Stantec Planning and Landscape Architecture, PC
226 Causeway St.
6th Floor
Boston, MA 02114

July 11, 2014

Attention: Ms. Allison Steinfeld
Planning Director
Town of Brookline
333 Washington Street
Brookline, MA 02445

Dear Allison,

Reference: The Residences of South Brookline

Stantec is in receipt of the document entitled "Residences of South Brookline 40B Civil Peer Review" prepared by BETA Group Inc., dated April 2, 2014. The information below represents BETA Group Inc's comments from the document referenced above followed by Stantec's responses.

We note that subsequent to the receipt of the BETA Group review, and in consideration of concerns and comments received from the Town of Brookline, we have revised the design of the site to reduce its density. The result has been that three buildings have been eliminated, providing the ability to provide additional open space. With the removal of three buildings from the plans, the buildings have been renumbered. Most notably, Building 13 on the previous design is numbered as Building 10 in the revised set of drawings. We note that BETA's comments reference the previous design and building numbers.

Additionally, the stormwater management system has been redesigned to eliminate most of the porous asphalt pavement, and instead incorporate a more traditional stormwater management system. Revised drawings, and a revised Stormwater Report, are provided to the Town in conjunction with this letter response.

General Comments:

1. *Existing contour, drainage and utility information is difficult to read on proposed plans. Provide supplemental existing conditions plans at appropriate scale.*

   Response: We have included reprinted existing condition plans. Proposed conditions plans now more clearly show existing contour, drainage and utility information, and we note that we have added the proposed lease lot line, as well as highlighted existing trees.

Site Demolition, Earthwork, and Site Preparation Comments:

1. *Provide earthwork calculation to determine earth and rock removal and the number of truck trips necessary.*

Reference: Residences at South Brookline

Response: We have performed earthwork calculations for the project, and based on those calculations estimate that the project will include 48,000 cubic yards of cut and 17,580 cubic yards of fill, resulting in net export from the site of approximately 30,420 cubic yards. The majority of the rock excavation on site will be in the vicinity of Building 10, and is anticipated to be approximately 34,000 cubic yards. We anticipate that the rock excavation operation will have a 2 month duration, with the overall earthwork operation occurring over a 6-8 month period, with an average of 6-9 trucks exporting material from the site per day over that period.

2. *Provide a truck route plan and document current conditions of roads to be used and verify that these roadway pavement structures will be able to handle the high number of heavy trucks during the construction.*

Response: At this point in time no contractor has been selected to do the earthwork. As a result, it is not possible to speculate on a specific truck route or as to where any excess material will be brought from the site. A more detailed truck route plan can be reviewed with the Brookline DPW and Police Department before construction starts. It has been our experience that a construction management plan is not required at this stage of a comprehensive permit process. Truck traffic is not allowed on the VFW Parkway, all truck traffic will leave thru the roundabout at Putterham Circle.

We note that the intent during construction will be to utilize as much material from areas of cut in areas of fill, and to manage truck traffic on site to the extent possible, with a crossing at Independence Drive, to transport material from the cut areas on the east side of the site to the fill areas on the west side of the site.

3. *Provide phasing plans for earthwork and construction to provide and maintain access to existing parking lots and buildings.*

Response: Phasing plans will be developed by the site contractor when one is selected for the work. Those plans will be provided to the Town at that time.

4. *Provide blasting plan for building 13 including methods to protect buildings, residents, pedestrians and vehicles and coordinated with utility owners.*

Response: A blasting plan will be prepared by the site contractor. A blasting plan is required by state regulations prior to blasting. When a site contractor is engaged, and that plan is prepared, it will be provided to the Town. All blasting activities will comply with applicable legal requirements.

Reference: Residences at South Brookline

Site Plans and Details Comments:

1. *Existing exercise stations were observed within the development area. Indicate if and or where these will be relocated.*

   Response: The existing exercise stations will be removed and stockpiled. After construction they will be field located at appropriate locations.

2. *Provide the location and detail of trash and recycling storage areas and schedule for disposal.*

   Response: A detail for a trash enclosure has been included on detail sheet #L803. A location for this area has been indicated on sheet L301. Existing trash enclosures are shown on drawing #L203. The Owner will evaluate revised schedules for pick up of trash and recyclables with their vendors to accommodate the additional units.

Site Access, Parking & Loading Comments:

West Site driveway is a new dead end road off Independence Drive which provides access to 36 units (68 parking spaces), is 920± feet in length, 20 feet wide and incorporates a turn-around area near the end. East Site driveway is a new dead end road off Independence Drive which provides access to 12 units (27 parking spaces), is 350± feet in length, varies 24 to 20 feet wide and incorporates a turn-around through the parking area. Asheville Road currently provides access to an unknown number of existing units with 181 parking spaces. The proposed development proposes adding 144 units with another 234 parking spaces for a total of 415 off Asheville Road. The plan includes walkways throughout the new development areas.

1. *Provide additional ingress/egress for emergency access to Building 13 and residents to the south and west of Building 13 and/or provide documentation from the Fire and Police Departments confirming their acceptance of the design.*

   Response: We have met with the fire chief and while no formal documentation was provided by him, the new layout was not objected to by him as long as we made all of the internal driveways a minimum of 23' in width and added the cul-de-sac at the end of the west driveway. The Town's Planning Director was in attendance at the meeting.

2. *Re-grade Asheville Road from Building No. 10 to the access drive to the lower parking level in Building 13 to reduce 10+% profile grade and 10% cross slope.*

   Response: Revised plans are provided. The site driveway from garage entrance to Building 10 to the east is graded at 10%. This grade matches the existing, and is necessary to meet grades at the limits of the paving.

Reference: Residences at South Brookline

3. *Provide information on how parking will be accommodated and indicate the pedestrian route from buildings to parking areas – see especially Building 10.*

   Response: As shown on the revised drawings dated July 11, 2014, all buildings are connected via walkways to parking areas.

4. *Existing parking area between Buildings 13 and 11 is currently designated as visitor parking; will this be maintained as such or relocated?*

   Response: This will be maintained.

5. *Recommend walkways be provided from parking areas to rear doors at Buildings 7-10 and 12.*

   Response: Where appropriate, we have added walkways.

6. *Consider adding a walk from the handicap space in the lot between Buildings 3 and 4 that connects to the walk in front of Building 4.*

   Response: All accessible spaces have a clear and accessible path to the nearby buildings.

Stormwater Management System Comments:

The proposed stormwater management system is designed to mitigate impacts from an increase in impervious area through a combination of structural practices including porous pavement, hydrodynamic separators, and subsurface infiltration/storage areas. The proposed project includes constructing 4.7 acres of roof and pavement areas. Stormwater is proposed to be captured on-site and slowly discharged to existing closed drainage systems. Some stormwater will ultimately be discharged to the D. Blakely Hoar Sanctuary; however, the project is located outside the limits of regulated resource areas and the jurisdiction of the Brookline Conservation Commission.

NRCS mapped soils in the project area consist of Newport-Urban land complex rated in Hydrologic Soil Group (HSG) C and unrated soils consisting of Charlton-Hollis-Urban land complex and Udorthents, wet substratum. Supplemental boring information indicates the presence of sandy clay loam throughout the site and is consistent with an HSG rating of C, soils having a low infiltration rate. Exposed ledge is visible on portions of the site and was also noted on the boring logs. Monitoring wells indicate high ground water in some areas.

In order to help identify existing drainage problems within proximity of the proposed project the Town has sent a drainage survey to residents in the area. Results from the survey will be made available to the proponent and BETA following the initial public hearing and will not be discussed during said hearing.

Reference: Residences at South Brookline

1. *Provide signature and stamp of Registered Professional Engineer on Stormwater Checklist.*

   Response: Revised Stormwater Report includes signature and stamp of Registered Professional Engineer.

2. *Porous pavements are not optimal in locations of low-permeability soils, high bedrock, high ground water, and steep grades. The design incorporates a conservative approach by assuming no infiltration beneath the porous pavement and utilizes it primarily as a storage and filtration system. Document the following:*

   a. *Provide information on why a conventional pavement and stormwater management system cannot be utilized.*

      Response: In conjunction with changes to the site plans that have resulted from working sessions between the Applicant and the Town of Brookline, the approach to the stormwater management design has been revised so that conventional pavement and stormwater management systems are utilized for the majority of the project. Porous pavement is still proposed for one parking area behind #18-44 Thornton Road.

   b. *Previous porous pavement projects utilized and maintained by proponent or designed by Engineer - sites with similar design constraints preferred.*

      Response: The proponent has not utilized porous pavement at its existing properties. Stantec has designed porous pavement at several locations, including the following:
      - Temple Beth Elohim, Wellesley, MA
      - NewBridge on the Charles, Dedham, MA
      - Dolan Recreation Center, Dedham, MA

   c. *How pavement system will be protected during construction.*

      Response: Applicant will prepare phasing plans as the construction schedule is developed. Vehicle traffic over areas of proposed porous pavement will be limited until porous pavement is placed.

   d. *How abutters, Town stormwater systems and down-gradient wetland resources will be protected if the system were to fail.*

      Response: The revised site plans and stormwater management design includes one porous pavement parking area behind #18-44 Thornton Road. In the event that the porous asphalt in this area was to fail, conventional stormwater management BMPs are also provided for redundancy. In that event, stormwater will be collected in catch basins with deep sumps and hoods (CB3 and CB4), and will be routed through

a Water Quality Inlet (DMH-9, WQI-6) to remove pollutants. WQI-6 has been sized assuming that the porous pavement is draining to it for a conservative approach.

e. *Accommodations for repair or replacement of pavement in-kind upon end of useful life (15 to 20 years)*

Response: Repairs will be completed as part of any other maintenance operation at Hancock Village, including pavement repairs, overlays, etc.

f. *Provide specification for performance graded asphalt binder for porous pavement.*

Response: The design of the porous pavement will be based on specifications developed by the University of New Hampshire's Stormwater Center. A copy of those specifications is attached for reference.

g. *Indicate the minimum grade for porous asphalt where the steep slopes detail will be used.*

Response: Detail 3/L801 has been modified to clarify that it is intended to be used on all slopes.

h. *Ensure porous pavement asphalt details are consistent in regards to wording and symbols, where applicable.*

Response: The description of porous asphalt pavement is consistent on all drawings and details.

i. *Provide impermeable barrier at intersection of porous pavement and Independence Drive to prevent saturation of roadway subgrade.*

Response: Impermeable barrier (Miller #MBE40M) is detailed at the intersection of porous pavement and Asheville Road.

j. *Porous pavement is proposed as close as 20 feet of down gradient residences. Provide details for how migration of stormwater to said residences will be prevented.*

Response: The revised site and stormwater management design no longer includes porous pavement within 20' of any residences. The minimum setback between porous pavement and any residential structure is 30 feet. It is noted that this is in excess of DEP's Stormwater Management Handbook recommendations for a 10' setback to slab foundations and 20' setback to cellar foundations.

