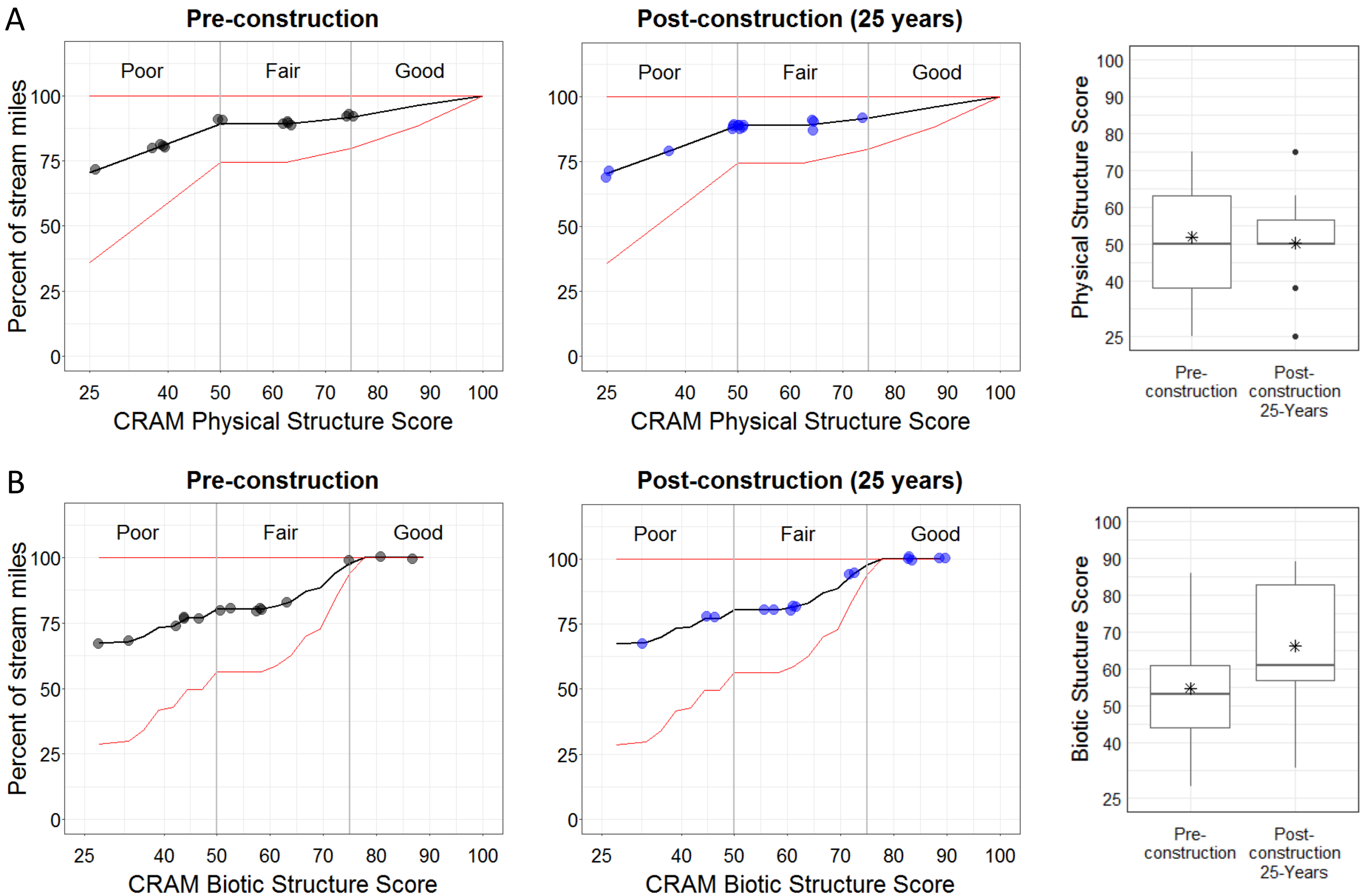


Figure 8. CRAM Physical Structure (A) and Biotic Structure (B) Attribute Scores from the Flood Control Project's onsite pre- and post-construction riverine assessments (n=15) plotted on the corresponding Llagas Creek watershed CDF, along with boxplots that visually summarize the distribution of onsite Project Scores.

Project Site - Summary of Index and Attribute Score Analyses

The Flood Control Project's riverine CRAM Index Scores ranged from Poor (Index Scores <50) to Good (Index Scores >75) and occupy the same range of condition as streams in the surrounding Llagas Creek watershed. About half the Project's streams are in relatively low ecological condition (with 7 of the 15 AA Index Scores classified as Poor) and compared to the lowest 10% of streams within the Llagas Creek watershed as a whole. A portion of the Project's stream miles will not be impacted or enhanced by Project actions, and three AAs from those areas had the lowest Index Scores, which are not expected to improve over time. Even so, the average overall ecological condition for 80% of the stream miles within the Project is expected to improve by 6 Index points in the future to an average Index Score of 65 (see Figure 4 post-construction, above).

Project Attribute scores were evaluated to characterize core wetland functions within a watershed context. The Project's pre-construction Buffer and Hydrology Scores generally fall within the lowest 25^{th} percentile of the condition of streams within the watershed. Physical and Biotic Structure within the Project are generally Poor, but are consistent with Physical and Biotic Structure of streams in the surrounding watershed. Project implementation plans are expected to increase Buffer and Landscape Context and Hydrology Attribute Scores by an average of 3 and 8-points, respectively. However, Physical Structure Scores will not increase based on the Project's implementation plans. The Project's Biotic Structure Attribute Scores are expected to improve the most with an estimated average increase in scores of 11-points. Additionally, 13 of the 15 AAs are expected to see an increase in Biotic Structure Scores of 3 to 25-points.

Lake Silveira Mitigation Site

At Lake Silveira, an historical stream reach that has evolved into depressional wetlands due to flow diversion will be restored to riverine wetlands, and the quarry-pond, which is classified as depressional wetlands, will be enhanced. Figure 9 presents a map of Lake Silveira and the CRAM AAs surveyed in 2015. Three riverine AAs, located in stream reaches upstream and downstream of the quarry-pond will remain riverine. The mature, post-construction conditions based on CRAM were estimated based on the detailed, site-specific mitigation plans.

