Tighe&Bond
Engineers | Environmental Specialists

L-0700-013
November 6, 2018

Mr. Dexter Legg, Chairman
Planning Board
City of Portsmouth Planning Department
1 Junkins Avenue
Portsmouth, New Hampshire 03801

Re: **Lonza Biologics – Proposed Industrial Development**
PDA Subdivision, Site Review & Conditional Use Permit Applications

Dear Chairman Legg:

On behalf of Lonza Biologics, we are pleased to submit the following information to the Planning Board to support a Pease Development Authority (PDA) Site Review Application for a proposed industrial development located at 70 and 80 Corporate Drive on Pease International Tradeport:

- Two (2) full size and ten (10) half size copies of the Site Plan Set last revised November 6, 2018
- Twelve (12) copies of the PDA Conditional Use Permit Application dated May 25, 2018;
- Twelve (12) copies of the PDA Site Review Application dated May 15, 2018;
- Twelve (12) copies of the PDA Subdivision Application dated May 15, 2018;
- Twelve (12) copies of the Subdivision Waiver Request letter dated May 21, 2018;
- Twelve (12) copies of Buildings Renderings prepared by Lonza dated August 20, 2018;
- Twelve (12) copies of the Aerial Site Plan Overlay last revised November 5, 2018;
- Twelve (12) copies of the Color Overall Site Plan last revised November 5, 2018
- Twelve (12) copies of the Color Phase 1 Site Plan last revised November 5, 2018
- Twelve (12) copies of the Land Area Exhibit last revised November 5, 2018;
- Twelve (12) copies of the TAC Stipulation Comment Response dated November 6, 2018;
- Twelve (12) copies of the Peer Review Comment Response last revised November 6, 2018;
- Twelve (12) copies of the Hodgson Brook Restoration Report prepared by Streamworks dated September 4, 2018;
- Twelve (12) copies of the Watershed Modeling for Hodgson Brook Memorandum prepared by Streamworks dated November 6, 2018;
- Twelve (12) copies of the Drainage Analysis (Section 6, 7, 8 & 11 of the Alteration of Terrain Report) last revised November 6, 2018;
- Two (2) copies of a Traffic Memorandum including appendices and ten (10) copies of a Traffic Memorandum without appendices dated April 3, 2018;
- Twelve (12) copies of the Revised Trip Distribution Analysis dated August 9, 2018;
- Twelve (12) copies of the 1992 Aerial Wetland Overlay Exhibit dated July 1, 2016;
- Twelve (12) copies of the Wetland Delineation Report prepared by Gove Environmental dated June 16, 2016
- Twelve (12) Copies of the Lighting Fixture Cut Sheets
- Twelve (12) copies of the Fire Truck Turning Exhibits dated August 21, 2018;
- One (1) CD containing digital copies (PDF) of the information list above;

Background

The proposed project will expand Lonza Biologics' facility to support its growing product development services to the pharmaceutical and biologic industries. The proposed project is located on a vacant 24-acre parcel, refered to as the Iron Parcel, that once consisted of row housing and streets for Pease Air Force Base. The houses and roads were removed in the mid to late 1990's as part of the Civil Redevelopment Plan for Pease after the closure of the Air Force Base. These demolition activities resluted in pockets of wetlands that did not previously exist in 1992.

Lonza's existing facilities are located at 101 International Drive which is across Goose Bay Drive from the proposed project site. The existing facility is approximately 800,000 SF in gross floor area and includes approximately 800 employees. Lonza maximized its potential building footprint growth at the 101 International Drive with the completion of a 300,000 SF building expansion project in 2008. In order to continue its growth to further serve existing and new customer demand, Lonza will need to expand its facilities across Goose Bay Drive.

Subdivision

The project will merge 101 International Drive with 70 and 80 Corporate Drive and portion of Goose Bay Drive to create a 43-acre parcel for Lonza's campus. The abandonment of the 1,700 LF of Goosebay Drive along Lonza's existing frontage will result in approximately 800 LF public right of way remaining with a dead-end. The full portion of Goosebay Drive cannot be abandoned and merged with the proposed parcel because there is an existing driveway to an abutting property on the portion of Goosebay Drive that will remain public right of way. A cul-de-sac will be constructed on the dead-end of the public right of to allow for municipal maintenance vehilces to turn around. Enclosed are waivers for the subdivision approval as the length of road with the cul-de-sac and the diameter of the cul-de-sac exceed the maximum size requirements in the PDA Subdivision Regulations. The length of road needs to exceed the maximum length requirement due to the location of the abutter's driveway and the diameter of cul-de-sac has been designed with a reduced size to avoid wetland impacts.

Site Plan

The total master plan build-out of the proposed industrial development is depecited in the enclosed Site Plan set. The master plan includes three (3) new buildings totaling approximately 1 million square feet of gross floor area and two (2) new parking garages. The full master plan build-out has the potential to create approximately 1,000 new jobs. The project's site improvements consist of drive aisles, sidewalks, fire lanes, utilities, lighting and landscaping. The site improvements will constist of new stormwater management systems that include two (2) gravel wetlands and one (1) rain garden. The project has already received Atleration of Terrain Permit form the New Hampshire Department of Environmental Services (NHDES) for the the stormwater management design.

In addition to the site improvments and LID stormwater practices, the project will include a stream restoration project for Hodgson Brook. There is an existing 50-Inch culvert that bisects the parcel which is a buried portion of upper Hodgson Brook. The project will remove this culvert and daylight the flow through a new 1,125 LF stream channel.

This master plan will be constructed in phases. Full-buildout will take several years and must be completed in phases as Lonza identifies clients and fits out the buildings to meet their client's needs. The first phase will be broken into sub phases. At this time Lonza is seeking a recommendation for approval from the Planning Board for Phase 1A and 1B of the development which are included in the Site Plan set that was enclosed with this letter. Future phases of the project will require noticed public hearings with the Technical Advisory Committee (TAC) and Planning Board. The following summarizes the work to be completed during Phase 1A and Phase 1B:

Phase 1A

- Construction of the stream
- Removal of the existing culvert
- Construction of the sidewalk and landscaping along Corporate Drive
- Construction of the cul-de-sac with gate at dead end created by partial taking of Goosebay Drive
- Construction of gated entrance and turn around for new driveway (formerly Goosebay Drive) off Corporate Drive

Phase 1B

- Construction of building #1 shell
- Construction site improvements for building #1 such as drive aisles, fire lanes, utilities, lighting, sidewalks and stormwater management including Gravel Wetland #1
- Construction of gravel pad for future parking in location of Proposed Parking Garage #1
- Temporary gravel area for construction trailers, parking and laydown in approximate location of Proposed Building #3
- Intermittent grading between stream and Building #1
- Temporary sedimentation basins at locations of Gravel Wetland #2 and Rain Garden #1

Conditional Use

The project will result in 55,555 SF of wetland impact and 66,852 SF of impacts in Pease Development Authority's 25 FT wetland buffer. As depicted in the enclosed 1992 Aerial Overlay Plan, most of these wetlands did not previously exist when the site consisted of the row housing and streets for the Pease Air Force Base. To mitigate impacts, the project will include a the stream restoration project for Hodgson Brook that is described above. This stream restoration will result in approximately 47,000 SF of restoration wetlatnd area that has a higher function and value than the existing wetlands on site that will be impacted.

Part 304-A.08 of the PDA Zoning Requirements, indicate that the following criteria shall be addressed for a Conditional Use Permit:

1. The land is reasonably suited to the use;

   The land is reasonably suited as it is located in the Aiport Business Commercial District and the proposed use is allowed. The parcel is located to the rear of Lonza's exisisting parcel, which allows for expansion of their facility given there is no more room to expand on their existing parcel.

2. There is no alternative location outside the wetland buffer that is feasible and reasonable for the proposed use;

   There is no alterative location outside the wetland buffer given the size and scale of the project. As noted above and shown on the enclosed 1992 Aerial

Wetland Overlay Plan, this parcel and most of the wetland buffers proposed to be impacted did not exist 20 years ago, as this site was previously developed with row housing and streets for the Air Force Base.

3. There will be no adverse impact on the wetland functional values of the site or surrounding properties;

   The impacted wetland areas are scrub shrub/emergent wetlands with functions and values that are limited to only some potential for groundwater recharge/discharge, flood flow alteration and nutrient removal in small areas. The proposed stream will have a higher function and value. In addition, the proposed Low Impact Design (LID) stormwater management practices will provide stormwater treatment and recharge as described in the enclosed Drainage Memorandum.

4. Alteration of the natural vegetative state or managed woodland will occur only to the extent necessary to achieve construction goals;

   Alteration of the natural vegetative state will only occur within the limits of the proposed development area. Areas adjacent to existing wetlands along the east portion of Goose Bay Drive will not be disturbed and will be kept in their existing vegetative state. In addition, the detailed Wetland Planting Plan has been included for the proposed stream.

5. Potential impacts have been avoided to the maximum extent practicable and unavoidable impacts have been minimized.

   Potential impacts have been avodied to the maximum extent practicable given the size and scale of the proposed project. To the extent possible, the site design avoids impacts to an existing portion of wetland area closest to Goose Bay Drive that appears to have been a wetland when the row housing and streets existed for the Air Force Base. As shown in the 1992 Aerial Wetland Overlay Plan, the remaining wetlands that are being impacted did not exist when this site was previously developed for the Air Force Base. In addition, impacts to wetlands are being mitigated with the construction of a new 1,000 LF stream channel that will result in approximately 42,500 SF of restoration area that has a higher function and value than the existing wetlands on site that will be impacted.

On June 13, 2018, the project received unanimous approval from the Conservation Commission to recommendal to the Planning Board for the Conditional Use Permit and to NHDES for the Wetland Impact Permit.

<u>Technical Advisory Committee (TAC)</u>

Since April 2018, the project has attended one (1) TAC work session and two (2) TAC public hearings. On September 4, 2018 TAC voted to recommend approval to the Planniing Board with twelve (12) stipulations. Enclosed with this package is a TAC Stipulation Report that provides a status on each of the recommended stipulations.

As part of the Site Plan Review process, TAC required a third party peer review be conducted for the stormwater management design. Altus Engineering, the third party peer review engineer, provided an original review letter dated August 6, 2018. On August 21, 2018, the applicant provided a response to this peer review letter as part of the last TAC submission package. Following the TAC meeting, the applicant receive a second peer review letter from Altus that identified items that had been addressed and a list of remaining items that required further response. Enclosed with this package, is a response to the second peer review letter which we anticipate addresses the remaining oustanding items. It should be noted that in addition to the local peer review, the stormwater design was also reviewed by NHDES and has been granted an Alteration of Terrain Permit.

Closing

We trust the enclosed information supports our request for a recommendation of approval to the Pease Development Authority for the Subdivision, Site Plan Review and Conditional Use Permit applications. We respectfully request to be placed on the November 15, 2018 Planning Board agenda. We look forward to meeting with the Planning Board on this important project. If you have any questions or need any additional information, please contact me at 603.433.8818 or pmcrimmins@tighebond.com.

Sincerely,

TIGHE & BOND, INC.

Patrick M. Crimmins, P.E.
Senior Project Manager

Enclosures

Cc: Lonza Biologics (via email)
DTC Lawyers (via email)
Streamworks (via email)
Gove Environmental Services (via email)
Pease Development Authority (via email)

Tighe&Bond
Engineers | Environmental Specialists

L-0700-013
May 21, 2018

Mr. Dexter Legg, Chairman
City of Portsmouth Planning Board
1 Junkins Avenue
Portsmouth, New Hampshire 03801

Re: **Lonza Biologics – Subdivision Application**
Waiver Request from Part 506.01(d) Cul-de-Sac Length and Diameter

Dear Mr. Legg:

On behalf of Lonza Biologics, we respectfully request a recommendation for approval to the Pease Development Authority (PDA) to grant the following waiver related to a PDA Subdivision Application for a proposed industrial development located at 70 and 80 Corporate Drive and 101 International Drive on Pease International Tradeport:

- Part 506.01 (d) – Minimum cul-de-sac radius of 80 feet required where 45 feet is provided and minimum cul-de-sac street length of 500 feet required where approximately 800 feet is provided.

The abandonment of the 1,800 LF of Goosebay Drive along Lonza's existing frontage will result in a approximately 800 LF public right of way that will remain with a dead-end. The full portion of Goosebay Drive cannot be abandoned and merged with the proposed parcel because there is an existing driveway to an abutting property on the northeast portion of Goosebay Drive. The City of Portsmouth Department of Public Works (DPW) maintains the roads on Pease International Tradeport as per agreements with the PDA. A cul-de-sac will be constructed on the dead-end of this remaining public right to allow DPW maintenance vehilces to turn around at the end of the road.

The length of road needs to exceed the maximum length requirement due to the location of the abutter's driveway that necessitates this portion of road to remain a public right of way. The diameter of cul-de-sac has been designed with a reduced size to avoid wetland impacts. This cul-de-sac is similar in size to two (2) recent cul-de-sacs our office has designed for two (2) previously approved projects in the City of Portsmouth, the Borthwick Forest subdivision and Foundry Place parking garage. Thus, we anticipate the size is adequate to meet the needs for DPW maintenance activities.

We respectfully request a recommendation for approval to the PDA for the above requested waiver. If you have any questions or require any additional information please do not hesitate to contact me at (603) 433-8818 or pmcrimmins@tighebond.com.

Very truly yours,
TIGHE & BOND, INC.

Patrick M. Crimmins, P.E.
Project Manager

Enclosures

177 Corporate Drive • Portsmouth, NH 03801-6825 • Tel 603.433.8818
www.tighebond.com

PROPOSED IRON PARCEL REDEVELOPMENT PROJECT - TAC STIPULATION RESPONSE **Date: November 6, 2018**

City of Portsmouth TAC, September 4, 2018:			
	TAC Stipulation	**Applicant Response**	**Sheet**
1	Applicant shall update the plans to show a turnaround after the gate on Goose Bay Drive to enable vehicles to tum around if no pass card is provided.	A turnaround after the gate on Goose Bay Drive has been added to the site plans.	C-105, C-125
2	Applicant shall update the plans to extend the sidewalk along the driveway along the southwest portion of the site to Corporate Drive. Plans shall be updated to clearly distinguish existing and proposed sidewalks.	The plans have been updated to show a sidewalk along the entrance driveway of the site to Corporate Drive. The plans shall be updated to clearly distinguish existing and proposed sidewalks.	C-105, C-145
3	Applicant shall update the plans to relocate the bike racks outside of the parking garages closer to the entrance of Building 3 or Buildings 1 and 2.	The bike racks have been relocated to the entrances of Building 1 and Building 2.	C-107, C-147
4	Applicant shall update the Traffic Analysis to include the Gosling Road interchange with Spaulding Turnpike. Timing of the update shall be included in the Phasing Plan (see item 9).	The applicant agrees to provide post construction monitoring and during the phased construction to validate the Traffic Analysis findings. The Gosling Road interchange will be incorporated into the post construction monitoring counts and the traffic study will be updated at this time to include this intersection. The timing of the post construction monitoring will be incorporated into a phasing agreement (see Response #9 below)	N/A
5	Applicant shall update the plans to show that all manholes located on the flatiron side of Corporate Drive are to be raised to grade as part of the sidewalk construction.	The plans have been revised to show that all manholes located on the flatiron side of Corporate Drive are to be raised to grade as part of the sidewalk construction.	C-109 to C-110 & C-129 to C-130
6	Plans shall show a 3' shoulder alongside the sidewalk before grading down to the stream.	The plans were revised to show a 3ft shoulder alongside the sidewalk before grading down to the stream.	C-109 to C-110 & C-129 to C-130
7	Applicant shall update the plan to include the revised standard note on radio strength testing.	Note #34 was added to the utility plan including the revised standard note on radio strength testing.	C-111
8	The applicant shall consider ways to modify the pavement treatment for the 20' emergency access drives and cul-de-sac to improve the overall aesthetic and break up the amount of uninterrupted asphalt. Consideration shall be given to suitability of the design for the multi-modal use of these areas. Final design shall be reviewed and approved by the Fire Department.	The applicant will review the potential to use alternative materials for fire lanes in the future phases of the project when the fire lanes are to be constructed. The only fire lane to be constructed as part of Phase 1A or 1B is adjacent to Proposed Building #1. Given that there will be a parking garage constructed adjacent to this fire lane in a phase subsequent to Phase 1B, this fire lane is proposed as gravel at this time so that it will not be damaged by future construction activity. Per the phasing agreement (See Response #9 below), the applicant will need to appear before the City land use boards prior to any work being done beyond Phase 1B. The cul-de-sac will be part of the Goose Bay Drive right of way and is provided for City roadway maintenance. The cul-de-sac will be the loading entrance for Lonza's existing facility and Proposed Building #1 and 2 and no other public traffic is anticipated to use this cul-de-sac. The applicant recommends that the cul-de-sac be paved. Alternative materials may be subject to damage from large vehicles that are entering/existing Lonza creating a maintenance issue for the City.	C-144
9	Applicant shall work with the City's Planning and Legal Departments to develop a recommended phasing plan for all site improvements, including interim grading plans, to present to the Planning Board. Subsequent phases shall require a noticed public hearing with TAC and Planning Board for amended site plan approval.	Phasing plans have been added to the plan set showing the first two phases (Phase 1A & Phase 1B) along with the master plan build out. The applicant agrees to continue work with City and PDA on a phasing agreement that will require all phases subsequent to Phase 1B be submitted for Amended Site Plan Review with noticed TAC and Planning Board public hearings.	N/A
10	Prior to the issuance of a building permit for the project, the applicant shall reach an agreement with the City regarding phasing of the water and wastewater services. This shall be in addition to the required industrial discharge permit, which is issued by the City.	Applicant agrees.	N/A

11	The City has reviewed the stormwater management and drainage and makes the following recommendations with the understanding that the project will be subject to additional review by the Pease Development Authority (PDA) to ensure compliance with the requirements of the Pease stormwater discharge permit as well as NHDES as part of the AOT permit process:	An Alteration of Terrain permit has been granted by NHDES for this project.	N/A
11a	PDA staff and Board should review and address any outstanding issues raised by the third party peer review and have the third party peer reviewer do a final review of the plans prior to construction.	The applicant anticipates it has addressed outstanding items included in the latest Peer Review Letter dated September 3, 2018 with the materials enclosed in this submission package. Included with this submission package is a response to the latest Peer Review Comments.	N/A
11b	Updated plans and drainage report should be provided to the City's Planning Department reflecting any future revisions to the drainage based on PDA's final review and approval.	Updated plans and drainage report are included in this submission package. See Response # 9 above relating to any future revisions.	N/A
12	Plans should include water and sewer easements to the benefit the City for any private portions of Goose Bay Drive.	The subdivision plan has been revised to include an easement for the water line in the portion of Goose Bay Drive that will abandoned and merged with the Lonza property. The applicant coordinated with DPW and an easement for the sewer line in the portion of Goose Bay Drive that will be abandoned has not been provided as this sewer line only services Lonza.	Subdivision Plan Sheet 1 of 2 and 2 of 2

Pease Development Authority
Application for Site Review

Applicant: Lonza Biologics, Inc.		**For PDA Use Only**	
Address: 101 International Drive Portsmouth, NH 03801		Date Submitted: / / Application Complete: / /	
Phone: 603-334-6100		Municipal Review:	
Other interested Parties: Tighe & Bond		Date Forwarded: / /	
Address 177 Corporate Drive Portsmouth, NH 03801		Fee $	Paid: / /
		Check #	
Phone: 603-433-8818		Notes:	
Site Location: 70 & 80 Corporate Drive	Zone: ABC	Plan # Map 305	Lot # 1 & 2

Individual in Charge of Project: Simon Trigg

Address:

Change of Use: Yes [X] No [ ] Exiting Use: Vacant lot Proposed Use: Commercial

Description of Project: The project potentially consists of the expansion of Lonza Biologics, which includes the construction of three (3) proposed buildings and two (2) parking garages, along with associated site improvements, including utilities and drainage infrastructure.