Reference: Residences at South Brookline

k. *How design will avoid frost heave and damage of pavements from standing water, particularly in areas of subsurface check dams on steep slopes.*

Response: The total depth of the porous asphalt pavement is 31". That depth will consist of crushed stone, which is not subject to frost heaving. The 31" depth to subgrade is sufficient to prevent heaving or limit any potential for heaving to the extent that no damage to pavement or curbing is expected.

3. *Provide flow arrows on all proposed drainage lines.*

Response: Flow lines have been added to drainage lines on the Drainage Plans (L505-L507).

4. *Revise low point catchbasins and catchbasins located at intersections to be double grate basins.*

Response: The revised plans have catch basins at low points in only two locations. At one of those locations, at CB-1, the flow to the catch basins is only 0.5 cfs during a 25-year storm, and we feel that a double catch basin is not warranted. The second location is at CB-6. At that location, the catch basins is a Stormceptor 450i water quality unit, and so a double catch basin is not needed . The flow to that structure during a 25-year storm event is estimated to be 2.3 cfs, a double catch basin is not warranted.

5. *Revise all structure to structure drainage connections to be a minimum of 12 inches (excluding detention systems) to minimize clogging potential.*

Response: Where warranted by hydraulic calculations, 12" pipe sizes have been provided.

6. *Grade all access driveways to direct stormwater towards catchbasins and curb lines.*

Response: Grading plans have been revised to direct flows towards catchbasins and curb lines.

7. *The function of drainage segment CB10 to DMH17 is unclear. Flow is captured at the down gradient portion of Asheville Road and directed through 300± feet of pipe (up to 9.5± feet deep) to a single dead end leaching basin. When the system fills, stormwater flow will be directed onto Russett Road. Provide design calculations for this system. Also, clarify if DMH17 is intended to function as a manhole or "leaching catch basin.".*

Response: This comment is not applicable at this point due to the revised stormwater management design.

8. *Proposed grading for build-out conditions will alter existing drainage paths near the property lines of abutting residences on Russett Road and Beverly Road. Provide additional area drains at locations that may trap water against abutting residences. Locations of*

concern include the area behind proposed Buildings 2 and 9 and the bottom of slope along Building 5/6 and 11/12 parking areas.

Response: Additional area drains have been added/provided as suggested. On the west side of Independence Drive, along Russett Road, four area drains are located to accept flow from abutting properties and offgrading from the proposed project. On the north side of Asheville Road, area drains AD9 and AD10 are provided to collect flow prior to discharge to abutting properties, and on the south side of Asheville Road, AD11 is provided also to accept collect flow prior to discharge to abutting properties.

9. *Proposed grading for subcatchment area PR-4B appears to direct flow towards down gradient properties. Revise grading and provide additional detail as necessary to direct stormwater to closed drainage system.*

Response: A label has been added to clarify the use of an existing paved swale adjacent to subcatchment PR-4B that will direct runoff into the proposed drainage system (CB7, WQI-10).

10. *Provide spot grade on Grading Plan for catchbasin CB5 to indicate catchbasin is at low point.*

Response: A spot grade has been added to all low points.

11. *Proposed cover over outlet pipe from CB4 is approximately 1.4 feet. Include provisions for protecting drainage pipe with shallow cover throughout project.*

Response: Ductile Iron Pipe will be provided for all catch basins with less than two feet (2') of cover.

12. *Provide details for foundation drains, area drains, and roof drain connections to porous pavement reservoirs.*

Response: This comment is no longer pertinent, as the design has changed and connections from foundation drains, area drains and roof drains to porous asphalt pavement are no longer part of the design.

13. *Provide dimensions, locations of access/inspections ports, and outlet invert information for infiltration basins P-4A and P4-D on drainage plans.*

Response: A detail sheet, Drawing No. L807, has been added that details dimensions, locations of inspection ports, and inlet/outlet pipe sizes and dimensions.

14. *Provide backup calculations for Times of Concentration (TOC). Overland flows across grassed surfaces in larger (>2 acres) subwatersheds may be greater than modeled 6 minutes.*

Response: As the inclusion of impervious surfaces reduces TOC, 6 minutes is a conservative minimum for proposed conditions. TOC has been calculated for existing conditions subcatchments with areas greater than two acres. Where less than 6 minutes was calculated for TOC, a minimum of 6 minutes was utilized. A minimum of 6 minutes was used for all proposed conditions subcatchments, a conservative assumption.

15. *Provide full size watershed plans with legible existing and proposed contour information and indicate TOC flow paths on watershed plans.*

Response: Full size watershed plans are provided at a scale of 1"=40'. Time of concentration flow paths are indicated for those existing conditions watersheds larger than two acres.

16. *Provide hydraulic analysis (rational method) for proposed drainage systems. Conduit tables indicating size, slope, velocity, capacity, and flow rate should be included. Also provide profile of systems with hydraulic grade lines. Note that DMH-18 indicates two 12-inch lines draining to a proposed 10-inch line.*

Response: A hydraulic analysis (Pipe Calculations) is included as Appendix M of the revised Stormwater Report. Also included in Appendix M are profiles with hydraulic grade lines for select portions of the drainage system. Profiles were drawn for those portions of the drainage system conveying significant amounts of the site's stormwater flows. We note that the pipe calculations were completed for a 25-year storm event, and that for a conservative analysis of hydraulic grade lines, the following conservative assumptions were made:

- 100-year storm flows from Subsurface Detention/Infiltration systems were utilized.
- Tailwater elevations at Subsurface Detention/Infiltration systems were assumed to be 100-year storm peak elevations.
- Tailwater elevations at existing drainage systems were assumed to be the crown of the existing pipe.

We further note that DMH-18 is longer shown as previously designed.

17. *Stormwater calculations include two feet of gravel storage beneath porous pavement. Porous pavement detail shows only one foot of storage. Revise stormwater calculations to reflect construction detail. Note that one foot of storage volume will be exceeded for 10 and 100 year storm events.*

Response: Porous Pavement detail has been revised to provide 2' of gravel storage beneath porous pavement.

18. *Grading plans indicate porous pavement will be installed on grade, whereas HydroCAD model assumes porous pavement storage areas are on a level surface. Actual storage areas will be much smaller than modeled due to flow towards low points. Revise model to*

reflect actual storage volumes or provide appropriate methods to keep stormwater distributed across system before outflow.

Response: The inclusion of check dams in the porous pavement profile is intended to slow the flow through the crushed stone beneath the pavement to promote infiltration. Water will be stored behind the check dams so that the storage that is included in the HydroCAD model is reasonably approximated.

19. *Although using a conservative approach for calculating recharge requirements is welcomed the proponent should clarify how the results of the subsurface investigation were used to determine a HSG rating of B.*

Response: The rationale for utilizing a HSG rating of B is discussed in Section 2.2 of the Stormwater Report.

20. *Provide boring log information for all borings indicated on Roadway and Parking Profiles (B and C series).*

Response: The geotechnical report prepared by Pare Corporation is included as an Appendix to the Stormwater Report. That report includes boring logs for the B and C series of borings.

21. *The project proposes significant removal of ledge within a dense residential area. Submit a report prepared by a geotechnical engineer or hydro geologist which outlines the potential impacts to groundwater as a result of the proposed project.*

Response: Stantec geotechnical engineers have reviewed the project plans, and note that bedrock removal and foundation construction with foundations drains will lower groundwater elevations in the vicinity of Building 10 (formerly Building 13). It is further noted that the local lowering of groundwater elevations should have no detrimental impact on surrounding buildings.

Comment [RC1]: Now building 10?

22. *Estimated seasonal high groundwater appears to be based upon monitoring well readings from a single day in January 2013. These readings do not account for seasonal fluctuation or preceding rainfall events (or lack thereof). Conduct test pits at storage/infiltration areas to determine high groundwater elevations via the presence of redox features. Identifying redox features is MassDEP's primary recommended method for determining seasonal high groundwater elevations. If redox features are not present, measured groundwater elevations must be adjusted using nearby groundwater wells monitored by the USGS.*

Response: To address concerns that monitoring well readings were based on a single day in January, 2013, additional readings were taken on April 29th, 2014. On average, it was found that groundwater elevations were approximately 10" higher in April, 2014 than they were in January, 2013. This difference in the readings did not require significant changes to the

design of drainage systems on the east side of Independence Drive, but on the west side of Independence Drive grades were raised to provide a minimum 2' separation from the measured groundwater elevations, considered to be representative of seasonal high groundwater elevation. That data is included in Section 2.2.1 of the revised Stormwater Report.

23. *Ledge is located in proximity to the bottoms of the proposed StormTank systems (as close as two feet). Provide assurance that the StormTank system will be able to drain down (empty) between rainfall events.*

Response: Drawdown calculations are provided within the Stormwater Report. The highest provided drawdown time is 35.82 hours at subsurface basin P-4A, lower than the maximum allowable drawdown time of 72 hours.

24. *High failure rates have been associated with the use of porous pavement and there is concern that pollutant loads discharging from the site may increase over time. Provide redundant treatment such as placing Stormceptors at down gradient portions of the new drainage system or at select locations of the existing drainage system. Redundant BMPs should provide an 80% TSS treatment for an impervious area equivalent to the proposed porous pavement.*

Response: A Stormceptor (DMH9 – WQI-6) has been added to the site) to provide treatment to porous pavement areas in case of failure. The Stormceptor was sized for the area draining to it from TD4 as well as from CB3 and CB4, under the assumption that the porous asphalt pavement were impervious.

25. *Revise location of Stormceptor from CB6 to DMH3 to provide redundant treatment of stormwater from porous parking area.*

Response: This comment is no longer valid due to the revised drainage design.

26. *No stormwater treatment is proposed for new westerly access drive to Building 13 or portion of reconstructed Asheville Road. Suggest replacing exiting catchment in down gradient parking area with a Stormceptor unit to provide treatment of new and reconstructed pavement areas.*

Response: This comment was discussed with BETA during our meeting held in April, and it was agreed that the drainage system in the downgradient parking area to the west of Building 10 (formerly Building 13) would not be altered. It was further agreed that treatment of stormwater from other existing paved areas to be reconstructed that are not currently treated, including the reconstructed portion of Asheville Road, would be treated. Within Asheville Road at the property line, TD5 has been added, which discharges to a Stormceptor (DMH13, WQI-7) In addition, we note that CB7(WQI-10) has been added to treat existing untreated pavement from a parking area between Buildings 8 and 10.

Reference: Residences at South Brookline

27. *Provide draft SWPPP to Town for review and comment prior to construction.*

Response: A SWPPP will be provided prior to construction, as required by EPA regulations.

Comment [RC2]: Per the requiremetns of ....

28. *Replace Catchbasin with Haybale Protection detail with silt sack detail on sheet L201.*

Response: Detail has been replaced as suggested.

29. *Detail locations of catchbasin protection.*

Response: Locations of catch basin protection are provided on the Erosion Control plan, drawings #L201 - L203.