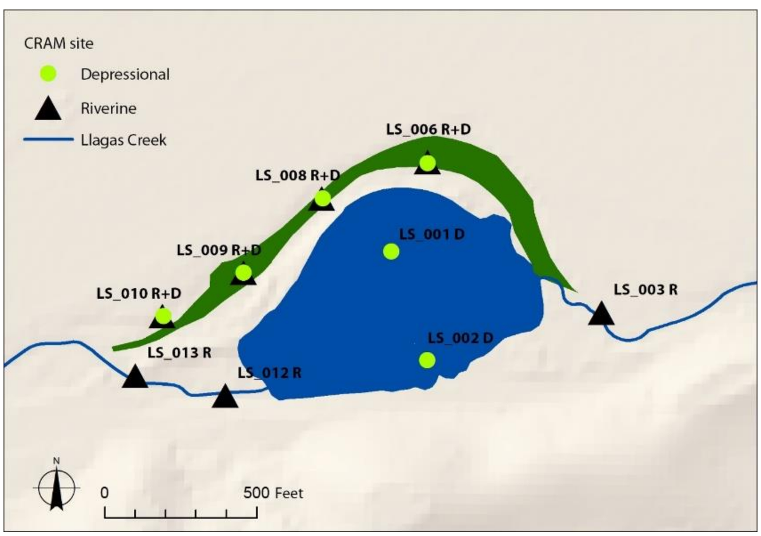


Figure 9. Lake Silveira Mitigation Site AAs. The green area, north of the quarry-pond, is an historical riverine channel that is currently depressional wetlands that will be restored.

Analysis of overall ecological condition based on CRAM Index Scores

CRAM field assessments of pre-construction and estimated post-construction conditions for riverine wetlands at the Lake Silveira Mitigation site were plotted on the Llagas Creek CRAM Index Score CDF for streams in the Llagas Creek watershed (Figure 10). Existing pre-construction riverine wetlands were assessed at 3 AAs and post-construction riverine wetlands included 7 AAs (they include the 3 AAs that will be enhanced and 4 AAs that will be restored from depressional wetlands in the historical channel north of the quarry-pond).

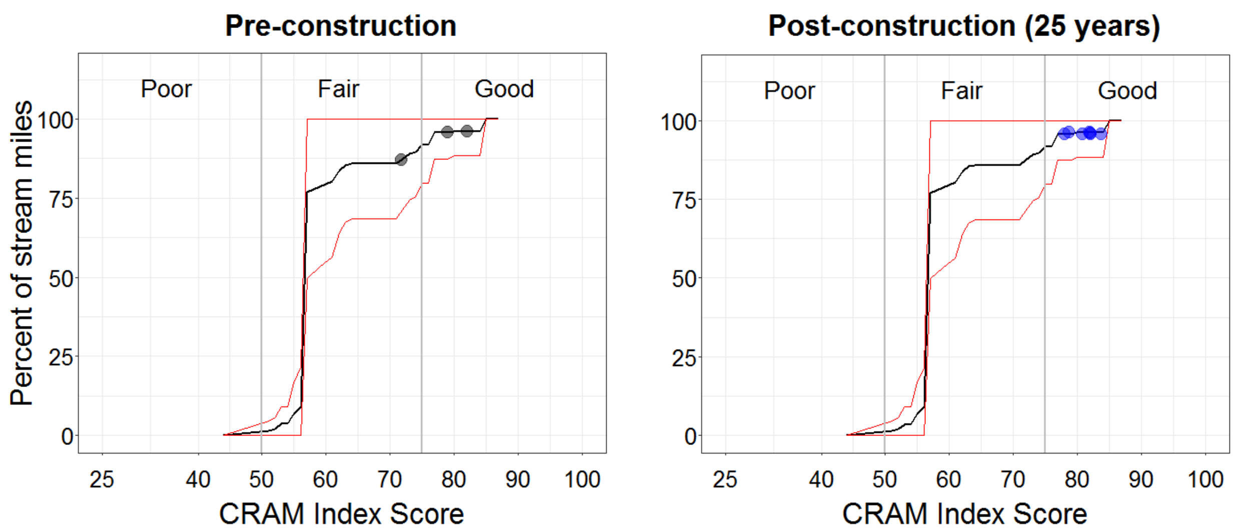


Figure 10. Pre- and post-construction CRAM Index Scores for riverine wetlands at the Lake Silveira Mitigation site plotted on the CDF of riverine wetlands for the Llagas Creek watershed.

The pre-construction riverine CRAM Index Scores fall within the top 20th percentile of streams in the Llagas Creek watershed. Boxplots in Figure 11 summarize basic statistics about the range of those Index Scores and indicate that the average expected increase in Index Scores for riverine wetlands at Lake Silveira is about 3-points, based on mitigation plans.

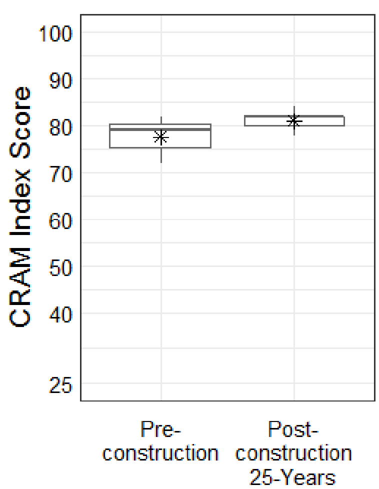


Figure 11. Boxplot showing the range of pre- and post-construction CRAM Index Scores for riverine wetlands at the Lake Silveira Mitigation site. Pre-construction riverine AAs (n=3) will be enhanced by mitigation efforts and existing depressional wetlands in the historical riverine channel will be restored to riverine wetlands (n=4). There are 7 post-construction scores represented here. There is an expected 3-point increase in the average riverine CRAM Index Scores (asterisks) due to enhancements and restoration.

To further evaluate the change in ecological conditions of the restored riverine wetlands within the Silveira site, depressional CRAM assessments from the historical riverine channel (north of the quarry-pond) were compared to the corresponding post-construction riverine assessments to characterize the change in condition between the pre-construction depressional wetlands and the expected post-construction riverine wetlands based on planned restoration actions. Based on that comparison, the restored riverine wetlands will score 17 points higher than the existing depressional wetlands Figure 12.

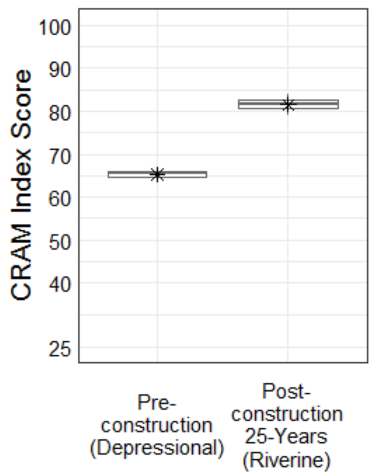


Figure 12. Boxplot showing the range of pre- and post-construction CRAM Index Scores for depressional wetlands that will be restored to riverine wetlands at the Lake Silveira Mitigation site. There is an expected 17-point increase in the average CRAM Index Scores (asterisks) due to this restoration effort.

