Accelerated Innovation Deployment (AID) Demonstration Project:

Gifford Pinchot National Forest Layout Creek Bridge Project

Implementation Plan and Final Report

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Technology and Innovation Deployment Program (TIDP)
Accelerated innovating Deployment (AID) Demonstration
Gifford Pinchot National Forest Layout Creek Bridge Project
Report on Data Collection and Implementation Plan and Results

Data Collection and Implementation Plan Purpose

This document will serve as a working document to be used to facilitate the development and implementation of information collection and reporting on the project's performance with respect to the relevant outcomes that are expected to be achieved through the use of the innovation in the project. As a requirement of the AID Demonstration program the award recipient is to work with FHWA on the development and implementation of this plan. Performance indicators need to be identified for each project, and will consider the individual project's stated goals as well as resource constraints of the award recipient. Performance indicators may include formal goals or targets, or at least include baseline measures as well as post-project outputs, and will inform the AID Demonstration program in working toward best practices, programmatic performance measures, and future decision-making guidelines.

Initial information in this template is based on the narrative provided in the application for the AID Demonstration grant.

The DC&I plan should assist in guiding the information that will be included in the final report. The award recipient shall submit a **final report to FHWA within 6 months of project completion** which documents the process, benefits, and lessons learned including development and/or refinement of guidance, specifications or other tools and methods to support rapid adoption of the innovation(s) as standard practice.

Accelerated Innovation Deployment (AID) Demonstration Program Information

The Accelerated Innovation Deployment (AID) program is one aspect of the multi-faceted Technology and Innovation Deployment Program (TIDP) approach, which provides funding and other resources to offset the risk of trying an innovation. The AID Demonstration funds are available for any project eligible for assistance under title 23, United States Code. Projects eligible for funding shall include proven innovative practices or technologies such as those included in the EDC initiative. Innovations may include infrastructure and non-infrastructure strategies or activities, which the award recipient intends to implement and adopt as a significant improvement from their conventional practice.

- **Project Information**

The Layout Creek Bridge Project was an aquatic restoration project that returned the previous undersized crossing to a more natural state by replacing a culvert that was constricting the channel with a larger and more open bridge structure. The substructure of the bridge consists of a Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) design based on FHWA GRS-IBS Interim

Implementation Guide (FHWA-HRT-11-026), while the superstructure was designed of prefabricated prestressed concrete beams, both of which are promoted under FHWA's Every Day Counts (EDC) initiative. The AID Demonstration funding was used to construct the GRS-IBS construction portion of the project while additional money from the Forest Service and partners was used to complete the bridge project. It is the intent of the Forest Service to use this project to evaluate and possibly accelerate the use of GRS-IBS structures technology on other national forests, particularly in combination with a prefabricated superstructure as in this case, by measuring the many potential benefits including time savings, cost savings, flexible design, increased constructability, safety advantages, and reduced environmental impact.

- **Innovation**

Identify the innovation and briefly describe current practice as these will define what is to be measured

Innovation explained:

The GRS-IBS substructure and design is an innovation new to current Forest Service practice. The design process was guided by the GRS-IBS Interim Implementation Guide (FHWA-HRT-11-026). This structure also carries only one lane, a notable difference from the two lane structure that current reference materials are geared toward.

Conventional practice explained:

Conventional designs typically used by the Forest Service include, steel, timber, or cast-in-place concrete superstructures founded on piles or spread-footings on bedrock in order to provide required bearing capacity and scour resistance. In recent years the use of pre-cast, prefabricated, concrete structure elements has become more common in bridge construction. Scour designs typically require substructures that are founded on bedrock or piles.

Comparison of innovation to conventional practice:

A conventional bridge design at this site would have required piles to be driven, as there was no bedrock to tie into near the bottom of the channel. Driving piles would have required increased time and cost to perform subsurface investigations, design and deliver the piles, as well as drive the piles during construction. In addition, the sound produced during pile driving is an issue for certain protected animals on the forest. The estimated cost associated with piles on a structure such as this would be around $50K. The initial subsurface drilling estimated at $10-15K, was also an initial barrier to overcome on this project, as all initial funding for the project came from partners, interested in funding tangible results more so than investigative reports.