30. *Add locations of temporary sediment basins.*

Response: Given the constrained nature of the project site, temporary sediment basins are not likely to be feasible in most locations. To prevent erosion from the project site, perimeter controls and drainage structure inlet protections will be utilized. One temporary sediment basin is located in the area of the proposed Bioretention Basin. Construction Drawings for the project will require filter fabric to be placed at the bottom of the temporary basin, to be removed prior to construction of the bioretention basin, to protect the subgrade from being clogged with sediment.

31. *Provide detail for stabilized construction entrance and indicate location on Erosion Control Plans.*

Response: A detail has been added as suggested to Drawing L201, and the locations of the stabilized construction entrances are shown on Drawings –L201-L-203.

32. *Indicate location of anticipated stockpile areas on Erosion Control Plans and provide erosion controls around perimeter of stockpiles.*

Response: Approximate locations of stockpiles are shown on Drawings L201 through L203. Final location of stockpile areas will be determined by the Contractor.

33. *Evaluate suitability of erosion controls in areas of concentrated flow (e.g. DP-1A).*

Response: The erosion controls proposed are typical and are anticipated to be appropriate for the proposed project. During construction, a SWPPP will be in place and the contractor will be responsible for monitoring the performance and effectiveness of all erosion controls, and to make adjustments as required.

Reference: Residences at South Brookline

34. *Provide an anticipated construction sequence. Crushed stone reservoir course and porous pavement will be susceptible to clogging from construction traffic.*

Response: An anticipated construction sequence will be developed once a contractor is engaged in the project. Upon request, the construction sequence can be provided to the Town for information. The construction sequence will include provisions to protect the crushed stone reservoir course and porous asphalt pavement during construction. Given the location of the one remaining porous asphalt pavement parking area between Asheville Road and Thornton Road, there is no other construction shown on the revised plans between those two streets and therefore it will be very easy to protect that area from construction vehicles.

35. *Indicate the name and contact information for the party responsible for operation and maintenance.*

Response: Chestnut Hill Realty will be responsible for the operation and maintenance of the project's stormwater management systems. Their contact information is provided in the Stormwater Report.

36. *Include provisions for the storage and handling of snow coordinated with proposed landscaping.*

Response: Anticipated snow storage areas are shown on drawings L301 through L303 Snow that cannot be managed in available snow storage areas will be removed from the property by CHR.

37. *Include a plan that is drawn to scale that shows the location of all stormwater BMPs and discharge points. Also, detail snow storage locations.*

Response: A plan indicating all Stormwater BMPs and discharge points is included as part of the Long Term Operation and Maintenance Plan. Snow storage locations are shown on Drawings L301 through L303.

38. *Provide an estimated operations and maintenance budget.*

Response: An estimated Operation and Maintenance budget is being developed, and will be provided under separate cover.

39. *Include provisions for how porous pavement areas will be distinguished from conventional pavement areas during winter maintenance operations and how winter maintenance crews will be trained in the proper care of porous pavement. Consider posting warning signs at entrances to porous pavement lots restricting the use of sand.*

Response: Warning signs will be posted at the entrance to the porous pavement parking

area warning that no sanding should occur in that parking area. CHR performs their own snow management, and will train their maintenance personnel on the proper methods for snow and ice removal in the porous pavement area.

40. *Several Town departments have noted sewer contamination in the stormwater system on Gerry Road. Provide a plan to investigate and eliminate contamination.*

Response: The Owner worked with the Town in 2009 to identify and address this concern. At that time, the Owner, in coordination with the Town, excavated test pits along their existing sewer force main in Gerry Road to investigate potential leaks in the force main. During those investigations, a section of force main was found to be leaking, and the leak was repaired by installing a new section of pipe. From the point of the leak to the Independence Drive, the force main was relined. All of this work was observed by the Town of Brookline. After that work was complete, the Owner understood that the problem was solved, and has not been aware of ongoing reports of water quality issues. The Owner is committed to working with the Town to identify any other potential sources of water quality concerns, and is willing to work with the Town to accomplish this. We have begun discussions with the Town Engineer, and we agreed that the first step should be additional sampling of the drainage system upstream of the Hancock Village property, and on the property, to collect more information about the location of the source of the problem.

Utility Services Comments:

The project proposes installation of water, sewer, electric, gas, telephone, and cable services to each building.

1. *Provide projected demand and documentation, including capacity analysis and flow test data, to indicate that there is sufficient existing and proposed infrastructure for public utility services for the project.*

Response: Capacity analysis of the existing sewer system is attached. The analysis indicates that sufficient capacity is available for the projects projected sewer flows. Flow tests have been requested from the Town of Brookline, and the results will be provided upon receipt.

2. *Recommend revising the site design to eliminate the pump station on west site drive, or provide pump station to service Building 4 only.*

Response: Revisions to the site plans have included adjusted grades on the west side of Independence Drive that have allowed for the sewer system to be by gravity, and eliminating the need for a pump station.

3. *Provide details of pump station including location of a control panel, emergency generator and maintenance procedures.*

Reference: Residences at South Brookline

Response: See previous response. Comment not applicable given revised plans.

4. *Provide locations, sizes and details of other proposed utility services including electric, cable and fire alarm, etc.*

Response: Locations of electric and cable services are shown on the Composite Utility Plans, L501 through L503. The locations are shown schematically, and do not include sizes. The design of the electric and cable services will be performed in coordination with private utility companies once the project proceeds to the Construction Documents phase, after permitting is complete. The design of the fire alarm system will be coordinated with the electric and cable utility designs.

5. *Recommend providing two additional fire hydrants; one adjacent to Building No. 5 and another at west end of Building 13.*

Response: There is an existing hydrant located 86' from Building #4, and a new hydrant is located 97' from Building #13.

6. *Any existing utility services to be disconnected must be done at the main or manhole.*

Response: Acknowledged.

Landscaping and Lighting Comments:

The project proposes to develop open space with buildings, access drives, walkways and parking areas. This will change the character of the neighborhood. The impact of this could be better mitigated by reducing the amount of clearing and/or providing a more robust landscape plan.

1. *Planting Notes – Notes 7 and 16 refer to quantities of plant material. Quantities are not shown on the Plant Schedule or on the plans.*

Response: Plant quantities have been added to the plans.

2. *Plant Schedule – Maples are potentially in danger from the Asian Longhorned Beetle. Consider using another genus. Quercus borealis may be difficult to find; consider specifying Quercus rubra as a worthy replacement.*

Response: Acknowledged

3. *Add additional screening of existing driveway behind Building 6.*

Response: Additional screening has been added between Building 5 (formerly Building 6) and the existing driveway.

Reference: Residences at South Brookline

4. *Show additional screening between parking lot to the north of Building 7 so that headlights from the cars do not shine on the abutting residences to north and east.*

   Response: The entire property line abutting the neighbors rear yards will be delineated with a 6' high solid fence.

5. *Add a couple of large evergreen trees to break up the line of smaller evergreens to the east of Building 7.*

   Response: The planting plan to the east of Building 6 (formerly Building 7) along the property line is planted with no gaps.

6. Add shrubs along the line of proposed evergreen trees that are behind the proposed garages (3-7).

   Response: The garages are no longer part of the site design. This area of the site has been redesigned to move the development further from the property line, saving existing trees and vegetation. Additional planting has been provided to supplement the existing.

7. *Consider adding some screening between the proposed parking lot to the north of Building 12 and the existing buildings to the east.*

   Response: The design has been modified and clarified in the area to save existing trees and to add additional trees.

8. *Consider adding plantings between the proposed parking that is in front of the proposed garages 3-7 and the existing building to the west.*

   Response: Garages have been removed in the revised plan. Note that the parking is several feet below the grade of the existing units. Additionally, the parking lot in this area is shorter in length than the previous version of the design, and the updated design calls for saving existing trees and adding additional planting

9. *Consider adding some screening between the proposed parking lot to the north of Building 12 and the existing buildings to the west and east.*

   Response: Acknowledged.

10. *The proposed landscaping seems incomplete around Building 13. It is difficult to know at this point what vegetation will remain after the rock removal is completed for this area. Screening is important between the existing buildings and this building.*

Reference: Residences at South Brookline

Response: Planting layout has been revised around Building 10 (formerly Building 13) to add significantly more planting.

11. *Detail 4 – Cast in Place Cheekwall – Consider showing posts for handrail in the cheekwall instead of the stair tread.*

Response: We disagree with this suggestion and will maintain our existing detail, for the reason that we may want to maintain flexibility with the top of cheekwall elevation.

12. *Add details showing planting of trees and shrubs on slopes.*

Response: Details have been added to drawing #L604.

13. *Add detail showing planting of trees in areas with ledge.*

Response: Details have been added to drawing #L604

14. *Provide information on seed / sod mix and show locations and limits on plans.*

Response: All disturbed areas will be seeded with a general lawn seed mix.

15. *Provide details and add to photometric plans all exterior wall mounted lights.*

Response: Wall mounted light fixtures have not been selected for this project. The photometric impact of these lights will be too low to accurately depict on the photometric plans at this scale.

16. *Recommend that lighting be provided for walkway on east side of Building 10.*

Response: Building 10 from the previous set of plans has been removed. In that general area, two buildings, Buildings 7 and 8 are shown on the revised plans. A parking area is shown on the east side of those buildings. Lighting will be provided in the parking area.

17. *Adjust lighting to eliminate spillage onto adjacent properties.*

Response: Lighting has been adjusted.

Reference: Residences at South Brookline

Environmental and Cultural Impacts Comments:

The lots are located within areas that are fully developed with residential units. Review of available on-line data and maps indicate that the project is not located within proximity to wetland resource areas, stormwater critical areas, FEMA mapped 100 year flood zones, or Natural Heritage and Endangered Species Program (NHESP) mapped habitat areas for rare or endangered species. Due to the snow cover during the site visits BETA was not able to verify if a low lying area located between proposed buildings 4 and 5 is a potential vernal pool. BETA's wetland scientist is scheduled to make observations and give their preliminary opinion later next week.

The project is located within the watershed of the Charles River which EPA lists as impaired for DDT, E. Coli, fish biossessments, nutrients, PCBs, Phoshorus with TMDLs for pathogens and total phosphorus. The proposed porous pavement filtration system is a low impact development (LID) technique / best management practice (BMP) when well maintained works well to address these pollutants.

The Town indicates that Lot No. 1 may be in an area of historical significance (see 1980 Massachusetts Historical Commission Reconnaissance Survey Town Report). MassGIS indicates that the Baker School located at 205 Beverly Road and office/single family dwelling located at 12 Beverly Road are registered historical sites in proximity to the project.

1. *Provide documentation from Massachusetts Historical Commission and Brookline Preservation Commission that the development will not adversely impact these or any other significant archaeological, historical or protected sites.*

   Response: After conclusion of the Comprehensive Permit process, the Applicant will confirm with the Mass Historical Commission to the extent that is required.

   The Brookline Preservation Commission has provided the Zoning Board of Appeals with their opinion on the project and has no jurisdiction over this comprehensive permit development.