Attachments (Check as Applicable)

[ ] 9 stamped copies of site plan [ ] Original Mylar [ ] Base Application Fee

[ ] Abutter's List [ ] Copy of Building permit application [ ] Copies of approvals for required state/federal permits

I hereby apply for Site Review and Acknowledge I will comply with all regulations and any conditions established by the Review Committee(s) and PDA Board in the development and construction of this project.

Applicant's Signature: [signature] Date: 15May18

Pease Development Authority
Subdivision Application

For Office Use Only
Case No.
Received By:
Date:
Referred to Municipality on:
Municipality Action:
Date:

Applicant: Lonza Biologics, Inc.

Address: 101 International Drive, Portsmouth, NH 03801

Telephone: 603-334-6100

Other Concerned Parties: Tighe & Bond, Inc.

Address: 177 Corporate Drive, Portsmouth, NH 03801

Telephone: 603-433-8818

CHECK ONE:

Subdivision: X **Lot Line Change:** ______ **Lot Line Verification:** ______

Location: 70 & 80 Corporate Drive

Zoning District: Airport Business Commercial (ABC)

Assessor Plan & Lot No.: Map 305, Lots 1, 2, 5, 6 **Building No.:** ______

Total Existing Lots: Four **Created:** ______

Lot Area Existing: ______ **Created:** ______

[signature] 15 May 18
(Signature of Applicant)

__Note:__ This application, together with a complete plat plan and sixteen (16) blue or black line copies thereof, must be filed with the Pease Development Authority (PDA) Building Inspector no later than the third Tuesday of the month in order to appear at the next regular meeting of the municipal Planning Board, if such referral is required. The signed mylar will be held by PDA for filing at the Registry of Deeds, and the following fees must be submitted before said plan is signed. Initial application fee per lots involved is as follows: Nonresidential Subdivisions $200.00 + $75.00 per lot; Lot line change $100.00 these are payable to PDA. Also, fee payable to Registry of Deeds is as follows: Mylar recording 8 1/2" x 11" = $7.00; 11" x 17" = $7.00; 11" x 22" = $11.00; and 22" x 34" =$19.00. Cost of notifying abutters (postage and advertising) and additional staff time will be billed separately as per Part 504.02 of the Subdivision Regulations.

Pease Development Authority
55 International Drive, Portsmouth, NH 03801, (603) 433-6088

PEASE INTERNATIONAL TRADEPORT

Conditional Use Permit Application

For PDA Use Only			
Date Submitted:__________	Municipal Review:__________	Fee:__________	
Application Complete:__________	Date Forwarded:__________	Paid:__________	Check #:__________

Applicant Information

Applicant: Lonza Biologics		Agent: Tighe & Bond
Address: 101 International Drive Portsmouth, NH 03801		Address: 177 Corporate Drive Portsmouth, NH 03801
Business Phone: 603-334-6100		Business Phone: 603-433-8818
Mobile Phone:		Mobile Phone:
Fax:		Fax:
Portsmouth Tax Map: 305	Lot #: 1 & 2	Zone: Aiport Business and Commercial
Address / Location of Work: 70 & 80 Corporate Drive		

Activity Information

Proposed Activity (check all that apply)

X New Structure

_____ Expansion of Existing Structure

_____ Other site alteration (specify):

____

Impacted Jurisdictional Area(s): Check all that apply

X Wetland

X Wetland Buffer

Total area of wetland on subject lot:	75,430 SF
Total area of wetland buffer on subject lot:	81,315 SF
Distance of proposed structure or activity to edge of wetland:	0 LF

	On subject lot	Off subject lot
Area of wetland impacted:	55,555 SF	
Area of wetland buffer impacted:	66,852 SF	
Total area of wetland and wetland buffer impacted:	122,407 SF	

Provide complete description of site and work to be completed:
The project potentially consists of the expansion of Lonza Biologics, which includes the construction of three (3) proposed buildings and two (2) parking garages, along with associated site improvements, including utilities and drainage infrastructure.

All above information shall be shown on a site plan submitted with this application.

Certification

I hereby certify under the penalties of perjury that the foregoing information and accompanying plans, documents, and supporting data are true and complete to the best of my knowledge.

____________________ 25 May 18
Signature of Applicant — Date

N:\Engineer\Conditional Use Permit Application.xlsx

GOVE ENVIRONMENTAL SERVICES, INC.

June 16, 2016

Patrick Crimmins, P.E.
Tighe & Bond
177 Corporate Drive
Portsmouth, NH 03801

Re: Lonza, Corporate Drive, Portsmouth
Subject: Wetland Delineation Report

Dear Mr. Crimmins:

Per your request, this letter is to verify that Gove Environmental Services, Inc., performed a site inspection to identify functions and values for the wetlands delineated at the above-referenced property.

The site consists of predominantly open land once used as row housing. These houses and associated roads and driveways were removed decades ago, as well as the smoothing of the site. This is still evident today through a layer of smooth fill material across the site. Dominant vegetation across the site is grass, and a few mature trees. A large detention pond is located on the site in the central portion, with a riprap bottom and berms along the edge. A large stockpile of material is also present on site and is stable and well vegetated.

Additionally on site are 5 wetland areas. These wetland areas are all isolated on site with some drainage from wetland 4, which drains to the west through a culvert and into Hogdson Brook. Hydrology is predominantly through ground water and some minor influence through sheet flow over the grass surface.

Wetland areas 1 and 4 are similar in make up and are classified as PSS/EM1E, scrub shrub/emergent wetlands, with dominant vegetation of Red maple and American elm in the tree layer, highbush blueberry, speckled alder and gray dogwood in the shrub layer and Cinnamon and sensitive fern, grasses and sedges in the herbaceous layer. Primary functions and values are Groundwater Recharge/Discharge, Flood flow Alteration, Nutrient Removal.

Wetland areas, 2,3,and 5 are also similar in make up and are classified as PEM1E, emergent wetlands, with dominant vegetation of grasses and sedges. Primary functions and values are Primary functions and values are Groundwater Recharge/Discharge, Flood flow Alteration, Nutrient Removal.

8 CONTINENTAL DR UNIT H, EXETER, NH 03833-7507
PH (603) 778 0644 / FAX (603) 778 0654
WWW.GESINC.BIZ
INFO@GESINC.BIZ

Copies of the USACE Highway Methodology sheets are included

If you have any questions or need anything else, please let me know.

Sincerely,

Luke D. Hurley, CWS, SSA
Vice President
Gove Environmental Services, Inc.

Wetland Function-Value Evaluation Form

Total area of wetland: 28,915 sf   Human made? No   Is wetland part of a wildlife corridor? no   or a 'habitat island'?

Adjacent land use Commercial/Industrial   Distance to nearest roadway or other development 50 feet

Dominant wetland systems present PEM1E   Contiguous undeveloped buffer zone present no

Is the wetland a separate hydraulic system? No   If not, where does the wetland lie in the drainage basin? Lower

How many tributaries contribute to the wetland? 0   Wildlife & vegetation diversity/abundance (see attached list)

Wetland ID: 1,4
Latitude   Longitude
Prepared by: LDH   Date 1/7/16
Wetland Impact: 28,915
Type PEM1E   Area
Evaluation based on:
Office   Field X
Corps manual wetland delineation completed? Y X   N

Function/Value	Occurrence Y/N	Rationale (Reference #)*	Principal Function/Value(s)	Comments
Groundwater Recharge/Discharge	Y	1,2,5,6,7,8,15,	Y	This wetland has some Groundwater Recharge/Discharge potential
Floodflow Alteration	Y	3,4,5,6,8,9,10,13,14,16,18	Y	This wetland has some Floodflow Alteration potential
Fish and Shellfish Habitat	N		N	
Sediment/Toxicant Retention	N	1,4	N	This wetland has some Sediment/Toxicant Retention potential
Nutrient Removal	Y	5,6,7,8,9,10,11,12,13	N	This wetland has some potential for Nutrient Removal, but only in small areas
Production Export	N		N	
Sediment/Shoreline Stabilization	N		N	This is not associated with a watercourse
Wildlife Habitat	N	7,8.18,21	N	
Recreation	N			
Educational/Scientific Value	N		N	This wetland has no scientific or educational value
Uniqueness/Heritage	N			
Visual Quality/Aesthetics	N		N	
Endangered Species Habitat	N			
Other				

Notes:

*Refer to backup list of numbered considerations.

Wetland Function-Value Evaluation Form

Total area of wetland: 24,759 sf   Human made? No   Is wetland part of a wildlife corridor? no   or a 'habitat island'?

Adjacent land use Commercial/Industrial   Distance to nearest roadway or other development 50 feet

Dominant wetland systems present PEM1E   Contiguous undeveloped buffer zone present no

Is the wetland a separate hydraulic system? No   If not, where does the wetland lie in the drainage basin? Lower

How many tributaries contribute to the wetland? 0   Wildlife & vegetation diversity/abundance (see attached list)

Wetland ID: 2,3,5
Latitude   Longitude
Prepared by: LDH   Date 1/7/16
Wetland Impact: 26,640
Type PEM1E   Area
Evaluation based on:
Office   Field X
Corps manual wetland delineation completed? Y X   N

Function/Value	Occurrence Y/N	Rationale (Reference #)*	Principal Function/Value(s)	Comments
Groundwater Recharge/Discharge	Y	1,2,5,6,7,8,15,	Y	This wetland has some Groundwater Recharge/Discharge potential
Floodflow Alteration	Y	3,4,5,6,8,9,10,13,14,16,18	Y	This wetland has some Floodflow Alteration potential
Fish and Shellfish Habitat	N		N	
Sediment/Toxicant Retention	N	1,4	N	This wetland has little Sediment/Toxicant Retention potential
Nutrient Removal	Y	5,6,7,8,9,10,11,12,13	N	This wetland has some potential for Nutrient Removal, but only in small areas
Production Export	N		N	
Sediment/Shoreline Stabilization	N		N	This is not associated with a watercourse
Wildlife Habitat	N		N	
Recreation	N			
Educational/Scientific Value	N		N	This wetland has no scientific or educational value
Uniqueness/Heritage	N			
Visual Quality/Aesthetics	N		N	
Endangered Species Habitat	N			
Other				

Notes: *Refer to backup list of numbered considerations.

Revised Trip Distribution Analysis
Lonza Biologics Proposed Industrial Development
Portsmouth, New Hampshire

TO: George Combes, PE, CPIP
Principal Design Lead - Global Engineering
Lonza Biologics
230 Corporate Drive
Portsmouth, NH 03801

FROM: Patrick Crimmins, P.E.
Vinod Kalikiri, P.E., PTOE

DATE: August 9, 2018

Tighe & Bond, Inc. (Tighe & Bond) has prepared this memorandum to summarize the revised trip distribution analysis for the above referenced project, prepared in response to a request for such analysis by the City's Technical Advisory Committee (TAC).

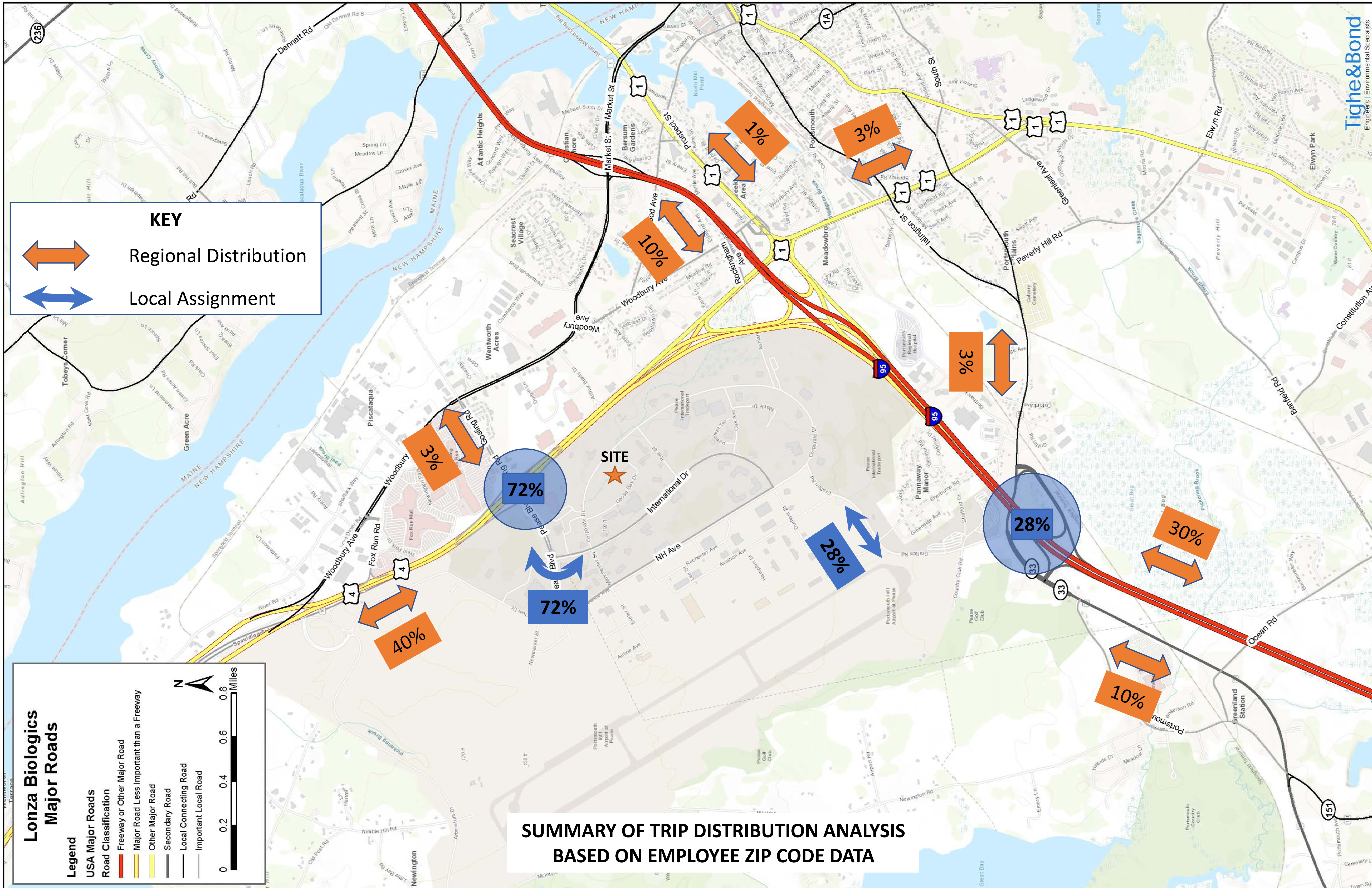
The original trip distribution analysis included in the April 2018 traffic study was based on calculations using the existing peak hour counts at intersections near the Site. This methodology, while reliable for use in intersection impact analysis presented in the study, does not extrapolate the trip percentages to the regional highway system and roadways outside of the study area.

To address the TAC's request for trip distribution percentages on the regional roadway network, Tighe & Bond requested and analyzed zip code data for Lonza employees' place of residence. The analysis results from the zip code data is presented both on a map as well as in a tabular form in the attachment to this memorandum. The new analysis is generally consistent with the corresponding analysis presented in the original study. Both analyses indicate that a majority of the Site traffic (as much as three quarters of the Site generate traffic) would be oriented to/from Pease Boulevard (i.e., north of the Site) and the remaining Site traffic oriented to/from Grafton Road (i.e., south of the Site).

