Summary of questions received from city of Medina regarding joint noise

Questions from **7/16/16**

- June 13 Medina City Council meeting packet

➢ June 24 email from Alex Morcos

o June 27 email from Cindy Adkins

History / Planning

- **Which of the Design Refinement and Transit Connections Workgroup [ESSB 6392] recommendations were actually constructed? What are the design specifications regarding the construction and/or implementation of each incorporated recommendation?**

ESSB 6392 recommendations included:

1. Encapsulating the underside of bridge expansion joints
2. Using quieter concrete pavement
3. Building noise walls to the extent reasonable and feasible

Additional ESSB 6392 recommendations that applied to the corridor west of the new floating bridge included:

4. 4-foot-tall barrier with sound absorptive material – sound absorptive material has since been removed from the design for safety reasons
5. Acoustically absorptive materials around lid portals – if absorptive materials are installed in these locations, it will be above the vehicle impact zone due to safety considerations
6. Speed limit reduction on the Portage Bay Bridge

➢ **Explain the modeling you did for the expansion joint noise at the new bridge.**

  ➢ **Which noise-reduction options did you consider, and how did each rank as to technical feasibility, effectiveness, safety, aesthetics and cost?**

In addition to the general noise reduction measures discussed above, at the time of bridge design, WSDOT had experience with unwanted joint noise from I-90, Tacoma Narrows and other bridges. Much of the noise issues in those locations were related to noise escaping through and below the joint. As a result, WSDOT designed an encapsulated joint system.

As documented in the June 20 memorandum: *SR 520 Noise Analysis New vs. Old Bridge*, the encapsulation system has been effective, reducing joint noise both near the joint and under the bridge by up to 10 dBA relative to the I-90 and Tacoma Narrows bridges.

During the development of the new floating bridge, the only expansion joint with plates that had been tested were plates that were welded onto the top of the joints. These welded plates had a history of failing over time and posed a safety hazard of being thrown up by vehicles traveling over them.

  ➢ **Which options were chosen, which were rejected, and why?**

Discussed above.

  ➢ **Did you consider the Mageba sinus plate?**

Mageba's current design of bolt-on sinus plates was not available and tested at the time of the floating bridge's design. The design for the floating bridge's expansion joints was conceptually approved in November 2011. See Attachment A of this document for a more complete timeline.

- **How does the noise from the installed expansion joints compare with the model(s) you ran? (And, if there are differences, please explain likely causation.)**

As documented in the June 13 handout *SR 520 Floating Bridge Sound Measurements*, the measured traffic noise levels are all within 3 dBA of the projected levels, and none of the measurements approach or exceed the FHWA/WSDOT noise abatement criteria. From a broad-spectrum time-averaged perspective, which is the basis of FHWA/WSDOT traffic noise impact criteria, the sound coming off of the bridge, including the joints, is very close to what was anticipated in the noise modeling 5 years ago.

- **Does WSDOT have any data regarding the likely expansion joint noise output, absent the encapsulations?**

Based on the measurements documented in the June 20 memorandum *SR 520 Noise Analysis New vs. Old Bridge*, the encapsulation system has reduced joint noise both near the joint and under the bridge by between 7 and 10 dBA relative to the I-90 and Tacoma Narrows bridges. Based on this data, without encapsulation, the bridge joints would be more than 5 dBA louder at and below the roadway deck than they are today.

Measurements

- **Has WSDOT's investigation accounted for the unique, intermittent/low frequency nature of the noise through methods other than traditional highway noise Leq/dBA measurements?**

As documented in the June 20 memorandum *SR 520 Noise Analysis New vs. Old Bridge*, WSDOT completed 1/3 octave band measurements to characterize the frequency/tone of the sound.

- **Has WSDOT taken Lmax measurements that correspond to the 15-minute interval Leq measurements reflected in its March 29, 2016 report? If so, what were those results?**

The June 20 memorandum *SR 520 Noise Analysis New vs. Old Bridge* includes Lmax measurements.

- **Has WSDOT evaluated the difference between Leq and Lmax measurements taken in the various locations described in its March 29, 2016 report?**

Yes, the Lmax readings, on their own, are inconclusive regarding joint noise analysis.

- **How does the difference between Lmax and Leq measurements taken near the 520 bridge differ from similar measurements taken in highway locations without expansion joints?**

The relative levels between Leq and Lmax are similar to what is expected for any highway noise situation. Lmax levels tend to be dominated by heavy trucks, and this appears to be the case for the levels measured at the joints. Looking at the data for 4/19 and 5/3, the Lmax levels at the expansion joints are within 3 dBA of Lmax levels measured along the bridge pavement and they were lower at the joint on the 4/19, while higher at the joint on the 5/3.