Reference: Residences at South Brookline

Regards,

STANTEC PLANNING AND LANDSCAPE ARCHITECTURE PC

Frank Holmes, PE, LEED AP
Principal
Phone: (617) 654-6059
frank.holmes@stantec.com

Copies:
Marc Levin, Chestnut Hill Realty
Philip Paradis, Jr., PE, BETA Group, Inc.
Matthew J. Crowley, PE, BETA Group, Inc.

Attachments:
Porous Asphalt Pavement Model Specifications
Sewer Capacity Analysis

Sewer System Pipe Calculation

Project Name: Residences at South Brookline, Brookline MA
Project Number: 210810271
Calculated By: ZY
Checked By: FH
Date: 7/11/2014
Revised Date:

Up SMH	Down SMH	Sewer Flow GPD	Min. Average Design Flow* Q_{min} (CFS)	Max. Average Design Flow** Q_{max} (CFS)	Ex. Sewer Size (IN)	Ex. Sewer Slope (%)	n	Flow Capacity Q_f (CFS)	Q_{min} / Q_f (%)	Q_{max} / Q_f (%)	Vf (FT/S)	V_{min} (FT/S)	V_{max} (FT/S)	Check
SMH7	INDEPENDENCE DRIVE	5,500	0.0085	0.0427	15.00	0.37%	0.011	4.66	0.18%	0.92%	3.79	0.64	1.02	**OK**
BLDG 5	INDEPENDENCE DRIVE	880	0.0014	0.0068	15.00	0.37%	0.011	4.66	0.03%	0.15%	3.79	0.38	0.60	**OK**
BLDG 6	THORNTON ROAD	1,100	0.0017	0.0085	8.00	4.69%	0.011	3.09	0.06%	0.28%	8.86	1.05	1.68	**OK**
SMH11	ASHEVILLE ROAD	25,630	0.0398	0.1988	8.00	6.00%	0.011	3.50	1.14%	5.68%	10.02	2.86	4.57	**OK**
EX. SMH	SEWER NEAR VFW PARKWAY	2,200	0.0034	0.0171	10.00	0.99%	0.011	2.58	0.13%	0.66%	4.72	0.72	1.15	**OK**

UNIVERSITY OF NEW HAMPSHIRE
STORMWATER CENTER

UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds

February 2014

University of New Hampshire Stormwater Center (UNHSC)
Gregg Hall ● 35 Colovos Road ● Durham, New Hampshire 03824-3534 ● http://unh.edu/unhsc/

UNHSC DESIGN SPECIFICATIONS FOR POROUS ASPHALT PAVEMENT AND INFILTRATION BEDS

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University of New Hampshire Stormwater Center (UNHSC)
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UNHSC DESIGN SPECIFICATIONS FOR POROUS ASPHALT PAVEMENT AND INFILTRATION BEDS

NOTICE

The specifications listed herein were developed by the UNHSC for UNHSC related projects and represent the author's best professional judgment. No assurances are given for projects other than the intended application. These design specifications are not a substitute for licensed, qualified engineering oversight and should be reviewed, and adapted as necessary.

ACKNOWLEDGEMENTS

The original 2007 specifications were completed by collaboration between the University of New Hampshire, of Durham, New Hampshire, and Pike Industries Inc., of Belmont, New Hampshire. The principal UNH authors were Joshua F. Briggs, Robert M. Roseen, PE, PhD, and Thomas P. Ballestero, PE, PhD, PH, CGWP, PG. The principal author from Pike Industries was the Corporate Quality Control Manager, Jeff Pochily. Other contributions to the project were made by Grant Swenson, also of Pike Industries. Revised specifications (2009) were prepared by the UNHSC after a round table discussion with New Hampshire Asphalt Manufacturers (Rick Charbonneau Mark Charbonneau, and Keith Dane of Continental Paving, Jeff Lewis of Brox Industries, and Mary Wescott, Dave Duncan, and Jeff Pochily of Pike Industries) and a round table discussion with design engineers. The 2009 specifications were also reviewed and revised by Antonio P. Ballestero, Jr., PE.

These latest modifications (2014) were authored by Thomas P. Ballestero, James J. Houle, and Timothy A. Puls of the UNHSC. The latest modifications were based upon UNHSC experiences as well as personal interviews with Mary Wescott and Dave Duncan of Pike Industries and Rick Charbonneau and Mark Charbonneau of Continental Paving. In addition, we are grateful to Jill Thomas, Executive Director of the Minnesota Asphalt Pavement Association for edits and comments.

The UNH Stormwater Center is housed within the Environmental Research Group (ERG) at the University of New Hampshire (UNH) in Durham, New Hampshire. Formerly, funding for the program was provided by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) and the National Oceanic and Atmospheric Administration (NOAA).

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PART 1 GENERAL

1.1 DESCRIPTION

1.1.1 This specification is intended to be used for porous asphalt pavement in parking lot, sidewalk, and light duty road applications, although heavy duty applications are possible and have been documented. Stormwater management functions of porous asphalt installations include water quality treatment, peak flow reduction, storm volume reduction via groundwater recharge, and increased hydrograph time lag. This specification is intended for a cold climate application based upon the field experiences of porous asphalt systems designed, installed, and monitored by the UNHSC since 2005. The specification can be adapted to projects elsewhere provided that selection of materials and system design reflects local conditions, constraints, and objectives.

1.1.2 The work of this Section includes subgrade preparation, installation of the underlying porous media beds, and porous asphalt mix (mix) design, production, and installation. Porous media beds refer to the material layers underlying the porous asphalt pavement. Porous asphalt pavement refers to the compacted mix of modified asphalt, aggregate, and additives.

1.1.3 The porous asphalt pavement specified herein is modified after the National Asphalt Pavement Association (NAPA) specification outlined in *Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131* (2003) and *Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115* (2002).

1.1.4 Alternative specifications for mix, such as Open Graded Friction Courses (OGFC) from Federal Agencies or state Departments of Transportation (DOT), may be used if approved by the Engineer. The primary requirements for the specifications of the mix are performance grade (PG) asphalt binder, binder content, binder draindown, aggregate gradation, air void content, retained tensile strength (TSR).

1.2 SUBMITTALS

1.2.1 Submit a list of materials proposed for work under this Section including the name and address of the materials producers and the locations from which the materials are to be obtained.

1.2.2 Submit certificates, signed by the materials producers and the relevant subcontractors, stating that materials meet or exceed the specified requirements, for review and approval by the Engineer.

1.2.3 Submit samples of materials for review and approval by the Engineer. For mix materials, samples may be submitted only to the QA inspector with the Engineer's approval.

1.2.4 Submittal requirements for samples and certificates are summarized in

1.2.5 Table 1 and discussed in further detail in the Materials section.

Table 1: Submittal Requirements

Material or Pavement Course*	Properties to be reported on Certificate**
choker course, reservoir course	gradation, max. wash loss, min. durability index, max. abrasion loss, air voids (reservoir course)
filter course	gradation, permeability/ sat. hydraulic conductivity
filter blanket (graded filter)	gradation
geotextile filter fabric	manufacturer's certification, AOS/EOS, tensile strength
striping paint	certificate
binder	PGAB certification
coarse aggregate	gradation, wear, fracture faces (fractured and elongated)
fine aggregate	gradation
silicone	manufacturer's certification
Fibers (optional)	manufacturer's certification
mineral filler (optional)	manufacturer's certification
fatty amines (optional anti-strip)	manufacturer's certification
hydrated lime (optional anti-strip)	manufacturer's certification

* Samples of each material shall be submitted to the Engineer (or QA inspector for mix). These samples must be in sufficient volume to perform the standardized tests for each material.
** These are the minimum properties to be reported, additional material properties may be required (refer to Materials Section).

1.3 QUALITY CONTROL AND QUALITY ASSURANCE (QC/QA)

1.3.1 Use appropriate equipment and adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work in this section.

1.3.2 Codes and Standards - All materials, methods of construction, and workmanship shall conform to applicable requirements of AASHTO, ASTM Standards, NHDOT Standard Specifications for Road and Bridge Construction (or similar state DOT) specifications, latest revised (including supplements and updates), or other standards as specified.

1.3.3 QC/QA requirements for mix production are discussed in the Materials Section, and for construction of the porous media beds and paving, in the Execution Section.

1.4 PROJECT CONDITIONS

1.4.1 Site Assessment should be performed per the steps outlined in IS 131 (NAPA, 2003).

1.4.2 Construction Phasing should be performed as outlined in IS 131 (NAPA, 2003).

1.4.3 Protection of Existing Infrastructure

a. Protect adjacent work from the unintended dispersal/splashing of pavement materials. Remove all stains from exposed surfaces of pavement, structures, and grounds. Remove all waste and spillage. If necessary, limit access to adjacent work/structures with appropriate signage and/or barriers.

b. Protection of pavement work area from run-on during construction and post-construction periods minimize maintenance and prolong pavement lifespan.

c. Proper erosion and sediment control practices shall be provided in accordance with existing codes and regulations. Do not damage or disturb existing improvements or vegetation. Provide suitable protection where required before starting work and maintain protection throughout the course of the work. This includes the regular, appropriate inspection and maintenance of the erosion and sediment control measures.

d. Restore damaged areas, including existing pavement on or adjacent to the site that was damaged as a result of construction work, to their original condition or repair as directed to the satisfaction of the Engineer at no additional cost.

1.4.4 Safety and Traffic Control

a. Notify and cooperate with local authorities and other organizations having jurisdiction when construction work will interfere with existing roads and traffic.

b. Provide temporary barriers, signs, warning lights, flaggers, and other protections as required to assure the safety of persons and vehicles around and within the construction area and to organize the smooth flow of traffic.

1.4.5 Weather Limitations

a. In cold climates, porous asphalt, open graded friction course, or dense-mixed asphalt is generally not placed between November 15 and March 15. More specifically when the ambient air temperature at the pavement site in the shade away from artificial heat is below 16 °C (60 °F) or when the actual ground temperature is below 10 °C (50 °F) any placement of porous asphalt materials should proceed with extreme caution, and is generally not recommended. Only the Engineer may adjust this air temperature requirement, soil temperature requirement, or extend the dates of the pavement season.

b. The Contractor shall not pave on days when it is raining or when rain is forecast for the day, unless a change in the weather results in favorable conditions as determined by the Engineer.

1.5 REFERENCES

General Porous Asphalt Bituminous Paving and Groundwater Infiltration Beds, specification by UNH Stormwater Center, October, 2009.

Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131, National Asphalt Pavement Association (NAPA), November, 2008. http://www.asphaltpavement.org/

Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115, NAPA, May, 2002. http://www.asphaltpavement.org/

Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, PA, 2014 or latest edition. http://www.astm.org/Standard/

Standards of the American Association of State Highway and Transportation Officials (AASHTO), 2014 or latest edition. http://www.ihs.com/products/industry-standards/organizations/aashto/index.aspx

Section 401- Plant Mix Pavements – General, in Standard Specifications for Road and Bridge Construction – State of New Hampshire Department of Transportation, 2010. http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/specifications/documents/2010_Spec_Book.pdf

Section 02725 - General Porous Pavement and Groundwater Infiltration Beds, specification from NAPA Porous Asphalt Seminar handout, Cahill Associates, Inc., 2004.