Conventional cast-in-place design results in very long construction windows to allow time for concrete to cure. These long windows increase costs, extend impacts to commercial and public traffic through the corridor, increase worker exposure to construction hazards, and increase the need for environmental controls during curing in the field. If weather conditions deteriorate at the site during curing, constructability is decreased as the complexity of curing the concrete properly increases.

Historically speaking, in the recent past, pre-cast, prefabricated, concrete bridge structures have replaced most cast-in-place construction. These structures are constructed more quickly than cast-in-place designs, reducing many of the issues listed above. However, these structure elements often require additional cost for the Forest Service due to outsourcing of the design along with the additional profit taken by the designer and fabricator. Large structural components may also require larger vehicles such as cranes in order to be put into place, which can add complexity to the contract schedule and traffic control, in addition to adding additional cost.

Steel structures generally suffer from the drawback of increased life-cycle costs in the form of maintenance. Often times the maintenance includes painting or replacement of the deck and/or wearing surface elements.

- **Performance**

How the innovation will be monitored, assessed, and documented to determine if the performance goals and measures are achieved, including a timeline of demonstration, deployment, implementation, and/or adoption activities.

- **Performance Measures**

The following performance measures have been established for this project to qualify or quantify, the effectiveness of the innovation to inform the AID Demonstration program in working toward best practices, programmatic performance measures, and future decision making guidelines:

- *Goal #1: Reduce mean value of construction time from that of conventional construction.*

    - *Measure: Length of time measured in days. One measurement will be taken starting at the beginning and end of fabrication. A second measurement will be taken starting at the beginning and end of field construction starting with mobilization and ending with approval of final construction inspection. Compare with the time needed for implementing traditional alternatives.*

      Discussion of Results:
      Actual Construction Time: Fabrication of superstructure slabs was done prior to construction. It took two days to construct and pour the slabs and another to remove from forms and place into storage. In addition, there were 4 days of field construction to finish in-place work, consisting of 2 days to place the beams, install tie-rods, and key groutways, and 2 days to form and pour curbs. Total number of days of construction for entire structure was documented at 28 days.

      Conventional Construction Time Comparison: Entire project was completed in 28 days. A conventional and traditional fully cast-in-place design typical to that found in the Forest Service inventory would have taken months longer due to the time required in order to build formwork as well as to allow 7-28 days for concrete curing as required for strength and by specifications. However, recent trends have been moving to quicker

precast ABC designs that are competitive, if not outright quicker than GRS-IBS construction. These newer designs can often be installed in a matter of days.
Summary conclusion:
28 days is faster than conventional CIP methods but is not faster than fully precast ABC designs.

- *Goal #2: Reduce mean value of project cost from that of conventional construction.*
  - *Measure: Total cost measured in USD. Cost to include design, fabrication, delivery, and construction. Compare with the cost of implementing traditional alternatives.*

    Results: Final Total Cost at $291,491. Conventional design option cost estimate at $312,000. Final cost was less than that of a conventional design at this site, with additional savings expected as local contractor experience increases. After removing approximately $25K in project costs unique to this specific project site, it is estimated that the final cost of the structure represented a savings of approximately 15% over conventional design.

- *Goal #3: Project that is easy to construct with common equipment.*
  - *Measure: Document and list any equipment needed for construction that is not common.*

    Results: No uncommon equipment was required to complete construction. However, the contractor did elect to purchase special hand tools to assist with grabbing the CMU blocks and moving them into place. The cost of the hand tools was insignificant relative to project cost.

- *Goal #4: Design that can adapt to unforeseen conditions.*
  - *Measure: Document any challenges that had to be overcome as a result of unforeseen conditions, and how well the design and/or construction plan was able to adapt to overcome the challenge.*

    Unforeseen Challenges:

    Unforeseen condition #1 – Compaction challenges due to subsurface groundwater:

    Construction plans included a submittal for dewatering the site if necessary. Although little to no water was visible at ground surface, a significant amount of groundwater was found flowing subsurface through the site upon excavating the site. Moisture content was notably high reducing the effectiveness of compaction efforts. At first nuclear densometer tests confirmed that compaction efforts to meet 100% of T-180 were not being met, a required specification needed in order for the available rock to meet original design values for backfill density.