Attachments

Trip Distribution Map

Calculation worksheet



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OBJECTID	ZIP_CODE	PO_NAME	STATE	employeeCount	Shape_Area	Direction	I-95 South	I-95 North	Route 33 South	Route 33 East	Route 1 East	Route 1 North	Route 4 West	Gosling Road North	check	I-95 South	I-95 North	Route 33 South	Route 33 East	Route 1 East	Route 1 North	Route 4 West	Gosling Road North
1	1010.00	Brimfield	MA	1	0.010514		100.00%								OK	1	0	0	0	0	0	0	0
2	1451.00	Harvard	MA	1	0.006399		100.00%								OK	1	0	0	0	0	0	0	0
3	1507.00	Charlton	MA	1	0.012443		100.00%								OK	1	0	0	0	0	0	0	0
4	1522.00	Jefferson	MA	1	0.00476		100.00%								OK	1	0	0	0	0	0	0	0
5	1581.00	Westborough	MA	1	0.005997		100.00%								OK	1	0	0	0	0	0	0	0
6	1730.00	Bedford	MA	2	0.003859		100.00%								OK	2	0	0	0	0	0	0	0
7	1772.00	Southborough	MA	1	0.004393		100.00%								OK	1	0	0	0	0	0	0	0
8	1801.00	Woburn	MA	1	0.00367		100.00%								OK	1	0	0	0	0	0	0	0
9	1810.00	Andover	MA	2	0.009116		100.00%								OK	2	0	0	0	0	0	0	0
10	1826.00	Dracut	MA	2	0.006115		100.00%								OK	2	0	0	0	0	0	0	0
11	1830.00	Haverhill	MA	6	0.004248		100.00%								OK	6	0	0	0	0	0	0	0
12	1832.00	Haverhill	MA	2	0.003408		100.00%								OK	2	0	0	0	0	0	0	0
13	1833.00	Georgetown	MA	1	0.003762		100.00%								OK	1	0	0	0	0	0	0	0
14	1835.00	Haverhill	MA	1	0.002461		100.00%								OK	1	0	0	0	0	0	0	0
15	1844.00	Methuen	MA	10	0.006546		100.00%								OK	10	0	0	0	0	0	0	0
16	1845.00	North Andover	MA	2	0.007855		100.00%								OK	2	0	0	0	0	0	0	0
17	1852.00	Lowell	MA	1	0.001495		100.00%								OK	1	0	0	0	0	0	0	0
18	1854.00	Lowell	MA	2	0.001247		100.00%								OK	2	0	0	0	0	0	0	0
19	1860.00	Merrimac	MA	2	0.002536		100.00%								OK	2	0	0	0	0	0	0	0
20	1876.00	Tewksbury	MA	2	0.006037		100.00%								OK	2	0	0	0	0	0	0	0
21	1880.00	Wakefield	MA	1	0.00226		100.00%								OK	1	0	0	0	0	0	0	0
22	1886.00	Westford	MA	1	0.008731		100.00%								OK	1	0	0	0	0	0	0	0
23	1907.00	Swampscott	MA	1	0.00085		100.00%								OK	1	0	0	0	0	0	0	0
24	1913.00	Amesbury	MA	5	0.003893		100.00%								OK	5	0	0	0	0	0	0	0
25	1915.00	Beverly	MA	1	0.00446		100.00%								OK	1	0	0	0	0	0	0	0
26	1921.00	Boxford	MA	2	0.006996		100.00%								OK	2	0	0	0	0	0	0	0
27	1938.00	Ipswich	MA	1	0.009451		100.00%								OK	1	0	0	0	0	0	0	0
28	1950.00	Newburyport	MA	7	0.003159		100.00%								OK	7	0	0	0	0	0	0	0
29	1951.00	Newbury	MA	2	0.005088		100.00%								OK	2	0	0	0	0	0	0	0
30	1952.00	Salisbury	MA	3	0.004937		100.00%								OK	3	0	0	0	0	0	0	0
31	1960.00	Peabody	MA	1	0.004791		100.00%								OK	1	0	0	0	0	0	0	0
32	1970.00	Salem	MA	1	0.002453		100.00%								OK	1	0	0	0	0	0	0	0
33	1985.00	West Newbury	MA	1	0.004183		100.00%								OK	1	0	0	0	0	0	0	0
34	2127.00	Boston	MA	1	0.000853		100.00%								OK	1	0	0	0	0	0	0	0
35	2145.00	Somerville	MA	1	0.000407		100.00%								OK	1	0	0	0	0	0	0	0
36	2176.00	Melrose	MA	1	0.001348		100.00%								OK	1	0	0	0	0	0	0	0
37	2180.00	Stoneham	MA	1	0.001849		100.00%								OK	1	0	0	0	0	0	0	0
38	2461.00	Newton Highlands	MA	1	0.000427		100.00%								OK	1	0	0	0	0	0	0	0
39	2472.00	Watertown	MA	3	0.001181		100.00%								OK	3	0	0	0	0	0	0	0
40	2492.00	Needham	MA	1	0.00267		100.00%								OK	1	0	0	0	0	0	0	0
41	3031.00	Amherst	NH	5	0.010143		100.00%								OK	5	0	0	0	0	0	0	0
42	3032.00	Auburn	NH	1	0.008167		100.00%								OK	1	0	0	0	0	0	0	0
43	3034.00	Candia	NH	3	0.01063		100.00%								OK	3	0	0	0	0	0	0	0
44	3037.00	Deerfield	NH	4	0.014317		100.00%								OK	4	0	0	0	0	0	0	0
45	3038.00	Derry	NH	8	0.010857		100.00%								OK	8	0	0	0	0	0	0	0
46	3042.00	Epping	NH	11	0.007973		50.00%						50.00%		OK	5.5	0	0	0	0	0	5.5	0
47	3044.00	Fremont	NH	4	0.004945		50.00%		50.00%						OK	2	0	2	0	0	0	0	0
48	3045.00	Goffstown	NH	2	0.010311		100.00%								OK	2	0	0	0	0	0	0	0
49	3047.00	Greenfield	NH	1	0.008001		100.00%								OK	1	0	0	0	0	0	0	0
50	3051.00	Hudson	NH	1	0.008357		100.00%								OK	1	0	0	0	0	0	0	0
51	3052.00	Litchfield	NH	1	0.004289		100.00%								OK	1	0	0	0	0	0	0	0
52	3053.00	Londonderry	NH	10	0.011616		100.00%								OK	10	0	0	0	0	0	0	0
53	3054.00	Merrimack	NH	1	0.009547		100.00%								OK	1	0	0	0	0	0	0	0
54	3055.00	Milford	NH	1	0.007092		75.00%		25.00%						OK	0.75	0	0.25	0	0	0	0	0
55	3062.00	Nashua	NH	1	0.003368		100.00%								OK	1	0	0	0	0	0	0	0
56	3070.00	New Boston	NH	2	0.012502		75.00%		25.00%						OK	1.5	0	0.5	0	0	0	0	0
57	3076.00	Pelham	NH	3	0.007647		100.00%								OK	3	0	0	0	0	0	0	0
58	3077.00	Raymond	NH	8	0.008318		100.00%								OK	8	0	0	0	0	0	0	0
59	3079.00	Salem	NH	6	0.007438		100.00%								OK	6	0	0	0	0	0	0	0
60	3101.00	Manchester	NH	1	0.000226		90.00%						10.00%		OK	0.9	0	0	0	0	0	0.1	0
61	3102.00	Manchester	NH	9	0.002627		90.00%						10.00%		OK	8.1	0	0	0	0	0	0.9	0
62	3103.00	Manchester	NH	6	0.002887		90.00%						10.00%		OK	5.4	0	0	0	0	0	0.6	0
63	3104.00	Manchester	NH	9	0.002441		90.00%						10.00%		OK	8.1	0	0	0	0	0	0.9	0
64	3106.00	Hooksett	NH	3	0.010556		100.00%								OK	3	0	0	0	0	0	0	0
65	3109.00	Manchester	NH	1	0.002277		90.00%						10.00%		OK	0.9	0	0	0	0	0	0.1	0
66	3110.00	Bedford	NH	4	0.009428		100.00%								OK	4	0	0	0	0	0	0	0
67	3225.00	Center Barnstead	NH	1	0.008176								100.00%		OK	0	0	0	0	0	0	1	0
68	3234.00	Epsom	NH	1	0.009624								100.00%		OK	0	0	0	0	0	0	1	0
69	3235.00	Franklin	NH	1	0.009122			50.00%					50.00%		OK	0	0.5	0	0	0	0	0.5	0
70	3244.00	Hillsborough	NH	1	0.024593		100.00%								OK	1	0	0	0	0	0	0	0
71	3245.00	Holderness	NH	1	0.010031								100.00%		OK	0	0	0	0	0	0	1	0
72	3253.00	Meredith	NH	1	0.014683								100.00%		OK	0	0	0	0	0	0	1	0
73	3255.00	Newbury	NH	1	0.010912		50.00%						50.00%		OK	0.5	0	0	0	0	0	0.5	0
74	3258.00	Chichester	NH	3	0.005796								100.00%		OK	0	0	0	0	0	0	3	0
75	3261.00	Northwood	NH	9	0.008624								100.00%		OK	0	0	0	0	0	0	9	0
76	3263.00	Pittsfield	NH	1	0.007336								100.00%		OK	0	0	0	0	0	0	1	0
77	3275.00	Suncook	NH	1	0.011764		50.00%						50.00%		OK	0.5	0	0	0	0	0	0.5	0

Tighe&Bond

LONZA BIOLOGICS
EMPLOYEE RESIDENTIAL ZIP CODE BASED TRIP DISTRIBUTION ANALYSIS

OBJECTID	ZIP_CODE	PO_NAME	STATE	employeeCount	Shape_Area	Direction	I-95 South	I-95 North	Route 33 South	Route 33 East	Route 1 East	Route 1 North	Route 4 West	Gosling Road North	check	I-95 South	I-95 North	Route 33 South	Route 33 East	Route 1 East	Route 1 North	Route 4 West	Gosling Road North	
78	3280.00	Washington	NH	1	0.013125		100.00%								OK	1	0	0	0	0	0	0	0	
79	3281.00	Weare	NH	1	0.017189		50.00%						50.00%		OK	0.5	0	0	0	0	0	0.5	0	
80	3290.00	Nottingham	NH	18	0.013032		50.00%						50.00%		OK	9	0	0	0	0	0	9	0	
81	3301.00	Concord	NH	2	0.014821		50.00%						50.00%		OK	1	0	0	0	0	0	1	0	
82	3303.00	Concord	NH	1	0.020526		50.00%						50.00%		OK	0.5	0	0	0	0	0	0.5	0	
83	3570.00	Berlin	NH	1	0.023446								100.00%		OK	0	0	0	0	0	0	1	0	
84	3576.00	Colebrook	NH	1	0.057233			34.00%	33.00%				33.00%		OK	0	0.34	0.33	0	0	0	0.33	0	
85	3801.00	Portsmouth	NH	116	0.008103				20.00%	20.00%	20.00%		20.00%	20.00%	OK	0	0	23.2	23.2	23.2	0	23.2	23.2	
86	3809.00	Alton	NH	1	0.014804								100.00%		OK	0	0	0	0	0	0	1	0	
87	3810.00	Alton Bay	NH	3	0.008575								100.00%		OK	0	0	0	0	0	0	3	0	
88	3811.00	Atkinson	NH	2	0.003295		100.00%								OK	2	0	0	0	0	0	0	0	
89	3812.00	Bartlett	NH	1	0.02191								100.00%		OK	0	0	0	0	0	0	1	0	
90	3819.00	Danville	NH	3	0.003186		50.00%						50.00%		OK	1.5	0	0	0	0	0	1.5	0	
91	3820.00	Dover	NH	116	0.00875								100.00%		OK	0	0	0	0	0	0	116	0	
92	3823.00	Madbury	NH	5	0.003217								100.00%		OK	0	0	0	0	0	0	5	0	
93	3824.00	Durham	NH	7	0.007376								100.00%		OK	0	0	0	0	0	0	7	0	
94	3825.00	Barrington	NH	20	0.014117								100.00%		OK	0	0	0	0	0	0	20	0	
95	3826.00	East Hampstead	NH	2	0.001192		100.00%								OK	2	0	0	0	0	0	0	0	
96	3827.00	East Kingston	NH	3	0.00496		100.00%								OK	3	0	0	0	0	0	0	0	
97	3830.00	East Wakefield	NH	2	0.003238								100.00%		OK	0	0	0	0	0	0	2	0	
98	3833.00	Exeter	NH	39	0.013793		50.00%		50.00%						OK	19.5	0	19.5	0	0	0	0	0	
99	3835.00	Farmington	NH	15	0.010892								100.00%		OK	0	0	0	0	0	0	15	0	
100	3839.00	Rochester	NH	9	0.002018								100.00%		OK	0	0	0	0	0	0	9	0	
101	3840.00	Greenland	NH	24	0.003048				100.00%						OK	0	0	24	0	0	0	0	0	
102	3841.00	Hampstead	NH	7	0.003098		100.00%								OK	7	0	0	0	0	0	0	0	
103	3842.00	Hampton	NH	27	0.003921		100.00%								OK	27	0	0	0	0	0	0	0	
104	3844.00	Hampton Falls	NH	4	0.003506		100.00%								OK	4	0	0	0	0	0	0	0	
105	3848.00	Kingston	NH	3	0.005907		100.00%								OK	3	0	0	0	0	0	0	0	
106	3851.00	Milton	NH	10	0.008272								100.00%		OK	0	0	0	0	0	0	10	0	
107	3852.00	Milton Mills	NH	1	0.001669								100.00%		OK	0	0	0	0	0	0	1	0	
108	3855.00	New Durham	NH	9	0.012785								100.00%		OK	0	0	0	0	0	0	9	0	
109	3856.00	Newfields	NH	5	0.00225				100.00%						OK	0	0	5	0	0	0	0	0	
110	3857.00	Newmarket	NH	25	0.004782		50.00%						50.00%		OK	12.5	0	0	0	0	0	12.5	0	
111	3858.00	Newton	NH	1	0.002836		100.00%								OK	1	0	0	0	0	0	0	0	
112	3861.00	Lee	NH	7	0.005561								100.00%		OK	0	0	0	0	0	0	7	0	
113	3862.00	North Hampton	NH	9	0.003932				100.00%						OK	0	0	9	0	0	0	0	0	
114	3864.00	Ossipee	NH	2	0.01136								100.00%		OK	0	0	0	0	0	0	2	0	
115	3865.00	Plaistow	NH	4	0.002967		100.00%								OK	4	0	0	0	0	0	0	0	
116	3867.00	Rochester	NH	58	0.009024								100.00%		OK	0	0	0	0	0	0	58	0	
117	3868.00	Rochester	NH	15	0.002244								100.00%		OK	0	0	0	0	0	0	15	0	
118	3869.00	Rollinsford	NH	5	0.001979			50.00%				50.00%			OK	0	2.5	0	0	0	2.5	0	0	
119	3870.00	Rye	NH	10	0.003512		50.00%		50.00%						OK	5	0	5	0	0	0	0	0	
120	3872.00	Sanbornville	NH	3	0.012299								100.00%		OK	0	0	0	0	0	0	3	0	
121	3873.00	Sandown	NH	4	0.004147		50.00%		50.00%						OK	2	0	2	0	0	0	0	0	
122	3874.00	Seabrook	NH	5	0.002676		100.00%								OK	5	0	0	0	0	0	0	0	
123	3878.00	Somersworth	NH	50	0.002836								100.00%		OK	0	0	0	0	0	0	50	0	
124	3882.00	Effingham	NH	2	0.011411								100.00%		OK	0	0	0	0	0	0	2	0	
125	3884.00	Strafford	NH	5	0.014538								100.00%		OK	0	0	0	0	0	0	5	0	
126	3885.00	Stratham	NH	24	0.004492				100.00%						OK	0	0	24	0	0	0	0	0	
127	3887.00	Union	NH	7	0.006041								100.00%		OK	0	0	0	0	0	0	7	0	
128	3894.00	Wolfeboro	NH	1	0.020419								100.00%		OK	0	0	0	0	0	0	1	0	
129	3901.00	Berwick	ME	10	0.0107			100.00%							OK	0	10	0	0	0	0	0	0	
130	3902.00	Cape Neddick	ME	9	0.005456			100.00%							OK	0	9	0	0	0	0	0	0	
131	3903.00	Eliot	ME	13	0.006136			100.00%							OK	0	13	0	0	0	0	0	0	
132	3904.00	Kittery	ME	10	0.003178			100.00%							OK	0	10	0	0	0	0	0	0	
133	3905.00	Kittery Point	ME	3	0.002057			100.00%							OK	0	3	0	0	0	0	0	0	
134	3906.00	North Berwick	ME	7	0.011124			100.00%							OK	0	7	0	0	0	0	0	0	
135	3907.00	Ogunquit	ME	1	0.0011			100.00%							OK	0	1	0	0	0	0	0	0	
136	3908.00	South Berwick	ME	13	0.009329			100.00%							OK	0	13	0	0	0	0	0	0	
137	3909.00	York	ME	9	0.010628			100.00%							OK	0	9	0	0	0	0	0	0	
138	4005.00	Biddeford	ME	2	0.014128			100.00%							OK	0	2	0	0	0	0	0	0	
139	4009.00	Bridgton	ME	1	0.018959			100.00%							OK	0	1	0	0	0	0	0	0	
140	4021.00	Cumberland Center	ME	1	0.005747			100.00%							OK	0	1	0	0	0	0	0	0	
141	4027.00	Lebanon	ME	5	0.016093			100.00%							OK	0	5	0	0	0	0	0	0	
142	4038.00	Gorham	ME	1	0.014925			100.00%							OK	0	1	0	0	0	0	0	0	
143	4042.00	Hollis Center	ME	2	0.009715			100.00%							OK	0	2	0	0	0	0	0	0	
144	4043.00	Kennebunk	ME	9	0.009994			100.00%							OK	0	9	0	0	0	0	0	0	
145	4046.00	Kennebunkport	ME	2	0.013092			100.00%							OK	0	2	0	0	0	0	0	0	
146	4061.00	North Waterboro	ME	1	0.005735			100.00%							OK	0	1	0	0	0	0	0	0	
147	4062.00	Windham	ME	3	0.014431			100.00%							OK	0	3	0	0	0	0	0	0	
148	4072.00	Saco	ME	2	0.011271			100.00%							OK	0	2	0	0	0	0	0	0	
149	4073.00	Sanford	ME	4	0.010941			100.00%							OK	0	4	0	0	0	0	0	0	
150	4076.00	Shapleigh	ME	3	0.011892			100.00%							OK	0	3	0	0	0	0	0	0	
151	4083.00	Springvale	ME	2	0.002897			100.00%							OK	0	2	0	0	0	0	0	0	
152	4087.00	Waterboro	ME	1	0.005467			100.00%							OK	0	1	0	0	0	0	0	0	
153	4090.00	Wells	ME	2	0.016786			100.00%							OK	0	2	0	0	0	0	0	0	
154	4105.00	Falmouth	ME	1	0.008846			100.00%							OK	0	1	0	0	0	0	0	0	
155	4281.00	South Paris	ME	1	0.012843			100.00%							OK	0	1	0	0	0	0	0	0	
156	4938.00	Farmington	ME	1	0.036329			100.00%							OK	0	1	0	0	0	0	0	0	1020
			SUM	1020												285.65	122.34	114.78	23.2	23.2	2.5	425.13	23.2	
				0												28%	12%	11%	2%	2%	0%	42%	2%	
																30%	10%	10%	3%	3%	1%	40%	3%	