Correlations of Permeability and Grain Size, Russell G. Shepherd, Groundwater 27 (5), 1989.

Groundwater, R. Allan Freeze and John A. Cherry, 1979.

PART 2 MATERIALS

2.1 Porous Media Infiltration Beds

2.1.1 Conceptual Design Below the porous asphalt itself are located various layers intended for structure, hydrologic control, and water quality improvement (Figure 1). From top to bottom: a 4" – 8 " (10 - 20 cm) minimum thickness layer of choker course of crushed stone; an 8" to 12" (20 cm to 30 cm) minimum thickness layer of filter course of poorly graded sand (a.k.a. bank run gravel or modified 304.1); 3" (8 cm) minimum thickness filter blanket (pea gravel) that is an intermediate setting bed between the filter course and the reservoir course below; and a reservoir course of crushed stone, thickness dependent on required storage, desired infiltration, and underlying native materials. Alternatively, the pea gravel layer could be thickened and used as the reservoir course depending upon subsoil suitability. This alternative simplifies subbase construction. The fine gradation of the filter course is for enhanced filtration (water quality improvement) and delaying infiltration (this layer throttles the downward movement of water). The high air void content of the uniformly graded crushed stone reservoir course maximizes storage of filtered water thereby allowing more time for water to infiltrate the native soil below between storms; and creates a capillary barrier that arrests any upwards vertical water movement and in doing so prevents winter freeze-thaw and heaving. The filter blanket is placed to prevent downward migration of filter course material into the reservoir course. An optional perforated or slotted drain pipe installed in the reservoir course is for hydraulic relief (typically raised off of the bottom of the reservoir stone layer for enhanced groundwater recharge, if no groundwater recharge is desired, pipe is at base of stone or even in a lower section (trench) of stone). Nonwoven geotextile filter fabric (geotextile) is used only for stabilizing the sloping sides of the porous asphalt system excavation and is not to be used on the bottom of the system unless needed for structural reasons. Filter fabrics are not recommended as a horizontal layer between any of the above mentioned layers.

For high permeability soils (saturated infiltration rate of > 2 inches per hour {5 cm/hr}) where infiltration to groundwater is acceptable, the reservoir course and filter blanket may be unnecessary. In cold regions, the filter blanket should be included to create a capillary barrier in lieu of more detailed study of frost heave susceptibility.

2.1.2 Material for the choker course and reservoir course shall meet the following:

a. Maximum Wash Loss of 0.5%

b. Minimum Durability Index of 35

c. Maximum Abrasion Loss of 10% for 100 revolutions, and maximum of 50% for 500 revolutions.

d. Material for the choker course and reservoir course shall have the AASHTO No. 57 and AASHTO No. 3 gradations, respectively, as specified in Table 2. If the AASHTO No. 3 gradation cannot be met, AASHTO No. 5 is acceptable with approval of the Engineer. AASHTO no. 3 is also suitable for the choker course.

Figure 1: Typical Cross-Section for Pervious Pavement System

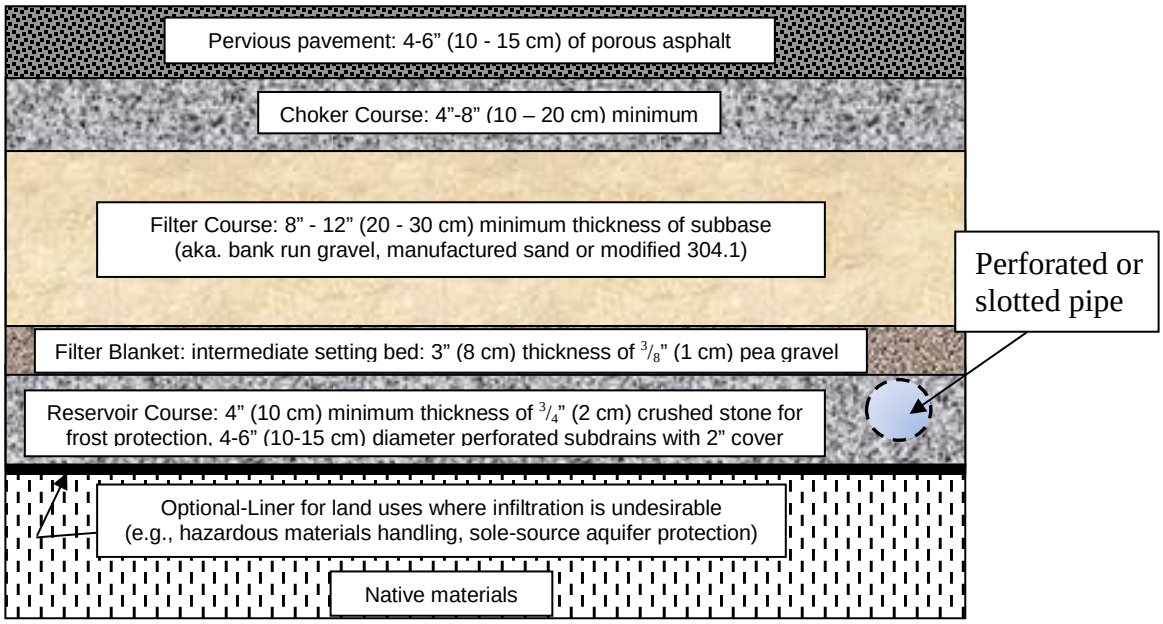

Table 2: Gradations of choker, filter, and reservoir course materials.

US Standard Sieve Size Inches/mm	Per Cent Passing (%)			
	Choker Course (AASHTO No. 57/ No. 67*)	Filter Course (Manufactured Sand/Modified NHDOT 304.1)	Reservoir Course (AASHTO No. 3)	Reservoir Course Alternative** (AASHTO No. 5)
6/150	-	100	-	
2½/63	-		100	-
2 /50	-		90 – 100	-
1½/37.5	100		35 – 70	100
1/25	95 - 100		0 – 15	90 – 100
¾/19	-		-	20 - 55
½/12.5	25 - 60		0 - 5	0 - 10
3/8/9.5	-		-	0 - 5
#4/4.75	0 - 10	25 - 70	-	
#8/2.36	0 - 5	0 – 6***	-	

* Alternate gradations (e.g. AASHTO No. 67) may be accepted upon Engineer's approval.
** Alternate gradations (e.g. AASHTO No. 5) may be accepted upon Engineer's approval.
*** Preferably less than 4% fines

2.1.3 Reservoir course thickness is dependent upon the following criteria (that vary from site to site). The reservoir course is located at the interface between native materials and the filter blanket.

a. A 4-in (10 cm) minimum thickness of reservoir course to act as a capillary barrier for frost heave protection.

b. 4-in. (10 cm) minimum thickness if the underlying native materials are well drained (Hydrologic Group A soils).

c. 8-in. (20 cm) minimum thickness if subdrains are installed. Subdrains insure that the subbase is well drained

d. Subdrains, if included, are elevated a minimum of 4" (10 cm) from the reservoir course bottom to provide storage and infiltration for the water quality volume. For lower permeability native soils, perforated or slotted drain pipe is located in the stone reservoir course for drainage. This drain pipe can be day lighted to receiving waters or wetlands or connected into other stormwater management infrastructure (catch basin, storm sewer, etc.). If the system is lined and infiltration is undesirable, subdrains are at the bottom of the reservoir course.

e. Subbase thickness is determined from subbase materials having sufficient void space to store the design storm.

> **Example:** If the design storm is 5.1" (13 cm) of rainfall depth, and the reservoir void space is 30%, then the minimum subbase thickness = 5.1"/0.3 = 17" (43.2 cm). This example reflects infiltration from solely the porous asphalt surface and no additional runon.

f. The total porous pavement system thickness (porous pavement layer down to the base of the stone reservoir course) thickness is $\geq$ 0.65 * local design depth of frost.

> **Example:** Durham, New Hampshire design depth of frost = 48" (122 cm) = $D_{maximum\ frost}$, therefore the *minimum* depth to the base of the stone reservoir course = 0.65(48") = 32" (81 cm).

2.1.4 Optional Bottom Liner is only recommended for aquifer protection or infiltration prevention. If a liner is employed, stone reservoir course and subdrains must be included above the liner. This liner is to be located at the interface between subbase and native materials and is dependent upon the following:

a. As with any infiltration system, care must be taken when siting porous asphalt systems close to locations where hazardous materials are handled/trafficked, or where high contaminant loading may threaten groundwater, or where infiltration is undesirable (nearby foundations, buried utilities, slope stability, etc.). In such cases, the porous asphalt system can be lined to prevent infiltration yet still improve stormwater quality, lag hydrograph peak, and dramatically reduce hydrograph peak flow.

b. Refer to state or USEPA guidelines regarding the use of infiltration systems (USEPA, 1999, CalTrans, 2003, WI DNR, 2004, USEPA, 2004).

c. Suitable liners may include Hydrologic Group D soils, HDPE liners, or equivalent. Refer to state or USEPA guidelines regarding selection of impermeable liners (USEPA, 2004). Liner permeability should be no greater than 0.4 in/day = 1 cm/day.

d. Filter fabrics or geotextile liners are not recommended for use as a separation layer (filter blanket) on the bottom of the porous asphalt system (at the base of the stone reservoir subbase) if designing for infiltration. Filter fabric usage in stormwater filtration has been known to clog prematurely. Graded stone filter blankets are recommended instead. Additionally, geotextile filter fabrics should not be used as any horizontal layer within the porous asphalt system.

e. Geogrids may be used if designing on poor structural or low hydraulic conductivity soils. Geogrid usage is limited to the bottom and possibly sides of the excavation.

2.1.5 Filter course material shall have a hydraulic conductivity (also referred to as coefficient of permeability) of 10 to 60 ft/day (0.0036 to 0.022 cm/sec) at 95% compaction unless otherwise approved by the Engineer. Great care needs to be used to not over-compact materials. Over-compaction results with loss of infiltration capacity. The filter coarse material is commonly referred to as a bankrun gravel (modified NHDOT 304.1). In order to select an appropriate gradation, coefficient of permeability may be estimated through an equation that relates gradation to permeability, such as described in *Correlations of Permeability and Grain Size* (Shepherd, 1989) or in *Section 8.7 Estimation of Saturated Hydraulic Conductivity* (Freeze and Cherry, 1979). Preferably, the coefficient of permeability (saturated hydraulic conductivity) for the selected filter course material shall be measured by ASTM D5084 and reported to the Engineer.

2.1.6 Filter blanket material between the filter course and the reservoir course shall be an intermediate size between the finer filter course above, and the coarser reservoir course below, for the purpose of preventing the migration of a fine setting bed into the coarser reservoir material. An acceptable gradation shall be calculated based on selected gradations of the filter course and reservoir course using criteria outlined in the *HEC 11* (Brown and Clyde, 1989). A pea-gravel with a median particle diameter of 3/8" (9.5 mm) is commonplace.