Analysis of specific ecological functions within Lake Silveira Mitigation Site based on CRAM Attribute Scores

The following analysis characterizes of the underlying CRAM Attribute Scores that comprise the overall riverine CRAM Index Scores presented above. CRAM Attribute Scores from pre- and post-construction riverine assessments from the Lake Silveira Mitigation site were plotted on the Attribute CDFs for streams in the Llagas Creek watershed, summarized visually as boxplots (Figures 13 and 14), and listed in Appendix 2.

80% of streams in the Llagas Creek watershed have Good Buffer and Landscape Context Attribute Scores (Buffer Scores >75), and the pre-construction riverine wetlands in the Mitigation site had very high Buffer Scores (ranging from 86-90) placing them in the top 5% of streams in the Llagas Creek watershed. Enhancement and Restoration of riverine wetlands are expected not to change the overall riverine Buffer Scores. The Buffer Scores at the 4 AAs in the historical riverine channel are expected to increase between 20 and 45-points.

75% of streams in the Llagas Creek watershed have Good Hydrology Attribute Scores (>75), while the pre-construction riverine wetlands at the Mitigation site ranged from Fair (58, n=1) to Good (83, n=2) condition. Enhancement and Restoration of riverine wetlands are expected to increase Hydrology Scores in the historical riverine channel by an average of 14-points (based on the restoration plans), and scores in the existing riverine wetlands are expected to increase as well by an average of 3-points.

Only about 7% of streams in the Llagas Creek watershed have Good scores for the Physical Structure Attribute, 3% have Fair scores, and 90% of the streams have Poor scores. The pre-construction Physical Structure Scores of the existing riverine wetlands are all borderline Good. Enhancement and Restoration of riverine wetlands are not expected to change the Physical Structure Scores with the exception of one AA, within the historical channel, that will increase to an expected Score of 88.

Only 12% of streams in the Llagas Creek watershed have Good Biotic Structure Attribute Scores. 8% have Fair structure Scores, and 80% of the streams have Poor Scores. Pre-construction Biotic Structure Scores for riverine wetlands within the Mitigation site ranges from 64 to 81. Enhancement and Restoration of riverine wetlands are expected to increase the Biotic Structure Scores in the historical riverine channel by an average of 19-points based on the restoration plans, and Scores in the existing riverine wetlands are expected to increase as well by an average of 9-points.

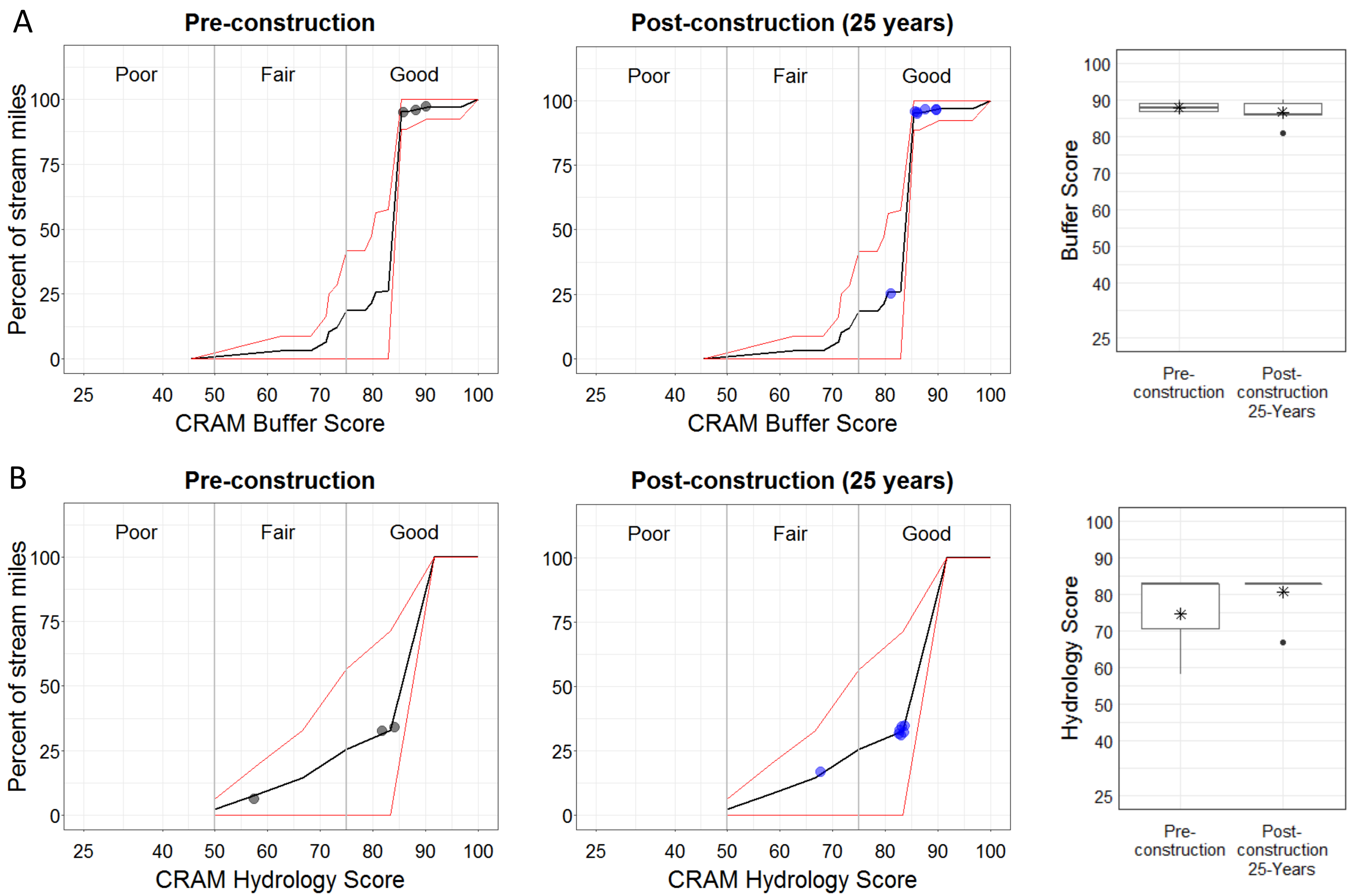


Figure 13. CRAM Buffer and Landscape Context (A) and Hydrology (B) Attribute Scores from the Lake Silveira Mitigation site pre- (n=3) and post-construction (n=7) riverine assessments plotted on the corresponding Llagas Creek watershed CDF, along with boxplots that visually summarize the distribution of the onsite Project scores.