Tighe&Bond

The Restoration of Hodgson Brook at the Iron Rail Parcel at Pease Tradeport in Portsmouth, NH

The benefits of stream restoration

Collecting and processing reference data

Design metrics for the stream and floodplain using natural channel design

Construction sequencing

Planting plan for the floodplain and riparian corridor

Five year monitoring plan and methods

Streamworks, PLLC

Joel Ballestero

Thomas P. Ballestero

04 September 2018

The Benefits of Stream Restoration

The benefits to stream restoration are numerous to an ecosystem, especially so when land that had been developed into an urban area is reconstructed and allowed to grow more naturally again. This is the case throughout the history of Hodgson Brook, a stream whose watershed has been almost entirely developed. The watershed for the stream begins at the Pease Tradeport in Newington (though most of the watershed, including the site, is in Portsmouth), and ends in the tidal waters of North Mill Pond in Portsmouth. At the project site and upstream, other than flowing through open drainage ditches and some wetlands, the stream is buried through a network of pipes that carry water flowing directly off impervious surfaces. This system prevents precipitation from filtering into the ground and recharging the groundwater table, a process which otherwise would filter the water from the urban contaminants it collects along its path. With the reduction of water lost into the ground, the amount that ends up directly in the waterway is increased, and commonly, the time it spends in a healthier environment is reduced. The time the water does spend in open channels, is spent under a lack of natural cover where in the summer it therefore warms due to a lack of shade and a lack of cooler groundwater inflows that recharge the base flow, and moderate biogeochemical processes. The drainage ditch that is now Hodgson Brook is also poor habitat, lacking a diversity of flora and fauna that exist in a more natural setting.

This project proposes to daylight a section (~1,000 feet along the valley, ~1,200 feet of stream) of Hodgson Brook where it currently lies buried in a 4.5-foot diameter culvert before exiting the project site into a drainage ditch; this stream restoration will result in approximately 42,500 square feet (sf) of stream and riparian buffer being created.

Daylighting the stream will restore a more natural riffle-pool sequence to a system that when it is presently in the open, is unnaturally straight, having been relocated and straightened to make way for development. The new stream corridor will provide an opportunity for storm flows to enter into the channel and adjacent floodplain, providing a connection for water to reenter and filter into the ground, in addition to being filtered and used by vegetation. The stream and corridor are hydraulically rougher and longer than the existing pipe, and will create a slower travel time over the same valley distance, in addition to increased storage volume. The corridor will benefit from native, riparian vegetation that will be allowed to grow in a natural state, encouraging wildlife use, nutrient/pollutant removal, and shade to keep the water cool. The habitat will help filter out common pollutants such as nitrogen and phosphorous, all while reducing the amount of contaminated water that enters North Mill Pond. Obviously this is one piece of a greater system between the Tradeport and North Mill Pond, therefore while the benefits of this specific projects are very high, it should be recognized that there are other impairments along the watershed also in need of attention.

The restoration work will provide a reconnection for a portion of a watercourse that has been heavily altered in the past, and hopefully provide an example of how a stream corridor may be restored in an urban environment and serve as a reference for the future.

Collecting and Processing Existing Data

Hodgson Brook at the project site is extremely impaired. What was likely once a naturally-functioning stream – efficiently transporting water, sediment, and nutrients; providing habitat; and operating with relatively stable geomorphic metrics – has been almost entirely paved and piped through its course along the watershed. Relatively little sediment enters or exists the system; less surface water is able to enter into the ground; and almost no in-stream habitat is supported. To restore the system back to a functioning stream and valley corridor, a process of observing and mimicking nature will be employed in an attempt to maximize the effectiveness of the restoration.

Natural Channel Design involves obtaining fluvial geomorphic metrics that are measured on natural, healthy systems (reference stream) which are then employed to serve as a template for the design metrics to the impaired watercourse, as long as the watersheds and streams have similar properties. It is not uncommon for this reference stream section to exist in healthy sections of the same stream, or at sections of adjacent streams. In the case of Hodgson Brook, unfortunately there is no existing healthy/natural/undeveloped section of the brook that exists today, as most of the stream and its watershed exhibit significant urbanization and lack of stormwater management. There also exist few nearby streams that meet the criteria of being healthy, natural, and relatively unaltered that also share similar watershed characteristics; arguably, there exist few healthy, natural, and relatively unaltered streams in regions that exhibit highly impervious watersheds and little vegetation which also have low stream slopes and that are located near the New Hampshire coast. Simply put, there aren't many healthy streams (to say nothing of natural) that exist in an urban environment. In this case, the stream should aim to mimic its historic, natural system as best as possible while accounting for the upstream watershed conditions.

Luckily, there exists a relative wealth of information that has already been collected about the history of the Hodgson Brook watershed, the development over the years, how it exists now, and goals for restoring it. A 2004 restoration plan for Hodgson Brook was prepared by D. B. Truslow Associates with cooperation from the Hodgson Brook Local Advisory Committee, with funding provided by NHDES. This publication (among others) is available online at the DES' website for the watershed[1]. The publication contains much information about the history of the watershed, which provides a good place to start in order to find a relevant reference reach.

After reading the report, two sites were identified as having been restored at Pease – Grafton Ditch and Railroad Brook. Upon investigation of the two sites, and taking some brief measurements, neither site was suitable for use as a reference reach for Hodgson Brook. Both sites were rebuilt with very hard measures (a lot of rock bank and grade control), and both were far over-widened with little plan form geometry. However, stream form measurements were taken on Hodgson Brook immediately at the outlet from the Iron Rail Parcel – where the stream is in no way natural or healthy – but years of flowing through the drainage ditch there has allowed the confined brook to erode some of the banks, and establish some plan form geometry, and can provide metrics on what the channel is able to pass

[1] The website is located at: https://www.des.nh.gov/organization/divisions/water/wmb/was/hodgson/index.htm

currently. Classification of this section of stream, and the parameters used for evaluating the classification, may be seen in Table 2. The pipe system through the site was also surveyed, which provided the controlling upstream and downstream elevation, as well as the valley length.

Knowing the valley slope, the historic properties of the watershed, and approximate metrics from the regional geomorphic curves developed for New Hampshire, a dozen or so reference reaches around the seacoast area were walked and visually assessed. The most representative of all the reference reaches, Hutchins Creek in Kittery (43.106989°N, 70.705805°W), was then surveyed for plan form, cross sections, profile, and geomorphic properties. Overall, a 150-foot section of Hutchins Creek was surveyed (channel and floodplain). Planform geometry was collected for seven riffle-pool sequences over four meander wavelengths along the valley. Profiles of the thalweg, top of bank, bankfull, and water surface elevation were all collected. A total of 11 cross sections (7 riffles and 4 pools) were taken at locations where bankfull indicators were evident, and for each section all stream and floodplain widths, depths, and ratios were extracted and calculated. Of those, the sections were weighted according to which appeared to be the healthiest and most stable in the field.

The parameters for the Hodgson Brook and Hutchins Creek watersheds may be found in Table 1, and the geomorphic metrics for the profile, cross section, and planform of Hutchins Creek in Table 3 and Lower Hodgson Brook in Table 2b. Select values from the observed particle size distribution (done by pebble counts) for Lower Hodgson Brook may be found in Table 2a – with a plot of the data found in Figure 1. Additionally, planform and cross sectional definitions are shown on pages A1 and A2 of the Appendix, for reference.

It is important to note that at the time of this report, a brief investigation into the historic stream and valley slope of Hodgson Brook before development began revealed that the brook had approximate slopes of 0.25% and 0.30%, respectively. These slopes closely match those which were observed for Hutchins Creek, which are part of the many reasons it was chosen – along with the valley type, low development and highly natural watershed, watershed size, among others – to be the reference reach for this project.

Also of note, the flow values for Hodgson Brook at the Iron Rail parcel are preliminary estimates, having been developed using only two estimated flow points. A further investigation into flow values including a full watershed model is in progress, and is to be completed pending the full stream design. Included in this report are design metrics for planning purposes, with the full stream design pending further watershed investigations.

Table 1 - Select Watershed and Hydrologic Properties				
Property	Code	Units	Lower Hodgson Brook - Iron Rail	Hutchins Creek
Drainage Area	DA	mi^2	0.32	0.40
2-yr Peak Flow	Q2	cfs	6.80	6.46
5-Yr Peak Flow	Q5	cfs	11.1	14.3
10-yr Peak Flow	Q10	cfs	15.5	18.4
25-yr Peak Flow	Q25	cfs	24.0	24.0
50-yr Peak Flow	Q50	cfs	38.2	28.5
100-yr Peak Flow	Q100	cfs	53.0	33.4
Pipe/Valley Slope	S	ft/ft	0.01057	0.00176

Table 2a - Particle Size Results for Pebble Counts at Riffles Along Lower Hodgson Brook		
Particle	Size (mm)	Size (in)
D10	0.19	0.007
D50	0.38	0.015
D80	1.5	0.059
D90	7	0.276
D95	14	0.551

Figure 1 - Riffle PSD for Lower Hodgson Brook

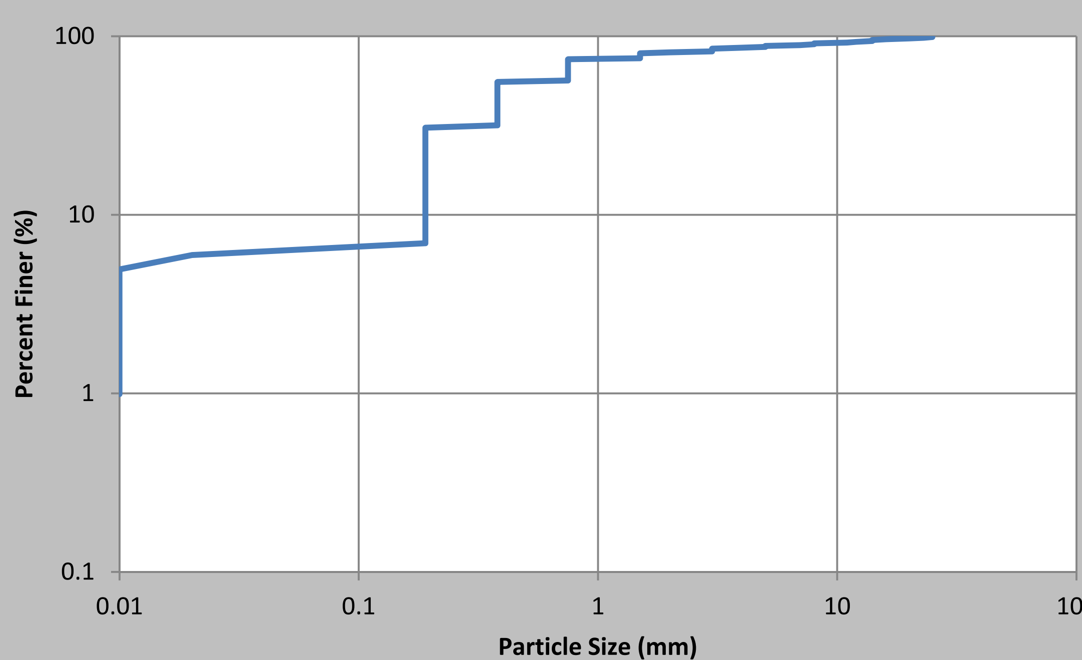


Table 2b - Lower Hodgson Brook at Iron Rail Parcel Reference Reach Data							
	Characteristic	Code	Units	Lower Hodgson Brook Observations			
				1	2	3	4
Profile	Stream Slope	S	ft/ft	0.00316			
	Valley Slope	V_s	ft/ft	0.00565			
	Sinuosity	k		1.072			
	Pool Length	L_p	ft	9.2	5.3	20.6	10.6
	Pool to Pool Spacing	P-P	ft	18.7	11.1	22.6	37.6
Cross Section	Bankfull Width	W_{bkf}	ft	5.76	4.60	3.69	5.54
	Floodprone Width	W_{fp}	ft	7.03	9.35	6.26	9.67
	Maximum Bankfull Depth	D_{max}	ft	0.89	0.76	0.62	0.80
	Average Bankfull Depth	D_{avg}	ft	0.55	0.44	0.51	0.40
	Entrenchment Ratio	ER	ft/ft	1.22	2.03	1.70	1.75
	Width to Depth Ratio	W/D	ft/ft	10.50	10.49	7.22	13.81
Plan Form	Radius of Curvature	R_c	ft	40.7	15.8	22.4	8.9
	Arc Length		ft				
	Average Bankfull Width	W_{bkf}	ft	5.8	5.5	5.0	4.6
	Rc:Wbkf Ratio		ft/ft	7.01	2.87	4.48	1.94
	Meander Belt Width	MBW	ft	13.1	16.9	14.7	
	Average Bankfull Width	W_{bkf}	ft	4.6	5.0	5.8	
	MBW/Wbkf		ft/ft	2.85	3.38	2.53	
	Meander Length	ML	ft	56.04	56.53	46.32	
	Average Bankfull Width	W_{bkf}	ft	5.8	5	4.6	
	ML/Wbkf		ft/ft	9.66	11.31	10.07	
Classification	Entrenchment Ratio	ER	ft/ft	1.22	2.03	1.70	1.75
	Width to Depth Ratio	W/D	ft/ft	10.50	10.49	7.22	13.81
	Sinuosity	k		1.072	1.072	1.072	1.072
	Stream Slope	S	ft/ft	0.00316	0.00316	0.00316	0.00316
	Bed Material	-	-	Sand	Sand	Sand	Sand
	Classification	-	-	G5c	B5c	G5c	G5c

Table 3 - Hutchins Creek Reference Reach Data														
	Characteristic	Code	Units	Hutchins Creek Observations										
				1	2	3	4	5	6	7	8	9	10	11
Profile	Stream Slope	S	ft/ft	0.00165										
	Valley Slope	Vs	ft/ft	0.00176										
	Sinuosity	k		1.20										
	Pool Length	Lp	ft	10.9	7.3	1.4	9.8	11.5	10.3	3.7				
	Pool to Pool Spacing	P-P	ft	24.4	13.5	14.6	15.1	15.1	21					
Cross Section	Bankfull Width	Wbkf	ft	7	6.5	6.5	5	5	7	5.5	5.5	6	5.5	5.0
	Floodprone Width	Wfp	ft	25	18	20	30	20	30	20	20	25	39.1	37.8
	Maximum Bankfull Depth	Dmax	ft	0.68	0.62	0.55	0.65	0.58	0.96	0.87	0.65	0.64	0.69	0.74
	Average Bankfull Depth	Davg	ft	0.476	0.434	0.385	0.455	0.406	0.672	0.609	0.455	0.448	0.38	0.48
	Entrenchment Ratio	ER	ft/ft	3.57	2.77	3.08	6.00	4.00	4.29	3.64	3.64	4.17	7.11	7.60
	Width to Depth Ratio	W/D	ft/ft	14.71	14.98	16.88	10.99	12.32	10.42	9.03	12.09	13.39	14.42	10.38
Plan Form	Radius of Curvature	Rc	ft	11.8	7.6	8.3	9.6	7.6	15.3	3.7	13.6			
	Arc Length		ft	16.3	7.0	10.1	11.6	8.1	13.6	7.4	12.0			
	Average Bankfull Width	Wbkf	ft	4.8	4.0	4.0	4.6	3.3	3.8	3.4	5.0			
	Rc:Wbkf Ratio		ft/ft	2.48	1.91	2.07	2.08	2.33	4.02	1.10	2.72			
	Meander Belt Width	MBW	ft	14.5	13.5	10.0	10.5	9.0	17.0					
	Average Bankfull Width	Wbkf	ft	5.0	4.5	4.5	4.0	4.0	5.0					
	MBW/Wbkf		ft/ft	2.90	3.00	2.22	2.63	2.25	3.40					
	Meander Length	ML	ft	40.1	23.8	27.2	30.4	30.3	36.0					
	Average Bankfull Width	Wbkf	ft	5.0	4.5	4.5	4.0	4.0	5.0					
	ML/Wbkf		ft/ft	8.02	5.28	6.04	7.59	7.57	7.20					
Classification	Entrenchment Ratio	ER	ft/ft	3.57	2.77	3.08	6.00	4.00	4.29	3.64	3.64	4.17	7.11	7.60
	Width to Depth Ratio	W/D	ft/ft	14.71	14.98	16.88	10.99	12.32	10.42	9.03	12.09	13.39	14.42	10.38
	Sinuosity	k		1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	Stream Slope	S	ft/ft	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165	0.00165
	Bed Material	-	-	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
	Classification	-	-	C5	C5	C5	C5	C5	C5	E5	C5	C5	C5	C5

Design Metrics for Stream and Floodplain Using Natural Channel Design

The natural channel design process uses the collected reference reach data to develop proposed metrics to create a stream design which can accommodate site constraints (usually things like incoming flows, upstream and downstream invert elevations, valley width, sediment supply, etc.) and provide a stable stream form. The site constraints control selected design metrics, which are then used to calculate – often quite iteratively – the remaining metrics within a range, determined by the reference reach data. The constraints at the project site include the stream inverts at the start and end (therefore the maximum stream slope), the valley width, the watershed properties, and the site hydrology. The most difficult of all the constraints to calculate for this project were the flows incoming to the site. Upstream of the site, the watershed is extremely developed, and in order to calculate flows using common methods (Rational Method, SCS Curve Number Method, regression equations, etc.), a full watershed model would have been necessary. Such a model is in development at the writing of this report; the output from which will provide return period flows, but may not well represent the most geomorphically-appropriate flows. The dominant channel-forming flow is referred to as the bankfull flow, and for undeveloped watersheds is commonly in the range of the 1.5- to 2-year peak flow. However, this is just an approximation, and is not globally true for all watersheds and streams. Recently, project team members were involved with a geomorphic assessment on a highly-impacted, urban stream in northeast Ohio. It was found that the bankfull flow for this stream was 60% of the Q1 – well below the expected return period for a typical, more natural stream. Ohio district employees further reaffirmed this finding, stating that nearby streams were found to have bankfull flows with return periods of 1 year and less. Across the United States, others have documented that the higher the degree of urbanization, the more frequent the bankfull flow (1-5 year return period or lower). So while flows with defined return periods are to be determined, the actual channel-forming flow may have a less common return period, and that is the flow to which the channel should be designed.