2.1.7 Non-woven geotextile filter fabric (only recommended for the sloping sides of the porous asphalt system excavation) shall be Mirafi 160N, or approved equivalent and shall conform to the specifications in Table 3. Mirafi ® 160N is a non-woven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. 160N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and

acids.

2.1.8 Alternative materials for the porous media beds filter blanket, and geotextile may be substituted at the discretion of the Engineer.

Table 3: Non-woven geotextile filter fabric properties.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Values	
			MD*	CD**
Grab Tensile Strength	ASTM D 4632	kN (lbs)	0.71 (160)	0.71 (160)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Shear Strength	ASTM D 4533	kN (lbs)	0.27 (60)	0.27 (60)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	2100 (305)	2100 (305)
Puncture Strength	ASTM D 4833	kN (lbs)	0.42 (95)	0.42 (95)
Apparent Opening Size (AOS)	ASTM D 4751	mm (US Sieve)	0.212 (70)	0.212 (70)
Permittivity	ASTM D 4491	sec^{-1}	1.4	1.4
Permeability	ASTM D 4491	cm/sec	0.22	0.22
Flow Rate	ASTM D 4491	lpm/m^2 (gpm/ft^2)	4,477 (110)	4,477 (110)
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	70

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	g/m^2 (oz/yd^2)	217 (6.4)
Thickness	ASTM D 5199	mm (mils)	1.9 (75)
Roll dimension (width x length)		m (ft)	4.5 x 91 (15 x 300)
Roll area		m^2 (yd^2)	410 (500)
Estimated roll weight		kg (lb)	99 (217)

*MD - Machine Direction; **CD - Cross-machine Direction

2.2 Porous Asphalt Mix

2.2.1 Mix materials consist of performance grade asphalt binder (PGAB), coarse and fine aggregates, and optional additives such as polymer modified asphalt (PMA), fibers, or other select additives. Materials shall meet the requirements of the NAPA's Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115 (2002) and Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131, except where noted otherwise below or approved in writing by the Engineer.

2.2.2 Polymer Modified PGAB The asphalt binder shall be a polymer and/or fiber modified performance grade asphalt binder (PGAB) used in the production of Superpave Hot Mix Asphalt (HMA) mixtures. Ideally for maximum durability, the PGAB shall be two grades stiffer than that required for dense mix asphalt (DMA) parking lot installations, which is often achieved by adding a polymer and/or fiber. In New Hampshire the standard DMA asphalt binder is PG 64 -28, meaning that the preferred asphalt binder for porous asphalt applications is PG 76 -22. The PGAB

polymer modifiers are to be either styrene butadiene rubber (SBR) or styrene butadiene styrene (SBS). SBS is generally reserved for large projects as pre-blending is required. SBR is feasible for smaller projects as it can be blended at the plant. The dosage of fiber additives shall be added at 1.5% by total mixture volume. Fibers are a simple addition either manually for a batch plant or automated for larger plants. The binder shall meet the requirements of AASHTO M320.

The PGAB may be pre-blended or post-blended. The pre-blended binder can be blended at the source or at a terminal. For post-blended addition, the modifier can either be in-line blended or injected into the pugmill at the Plant.

2.2.3 Mix Designs The following asphalt mix designs are recommended (listed in order of increasing strength):

a. PG 64-28 with 5 pounds of fibers per ton of asphalt mix. This mix is no longer considered suitable for PA wearing course applications in any development. It may be used as a base course where approved by the engineer for smaller projects with lower traffic counts or loading potential.

b. Post-Blended PG 64-28 SBR (to effectively obtain PG 76 -22*) at 1.5% by volume with 5 pounds of fibers per ton of asphalt mix. This mix is recommended for large projects > 1acre where high durability pavements are needed. The SBR will be supplied by an approved PGAB supplier holding a Quality Control Plan approved by the state DOT. A Bill of Lading (BOL) will be delivered with each transport of PG 64-28 SBR. A copy of the BOL will be furnished to the QA inspector at the Plant. A Post-Blended SBR Binder Quality Control Plan (Table 4) will be submitted to the Engineer for approval at least 10 working days prior to production.

**It is noted that with post-blended SBR mixes, performance grade is assumed as it is challenging to determine.*

c. Pre-Blended PG 76-28 modified with SBS (this mix has been used with great success since 2011 in New England). This mix is recommended for large sites anticipating high wheel load (H-20) and traffic counts for maximum durability. The SBS will be supplied by an approved PGAB supplier holding a Quality Control Plan approved by the state DOT. A Bill of Lading (BOL) will be delivered with each transport of PG 76-28 SBS. A copy of the BOL will be furnished to the QA inspector at the Plant.

2.2.4 Quality control plans may always be altered at the discretion of the Engineer and based on feasible testing as suggested by the asphalt producer. Certain QC testing requirements during production may not be feasible for small projects in which limited asphalt is generated. Some testing methods cannot be completed during the time needed during small batch (less than approximately 50 tons of porous asphalt mix) production. The feasibility should be assessed with the Engineer and producer.

Table 4: Post-Blended SBS/SBR Binder QC Plan requirements.

The QC Plan will Contain
1. Company name and address
2. Plant location and address
3. Type of facility
4. Contact information for the Quality Control Plan Administrator
5. QC test to be performed on each PGAB
6. Name(s) of QC testing lab to perform PC and process control testing
7. Actions to be taken for PGAB and Polymer Modifier in non-compliance
8. List of mechanical controls (requirements below)
9. List of process controls and documentation (requirements below)
List of Mechanical Controls
1. Liquid Polymer Modifier no-flow alert system with an "alert" located in the control room and automatic documentation of a no flow situation on the printout
2. Provide means of calibrating the liquid Polymer Modifier metering system to a delivery tolerance of 1%
3. A batching tolerance at the end of each day's production must be within 0.5%
4. Mag-flow meter (other metering system may be considered)
5. Method of sampling liquid Polymer Modifier
List of Process Controls and Documentation
1. Printouts of liquid Polymer Modifier and PGAB quantities must be synchronized within 1 minute of each other
2. Polymer Modifier supplier certification showing the percent of Polymer Modifier solids in liquid Polymer Modifier
3. Test results of a lab sample blended with the specified dosage of Polymer Modifier. At a minimum, provide the name of the PGAB and liquid Polymer Modifier suppliers and PGAB information such as grade and lot number and Polymer Modifier product name used for the sample
4. MSDS sheet for liquid Polymer Modifier
5. Handling, storage and usage requirements will be followed as required by the liquid Polymer Modifier manufacturer
6. At a minimum, provide a table showing proposed rate of Polymer Modifier liquid (L/min) in relation to HMA production rate (tons per hour) for the percent solids in liquid Polymer Modifier, quantity of Polymer Modifier specified for HMA production and the specific gravity of the Polymer Modifier
7. QCT or QC plan administrator must be responsible for documenting quantities and ensuring actual use is within tolerances. All printouts, calculations, supplier certifications, etc., must be filed and retained as part of the QCTs daily reports
8. Method and frequency of testing at the HMA plant including initial testing and specification testing

* This plan shall be submitted to the engineer 10 days before production

2.2.5 Anti-Stripping Mix Additives The mix shall be tested for moisture susceptibility and asphalt stripping from the aggregate by AASHTO T283, or improved updated method. If the retained tensile strength (TSR) < 80% upon testing, a heat stable additive shall be furnished to improve the anti-stripping properties of the asphalt binder. Test with one freeze-thaw cycle (rather than five recommended in *NAPA IS 115*). The amount and type of additive (e.g. fatty amines or hydrated lime) to be used shall be based on the manufacturer's recommendations, the mix design test results, and shall be approved by the Engineer.

Silicone shall be added to the binder at the rate of 1.5 mL/m^3 (1 oz. per 5000 gal).

Fibers may be added per manufacturer and *NAPA IS 115* recommendation if the draindown requirement cannot be met (<0.3% via ASTM D6390) provided that the air void content requirement is met (>18%, or >16% as tested with CoreLok device).

Additives should be added per the relevant DOT specification and *NAPA IS 115*.

2.2.6 Coarse Aggregate Coarse aggregate shall be that part of the aggregate retained on the No. 8 sieve; it shall consist of clean, tough, durable fragments of crushed stone, or crushed gravel of uniform quality throughout.

Coarse aggregate shall be crushed stone or crushed gravel and shall have a percentage of wear as determined by AASHTO T96 of not more than 40 percent. In the mixture, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces, and 90 percent shall have one or more fractured faces (ASTM D5821). Coarse aggregate shall be free from clay balls, organic matter, deleterious substances, and not more than 8.0% of flat or elongated pieces (>3:1) as specified in ASTM D4791.

2.2.7 Fine Aggregate The fine aggregate shall be that part of the aggregate mixture passing the No. 8 sieve and shall consist of sand, screenings, or combination thereof with uniform quality throughout. Fine aggregate shall consist of durable particles, free from injurious foreign matter. Screenings shall be of the same or similar materials as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested in accordance with AASHTO T90. Fine aggregate from the total mixture shall meet plasticity requirements.

2.2.8 Recycled Asphalt (RAP) Recycled asphalt can be used to supplement, or in place of, fine aggregate. RAP should be a ½" minus or properly managed product with known asphalt content in quantities not to exceed more than 10% by weight.

2.2.9 Porous Asphalt Mix Design Procedures The Contractor shall submit a mix design at least 10 working days prior to the beginning of production. The Contractor shall make available samples of coarse aggregate, fine aggregate, RAP, fibers and a sample of the PGAB that will be used in the design of the mixture. A certificate of analysis (COA) of the PGAB will be submitted with the mix design. The COA will be certified by a laboratory meeting the requirements of AASHTO R18. The Laboratory will be certified by the state DOT, regional equivalent (e.g. NETTCP), and/or qualified under ASTM D3666. Technicians will be certified by the regional certification agency (e.g. NETTCP) in the discipline of HMA Plant Technician.

The mixture will be designed according to the NAPA IS 131, with the exception of testing for air

void content. Bulk specific gravity (SG) used in air void content calculations shall not be determined and results will not be accepted using AASHTO T166 (saturated surface dry), since it is not intended for open graded specimens (>10% AV). Bulk SG shall be calculated using AASHTO T275 (paraffin wax) or ASTM D6752 (automatic vacuum sealing, e.g. CoreLok). Air void content shall be calculated from the bulk SG and maximum theoretical SG (AASHTO T209) using ASTM D3203.

The materials shall be combined and graded to meet the composition limits by mass (weight) as shown in Table 5.

2.2.10 Porous Asphalt Mix Production

a. Mixing Plants. Mixing plants shall meet the requirements of hot mix asphalt plants as specified in the state DOT or regional equivalent unless otherwise approved by the Engineer (e.g. *Section 401- Plant Mix Pavements – General for Quality Assurance specifications* in the *Standard Specifications for Road and Bridge Construction* – State of New Hampshire DOT, 2010, or latest revised edition and including supplemental specifications and updates).