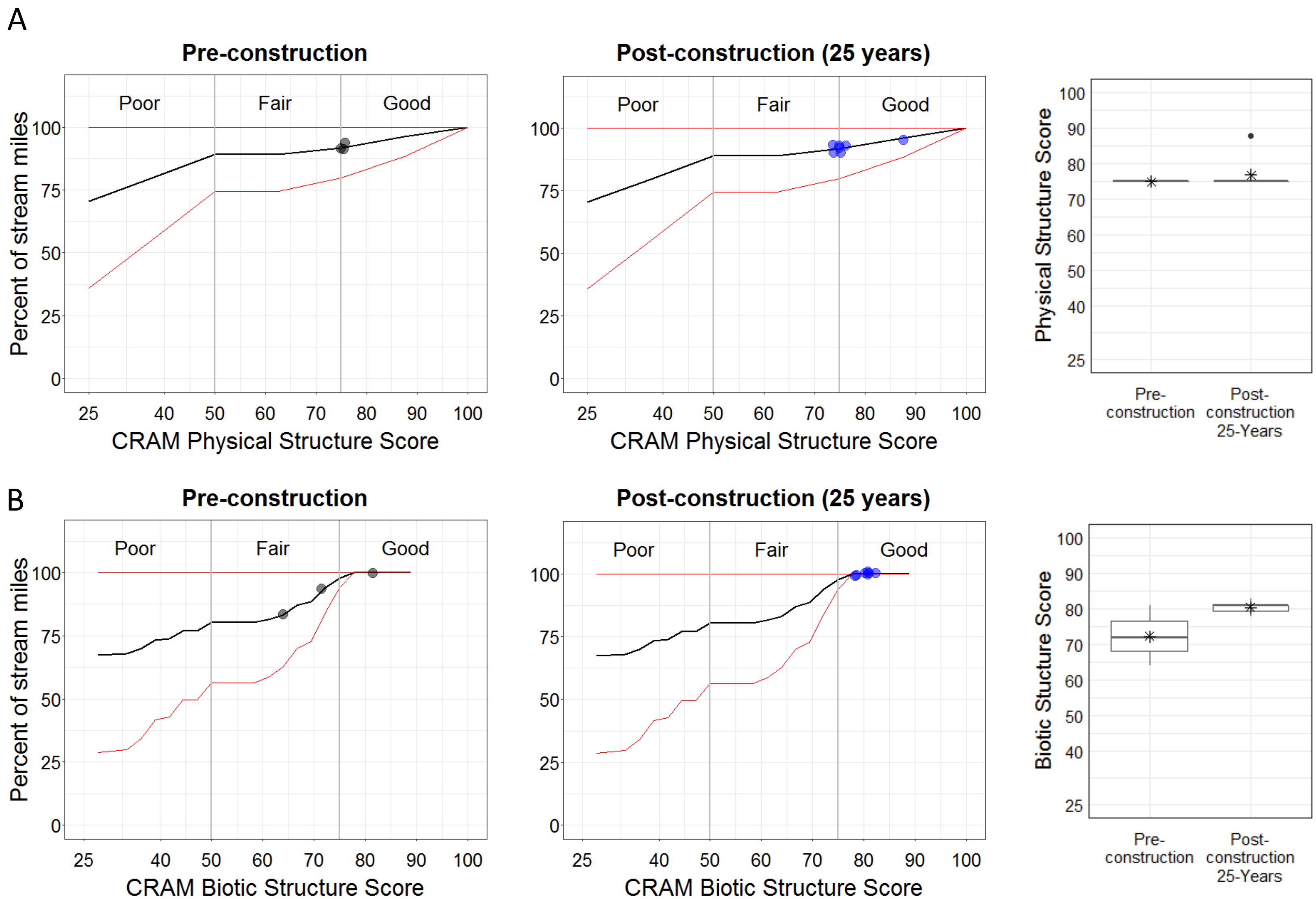


Figure 14. CRAM Physical Structure (A) and Biotic Structure (B) Attribute Scores from the Lake Silveira Mitigation site pre- (n=3) and post-construction (n=7) riverine assessments plotted on the corresponding Llagas Creek watershed CDF, along with boxplots that visually summarize the distribution of the onsite Project Scores.

Mitigation Site - Summary of Riverine Index and Attribute Score Analyses

The project will convert depressional wetlands to riverine wetlands. The overall impact of the riverine wetland creation and enhancement to existing riverine wetlands is expected to increase the overall amount and condition of riverine wetlands within the Lake Silveira mitigation site. All Index Scores are expected to be in "Good condition" in the future. The lowest expected Score will be 78 - at one of the enhanced sites [LS_003_R]). Lake Silveira riverine wetland conditions will be similar to the top 10% of streams within the watershed based on the Llagas Creek watershed CDF (Figure 10 post-construction, above). The wetland functions that increase the most, based on the mitigation plans, are the Buffer and Landscape Context and Biotic Structure. The improved riverine condition scores will be most evident in the restored historical channel.

Whether or not the enhancements would increase the 50th percentile score for the watershed depends on the proportion of total miles of riverine wetlands in the Llagas Creek watershed represented by the enhancement and restoration project, which is very small compared to the 250 miles of streams within the Llagas Creek watershed.

Depressional Wetlands - Quarry-Pond Index and Attribute Scores

The depressional wetland mitigation plans in the quarry-pond at Lake Silveira are likely to improve the overall ecological conditions on the north side of the quarry (LS_001 D) by 5 CRAM Index points, Buffer Scores are expected to increase by 6-points; Physical Structure by 13-points; and Biotic Structure by 17-points. However, the Hydrology Attribute Scores are expected to decrease by 17-points. This is because the mitigation efforts will increase the dependency of the pond on unnatural, managed hydrology. The south side of the quarry-pond (LS_002 D) is not expected to change much with the exception of changes in Hydrology based on the larger Mitigation planned at the Site.

Application of Habitat Development Curves

The future conditions of post-construction riverine and depressional wetlands can also be estimated using habitat development curves (HDCs). An HDC relates the condition of habitat to its developmental age. HCDs can be derived for any indicator of condition or stress, including indices of combined indicators. Multiple HDCs might be used in a weight-of-evidence approach to habitat assessment.

HDCs for CRAM are only available for a few common wetland types, and few watersheds have enough restoration or mitigation projects to support their own HDC. At this time, the only HDCs available for assessing mitigation for this Project are based on regional or statewide CRAM assessments of depressional and riverine wetlands.

To help assure that a wetland mitigation or restoration project improves the overall condition of wetlands within a watershed or other landscape, its condition should fall on or above the appropriate HDC. If not, corrective measures in project design or management should be considered to either reset the initial condition to a higher level or to elevate the condition over time and implement adaptive management efforts, such that the project has a developmental trajectory that intercepts the HDC within a reasonable timeline.