In order to appropriately estimate what this flow might be, a more site-specific method was used: estimating the bankfull flow from channel indicators. Immediately downstream of the site, Hodgson Brook has – for decades – existed in an overly deep drainage ditch with no access to its floodplain. Over those years, it has eroded the banks during larger flows, and created some observable bankfull indicators. Using the survey data taken at this location, with specific data taken at bankfull locations, values could be calculated to estimate the channel-forming and larger flows. The flows that formed the more natural sections of the unnatural drainage ditch may be assumed to be the same as what would flow in Hodgson Brook at the site. The return period of these flows were not estimated; rather, the flows which caused bankfull indicators were called the bankfull flows. In theory, the bankfull flow is the flow at which the majority of moves; or the discharge at which channel dimension maintenance is most effective. This happens in healthy streams, on average, around the 1.5- to 2-yr flow. For the stream and watershed at the site – the watershed being highly impervious, and lacking a consistent sediment supply – the return period of the bankfull flow is challenging to estimate. This is why the use of geomorphic indicators downstream of the site, coupled with the survey of those indicators and the stream, was determined the best way to estimate the bankfull flow for preliminary stream sizing. These calculated bankfull flows may be found in Table 1. Similarly, the historic drainage network design flow – though there is no return period placed on it – may be estimated by the constraining factors of the stream system upstream of the restoration. The proposed pipe diameter, material, and slope were used with assumed outlet control (no effect of the stream system on the pipe's ability to move water – internal losses accounting for the control of the flow), to calculate the maximum amount of water which may reasonably be seen entering the system. A quick Manning's Equation check (for the assumed outlet control type of flow) showed that that flow (approximately 155 cfs) would not overtop the stream corridor valley walls. Regardless of when this flow or any other flow higher than the bankfull overtop the stream banks, the goal of the design metrics were to include as much floodplain as possible, allowing the flood flows to use the floodplain as necessary, while containing the bankfull flow.

Knowing all the constraints at the site, the stream geomorphic metrics dictated by those constraints were calculated, and the remaining design metrics were iteratively determined to address the hydrology as best as possible. The calculated stream geomorphic metrics and constraining variables may be found in Table 4. These proposed metrics were given as a guide for design – they do not have to be strictly followed, but should be near to or within the range of values shown in the table. They are dependent on the controlling factors, such as inlet and outlet inverts, which allow adjusting the stream dimensions within the ranges shown (or, if outside the ranges, the metrics may be adjusted based off the ratios shown: entrenchment ratio, width to depth ratio, pool-to-pool spacing, etc.

In addition to the designed stream metrics, several other site-specific factors are important to consider, and should be accounted for in the design. Due to the highly developed nature of the watershed, the sediment supply to the site will be quite limited. Aside from the restored stream's bed and banks, there is not much of a source of sediment, other than construction activities and sanding during the winter. Thus, the sediment supply is sure to be of a much finer gradation and in much more limited supply than the natural stream used to have. Because of this, bankside vegetation will be very important to maintaining the stream dimensions/alignment, and the sediment gradation used for stream construction will need to be sized and mixed well to prevent against vertical erosion of the restored stream. In addition to the vegetation and sediment, in-stream structures (log cross vanes) are recommended to help keep the stream in place both vertically and horizontally, and floodplain sills are recommended to help prevent against avulsions. To help the stream keep its plan form while vegetation grows, the banks may be constructed out of staked, biodegradable compost sock or coir logs. These usually have a lifespan of 3-5 years before they begin to degrade, which should allow sufficient growing seasons for faster-growing riparian vegetation and plants to take root and hold the stream form. Please refer to Figure 2 for a better idea of how these banks are to be used, and what one such project looks like four years after construction. These coir log banks should also provide stability, and help prevent against any avulsions, though the floodplain and channel should be able to handle them on their own.

Some of the design metrics are presented on pages A3 and A4 of the Appendix, for reference of each portion of the restored stream they apply, and their values. A more complete table of the proposed metrics may be found on pages A15 and A16 Conceptual details for constructing a log cross vane and a floodplain sill may also be found in the Appendix, on pages A5 and A6.

Figure 2 - Coir Log Rolls along Restored Pettee Brook, near Adams Towers on UNH Campus in Durham, four years after construction. Note how the coir logs are still intact, and have trapped sediment. Roots and grasses have grown into and through them.

Table 4 – Hodgson Brook Proposed Stream Metrics and Ranges					
Property		Code	Units	Value	Range (+/-)
Cross Section	Maximum Bankfull Depth	Dmax	ft	0.75	0.1
	Average Bankfull Depth	Davg	ft	0.50	0.1
	Floodprone Depth	Dfp	ft	1.50	0.2
	Bankfull Width	Wbkf	ft	5.5	0.5
	Floodprone Width	Wfp	ft	30.0	2
	Width/Depth Ratio	W/D	-	11.0	1.3
	Entrenchment Ratio	ER	-	5.5	0.1
	Bankfull Area	Abkf	sqft	2.75	0.8
Plan Form	Sinuosity	k	-	1.23	0.05
	Meander Belt Width	MBW	ft	18.0	2
	Meander Length	ML	ft	40.0	5
	Radius of Curvature	Rc	ft	12.5	2.5
	Pool Length	Lp	ft	16.2	4
	Pool to Pool Spacing	P2P	ft	24.5	4.5
	Stream Slope	Slope	ft/ft	0.00946	0.0020
	Valley Slope	VS	ft/ft	0.01160	0.0010
Flow	Low Flow	Qlf	cfs	0.2	0.1
	Bankfull Flow	Q	cfs	6.9	0.4
	Floodprone Flow	Qfp	cfs	32	2
Riffle Stable Particle Size	Low Flow - Rosgen	RDlf	in	0.7	-
	Bankfull - Rosgen	RDbkf	in	2.5	-
	Floodprone - Rosgen	RDfp	in	2.8	-
	Full Flow - Rosgen	RD100	in	5.7	-
	Low Flow - LWM	LDlf	in	0.2	-
	Bankfull - LWM	LDbkf	in	0.9	-
	Floodprone - LWM	LDfp	in	1.1	-
	Full Flow - LWM	LD100	in	2.9	-
	Low Flow	LDlf	in	0.4	0.3
	Bankfull	LDbkf	in	1.7	0.8
	Floodprone	LDfp	in	1.9	0.9
	Full Flow	LD100	in	4.3	1.4

The design metrics shown in the above table were initially provided based upon conceptual constraints at the site, and were intended for use as a baseline upon which a full design could be proposed for the site. Subsequent meetings, revisions, and plans have resulted in the Streamworks team being contracted to perform the full stream design for the site. These metrics are to be used as base values and constraints, but ultimately will be defined as part of the site construction plan sheets.

Construction Sequencing

In general, stream restoration begins at the upstream end of the project and works downstream. At the site, the proposed stream corridor does not follow the path of the existing pipe carrying Hodgson Brook, but parallels that pipe and will be reconnected to this infrastructure at the start and end of the project. This is beneficial, as the stream can be constructed in the dry and temporarily stabilized before being opened up to flows and fully vegetated. As this is a part of a larger development project, the construction sequence below details only activities pertaining to the stream corridor. It does not include activities that might usually be included in such a sequence, such as (but not limited to) clearing and grubbing, construction layout, traffic control, erosion control, staging areas and material disposal. The sequence is subject to change to integrate fluidly with the entire project, and may change to the desires of the contractor, as they see best fit. Any changes shall be discussed, cleared, and/or proposed by project engineers, and may be made in the field during construction. This construction sequence assumes that the existing drainage infrastructure is to remain in place until the stream is built, and that proposed drainage infrastructure that will direct flows into the stream will have already been installed. An overview of the sequence is listed below, followed by a detailed sequence which describes each step in greater detail.

Stream Corridor Construction Sequence Overview:

1. Excavate and grade the stream corridor from the top of the valley, down to the top of the floodplain, and on down towards the center of the corridor.
2. Perform fine grading of stream channel, banks, structures, and sills.
3. Seed the site with temporary stabilization grasses and allow to grow.
4. Open up the stream at each end to flows.
5. Seed and plant the site fully.
6. Establish monitoring locations and components.

Detailed Stream Corridor Construction Sequence:

1. Excavate and grade the stream corridor, from the top of the valley elevation, down to the top of the floodplain elevation and into the center of the corridor, leaving a construction access ramp at the start and end of the project. If required, the floodplain grade may be initially set lower to allow for backfilling of loam, should the existing earth be of poor material. Do not over-compact floodplain or valley slopes; compact only by track-walking or applying pressure with the bucket of the excavator. The floodplain and slopes should be left rough, to allow seed to grow more easily. Leave an access path along the top of the valley to one or both sides, to allow for the transport and temporary staging of in-stream materials and movement of heavy equipment. This may also be accomplished using the upstream access ramp to deliver materials behind the excavator, using the corridor as the path. This is not preferred, since over-compaction is likely to occur resulting from the excessive traffic of heavy equipment.
2. Construction will be performed in the dry, and will begin at the downstream end of the restored Hodgson Brook. Starting at the downstream end of the stream, begin by excavating the pool which will redirect water into the existing culverts below Goose Bay Drive from upstream of the

pool. Working from upstream of the section under construction, begin the fine grading of the stream channel. This may be done by over-excavating the channel and banks, then installing the compost/coir log roll stream banks (one base roll and one top roll – the base almost entirely embedded in the bed material, with the top roll forming the channel bank). Initially the bed slope of the stream is graded uniform, then riffles and pools may be graded near the finishing steps. The compost/coir log base should sit below the thalweg of the stream, and once set in place at the correct elevation, may have fill placed behind the rolls. The stream channel should then be backfilled at the riffles and pools with appropriately graded material, leaving the pools as deeper features in the stream channel. As construction continues upstream, merging the compost log rolls should be done such that the upstream-most end of the rolls is curled out from the bank, and the next upstream roll may be placed linearly into the bank, and flows will be directed as to not cause erosion or avulsion between the rolls (shiplapped construction). Extra heavy attachment (connections) of the rolls at these locations should be performed with biodegradable materials. While construction continues, backfilling of any floodplain loam – should it be deemed necessary – should be performed to the final floodplain grade. Construct in-stream structures (log cross vanes) as they are reached, as well as floodplain sills. Additional floodplain features may be constructed at this time, such as habitat logs and boulders, tree stands, and vernal pools (all optional, but recommended). Construction materials may be provided on-demand using the access path along the top of the valley. Materials (logs, rebar, geotextile, riffle material, compost rolls, etc.) may be set outside the stream corridor, and gathered by the excavator from inside the corridor, or less preferably, placed behind the excavator in the corridor. All fine grading and structures should be checked for elevations and geomorphic metrics before starting the next upstream section.

3. Seed and mulch the corridor and top of valley with the temporary stabilization seed mix (preferably a conservation mix with at least 10% wildflower seeds, though may be of a perennial ryegrass). Seed to the amounts as specified by the seed manufacturer – with greater application on the steeper valley slopes – and mulch with wood chips (90% ground coverage) or straw (to a depth of 1 inch). Water as specified by the seed manufacturer, if drought persists longer than the recommended watering frequency. Allow the grass to grow to a height of at least 3 inches before proceeding to the next step. If any bare patches exist, reseed and mulch to ensure stabilization. This step may be performed as a section of stream is completed, which may reduce the overall construction duration, though it may come at a cost of increased watering effort.
4. When all previous steps have been completed, the stream should be opened up to flows. First, the existing drainage culvert at the downstream end should be excavated and removed. Grade and temporarily stabilize the incoming flows to the downstream pool. Proceed to the upstream inlet to the stream and construct (if not already done in step 2) the inlet pool and grading. Flows may then be directed into the stream channel, in a manner that shall be determined in the field, based on the manner in which the incoming culvert and upstream infrastructure is being constructed. Allowing incoming flows to the stream may be performed concurrently with that of the outlet, provided the contractor has the labor and equipment available. However, caution should be exercised to ensure that flows are able to exit the corridor fully and appropriately, to prevent damage and/or flooding to the site. This step should be performed at low-flows.

5. With the stream now carrying flows, the relic culvert that carried the stream may be removed, and the entire site should be seeded and planted as specified in the planting plan. This may be done completely or partially as construction of the stream takes place. At this point the temporary stabilization grass should have taken hold enough to provide some cover for seeds, and keep in moisture during the day. This step should only be done during a growing season and not in mid-summer or winter, to help ensure planting success. This step may be done after step 6, if construction ends before a planting season is set to begin. This step should be performed when the appropriate equipment is available. This may help expedite the process, rather than performing it all completely by hand.
6. Finally, monitoring devices and components should be installed, measurements recorded, and instruments calibrated as necessary. Please refer to the monitoring plan section of this report for more details on the monitoring methods and schedules.

As noted in the detailed construction sequencing, some aspects of construction may overlap, or may be done concurrently, per the desires of the contractor. For example, backfilling of loam may be reserved for after the stream has been constructed, if it is desired to be performed from the top of the valley. Planting of livestakes and other riparian plants may be done as the stream is constructed. This may require watering to be performed regularly, especially lower on the floodplain, to ensure the vegetation has enough water to grow without any baseflow in the stream. It may also require longer stagnant time for the plants, which would have to be kept healthy during the duration of the construction. More detailed information and planting notes may be found in the following section. Habitat features (floodplain boulders, logs, vernal pools, etc.) may be constructed after the stream is finished, from the top of the valley. As stated before, any alterations to the construction sequence will first be cleared by the project engineers before implementing them during construction.

Planting Plan for the Floodplain and Riparian Corridor

The stream corridor has two distinct zones for planting: the floodplain (Zone 1) and the upland, or valley slopes (Zone 2). These two zones are defined, based on the available water, rate of inundation, and the drain rate. The two zones were broken down even further, with each zone having a Lower and an Upper part (1L, 1U; 2L, 2U). Furthermore, Zone 1L contains an additional sub-zone that refers to the stream banks, just up onto the top of the banks. Here, grasses and groundcover is often not successful, but shrubs may, and these are to be planted differently than the rest of Zone 1L, resulting in its own classification. This sub-zone contains two sections, one along the outer bank of each bend, and the other containing all the other banks (inner bend and riffles). The outer bank of each pool is referred to as Zone 1Lp, and the other banks are in Zone 1Lb. The difference in the two zones is only to differentiate between planting densities, and to help determine quantities.

Table 5 – Planting Plan Species

Planting Species		Common Name	Zone
Grasses	Lolium Perenne	Perennial Ryegrass	1, 2
	Cornus canadensis	Bunchberry	1U
	Solidago spp.	Goldenrod	1
	Impatiens capensis	Jewelweed	1
	Mitchella repens	Partridgeberry	1U, 2
	Asclepias incarnata	Swamp Milkweed	1
	Thalictrum polyganum	Tall Meadow Rue	1
Shrubs	Prunus virginiana	Chokecherry	1U, 2
	Cornus racemosa	Gray Dogwood	1U, 2
	Viburnum alnifolium	Hobblebush	1
	Vaccinium angustifolium	Lowbush Blueberry	2
	Salix discolor	Pussy Willow	1
	Rubus idaeus	Raspberry	2
	Cornus stolonifera	Red Osier Dogwood	1
	Cornus amomum	Silky Dogwood	1
	Alnus rugosa	Speckled Alder	1
	Hammamelis virginiana	Witch Hazel	1
Trees	Salix nigra	Black Willow	2U
	Prunus serotine	Black Cherry	2U
	Acer rubrum	Red Maple	2U
	Quercus alba	White Oak	2U
	Fraxinus americana	White Ash	2U

The species selected for the project are listed in Table 5, and are sorted by the type of species – grasses and ground cover, bush-like trees and shrubs, and trees. Each species is listed by both their common name and Latin name, as well as the zone at which it is to be planted. The zone for each may be listed specifically (1L), or more broadly (2). These species were selected from the list of Native Shoreland/Riparian Buffer Plantings for New Hampshire; a table of species which are both native and non-invasive, which was published by the NH Department of Environmental Services. While this list provides many species, the final species used in construction of the site may not be limited to those listed. Any other species will be checked and approved by the engineer before being ordered, or placed in the field. This is especially true of any seed mix that may be used at the site; the selected mix (mixes) that the contractor shall use should be checked by the engineer before placement, or before ordering any such seed mix.