Table 5: Porous Asphalt Mix Design Criteria

Sieve Size (inch/mm)	Percent Passing (%)
0.75/19	100
0.50/12.5	85-100
0.375/9.5	55-75
No.4/4.75	10-25
No.8/2.36	5-12
No.200/0.075 (#200)	2-4
Binder Content (AASHTO T164)	5.8 - 6.5%
Air Void Content (ASTM D6752)	16.0-22.0%
Draindown (ASTM D6390)*	$\leq$ 0.3 %
Retained Tensile Strength (AASHTO 283)**	$\geq$ 80 %
Cantabro abrasion test on unaged samples	$\leq$ 20%
Cantabro abrasion test on 7 day aged samples	$\leq$ 30%

* Either method is acceptable

**Cellulose, mineral, or polyester fibers may be used to reduce draindown.

***If the TSR (retained tensile strength) values fall below 80% when tested per NAPA IS 131 (with a single freeze thaw cycle rather than 5), then in Step 4, the contractor shall employ an antistrip additive, such as hydrated lime (ASTM C977) or a fatty amine, to raise the TSR value above 80%.

b. Preparation of Asphalt Binder. The asphalt material shall be heated to the temperature specified in the state DOT specification (if using a DOT spec for the mix) in a manner that will avoid local overheating. A continuous supply of asphalt material shall be furnished to the mixer at a uniform temperature.

c. Preparation of Aggregates. The aggregate for the mixture shall be dried and heated at the mixing plant before being placed in the mixer. Flames used for drying and heating shall be properly adjusted to avoid damaging the aggregate and depositing soot or unburned fuel on the aggregate.

Mineral filler, if required to meet the grading requirements, shall be added in a manner approved by the Engineer after the aggregates have passed through the dryer.

The above preparation of aggregates does not apply for drum-mix plants.

d. Mixing. The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregate required to meet the job-mix formula and thoroughly mixed prior to adding the asphalt material.

The dried aggregates shall be combined with the asphalt material in such a manner as to produce a mixture that when discharged from the pugmill is at a target temperature in the range that corresponds to a recommended range supplied by the PGAB supplier.

The asphalt material shall be measured or gauged and introduced into the mixer in the quantity determined by the Engineer for the particular material being used and at the temperature specified in the relevant specification.

After the required quantity of aggregate and asphalt material has been introduced into the mixer, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt material throughout the aggregate is secured and there is no residual moisture in the coated aggregate.

All plants shall have a positive means of eliminating oversized and foreign material from being incorporated into the mixer.

e. QC During Production. The Contractor shall provide process control and/or QC test results to the Engineer or the Engineer's designee. The QC plan may be altered at the discretion of the Engineer and based on feasible testing as suggested by the asphalt producer. Certain QC testing requirements during production may not be feasible for small projects in which limited asphalt is generated. Some testing methods cannot be completed during the time needed during small batch production. The feasibility should be assessed with the Engineer and producer.

The mixing plant shall employ a Quality Control Technician (QCT). The QCT will perform QC testing and will be certified in the discipline of HMA Plant Technician by the relevant certifying agency (e.g. NETTCP in New England). The Contractor shall sample, test and evaluate the mix in accordance with the methods and minimum frequencies in Table 6 and the Post-Blended SBR Binder Quality Control Plan (if applicable).

Table 6: QC/QA testing requirements during production.

Test	Min. Frequency	Test Method
Temperature in truck at plant	6 times per day	
Gradation	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	AASHTO T30
Binder Content	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	AASHTO T164
Air Void Content	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	ASTM D6752
Binder Draindown	Greater of either (a) 1 per 500 tons, (b) 1 per day, or (c) 1 per job	ASTM D6390

If an analyzed sample is outside the testing tolerances immediate corrective action will be taken by the contractor. After the corrective action has been taken the resulting mix will be sampled and tested. If the re-sampled mix test values are outside the tolerances the Engineer will be immediately informed. The Engineer may determine that it is in the best interest of the project that production is ceased. The Contractor will be responsible for all mix produced for the project.

f. Testing Tolerances During Production. Testing of the QC requirements shall be within the limits set in Table 6. The paving mixture produced should not vary from the design criteria for aggregate gradation and binder content by more than the tolerances in Table 7.

Table 7: QC/QA testing tolerances during production.

Sieve Size (inch/mm)	Percent Passing
0.75/19	-
0.5/12.5	± 6.0
0.375/9.5	± 6.0
0.187/4.75	± 5.0
0.093/2.36	± 4.0
0.0029/0.075	± 2.0
% PGAB	± 0.3

g. Plant Shutdown and Rejection of Mix. Should the porous asphalt mix not meet the tolerances specified in this section upon repeat testing, the Engineer may reject further loads of mix. Mix that is loaded into trucks during the time that the plant is changing operations to comply with a failed test shall not be accepted, and should be recycled at the plant.

2.2.11 Striping Paint shall be latex, water-base emulsion, ready-mixed, and complying with pavement marking specifications PS TT-P-1952.

PART 3 EXECUTION & INSTALLATION

3.1 Grade Control

3.1.1 Establish and maintain required lines and elevations. The Engineer shall be notified for review and approval of final stake lines for the work before construction work is to begin. Finished surfaces shall be true to grade and even, free of roller marks, and free of puddle-forming low spots. All areas must drain freely. Excavation elevations should be within +/- 0.1 ft (+/- 3 cm).

3.1.2 If, in the opinion of the Engineer, based upon reports of the testing service and inspection, the quality of the work is below the standards which have been specified, additional work and testing will be required until satisfactory results are obtained.

3.1.3 General criteria for watershed area to treatment area ratios for permeable pavements are defined by the state. Hybrid designs (dense-mix drive-lanes with permeable pavement parking stalls) have been used to address diminished strength of permeable asphalt materials in high traffic volume/load locations. A 1:1 watershed area to permeable pavement area is preferred (implying no runon). Improvements to materials and designs have addressed many of the strength deficiencies associated with older designs and materials specifications.

3.2 Notification

The Engineer shall be notified at least 24 hours prior to all porous media bed and porous pavement work.

3.3 Subgrade preparation

3.3.1 The existing native subgrade material under all bed areas shall NOT be compacted or subject to excessive construction equipment traffic prior to stone bed placement. Compaction is acceptable if an impermeable liner is used at the base of the porous asphalt system and infiltration is not desired.

3.3.2 Where erosion of the native material subgrade has caused accumulation of fine materials and/or surface ponding at the base of the excavation, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6 inches (15 cm) with a York rake or equivalent and light tractor.

3.3.3 Bring subgrade of stone porous media bed to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction before the placing of the stone. For parking lots all bed bottoms are level grade to promote uniform infiltration. For road applications, typically the slope of the bottom of excavation parallels that of the road surface.

Interior berms in the stone layer are then necessary to prevent infiltrated water from flowing in the reservoir stone parallel to the road. Interior berms should be almost as tall as the reservoir course thickness and made of relatively impermeable material (this may be accomplished with geofabric or geotextile). On the upstream side of the berm, water may infiltrate. If soil infiltration capacity is low, then a drainage pipe should be located on the upstream side of the berm to remove water from the reservoir course and drain (daylight) to natural receiving waters, wetlands, or plumbed into existing stormwater drainage infrastructure (swales, catch basins, storm sewers).

3.4 Porous Media Bed Installation

3.4.1 Upon completion of subgrade work, the Engineer shall be notified and shall inspect at his/her discretion before proceeding with the porous media bed installation.

3.4.2 Side slope geotextile (when used) and porous media bed aggregate shall be placed immediately after approval of subgrade preparation. Any accumulation of debris or sediment which has taken place after approval of subgrade shall be removed prior to installation of geotextile or porous media at no extra cost to the Owner.

3.4.3 Place side slope geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile shall overlap a minimum of sixteen inches (16" or 41 cm). Secure geotextile at least four feet (1.2 m) outside of the bed excavation and take any steps necessary to prevent any runoff or sediment from entering the storage bed.

3.4.4 Install coarse aggregate in lifts no greater than 8-inches (20 cm). Lightly compact each lift with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregate to grades indicated on the drawings.

3.4.5 Install choker base course (see Materials section) aggregate evenly over surface of filter course bed, sufficient to allow placement of pavement, and notify Engineer for approval. Choker base course thickness shall be sufficient to allow for even placement of the porous asphalt but no less than 4-inches (10 cm) in depth.

3.4.6 The infiltration rate of the compacted filter course shall be determined by ASTM D3385 or an approved alternate at the discretion of the supervising engineer. The infiltration rate shall be no less 5-30 ft/day or 50% of the hydraulic conductivity (D2434) at 95% standard proctor compaction (refer to section 2.1.5).

3.4.7 Following placement of bed aggregate, the sideslope geotextile shall be folded back along all bed edges to protect from sediment washout along bed edges. At least a four-foot (1.2 m) edge strip shall be used to protect beds from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to beds are stabilized and vegetated. In addition, take any other necessary steps to prevent sediment from washing into beds during site construction. When the site is fully stabilized, temporary sediment control devices shall be removed.

3.5 QC/QA requirements for Porous Media Bed Construction

QC/QA activities are summarized in Table 8.

Table 8: QC/QA requirements for porous media bed construction.

Activity	Schedule
Contractor to notify engineer for approval	24 hours in advance of start of work
Contractor to employ soil inspector acceptable to engineer	NA
Contractor to employ staking and layout control inspector acceptable to engineer	NA
Contractor to employ site grading inspector acceptable to engineer	NA
Contractor to employ pavement work inspector acceptable to the engineer	NA
Contractor to notify engineer for approval	after subgrade preparation, before construction of porous media bed
Contractor to notify engineer for approval	after filter course placement, before placement of choker course and pavement to verify proper compaction of filter course by ASTM D3385

3.6 Resurfacing

In cases where a porous asphalt system was constructed and the asphalt needs to be replaced, it is recommended to mill the older asphalt and to resurface on the choker course rather than to use a tackifier and pave over the older asphalt. While there is little documented experience with partial milling and resurfacing it has been done with success for porous asphalt pavements. Attention to cleaning milled surface is critical.

3.6.1 Mill older asphalt down to specified depth or to choker course

3.6.2 Restore the infiltration capacity with low angle pressure washing or air to a vacuum (for example the 15” vacuum attachment hose of a Tymco regenerative air vac)

3.6.3 Level and compact choker course

3.7 Porous Asphalt Pavement Installation

3.7.1 The mixing plant, hauling and placing equipment, and construction methods shall be in conformance with NAPA IS 131 and applicable sections of the state DOT’s specification for asphalt mixes.

3.7.2 The use of surge bins shall not be permitted.

3.7.3 Hauling Equipment The open graded mix shall be transported in clean vehicles with tight, smooth dump beds that have been sprayed with a non-petroleum release agent or soap solution to prevent the mixture from adhering to the dump bodies. Mineral filler, fine aggregate, slag dust, etc. shall not be used to dust truck beds. The open graded mix shall be covered during transportation with a

suitable material of such size sufficient to protect the mix from the weather and also minimize mix cooling and the prevention of lumps. When necessary, to ensure the delivery of material at the specified temperature, truck bodies shall be insulated, and covers shall be securely fastened. Long hauls, particularly those in excess of 25 miles (40 km), may result in separation of the mix and its rejection.