Design / Engineering

- **In what precise locations has WSDOT installed noise absorptive materials on the new bridge? Which of these installations were intended to remedy expansion joint noise, specifically?**
  Noise absorptive materials have not been installed in the SR 520 corridor. Noise absorptive materials were planned to be installed on barrier and around lid portals at the west end of the 520 corridor. Noise walls are not planned for the west side and the absorptive materials were considered as a potential option to help reduce noise impacts. However after a safety test, WSDOT is no longer planning to include the material on barriers.

  The design team is currently evaluating including noise absorptive material on lid portals (on the west end). If it is installed, it would only be installed above the impact zone due to the results of the safety tests which showed that the material could easily become airborne in a collision potentially blinding drivers and causing material to get into the lake.

- **Is it possible to expand the joint encapsulation presently in place underneath the expansion joints?**
  The encapsulation currently runs the full width of the bridge, enclosing the bottom of both the eastbound and westbound joints. It is not practical to build an above deck encapsulation (or lid) system above the expansion joint due to the added loading on the structure as well as the potential for creating a “sail” effect on the bridge.

- **Causes of noise and possible exacerbating factors**
  - **Joints, as installed, may not be flush (or not as flush as they could be) with the highway surface**
  - **Encapsulation of the cavity under the joint, which may be amplifying, changing and/or distorting the sound coming out of the top of the joint**
  - **Whether the current sound walls are directing the noise up the bike-path, and, if so, what the impacts are on residents; the speed of the traffic, etc.**

  The primary source of noise is definitely the wheel strike on the joint beams. Excitation of the beams themselves, resonance in the cavity below, or air pumping of bridge seals may be contributing factors. We do not have that level of understanding at this time. The sound walls do not appear to be increasing sound in the neighborhood, but could be a factor in what areas hear the joint sounds and how loudly, as one moves from an area where the walls block the view of all or part of the joints compared to where there is no blockage.

- **Eastbound joints seem to be less disturbing than the westbound joints. Any idea why? (A study could be quite revealing). Is it because the eastbound uphill direction results in different impact from cars going downhill and faster on the westbound? Or are the joints slightly more or less flush with the roadway in one case versus the other? Or the encapsulation chamber under the south side (eastbound) of the bridge slightly different than the north side (westbound)?**

  Direction of travel across the joints may be a factor. The configuration of pavement near the joint may also be a factor. At this time, WSDOT plans to take advantage of the next scheduled highway closure to evaluate the differences between the eastbound and westbound joints. This evaluation will include measuring the pavement around the joint and evaluating the joints with a straight edge to determine if there are humps/dips in the pavement contributing to impact noise at the joint.

  The encapsulation is essentially the same under both joints, since the enclosure is continuous.

- **Are additional noise walls that cross the line of sight around the expansion joints structurally feasible?**
  KGM has informed WSDOT that it would cost approximately $120,000 to complete an engineering analysis to study the feasibility of extending the noise walls further west from the east approach onto the floating bridge. When considering unplanned structures on the floating bridge, engineers must take into account a variety of issues, including the weight of the wall and it's impacts to the floating bridge. A complex structural analysis would be required to determine what changes to the buoyancy and ballasting would be required.

- **Has WSDOT evaluated alternative and/or additional joint noise mitigation efforts at this time? If so, what specific methods is WSDOT considering?**

  As Secretary Millar stated during the June 13 council meeting, WSDOT is committed to working with the city of Medina to evaluate the feasibility and effectiveness of potential mitigation options. At this time, because sound measurements from the new bridge are below Federal and State standards, WSDOT is not considering implementation of measures identified through the coordination process. Additional funding would need to be identified in order to implement any feasible options identified through the coordination process.

  Please see the table below for an overview of potential options currently being evaluated.