A list of densities and species to be planted in each zone may be found in Table 6, for quick reference.

Table 6 – Planting Plan Details			
Planting Zone	Zone Description	Species	Density
1Lp	On the outer bend of a pool from the point of curvature to the point of tangency, beginning at the mid-bank elevation, up over the top of the bank, and offset from the top of the bank 1 foot.	Livestakes of Pussy Willow, Red Dogwood, Silky Dogwood, and Speckled Alder	1 livestake per 2 sf
1Lb	From the mid-bank elevation up over the top of the bank and back 1 foot, for all stream banks other than Zone 1Lp	Livestakes of Pussy Willow, Red Dogwood, Silky Dogwood, and Speckled Alder	1 livestake per 4 sf
1L	From one outer bend of the channel down one meander wavelength to the next outer bend of the channel, inwards along the top of the bank.	Perennial Rye (temporary stabilization); Native Wetland Seed Mix including but not limited to: Tall Meadow Rue, Goldenrod, Swamp Milkweed, Jewelweed, and Ryegrass; Hobblebush, Pussy Willow, Red Dogwood, Silky Dogwood, Speckled Alder, and Witch Hazel	Rye: per seed mix Wetland Mix: per seed mix Shrubs: 1 plant per 75 sf
1U	On the floodplain bench, outside the meander belt width corridor, up to the top of the floodplain bench	Perennial Rye (temporary stabilization); Native Wetland Seed Mix (as described previously); Bunchberry, Partridgeberry, Swamp Milkweed, Chokecherry, Gray Dogwood, Hobblebush, Pussy Willow, Witch Hazel	Rye: per seed mix Wetland Mix: per seed mix Shrubs: 1 plant per 50 sf
2L	From the top of the floodplain bench, up 1/4 of the way up the riparian corridor slope	Perennial Rye (temporary stabilization); Native Conservation Seed Mix; Partridgeberry, Chokecherry, Gray Dogwood, Lowbush Blueberry, Raspberry, Black Willow	Rye: per seed mix Shrubs: 1 plant per 20 lf
2U	From the top of Zone 2L, up over the top of the riparian corridor and back 1 foot.	Perennial Rye (temporary stabilization); Native Conservation Seed Mix; Lowbush Blueberry, Raspberry; Black Willow, Black Cherry, Red Maple, White Oak, White Ash	Rye: per seed mix Shrubs: 1 plant per 25 lf Trees: 1 tree per 40 lf

For further details on the planting plan, including diagrams of the planting locations on a plan view and a complete description of the benefits of each species, please refer to the Appendix.

Vegetating the project site will be done using several types of planting methods. Closest to the stream, livestakes should be placed, rather than planting full shrubs. Livestakes are relatively straight clippings two to four feet in length and no greater than an inch in diameter at the base, cut from live and healthy species, and should be cleared from leaves and smaller branches. Leaves left on the livestake cause it to dry out more easily. From places where branches and buds are removed, roots and new branches will sprout from the clipping. Livestakes should be soaked in water for at least two days prior to installation, if at all possible, long enough for roots to sprout. To plant a livestake, first create a hole using a sledge hammer and a hammer rod (a piece of 1" diameter rebar works as well), to a depth of one third the length of the livestake. Gently place the livestake in the hole without damaging the base, and tamp-down the ground around the hole with a hand or foot. Livestakes should be kept wet for the first two weeks, until they have had the opportunity to sprout roots.

Seed will also be placed and mulched as described following, all along the floodplain and upland slopes. Seeding will first be done with a rye grass to stabilize any bare earth expected to exist longer than 5 days. The floodplain may then be seeded with a wetland, riparian, or conservation seed mix that contains no invasive or non-native species. Seeding with such a mix should follow the manufacturer's guidelines. A general specification for the final seeding is a conservation mix with at least 10% wildflower seeds.

Finally, planting of trees and shrubs (and flowering plants, should no wetland/riparian seed mix be used) will be performed throughout the floodplain and upland areas. It is preferable to have mature plants over planting seeds, and more mature plants are preferred to saplings. Younger plants are more vulnerable to being transplanted, and do not recover well – if at all – from grazing. Again, trees and shrubs should be placed in their appropriate zones, and should be planted in a non-linear fashion.

To begin the planting, first the grounds should be checked for any invasive plant species or any debris/trash, and cleared of these. Seeding should occur over the entire construction area, and should begin with temporary stabilization. Stabilization should be of a Rye seed mix, which should be mulched with straw, preferably (to a depth of 1"). The mulch should be clean and free of invasives and any other contaminants. The grounds should be watered as necessary, or as specified by the seed manufacturer. At the same time, livestakes (if they were not already set during construction) may be placed in the stream banks and at the top of the banks.

After the grass has been allowed to grow, and any bare spots have been reseeded, planting and seeding of the remaining site may be performed, beginning at the lowest part of the floodplain, on up to the top of the valley slopes. Protective tubing may be desirable to help prevent any young plants from grazing before they reach a more adult size. Support stakes and twine may also be used, to help stabilize the plants until they develop larger root systems. Planting instructions for each plant should be followed, as some require more specific needs than others, and may even have different planting seasons when they should be installed. The instructions for each may be very important, as a survival rate of 75% within the first 3 years is commonly determined to be the goal of a restoration project in New Hampshire.

When performing the final planting, it is important to note that the densities shown are for an average over the corridor, and to help determine quantities. Plantings should be performed in a non-linear (irregular) fashion, and should avoid being homogenous. Some areas should be more or less dense, with greater or fewer different species than other areas. Trees in the upland should be planted at the top of the valley, and partway down the slope; bushes may be clumped together near or far from the channel; livestakes should be planted mid-bank and to the top of the bank. The zones and densities are shown for reference, but are not firm constraints. Natural systems are usually very diverse and random, and projects should attempt to embrace and mimic that variability. In addition to Tables 5 and 6, a list of the wildlife which benefit from the planting species, as well as the food value each species provide, may be found in Table A1, on pages A7 and A8 in the Appendix.

Five Year Monitoring Plan and Methods

Hodgson Brook is the main source of fresh water to North Mill Pond in Portsmouth, and as such, the health of the stream is important to several local organizations (Advocates for the North Mill Pond [ANMP], Hodgson Brook Local Advisory Committee [HB LAC], Pease Development Authority [PDA]), and governments (City of Portsmouth, NH DES). There have been several studies completed on the watershed that are publicly available, and quite a few documents published that cover the history, water quality, and goals for restoring the watershed. Some of the publicly available documents include[2]: an Environmental Quality Characterization for Hodgson Brook in Portsmouth, New Hampshire (2003), a Watershed Restoration Plan for Hodgson Brook (2004), a Hodgson Brook Watershed Monitoring Plan – A guide for Monitoring Environmental Quality (2004), and an Implementation Plan for Hodgson Brook Watershed Restoration (2005). These documents provide detailed accounts of the history of the watershed, the current use and quality, and sets goals for restoring the watershed and methods to achieve those goals. The information provided in those documents was used to help develop the monitoring plan for the site. Monitoring of the site will be performed for five years after the construction of the project.

The NH DES lists water quality standards that provide a framework for assessing surface waters in the state, based on seven designated uses. The standards are divided into three parts: designated uses, water quality criteria, and antidegradation. The seven designated uses represent the ways in which the surface water is intended to be used: aquatic life, fish consumption, shellfish consumption, drinking water supply, primary contact recreation, secondary contact recreation, and wildlife. The water quality criteria are defined for each designated use by markers and limits, aimed at protecting each surface water use. Finally, the antidegradation provision is set to protect existing uses and to prevent any degradation to any surface water in terms of the existing water quality or designated uses.

Hodgson Brook (as detailed in the Watershed Monitoring Plan [WMP]), has been assigned three designated uses for which monitoring should be performed: Primary and Secondary Contact Recreation, and Aquatic Life. Indicators for each, and the recommended monitoring methods, were defined in the WMP, and are listed below. The methods and indicators below were cropped to eliminate indicators and methods that the report either did not recommend, or were considered not applicable. Also not included are some of the recommended monitoring methods that may not be applicable or may be included within other methods. Some of the monitoring frequencies have been adjusted in order to provide better data for a restoration project, and not existing conditions. In addition to the recommended monitoring methods given in the WMP, methods for monitoring the vegetation and stability of the constructed stream were developed. The full list of monitoring methods, schedules, and frequencies may be found in Table 7.

An annual monitoring report shall be produced and sent to all interested parties (ANMP, HB LAC,NH DES, etc.) and all data provided to NH DES for inclusion in the state databases at the same time. Please

[2] All four documents may be found at the DES website for Hodgson Brook: https://www.des.nh.gov/organization/divisions/water/wmb/was/hodgson/reports.htm

refer to state protocols for data reporting; different data may require different protocols. DES may also provide sampling kits and training for collecting select methods and indicators (1, 2, 3, 4, 5, and 10) through their Volunteer River Assessment Program (VRAP). The monitoring report should be produced annually in January or February, which gives enough time to process all the data collected during the previous year, and is after any sampling, vegetation monitoring, or surveying is likely to be done.

Table 7 - Iron Rail Parcel Restoration Monitoring Methods and Scheduling

Indicator Number		Indicator	Monitoring Method	Events per Year	Number of Locations	Total Events
Recreation	1	Bacteria	Minimum of 4 (2 dry and 2 wet) E. Coli samples collected annually between 6/1 and 9/15	4	2	40
	2	Various Indicators	During sampling dates, record water color and the presence of any of the following on the field data sheet: algal bloom, foam, debris, scum, slicks, odors, and surface floating solids	4	2	40
Aquatic Life	3	Dissolved Oxygen	Minimum of 4 (2 dry and 2 wet) measurements taken annually from 6/1 to 9/15 between 5:00 am and 8:00 am	4	2	40
	4	pH	Taken at the same schedule as DO	4	2	40
	5	Habitat Assessment	Complete using DES Habitat Assessment Field Data Sheets annually during late fall	1	1	5
	6	Flow	Monitor flow conditions to determine baseflow and stormwater discharge for a range of flows may be done concurrently with sampling events, or as required to obtain enough flows to develop a comprehensive rating curve	4	2	40
Additional Indicators	7	Stream Stability	Full site survey of all topographic features performed once as an as built, then again in years 3 and 5	1	1	3
	8	Planting Success	Visual site assessment for any high-mortality areas, assessment of 4 vegetation plots three times; once after the first full growing season, then every other year (may be done during full survey)	1	4	12
	9	Visual Health Assessment	Pictures taken at set photo points twice per year, during the spring and the fall	2	1	10
	10	Other Indicators (Temperature, Turbidity, Conductivity)	Taken at the same schedule as DO	4	2	40

In addition to the monitoring methods shown, per the request of DES and the local conservation commission, trash shall be removed from the stream and site as part of the scheduled maintenance for the landscaping at the site. If trash is observed during regular maintenance, it shall be removed and disposed of properly.

Monitoring locations for each of the methods listed in Table 7 should be determined either as construction is ongoing, or after completion. A map of suggested monitoring locations may be found on page A14 of the Appendix. Not all locations shown on the map are definite; many will be determined and set in the field, after construction is completed. For example, benchmarks and photo points will need to be located in locations with good viewing angles, and away from trafficked or maintained areas; staff gages (or monitoring probes) should be set in easily accessible locations, but in permanent water; vegetation plots should be set at areas of high interest, or in locations that represent a diverse range of variables (species, zones, sunlight, infrastructure, etc.), among other things. Detailed descriptions of the monitoring methods, recommended locations, and data are as follows:

Sampling

Sampling is recommended at two locations at the parcel: first at the existing junction box, located where the stream first enters the parcel (access may be obtained via the manhole cover and into the large junction box); the second, at the downstream end of the project where the stream empties into a pool which routes the water under Goose Bay Drive. If the first location is considered too dangerous, or no permission is granted to enter the box, sampling may occur at the outlet of the 54" HDPE pipe directing Hodgson Brook into the proposed stream corridor. It is preferred to sample at the junction box, as the water there has not come into contact with any proposed infrastructure (LID stormwater outfalls, stream corridor). This would be very useful to compare the quality of the water before the project and after. Sampling during high flows may easily be performed from outside the junction box, using sampling rods with attached sample containers. On sampling days, samples should first be taken at the downstream location, then upstream to minimize possible sample disturbance contamination. Performing the sampling should be completed in one day, with as little difference in time and climatic conditions as possible. Concurrent sampling is recommended. All sampling should conform to DES VRAP protocols, unless not available, in which case they should follow any State or EPA guidelines.

Sampling will be performed in two manners, with another set of data being collected observationally. Sampling for bacteria (E. Coli) will be conducted by obtaining samples collected in the field, preserved for transport, and having samples analyzed at a lab, reported in counts per 100 mL. For fresh water, DES has a limit of 126 counts per mL for E. Coli. Sampling for other indicators (Dissolved Oxygen, pH, Temperature, Turbidity, and Conductivity) will be done using probes or meters which can detect each parameter. Kits containing these devices may be available through the DES' VRAP program, and training for using the kit and contents may be available as well. Observational data to be taken at the same time as the samples include the weather, as well as other indicators of stream health: water color, algal bloom, foam, debris, scum, slicks, odors, or surface floating solids. These can be noted and recorded along with all the other indicators – except for bacteria – on the sample Hodgson Brook Field Data

Sheets, seen on pages A12 and A13 in the Appendix. These data sheets were adjusted slightly from the data sheets given as part of the VRAP program.

In the Hodgson Brook WMP document, it is recommended that at least five samples are taken every other year (between 5/24 and 9/15 for E. Coli and 6/1 to 9/30 for all others) at locations defined in the paper. One of the locations is just downstream of the site, on the brook to the east of the intersection of Corporate Drive and Rye Street. This location has quite a bit of environmental monitoring data (EMD) available publicly from the DES' OneStop data server, dating from 2005 to 2016. Sampling for the monitoring of this project is recommended to be performed four times each year – twice during 'dry' weather, and twice during 'wet' weather. Dry weather sampling should occur on a day without precipitation the day of sampling as well as the three full days prior to the sampling date. Wet weather sampling should occur during or immediately after a storm with a precipitation depth of >0.2 inches, when flows are elevated from the baseflow. Sampling during wet and dry weather provides a comparison of the water quality during baseflow and storm events, may help identify sources of contamination, and will show the performance of the site. It is preferable that sampling of all metrics be done at the same time, and to make the timing more easily defined, all sampling should be done between the latest start date and earliest end date defined in the WMP; thus sampling should take place from 6/1 to 9/15 between the hours of 5:00 am and 8:00 am.

Observations and Visual Assessments

Other data that will be taken at the site should assess the stream system health, and should include vegetation plots, photo points, habitat assessments, and flows. Photo points should be set after the construction has been completed, and should be marked at locations that can be repeated in subsequent years by both location and direction, so that pictures may be compared through the years. The photo points should capture the entire site, as well as any notable features, such as the vegetation plots, or any culvert inverts (to show scour, perhaps). Photo points should be taken twice per year, in the spring and fall, and should be included in the annual reports.

The habitat assessments will be performed using the Habitat Assessment Field Data Sheets for Low Gradient Streams. The assessment rates habitat parameters for health on a scale of 0 to 20, using descriptions to guide the assessor as to what to look for. The data should be compiled in the field, using any pictures as evidence and a field book for notes, and should be performed once each year in the fall, during a period of low flow. These sheets were obtained from the DES' VRAP website, and may be found reproduced here in the Appendix, on pages A9-A11.

Vegetation plots should be set after construction and the complete planting and seeding of the site has been completed, and should not be assessed until after one full growing season has passed. It is recommended that four vegetation plots be set, representing a thorough sample of variables; sunlight, planting zones, species density, etc. Two vegetation plots should span the width of the stream corridor, and two should be located in 10'x10' squares on the floodplain. These plots should be assessed for mortality of planted plants, coverage, invasives, and species diversity. In addition to the four plots, a site-wide visual assessment for the mortality of any of the planted plants should be conducted, tallied, and reported. A goal of 75% survival is usually recommended for projects of this type. The reason for the mortality of any plants should also be recorded to the most accurate extent possible – water content, sunlight, trampling, foraging, animal burrowing, etc.