The depressional wetland HDC used for this Project (Figure 15) was derived from a statewide survey of natural and restored sites (SFEI 2016). It indicates that depressional wetland projects are unlikely to attain reference conditions. This is probably an artifact of the dataset. In aggregate, the AAs represent a very broad range in structural complexity due to their broad range in hydroperiod, relative to the reference conditions.

The only available HDC for riverine wetlands was developed for coastal streams of the Southern California Bight (Figure 16 part A, SCCWRP 2016 [in preparation]). Its applicability to the Llagas Creek watershed is questionable. It is included in this evaluation of mitigation sites to further illustrate the use of HDCs.

Like the HDC for depressional wetlands, the existing HDC for riverine wetlands suggests projects will not achieve reference condition. However, unlike the depressional wetlands HDC, which is influenced by the great variability in hydroperiod among projects, the HDC for riverine wetlands is strongly influenced by low project scores for the Physical Structure Attribute (see Figure 16 part C). This suggests that riverine projects should include more physical complexity in their initial designs.

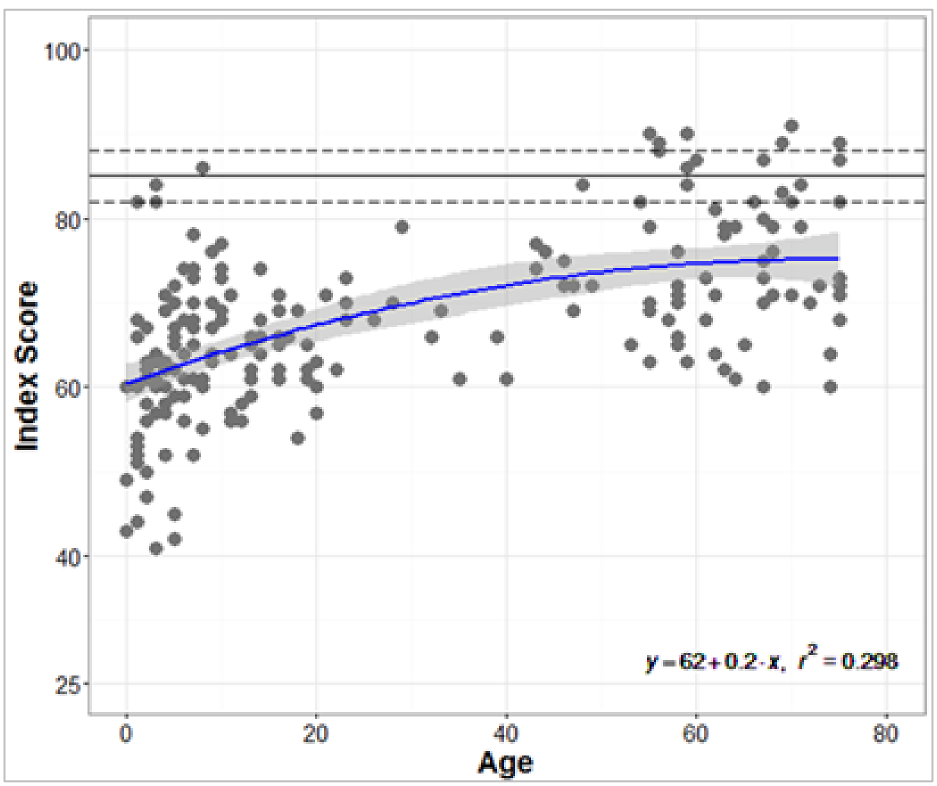


Figure 15. Depressional wetland Habitat Development Curve (HDC). The curve includes project sites, natural and naturalized sites, and represents a very broad range of hydroperiod. The solid horizontal line is the average reference CRAM Index score, bounded by dashed lines representing +/- one standard deviation.

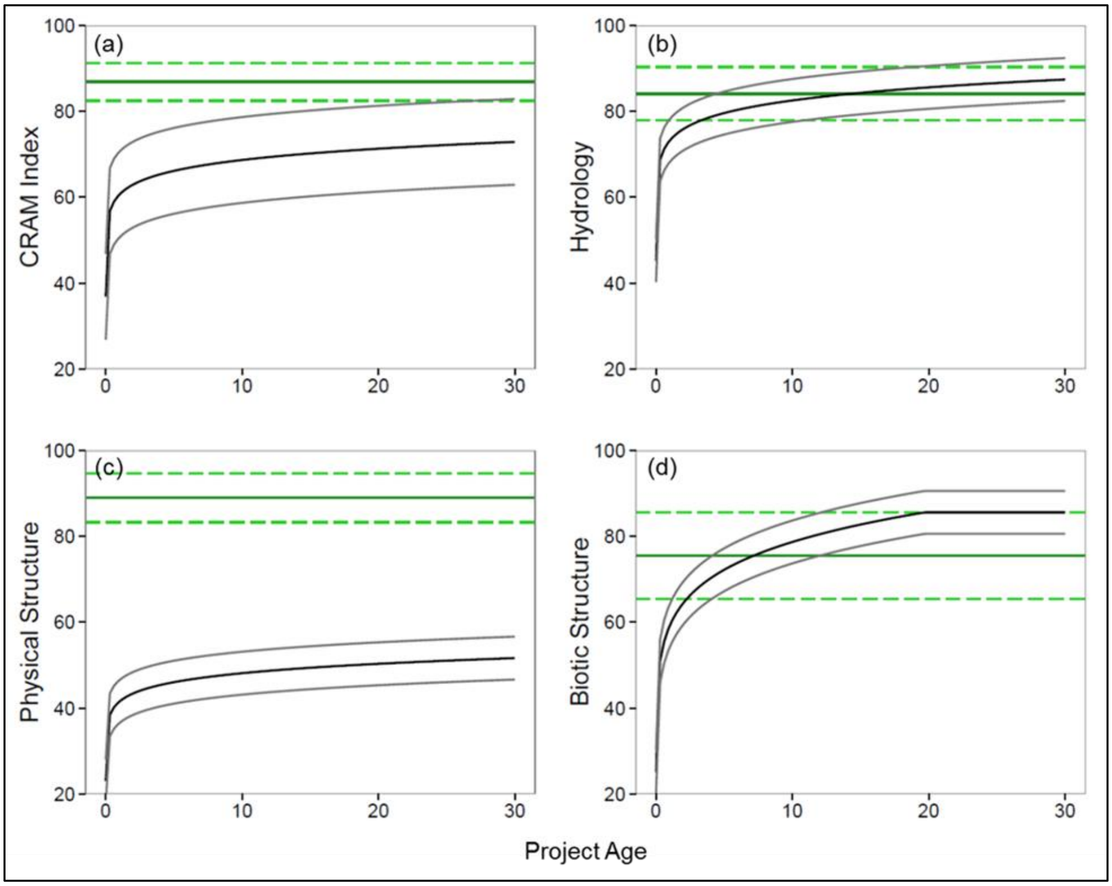


Figure 16: HDCs based on CRAM for riverine wetlands developed for coastal streams of the Southern California showing the development curves for the (A) CRAM Index Score, (B) Hydrology Attribute, (C) Physical Structure Attribute, and (D) Biotic Structure Attribute.