3.7.4 Placing Equipment The paver shall be a self-propelled unit with an activated screed or strike-off assembly, capable of being heated if necessary and capable of spreading and finishing the mixture without segregation for the widths and thicknesses required. In general, track pavers have proved superior for Porous Asphalt placement. The screed shall be adjustable to provide the desired cross-sectional shape. The finished surface shall be of uniform texture and evenness and shall not show any indication of tearing, shoving, or pulling of the mixture. The machine shall, at all times, be in good mechanical condition and shall be operated by competent personnel.

Pavers shall be equipped with the necessary attachments, designed to operate electronically, for controlling the grade of the finished surface.

The adjustments and attachments of the paver will be checked and approved by the Engineer before placement of asphalt material.

3.7.5 Rollers shall be in good mechanical condition, operated by competent personnel, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the asphalt mixture. The mass (weight) of the rollers shall be sufficient to compact the mixture to the required density without crushing of the aggregate. Rollers shall be equipped with tanks and sprinkling bars for wetting the rolls.

Rollers shall be two-axle tandem rollers with a gross mass (weight) of not less than 7 metric tons (8 tons) and not more than 10 metric tons (12 tons) and shall be capable of providing a minimum compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. All rolls shall be at least 1.1 m (42 inches) in diameter.

A rubber tired roller is not required on the open graded asphalt friction course surface.

3.7.6 Conditioning of Existing Surface Contact surfaces such as curbing, gutters, and manholes shall be painted with a thin, uniform coat of Type RS-1, or equivalent emulsified asphalt immediately before the asphalt mixture is placed against them.

3.7.7 Temperature Requirements The temperature of the asphalt mixture, at the time of discharge from the haul vehicle and at the paver, shall be between 135-163°C (275 to 325°F), within 6 °C (10 °F) of the compaction temperature for the approved mix design.

3.7.8 Spreading and Finishing The Porous Asphalt should be placed in two lifts at 1.5 to 2 inches (4 - 6 cm). One lift is not recommended because uniform compaction is difficult to achieve. Great care must be taken to insure that the porous asphalt layers join completely. This means: keeping the time between layer placements minimal; keeping the first layer clear from dust and moisture, and minimizing traffic on the first layer. However care should be taken to allow sufficient time for the asphalt placement to set, generally the following day or when the surface temperature of the first lift cools to 38°C (100 °F). Two lifts affords better compaction of the entire lift, especially in colder weather and for large sites. It also provides access to the site for finish work such as

curbing. Care must be taken to not damage or impair permeability of the base course if a multiple lift scenario is chosen. If significant site work will take place between placement of base and wearing courses higher durability mixes should be used for both layers.

The Contractor shall protect all exposed surfaces that are not to be treated from damage during all phases of the pavement operation.

The asphalt mixture shall be spread and finished with the specified equipment. The mixture shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, has the required thickness and conforms to the grade and elevation specified. Pavers shall be used to distribute the mixture over the entire width or over such partial width as practical. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture shall be spread and raked by hand tools.

No material shall be produced so late in the day as to prohibit the completion of spreading and compaction of the mixture during daylight hours, unless night paving has been approved and established for the project.

No traffic will be permitted on material placed until the material has been thoroughly compacted and has been permitted to cool to below 38 °C (100 °F). The use of water to cool the pavement is not permitted. The Engineer reserves the right to require that all work adjacent to the pavement, such as guardrail, cleanup, and turf establishment, is completed prior to placing the wearing course when this work could cause damage to the pavement. On projects where traffic is to be maintained, the Contractor shall schedule daily pavement operations so that at the end of each working day all travel lanes of the roadway on which work is being performed are paved to the same limits.

3.7.9 Compaction Immediately after the asphalt mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. The compaction objective is 16% - 19% in place void content (Corelock).

Breakdown rolling shall occur when the mix temperature is between 135-163°C (275 to 325°F). This is typically achieved with 1-2 passes with a 7.5 – 10 ton vibratory roller.

Finish rolling shall occur when the mix temperature is between 66-93°C (150 to 200°F). This is typically achieved with a 1-ton roller with no vibratory compaction. Finish rolling is largely aesthetic and done for a smooth finished surface. Care should be taken so as to not continually roll the same location for instance back and forth to a water source.

The cessation temperature occurs at approximately 79°C (175°F), at which point the mix becomes resistant to compaction. If compaction has not been performed at temperatures greater than the cessation temperature, the pavement will not achieve adequate durability. The temperatures referenced here are guidelines and have been used in the field to oversee successful porous asphalt installations.

The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking, or shoving.

Rollers or oscillating vibratory rollers, ranging from 7.5 – 10 tons, shall be used for breakdown

compaction. The number, mass (weight), and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Generally, one breakdown roller will be needed for each paver used in the spreading operation.

To prevent adhesion of the mixture to the rollers, rollers shall be kept moist with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot or lightly oiled hand tampers, smoothing irons or with mechanical tampers. On depressed areas, either a trench roller or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Other combinations of rollers and/or methods of compacting may be used if approved in writing by the Engineer, provided the compaction requirements are met.

The speed of the roller shall be slow and uniform to avoid displacement of the mixture, and the roller should be kept in as continuous operation as practical. Finish rolling shall continue below the threshold temperature until all roller marks and ridges have been eliminated.

Rollers will not be stopped or parked on the freshly placed porous asphalt.

It shall be the responsibility of the Contractor to conduct whatever process control the Contractor deems necessary. Acceptance testing will be conducted by the Engineer using cores provided by the Contractor.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture. The mixture shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of binder shall be removed and replaced. These replacements shall be at the Contractor's expense.

If the Engineer determines that unsatisfactory compaction or surface distortion is being obtained or damage to highway components and/or adjacent property is occurring using vibratory compaction equipment, the Contractor shall immediately cease using this equipment and proceed with the work in accordance with the sixth paragraph of this subsection.

3.7.10 Joints between old and new pavements or between successive day's work shall be made to ensure a thorough and continuous bond between the old and new mixtures. Whenever the spreading process is interrupted long enough for the mixture to attain its initial stability, the paver shall be removed from the mat and a joint constructed.

Butt joints shall be formed by cutting the pavement in a vertical plane at right angles to the centerline, at locations approved by the Engineer. The Engineer will determine locations by using a straightedge at least 3 m (10 feet) long. The butt joint shall be thoroughly coated with Type RS-1 or equivalent emulsified asphalt just prior to depositing the pavement mixture when pavement resumes.

Longitudinal joints that have become cold shall be coated with Type RS-1 or equivalent emulsified asphalt before the adjacent mat is placed. If directed by the Engineer, joints shall be cut

back to a clean vertical edge prior to applying the emulsion.

3.7.11 Surface Tolerances The surface will be tested by the Engineer using a straightedge at least 3 m (10 feet) in length at selected locations parallel with the centerline. Any variations exceeding 9.5 mm (3/8 inch) between any two contact points shall be satisfactorily eliminated. A straightedge at least 3 m (10 feet) in length may be used on a vertical curve. The straightedges shall be provided by the Contractor.

3.7.12 Work shall be done expertly throughout, without staining or injury to other work. Transition to adjacent impervious asphalt pavement shall be merged neatly with flush, clean line. Finished pavement shall be even, without pockets, and graded to elevations shown on drawing.

3.7.13 Repair of Damaged Pavement Any existing pavement on or adjacent to the site that has been damaged as a result of construction work shall be repaired to the satisfaction of the Engineer without additional cost to the Owner.

3.7.14 Striping Paint

a. Vacuum and clean surface to eliminate loose material and dust

b. Paint 4-inch wide (10 cm) parking striping and traffic lane striping in accordance with plan layouts. Apply paint with mechanical equipment to produce uniform straight edges. Apply in two coats at manufacturer's recommended rates. Provide clear, sharp lines using white traffic paint. Paint should conform with Federal Specification TT-P-85.

c. Color for Handicapped Markings: Blue

3.8 QC/QA for Paving Operations (optional as part of an installation contract)

3.8.1 The full permeability of the pavement surface shall be tested by application of clean water at the rate of at least 5 gpm (23 lpm) over the surface, using a hose or other distribution devise. Water used for the test shall be clean, free of suspended solids and deleterious liquids and will be provided at no extra cost to the Owner. All applied water shall infiltrate directly without large puddle formation or surface runoff, and shall be observed by the Engineer.

3.8.2 Testing and Inspection Employ at Contractor's expense an inspection firm acceptable to the Engineer to perform soil inspection services, staking and layout control, and testing and inspection of site grading and pavement work. Inspection and list of tests shall be reviewed and approved in writing by the Engineer prior to starting construction. All test reports must be signed by a licensed Engineer.

3.8.3 Test in-place base and surface course for compliance with requirements for thickness and surface smoothness. Repair or remove and replace unacceptable work as directed by the Engineer.

3.8.4 Surface Smoothness Test finished surface for smoothness using a 3 m (10 foot) straightedge applied parallel with and at right angles to the centerline of the paved area. Surface will not be accepted if gaps or ridges exceed 9.5mm (3/8 inch).

3.8.5 Porous pavement beds shall not be used for equipment or materials storage during construction, and under no circumstances shall vehicles be allowed to deposit soil on paved porous surfaces.

3.8.6 QC/QA requirements during paving are summarized in Table 9.

Table 9: QC/QA requirements during paving.

Activity	Schedule/Frequency	Tolerance
Inspect truck beds for pooling (draindown)	every truck	NA
Take temp of asphalt in truck	every truck	> 135°C (275°F)
Take temp of PA mix in the paver	each pull	within 6°C (10°F) of the recommended compaction temp
Consult with engineer to determine locations of butt joints	As needed	NA
Test surface smoothness and positive drainage with a 10' straightedge	after compaction	9.5 mm (3/8")
Consult with engineer to mark core locations	after compaction	NA
House test with at least 5 gpm water	after compaction	immediate infiltration, no puddling

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Note on Multiple Stress Creep Recovery Grading

Multiple Stress Creep Recovery (MSCR) Implementation

North East Asphalt User Producer Group (NEAUPG) States have agreed to launch MSCR grading for modified binders for the 2013 season. This only affects polymer modified products for now. NHDOT will be accepting either grade designation from suppliers this year.

MSCR grading measures binder properties at the local environment temperature. Stiffness properties above those of the standard grade are determined by applying traffic parameters, as follows.

S Standard
H Heavy
V Very Heavy
E Extremely Heavy

Environmental Grade	Old Modified Grade	New Modified Grade
NH 58^{o}	PG 76-28	PG 64V-28, or PG 64E-28
Maine 58^{o}	PG 70-28	
Mass 64^{o}	PG 64-28 (w/latex or tire rubber)	
RI 64^{o}	PG 76-28	

Binder suppliers can currently supply NH with PG 76-28 with > 3% SBS

PG 64E-28 can be produced with about 2.2% SBS

The PG 64E-28 being shipped to RI meets the MSCR testing and has 60% elastic recovery at 10^{o} C. ER test is normally run at 20^{o} C.