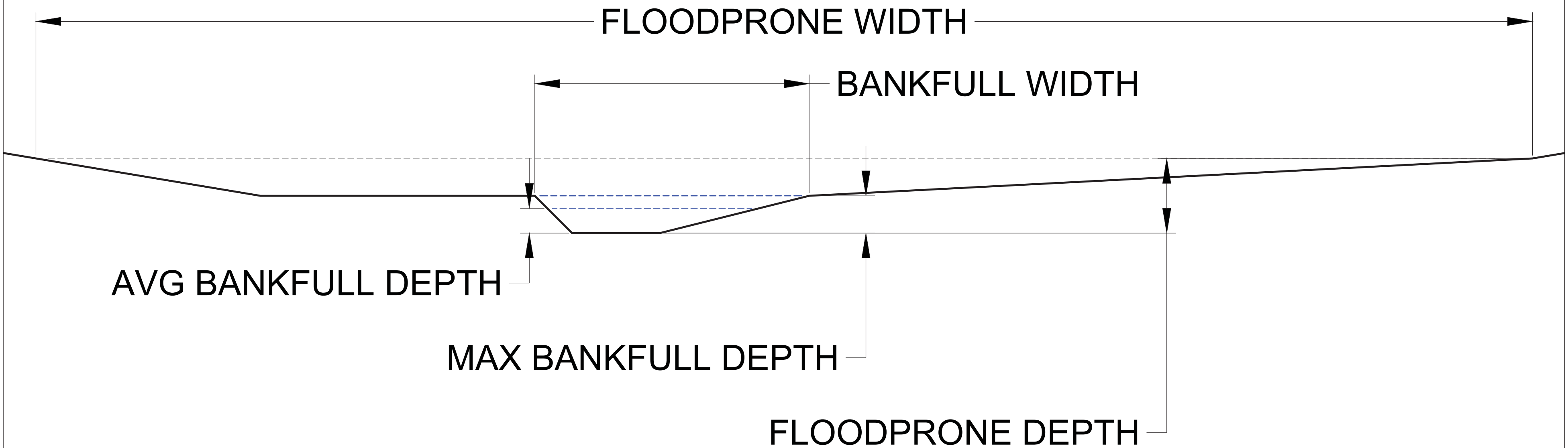
Finally, flows should be observed, recorded, or downloaded from pressure transducers during each of the sampling events, at a minimum. More data is recommended to help create an accurate rating curve for each location. It is recommended to have two flow locations at the same two sampling locations. To begin, theoretical hydraulic rating curves (water depth versus discharge) for each site should be developed. Over time, and with base flows and storm flows measurements, the curves may be more accurately empirically developed. Flow calibration should be performed at both sites for a range of flows, with a concentration of measurements at the low-flows. Calibration may be performed using a flow meter in the stream, or in a pipe, surveying a pipe and calculating the flow based on the flow depth, or by calibrated weirs or flumes that will give accurate flows, provided the water upstream has filled the reservoir created by the device. For each site, a minimum of 8 calibration flows are recommended for the empirical rating curve, and more points are encouraged. Early and frequent, accurate rating curve calibration will make the collection of this data go much more quickly in subsequent years.

Site Survey

The final monitoring method will be to perform a full site topographic survey, making sure to include all relevant and important features, such as: benchmarks, sampling locations, staff gages, infrastructure, in-stream structures, stream and corridor features, floodplain features, photo points, and all topographic features. From this survey, maps should be produced that display all monitoring locations, comparisons of the stream features from year-to-year, and any other relevant information. Stream comparisons may include stream profiles, cross sections, as well as any notable failures. A full site survey should be conducted first as an as-built survey of the site, then again in years 3 and 5, following the completion of the project. The products built from the site surveys should be included in the annual reports, during the years they are performed.

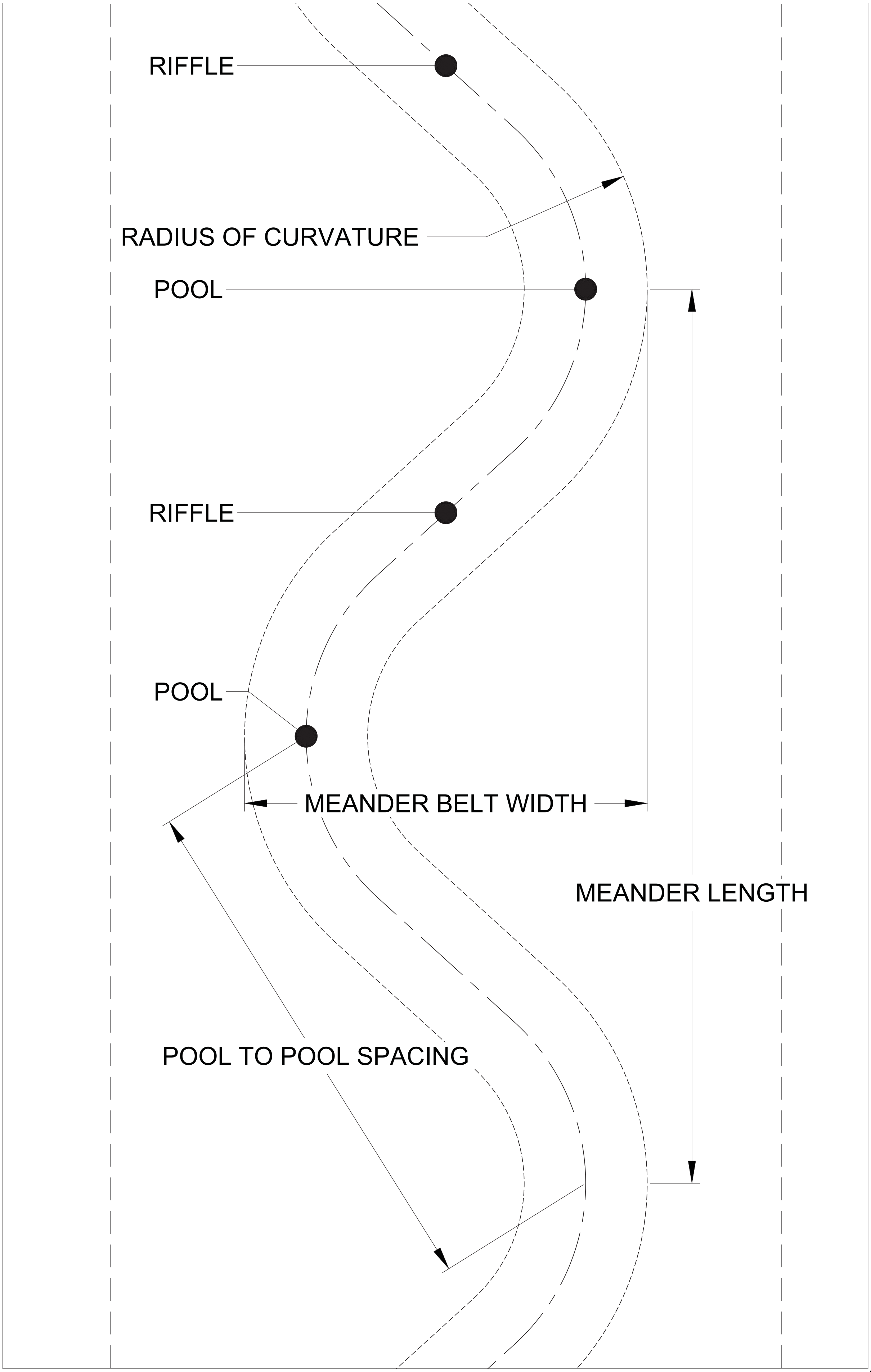
Appendix

Metric Definitions - Section



A1

Metric Definitions - Plan



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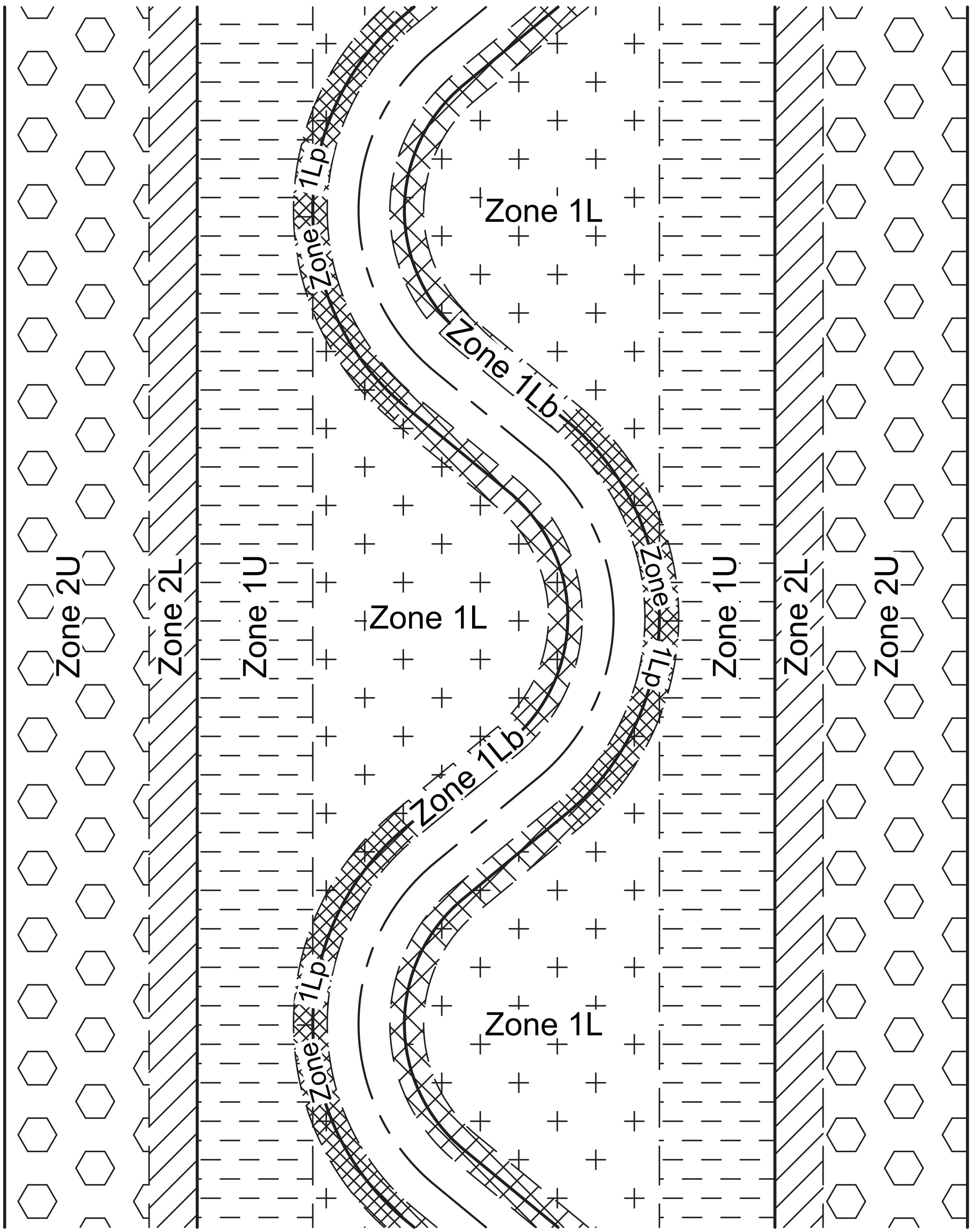
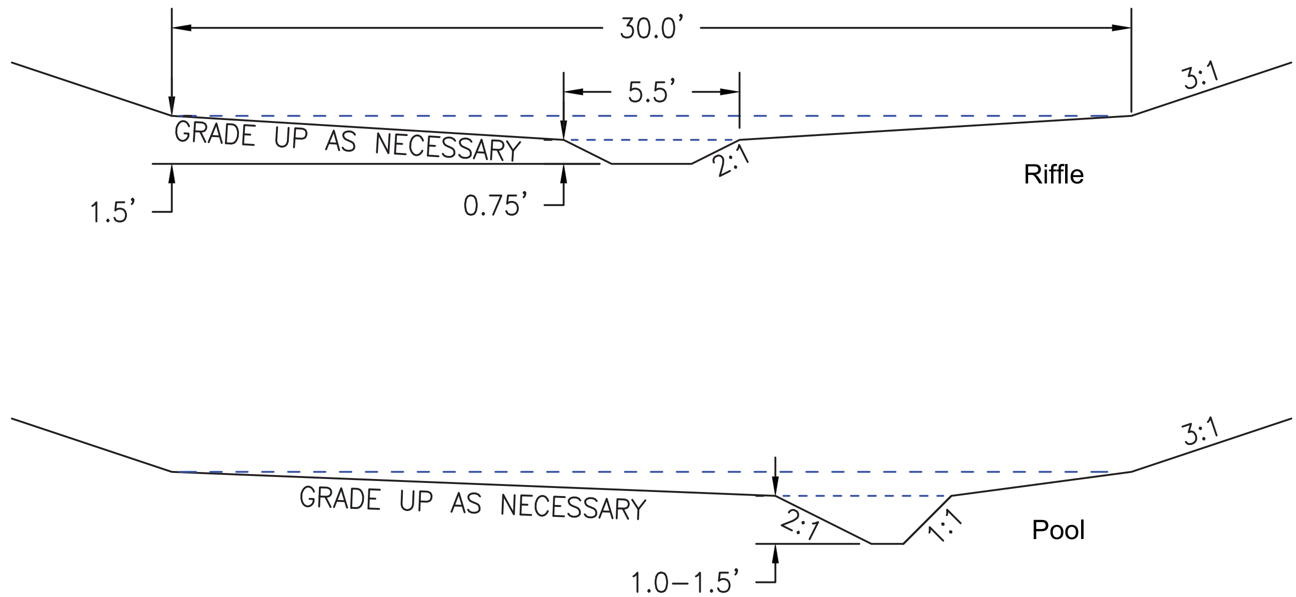
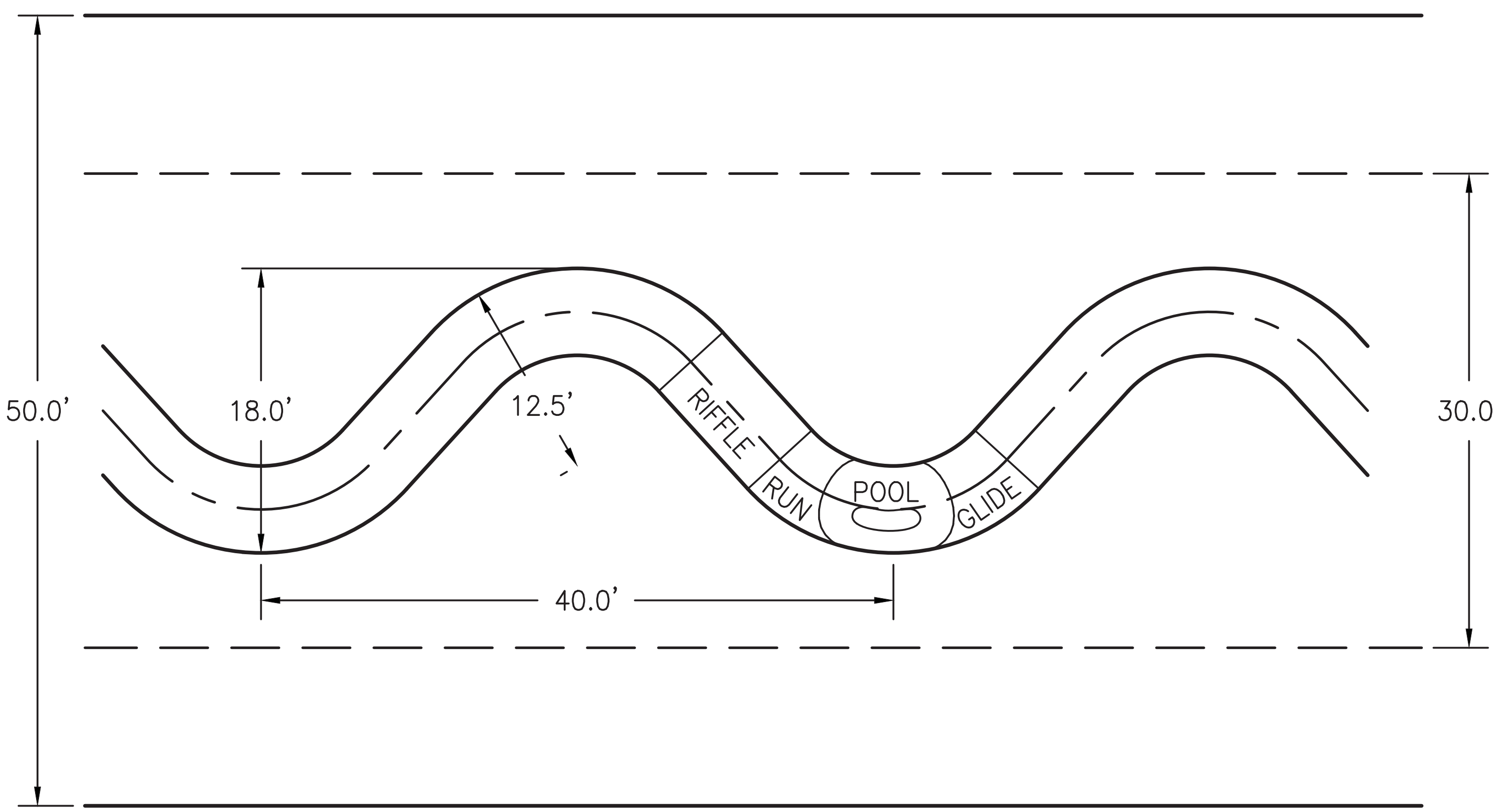