The condition of some restoration sites might be constrained by factors beyond the control of site planners and managers. Expecting such sites to ever achieve the reference conditions represented by the HDC might be unreasonable. In such cases, understanding site-specific constraints may be necessary to adjust expectations or to change sites.

For example, LS-001 D and LS-002 D are the two depressional wetland AAs located in the quarry-pond area of Lake Silveira (Figure 17). Current pre-construction conditions of LS-001 D and LS-002 D are above and below the HDC, respectively (Figure 18). The modeling of future scores suggests that the condition of LS-001 D will decrease, but remain above the HDC, whereas the condition of LS-002 D will increase but remain below the HDC. Both AAs get low scores for the Aquatic Area Abundance Metric due to the isolation of Lake Silveira in an otherwise terrestrial landscape. The District has very limited opportunity to affect any changes in the landscape that would increase the score for this metric. The score for the Hydroperiod Metric also decreases for both AAs. This is because the water level will be actively managed, making it reliant upon human actions, as compared to an entirely natural system. The score for the Topographic Complexity Metric remains moderately low because the steep banks make construction of topographic benches and other beneficial topographic elements very difficult. Further analysis of the costs and benefits of creatively building greater topographic complexity into the project could be conducted.

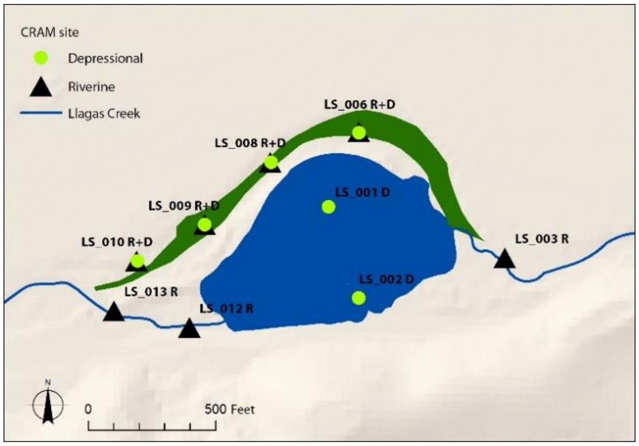


Figure 17. Pre-construction CRAM AAs for Lake Silveira showing the blue quarry-pond area and two AAs, on the north and south shores of the quarry-pond, which will be enhanced.

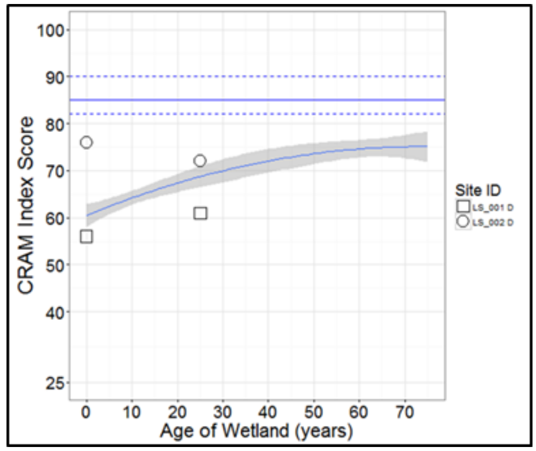


Figure 18. Selected pre- and post-construction depressional CRAM Index scores from the quarry-pond plotted on the statewide Habitat Development Curve (HDC) for depressional wetlands.

Summary

This memorandum illustrates how CDFs and HDCs based on CRAM can be used to evaluate wetland mitigation in the watershed context. To be specific:

- CRAM can be used in a probabilistic survey of wetlands within a watershed or project to develop a CDF that quantifies the relative abundance of wetlands based on their condition;
- CRAM can be used to estimate the future condition of mitigation wetlands based on their settings and designs;
- The condition of a project's impacted and mitigation wetlands relative to other wetlands in the project's watershed can be assessed by plotting the CRAM scores for the project onto the CDF for the watershed;
- Standard graphical and statistical procedures can be used to compare scores for different sets of wetlands, such as impact and mitigation wetlands, existing and proposed wetlands, and any set of wetlands over time;
- HDCs can be used to estimate the end-point condition of a mitigation site based on its early condition and thus estimate its eventual position on the CDF for its watershed.

- The scores for CRAM Attributes and Metrics can be used in combination with the CRAM Stressor Checklist to determine how the condition of a mitigation site might be improved through its design or management.

By applying these procedures to the Llagas Creek Flood Control Project, it has been determined that:

- Mitigation will at least moderately improve the condition of wetlands at the project and at the off-site mitigation area;
- Mitigation will not lessen the average condition of wetlands within the Llagas Creek watershed;
- The condition of some mitigation sites can be improved by decreasing the degree to which their hydrology is actively managed and by increasing their topographic complexity.