    Resolution:

    French style drains with perforated pipe and drain rock were constructed around the back edge of the excavation in order to bring the moisture content of the backfill to the optimal value so that it could be compacted enough to pass 100% of T-180. These drains terminated at the downstream end of the project in a hole where a pump ran continuously to keep the site drained until both abutments were well above ground surface.

Unforeseen condition #2 - Concrete masonry unit displacement at abutment face:

Displacement of the concrete masonry units at the abutment face from compaction forces ended up being a continuous challenge that drained the will and energy of the laborers, so much so that at one point they were pushing for a design change. The resisting frictional force between the CMU's and the very slippery geotextile fabric was not enough to allow the CMU's to stay in place, requiring continual block corrections to stay within alignment. It was believed that this was in part due to the rock source having been lighter than expected, which resulted in a much higher compaction effort needed, as well as the fact that the material was also a very large diameter well graded backfill that takes more effort to compact than a smaller diameter open graded material. The displacement required continuous reworking of the block alignments, and at one point began to effect lower levels that were no longer correctable, to the point where aesthetics and stability of the facial elements were called into question.

Based on these results of the current compaction effort at 95% of T-180, as well as preliminary compaction tests on site to achieve higher compaction values, it was determined that 100% compaction of T-180 would not be feasible within the bearing bed zone due to excessive CMU displacement expected to occur during the compaction effort.

At this point FHWA and FS technical specialists and reference materials were consulted in order to develop a solution to the CMU displacement and determine what level of T-180 compaction was actually necessary, as current references only refer to T-99 compaction specification efforts.

Resolutions:

The first change involved the compaction process used. In order to minimize CMU displacement, three phases of compaction were specified based on discussions with geotechnical specialists, with the intent to gradually increase the shear strength of the soil behind the blocks to better resist the increasing displacing compaction forces needed to meet specifications and design intent. The first stage required rodding and tamping of the material directly behind the CMU block for a distance of 2-3". The second stage involved using a plate compactor up to a distance of 3'-0" from the wall faces. The third stage involved using a larger remote controlled vibratory roller at distances more than 3'-0" from the wall face in order to finish the compaction effort at that layer. After further field tests the vibratory roller was replaced with a 900lb reversible plate compactor. Although this change in compaction process did reduce the amount of block displacement by a small amount, confidence that 100% of T-180 could be achieved was still not present with the building team nor justified as displacement was still occurring above 95% of T-180.

The second change involved reducing the compaction specification to 95% of T-180 within the bearing bed zone. Additional analysis determined that 95% of T-180 would be sufficient to pass design checks, while having the needed benefit of allowing construction to move forward without displacement at levels that significantly affect the stability of the wall face and its aesthetics. As T-180 compaction requires much more energy and effort than T-99 to meet, it was estimated this was more compaction than would have been achieved through 100% compaction of T-99.

Unforeseen Condition #3 – Contractor constructed East abutment 1ft high in elevation:

After 2/3's of the East abutment was constructed a contractor error was uncovered resulting in the elevation as constructed being one foot higher than designed.

Resolution:

As the design elevation was important in order to keep the substructures foundation below the channels scour potential, a modification to the design was done to help correct the error. The riprap scour countermeasure design was strengthened by two methods. The overall maximum rock diameter or class of rock was increased and the depth of placement was increased an additional foot in depth beyond that specified in the design.

- *Goal #5: Project that can be constructed in unfavorable weather.*
    - *Measure: Document any significant conditions that result from unfavorable weather and the effect that they do or do not have on construction.*

    Unfavorable weather conditions were mild to non-existent during construction. Most days were sunny and dry. Rain did occur on a few days during abutment construction, but no significant conditions were observed other than the subsurface water discussed above.