Option	Estimated Cost Range	Potential Effectiveness	Feasibility
Modifications to the joint			
Add absorptive batts under the joints in the encapsulation cavity	Low	Unknown • Likely low effectiveness • Requires additional research	High
Modify joint tuning with mass or dampening added to each beam	Medium	Unknown • Likely low effectiveness • Requires additional research	Medium
Replace joint between beams seals with hump seals (Mageba)	Medium-low	Low to moderate	Medium-High
Replace joint seals between beams with sound-absorptive joint inserts	Medium	Moderate	Medium-Low. Limited testing suggest short lifespan (~ 2 years) and escaped rubber material could enter lake. Potentially high long term maintenance cost.
Add Robomute to joint (Mageba)	Medium	Low to no effectiveness because the joint is already encapsulated	High

Add/extend/modify joint encapsulation	Unknown	Unknown • Joint is fully encapsulated, no known feasible means of additional encapsulation benefit	Low, joint is already fully encapsulated.
Sinus plates (retrofit or replace)	High	Medium-high • Total noise likely reduced somewhat, and the frequency is shifted closer to matching roadway tire noise • Mageba notes that effectiveness is speed dependent	Low, would require closure and complete reconstruction of joint area.
Other Options			
Noise wall	Medium-high	Unknown • Depends on exact configuration	Low, adds weight and wind load to the bridge.
Reduce speed	Low	Low • 10 mph speed reduction could result in a minor reduction in noise. • Would need test data.	Low, this would be entirely enforcement driven. Large-scale speed enforcement would be difficult. Facility design speed supports a safe high travel speed, so driver expectation is not to reduce speed.

Experts / Mageba

- **In particular, which experts have you engaged on this noise problem, and what's their scope of work -- to demonstrate that the FHWA noise requirements have been met, or to study and solve the joint-noise problem? (In particular, have you engaged Mageba (the joint manufacturer) to assist with possible solutions?)**

WSDOT has discussed this issue with Mageba who shared information about potentially retrofitting the existing joints and/or installing a new joint. This information will be shared at the July 18 COW meeting. We may also be able to have a representative from Mageba join a future COW meeting in-person or by phone.

Other experts that have been engaged on this issue include:

WSDOT Northwest Region Acoustics, Air Quality and Energy Program
-- Jim Laughlin, Manager
-- Peter Soderberg, Acoustics and Air Quality Specialist

SR 520 Environmental Consultant
-- Lawrence Spurgeon

Mageba
-- Guido Schwager, PE

Kiewit/General/Manson, A Joint Venture
-- BergerABAM

Experts consulted as part of the 2008 Noise Reduction Strategies Expert Review Panel
-- Dr. Paul Donavan, Illingworth & Rodkin, Inc.
-- Gary Fromm, PE (AZ, CA), Jacobs
-- Rob Greene, INCE Bd. Cert., Parsons Brinckerhoff
-- Dr. Steve Muench, PE (WA), University of Washington, Civil & Envir. Engineering
-- Mike Oliver, P. Eng, British Columbia Ministry of Transp. & Infrastructure
-- Dr. Robert Rasmussen, PE (TX), The Transtec Group, Inc.
-- Dr. Judy Rochat, US DOT / Volpe Center
-- Dr. Ulf Sandberg, INCE Bd. Cert., Swedish National Road and Transport Research Inst.
-- Leonard Sielecki, M. Sc, MCIP, R. P. Bio, British Columbia Ministry of Transp. & Infrastructure
-- John Stout, M.A. Econ, HDR Decision Economics
-- Clair Wakefield, M.A. Sc, P. Eng, Wakefield Acoustics, Ltd.

- **What have the experts advised to date re joint noise and solutions - causes, exacerbating factors (does encapsulation of cavity under the joint amplify, change and/or distort the sound coming out of the top of the joint?), possible confounding factors to keep in mind, and possible noise-reduction solutions (including effectiveness, feasibility and cost), etc.?**

Causes are touched on above. The cavity is not sealed, so it is not working like a drum. There are a couple of ways that the cavity could affect the sound, possibly with some resonance and with some sound escaping through openings. While possibly contributing, the cavity is not likely a dominant factor.

Other questions / suggestions

- **Another interim solution we have been asking for, and one that could be implemented relatively quickly -- without a costly change order -- is reducing the speed limit on the Eastside of the bridge, during off-peak hours, to 45-50 mph or less. (I believe this is one of the noise-reduction strategies used on the Seattle-side.)**

WSDOT will work with traffic engineers to determine the feasibility of this option. There will likely be concerns associated with enforcement of the speed limit and potential confusion for motorists. The Secretary of Transportation has the authority to set speed limits but generally delegates this decision to the State Traffic Engineer with input from the Washington State Patrol. General information about state laws regulating speed limits can be found on the WSDOT website.