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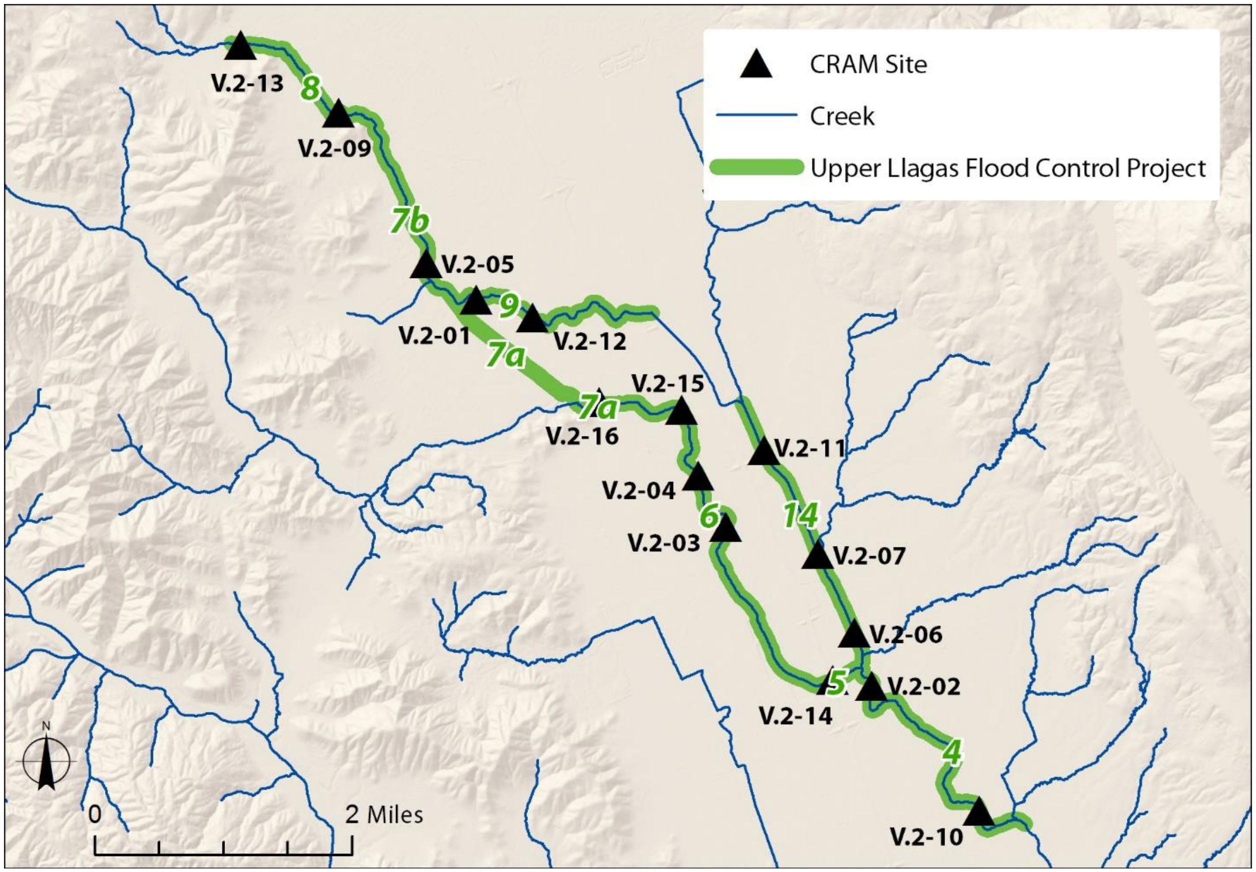
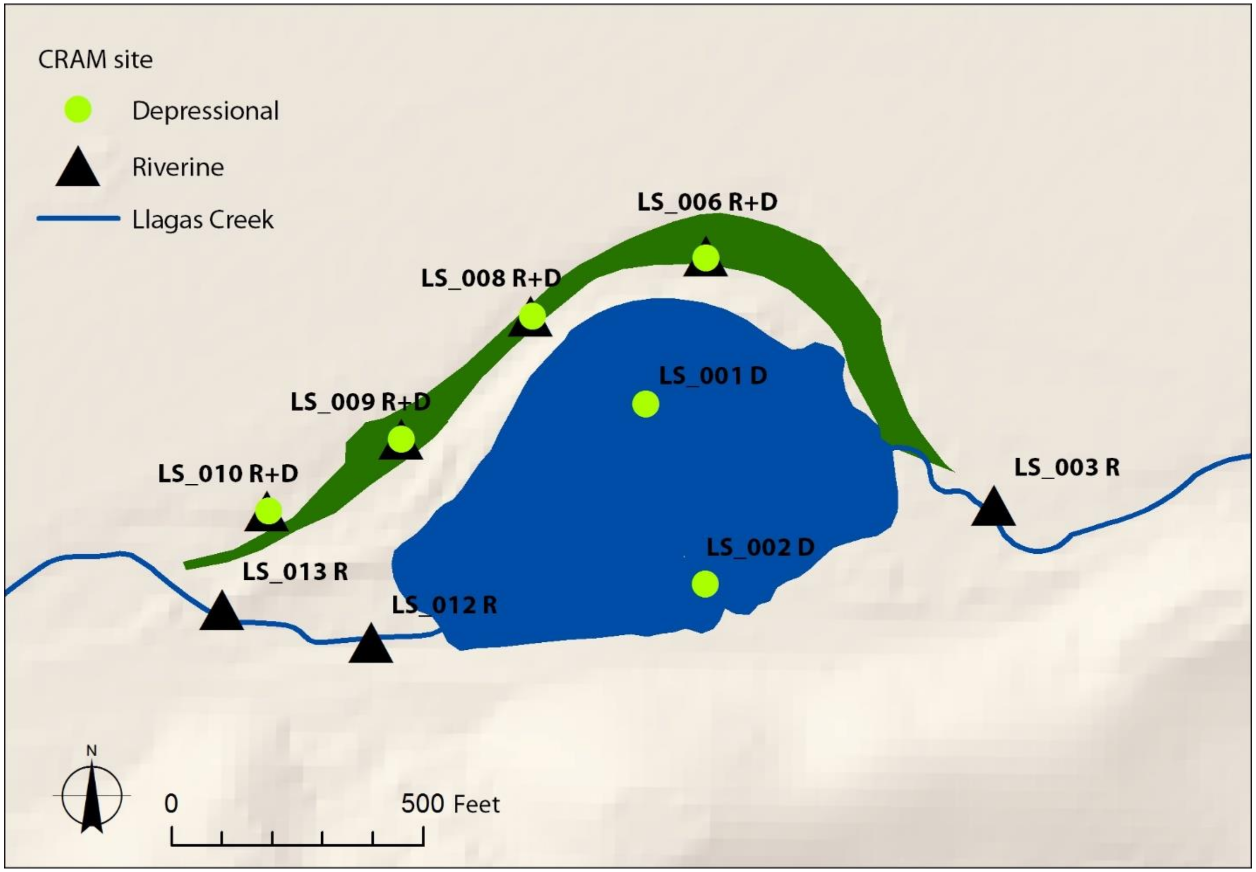
Appendix 1

CRAM AA location maps, descriptions, and pre-construction CRAM scores

for the Llagas Creek Flood Control Project and Lake Silveira Mitigation Site, 2015




CRAM site
Depressional
Riverine
Llagas Creek
LS_006 R+D
LS_008 R+D
LS_001 D
LS_009 R+D
LS_010 R+D
LS_003 R
LS_002 D
LS_013 R
LS_012 R
N
0
500 Feet