- *Goal #6: Reduced maintenance costs when compared to traditional alternatives.*
    - *Measure: Document all maintenance work items and their estimated cost in USD. Compare with the cost of maintaining traditional alternatives.*

    No maintenance has been performed on this structure to date. This performance measure will continue to be monitored.

- *Goal #7: Design provides a smooth transition from the roadway to the bridge and back, eliminating the "bump at the end of the bridge" problem that is common on FS roads.*
    - *Measure: Document condition of approach at bridge ends into the future using standard NBIS condition ratings with remarks.*

    There are no currently no bumps observed at either end of the bridge. This performance measure will continue to be monitored.

- **Data Collection**

The GPNF, in coordination with the FHWA Federal Lands Highway Headquarters Office, developed this implementation plan for collecting information in support of the identified performance measures.

  - *Describe methodology to be employed for each measure*
  - *Define baseline information*
  - *Define any interim measures (for stage work) that could be beneficial to collect*
  - *Construction projects only: customer satisfaction (before and after) determination*

This section does not seem to fit. Recommendation to combine with section above?

RECOMMENDATIONS AND IMPLEMENTATION

- **Recommendations**
  - Consider strongly recommending using open graded backfill in the zone that can best be described as from the top of the reinforced soil foundation up to the bottom of the IBS approach layers. Open graded material compacts with less effort, resulting in fewer forces to displace the wall face elements and fewer corrections as construction progresses up the wall. Additionally, open graded material can be compacted using a method spec that is faster and cheaper than using a nuclear densometer to check compaction at each layer. Overall open graded material would appear significantly faster and cheaper in this section to the point of stressing it of more importance than is currently noted.

  - Consider using a keyed block system rather than a standard CMU block. Prices for keyed block systems are minimal in comparison to the amount of time they could save the construction schedule, resulting in likely paying for themselves many times over in labor and equipment time savings. The keyed blocks would resist displacement from the compaction forces resulting in less time spent adjusting block alignments.

  - Consider providing design guidance regarding T-180 compaction. In this project T-180 had to be used in order to meet design values for density due to the local rock being lighter than expected, but there was no guidance regarding the effect that meeting T-180 compaction has on wall face elements having little resistance to displacement.

  - French-style drains drained the site of water very effectively without any problems. This solution is recommended for sites with heavy subsurface flows in order to meet design and compaction specifications of well graded reinforced soil foundations.

- **Status of Implementation and Adoption**

(Include discussion on partnering, cooperation, or coordination efforts, if applicable)

    - Partnership funds from D360A014 (FHWA Grant), CMLG0313 & CMLG0314, NFXN0813, & NFXF2014 paid for entire project. Partners included FHWA, Ecotrust, & Bonneville Power Administration.
    - Project advertisement June 21st, 2014
    - Project award August 18th, 2014
    - Project substantially complete as of November 5th, 2014

Since the completion of Layout Creek Bridge the Forest Service has undertaken the following activities to implement GRS-IBS into our standard operating procedures as a significant improvement from our traditional practice for similar type projects:

- *(list activities and status)*
    - Presented project at Region 6 Regional Engineering Leadership Team (RELT) Meeting in Vancouver, Washington on December 3rd, 2014.
    - Project news sharing with Washington Office.
- *(list any technology transfer activities)*
    - Provided Drawings, Specs, Calculations, and Costs to two Forest Engineers interested in the project and possible design opportunity based on the RELT presentation above.

Our plan for full adoption of GRS-IBS is as follows:

- *(list timeline and activities necessary for adoption)*
    - Promote GRS-IBS design concept when and where possible "Consultation"
    - Share with immediate peers
    - Share with Forest Service Bridge Engineers on internal Sharepoint Website

- **Reporting**

The GPNF shall submit a final report to the FHWA CAI within six months of project completion, currently scheduled for around 4/30/2014, which documents the process, benefits, and lessons learned from implementation of GRS-IBS on the Gifford Pinchot National Forest. The report shall include baseline data using traditional methods, observed data from implementation of the innovation, and discussion on the GPNF development and/or refinement of guidance, specifications or other tools and methods to support rapid adoption of the GRS-IBS as standard practice.