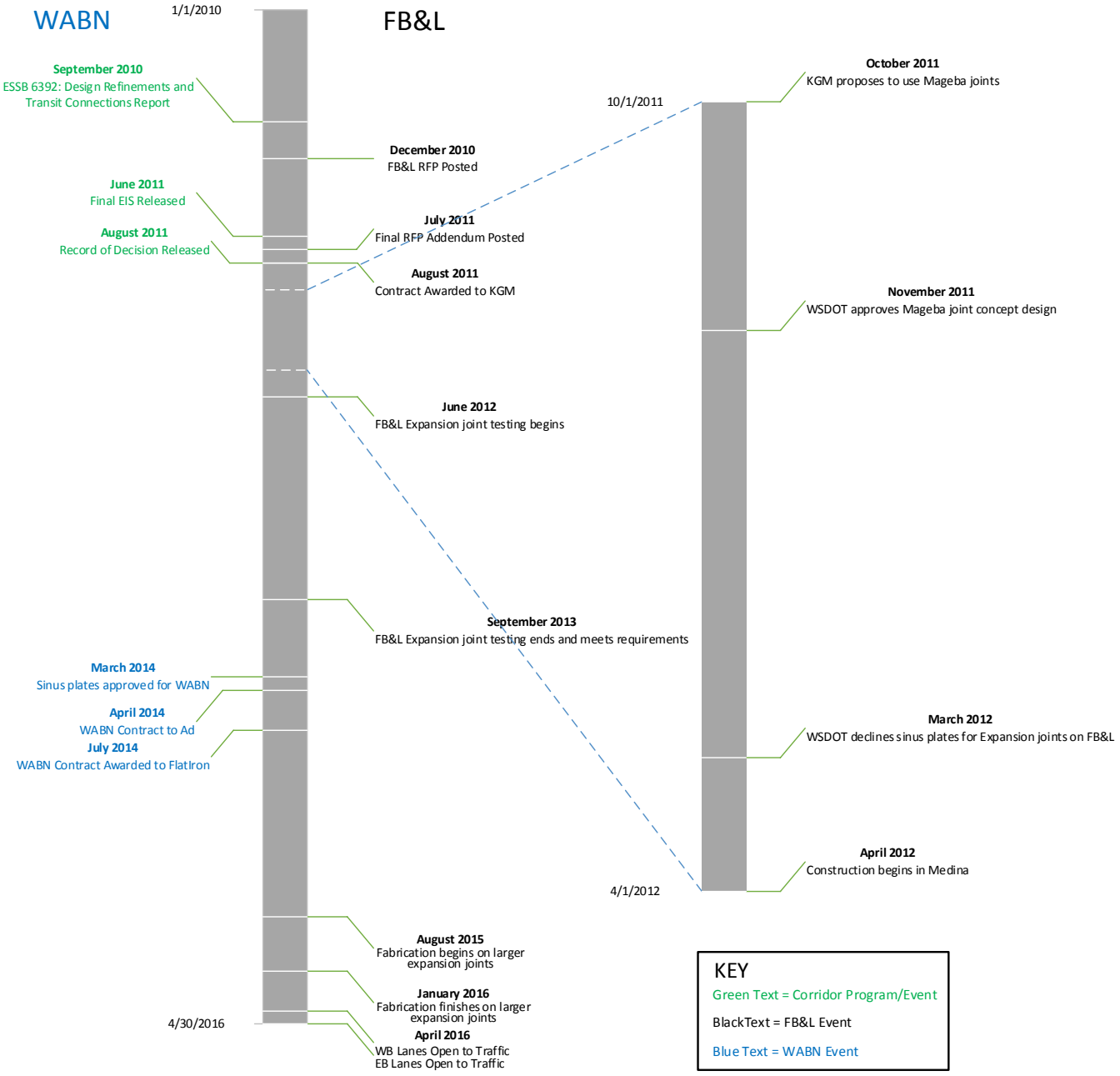
- **Please share your project plan [for the tech team/COW] with us - project scope, goals (what constitutes success?), team, timing, tasks/deliverables, required resources, and budget.**

WSDOT plans to work jointly with city of Medina staff to develop the work plan and schedule for this group. WSDOT is committed to continue to participate in the monthly Committee of the Whole meetings and on-going technical team meetings, which include both WSDOT and City staff.

- **What are the possible funding sources for the solutions?**
  As stated during the June 13 council meeting, the noise levels measured from the bridge do not meet federal or state criteria for additional mitigation. Additional funding for mitigation would need to be allocated by the legislature and/or secured from another source.

- **How can the city of Medina be most helpful?**
  The City can continue to fund the cost of city staff and expert participation in technical team and COW meetings. The City may also consider researching and/or soliciting funding sources, should a viable technical solution be determined through the evaluation/coordination process.

➢ ATTACHMENT A



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