Llagas Creek Flood Control Project 2015 Pre-construction CRAM Results																
SiteID	**AA Row ID**	**Latitude**	**Longitude**	**Visit Date**	**Wetland Class**	**Wetland Subclass**	**Hydroregime (Riverine)**	**AA Size (ha)**	**Bankfull Width (m)**	**Flowing Water**	**Index Score**	**Buffer & Landscape**	**Hydrology**	**Physical Structure**	**Biotic Structure**
V.2-01	4311	37.1073	-121.6375	9/1/2015	riverine	non-confined	intermittent	0.05	2.14	0	50	50	67	25	58
V.2-02	5106	37.0645	-121.5809	9/10/2015	riverine	non-confined	intermittent	0.22	7	0	67	85	58	75	50
V.2-03	4304	37.0812	-121.6018	8/24/2015	riverine	non-confined	intermittent	0.11	5.6	0	66	75	67	63	58
V.2-04	4312	37.0879	-121.6058	9/2/2015	riverine	non-confined	perennial	0.17	5.97	0	68	75	58	63	75
V.2-05	4314	37.1107	-121.6444	9/1/2015	riverine	non-confined	intermittent	0.07	3.05	0	52	75	67	38	28
V.2-06	4316	37.0705	-121.5835	9/3/2015	riverine	non-confined	intermittent	0.08	1.81	0	60	75	67	50	47
V.2-07	4317	37.0785	-121.5883	9/2/2015	riverine	non-confined	intermittent	0.06	3.61	0	55	75	50	50	44
V.2-09	4451	37.1279	-121.6571	8/31/2015	riverine	non-confined	intermittent	0.12	1.9	0	49	30	75	38	53
V.2-10	4322	37.0505	-121.5656	9/3/2015	riverine	non-confined	intermittent	0.16	8.73	0	64	73	58	63	64
V.2-11	4321	37.0909	-121.5966	9/2/2015	riverine	non-confined	intermittent	0.03	2.3	0	52	75	50	38	44
V.2-12	4324	37.1047	-121.6288	9/1/2015	riverine	non-confined	intermittent	0.04	2.73	NA	49	71	67	25	33
V.2-13	4325	37.1355	-121.6711	8/31/2015	riverine	non-confined	intermittent	0.09	5.32	0	55	75	67	38	42
V.2-14	4327	37.0649	-121.5857	9/3/2015	riverine	non-confined	intermittent	0.09	4.5	0	65	80	58	63	58
V.2-15	4328	37.0951	-121.6084	9/4/2015	riverine	non-confined	perennial	0.13	4.95	1	76	75	67	75	86
V.2-16	4330	37.0957	-121.6202	9/9/2015	riverine	non-confined	perennial	0.35	3.98	1	78	80	75	75	81

Lake Silveira Mitigation Site 2015 Pre-construction CRAM Results																
SiteID	**AA Row ID**	**Latitude**	**Longitude**	**Visit Date**	**Wetland Class**	**Wetland Subclass**	**Hydro-regime (Riverine)**	**AA Size (ha)**	**Bankfull Width (m)**	**Flowing Water**	**Index Score**	**Buffer & Landscape**	**Hydrology**	**Physical Structure**	**Biotic Structure**
LS_003 R	4605	37.0953	-121.6221	10/29/2015	Riverine	non-confined	perennial	0.34	6.47	1	72	90	58	75	64
LS_012 R	4629	37.0945	-121.6264	10/28/2015	Riverine	non-confined	perennial	0.12	3.86	1	82	88	83	75	81
LS_013 R	4626	37.0947	-121.6274	10/28/2015	Riverine	non-confined	perennial	0.14	5.04	1	79	86	83	75	72
LS_001 D	4641	37.0958	-121.6245	10/29/2015	Depressional	perennial/seasonal	NA	0.41	NA	NA	56	49	67	50	58
LS_002 D	4644	37.0949	-121.6241	10/29/2015	Depressional	perennial/seasonal	NA	0.60	NA	NA	76	63	67	100	75
LS_006 D	4609	37.0966	-121.6241	10/26/2015	Depressional	ephemeral	NA	0.45	NA	NA	66	45	67	75	75
LS_008 D	4610	37.0963	-121.6253	10/29/2015	Depressional	ephemeral	NA	0.28	NA	NA	66	65	67	75	56
LS_009 D	4607	37.0956	-121.6262	10/30/2015	Depressional	ephemeral	NA	0.43	NA	NA	64	49	67	75	64
LS_010 D	4608	37.0952	-121.6271	11/29/2015	Depressional	ephemeral	NA	0.42	NA	NA	65	61	75	75	47

Appendix 2

Table of pre-construction (2015) and estimated post-construction (25 years after construction is completed)

CRAM scores for the Llagas Creek Flood Control Project and Lake Silveira Mitigation Site

Flood Control Project Site pre- and post-construction CRAM scores

SiteID	PRE CRAM Index Score	POST CRAM Index Score	PRE Buffer & Landscape	POST Buffer & Landscape	PRE Hydrology	POST Hydrology	PRE Physical Structure	POST Physical Structure	PRE Biotic Structure	POST Biotic Structure
Flood Control Project										
V.2-01	50	50	50	50	67	67	25	25	58	58
V.2-02	67	74	85	85	58	75	75	63	50	72
V.2-03	66	68	75	81	67	58	63	50	58	83
V.2-04	68	70	75	81	58	67	63	50	75	83
V.2-05	52	63	75	75	67	83	38	50	28	44
V.2-06	60	65	75	81	67	67	50	50	47	61
V.2-07	55	65	75	81	50	67	50	50	44	61
V.2-09	49	50	30	30	75	75	38	38	53	56
V.2-10	64	73	73	73	58	83	63	63	64	72
V.2-11	52	67	75	81	50	75	38	50	44	61
V.2-12	49	49	71	71	67	67	25	25	33	33
V.2-13	55	64	75	75	67	83	38	50	42	47
V.2-14	65	73	80	80	58	67	63	63	58	83
V.2-15	76	79	75	86	67	67	75	75	86	89
V.2-16	78	73	80	86	75	67	75	50	81	89

Lake Silveira Mitigation Site pre- and post-construction CRAM scores

SiteID	PRE CRAM Index Score	POST CRAM Index Score	PRE Buffer & Landscape	POST Buffer & Landscape	PRE Hydrology	POST Hydrology	PRE Physical Structure	POST Physical Structure	PRE Biotic Structure	POST Biotic Structure
Quary-pond										
LS_001 D	56	61	49	55	67	50	50	63	58	75
LS_002 D	76	72	63	63	67	50	100	100	75	75
Historical Riverine Channel (depressional wetlands in the historical channel will be restored to riverine wetlands) Pre-construction scores are based the depressional CRAM field book. Post-construction scores are estimated based on the riverine field book.										
LS_006 DtoR	66	82	45	90	67	83	75	75	75	81
LS_008 DtoR	66	81	65	86	67	83	75	75	56	81
LS_009 DtoR	64	84	49	86	67	83	75	88	64	78
LS_010 DtoR	65	79	61	81	75	83	75	75	47	78
Riverine wetlands										
LS_003 R	72	78	90	90	58	67	75	75	64	81
LS_012 R	82	82	88	88	83	83	75	75	81	81
LS_013 R	79	82	86	86	83	83	75	75	72	83