Proposed Stream Metrics

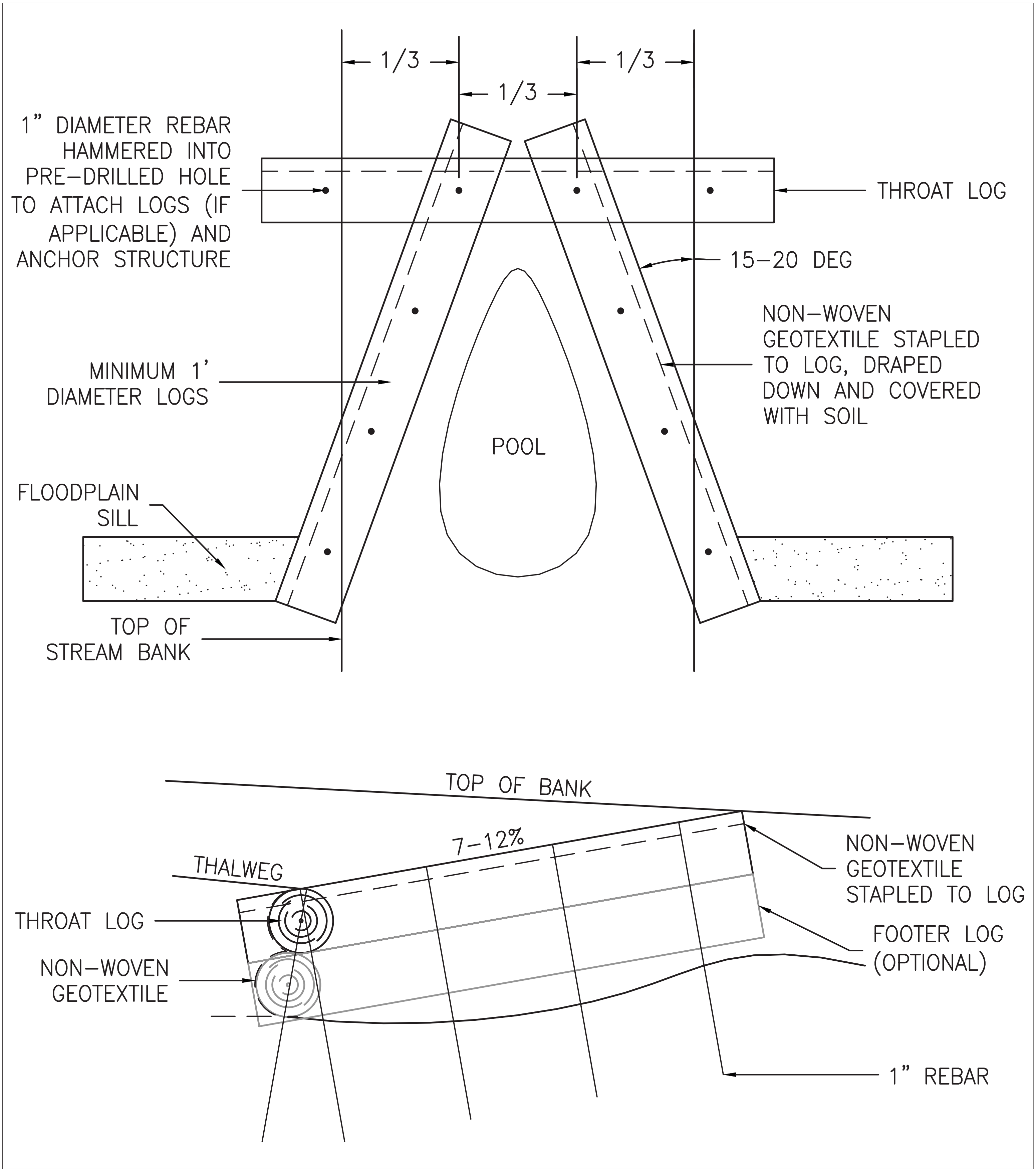
Section



Plan



GENERIC LOG CROSS VANE DETAILS



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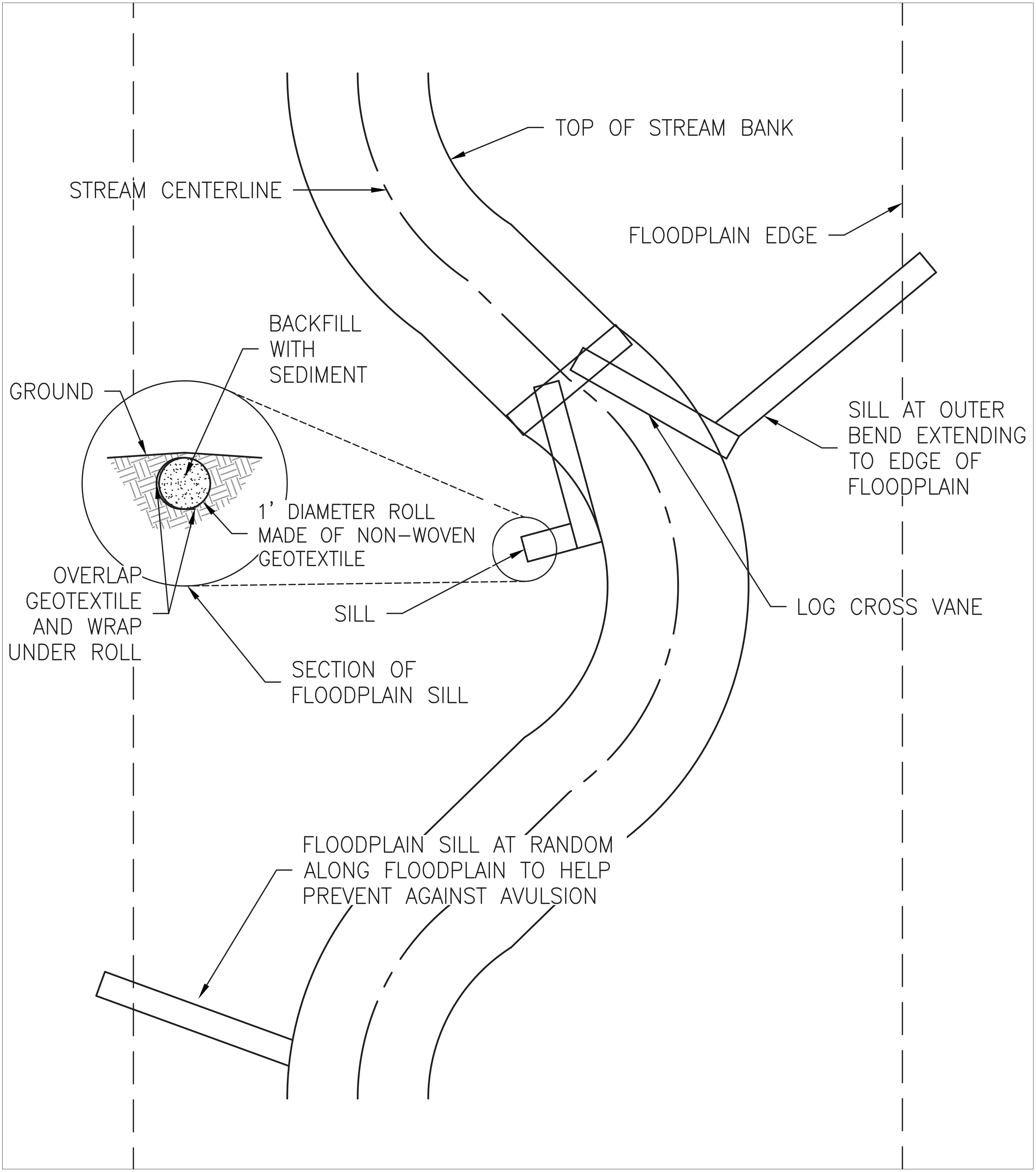


Table A1 – Associated Birds & Mammals, and Food Value	
Species	Wildlife and Food Value
Ryegrass	Temporary stabilization
Bunchberry	Wildlife: sharp-tailed grouse, spruce-grouse, moose Food: fruit, buds
Goldenrod	Wildlife: goldfinch, junco, ruffed grouse, swamp sparrow, butterflies and other insects, cottontail, meadow mice Food: seeds, nectar
Jewelweed	Wildlife: ring-necked pheasant, stuffed grouse, ruby-throated hummingbird, veery, butterflies and insects, white-footed mouse Food: nectar, seeds
Partridgeberry	Wildlife: grouse, mammals Food: berries
Swamp Milkweed	Wildlife: black duck, mallards, red-winged blackbird, ruby-throated hummingbird, monarch butterfly, other butterflies and insects, muskrat Food: nectar, seeds
Tall Meadow Rue	Wildlife: bees, butterflies Food: nectar
Chokecherry	Wildlife: bluebird, brown thrasher, catbird, crow, eastern kingbird, evening grosbeak, orioles, pileated woodpecker, ring-necked pheasant, robin, rose grosbeak, ruffed grouse, thrushes, yellow-bellied sapsucker, rabbit, squirrel Food: berries, buds, foliage
Gray Dogwood	Wildlife: blue jay, cardinal, catbird, cedar warwing, eastern kingbird, finch, flycatcher, grosbeak, hairy woodpecker, northern flicker, phoebe, pileated woodpecker, pine grosbeak, pine warbler, red-bellied woodpecker, ring-necked pheasant, robin, ruffed grouse, starling, swamp sparrow, tufted titmouse, veery, vireo, wild turkey, wood duck, wood thrush, woodcock, yellow-bellied sapsucker, chipmunk, deer, red fox, rabbit, squirrel Food: berries, twigs
Hobblebush	Wildlife: brown thrasher, cardinal, cedar warwing, evening grosbeak, robin Food: fruit
Lowbush Blueberry	Wildlife: blue jay, grouse, kingbird, oriole, robin, tangers, woodpeckers, squirrel Food: berries, foliage, twigs
Pussy Willow	Wildlife: American goldfinch, ruffed grouse, beaver, hare, rabbits, squirrel Food: buds, catkins, twigs, bark

Table A1 – Associated Birds & Mammals, and Food Value (cont.)	
Raspberry	Wildlife: songbirds and mammals Food: fruits
Red Osier Dogwood	Wildlife: bluebird, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, finches, northern flicker, pine warbler, purple finch, ringed-neck pheasant, ruffed grouse, vireo, wild turkey, woodpeckers, wood duck, chipmunk, deer, rabbit, squirrel Food: berries, twigs
Silky Dogwood	Wildlife: baltimore oriole, black-capped chickadee, blue jay, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, flycatcher, mockingbird, northern flicker, pine warbler, purple finch, red-bellied woodpecker, ringed-neck pheasant, robin, rose-breasted grosbeak, ruffed grouse, song sparrow, starlings, tufted-titmouse, wild turkey, wood duck, wood thrush, veery, chipmunk, deer, rabbit, raccoon, skunk, squirrel, white-footed mouse Food: buds, twigs, bark, leaves
Speckled Alder	Wildlife: alder flycatcher, catbird, goldfinch, mallards, pheasant, pine siskin, red-winged blackbird, ruffed grouse, swamp sparrow, yellow-bellied flycatcher, woodcock, bear, beaver, deer, cottontail, moose, muskrat, snowshoe hare Food: buds, twigs, bark, leaves
Witch Hazel	Wildlife: cardinal, ring-necked pheasant, ruffed grouse, wild turkey, deer, squirrels Food: seeds, buds, twigs, bark
Black Willow	Wildlife: songbirds and mammals Food: buds, catkins
Black Cherry	Wildlife: bluebird, blue jay, brown thrasher, cardinal, catbird, cedar waxwing, common crow, eastern kingbird, evening grosbeak, mockingbird, northern flicker, northern oriole, robin, ruffed grouse, sparrows, thrushes, veery, vireo, yellow-bellied sapsucker, bear, chipmunk, deer, fox, raccoon, squirrel Food: berries, buds, sap
Red Maple	Wildlife: cardinal, chickadee, evening and pine grosbeaks, finches, robin, yellow-bellied sapsucker, beaver, chipmunk, deer, opossum, squirrel, snowshoe hare Food: seeds, buds, bark, twigs, sap
White Oak	Wildlife: blue jay, brown thrasher, nuthatch, quail, ruffed grouse, towhee, wild turkey, wood duck, woodpecker, chipmunk, bear, deer, gopher, opossum, raccoon, squirrel Food: acorns
White Ash	Wildlife: finches, grosbeaks, red-winged blackbird, wood duck, deer, squirrel Food: seeds, foliage

Habitat Assessment Field Data Sheet
Low Gradient Streams

Stream Name	
Station #________ Rivermile _________	
Lat ____________ Long ____________	
Storet #	
Form Completed By	Date ______ Time _____ AM PM

Habit Parameter				
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30 - 50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10 - 30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	

4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50%-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7.Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note-channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable: evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clearcuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Hodgson Brook Field Data Sheet

Customized from the Volunteer River Assessment Program - Hodgson Brook Field Data Sheet, published by NH DES

Date: ____________ Start Time: ____________ End Time: ____________

Kit #: ____________ Data Collected By: ____________

Initial Turbidity Calibration Value: ____________ Time Dissolved Oxygen Meter Turned On: ____________

Initial Conductivity Calibration Value (175-225 µS): ____________ Time of First Dissolved Oxygen Calibration: ____________

Loca-tion Code	Location Name	Time Sampled (HH:MM)	Turbidity (NTU)	pH Cal. Slope ("SLP" = 92-102%)	pH (std. units)	Water Temp (°C)	Dissolved Oxygen Cal. (96-100%)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat.)	Dissolved Oxygen (% sat. in chamber)	Air Temp (°C)	Specific Conductance (µS)

Zero Oxygen Reading (mg/L): ____________ (% sat.): ____________ Station: ____________ Time: ____________

6.0 pH Buffer Reading (5.8-6.3): ____________ Station: ____________ Time: ____________

DI Blank Turbidity Reading: ____________ Station: ____________ Time: ____________

Hodgson Brook Field Data Sheet

Weather Condition:

Current Weather (circle one)   Clear   Partly Cloudy   Overcast   Foggy   Hazy   Showers   Downpour   Snow   Other: ______

Describle the past three days' local weather (days prior):   1: ______   2: ______   3: ______

Sampling Preparation Checklist (check if complete): ______

Scribe: ______

Check Maintenance Log ______
Fresh Solutions ______
Batteries ______

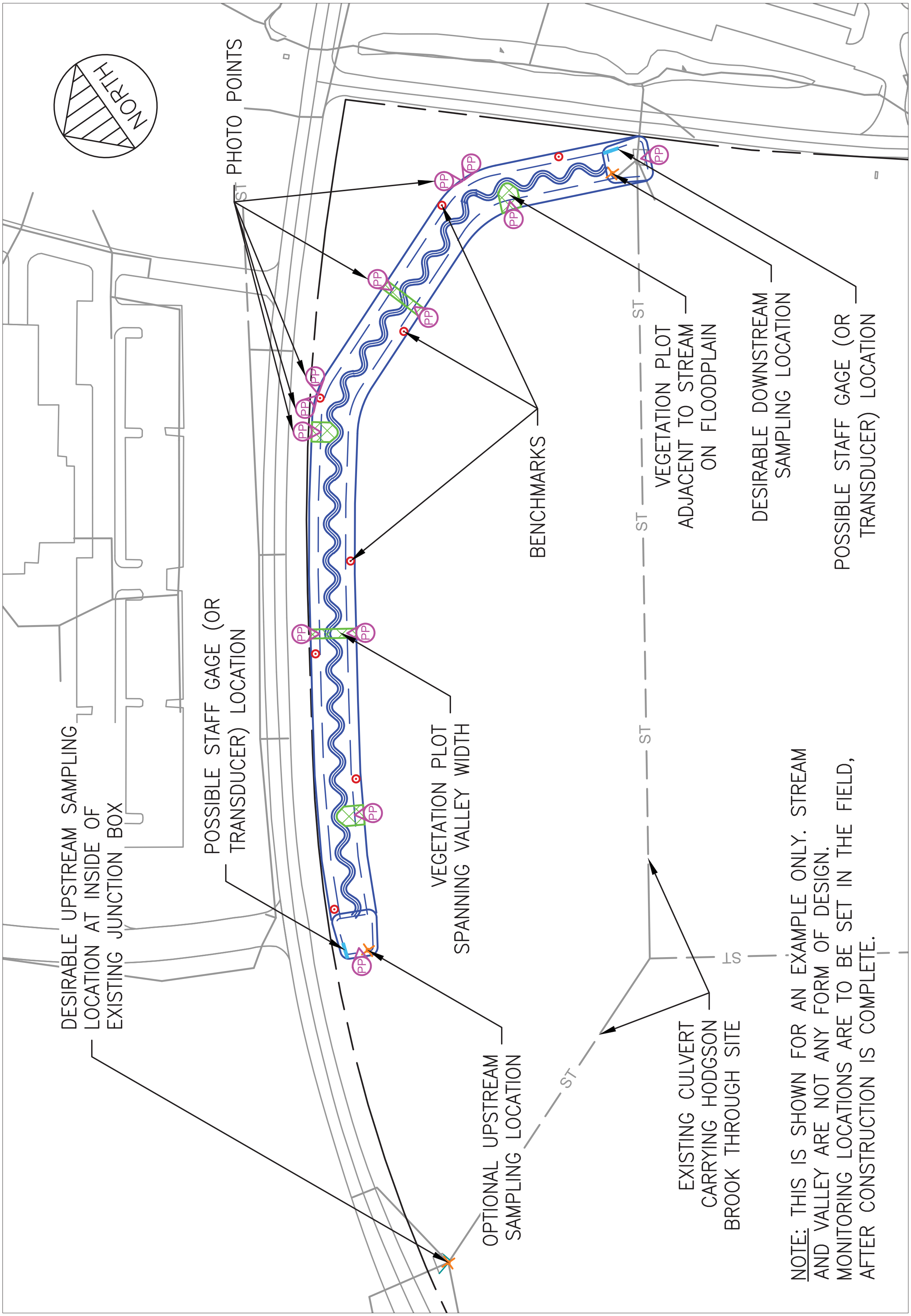
Post Calibrations: ______
pH Cal. Slope: ______
DO Cal. ______
Turbidity (1.0 std.) ______
Conductivity (200 µS std.) ______

End of the Day (check if completed): ______
All meters dry and off: ______
DO probe in chamber with wet sponge: ______
pH probe upright in storage solution ______
Turbidity sample vial rinsed and filled with DI water ______
Conductivity probe cleaned and in chamber ______
Kit clean of kimwipes, dirt, moisture ______

Indicate Presence of Visual Indicators for Each Sampling Station			
Indicator	Site		
Color			
Algal Bloom			
Foam			
Debris			
Scum			
Slicks			
Odors			
Surface Floating Solids			
Benthic Deposits			

NOTES:

Example Monitoring Locations



Complete Table of Proposed Metrics

	Property	Units	Symbol/Equation	Proposed Design
Proposed Metrics	Maximum Bankfull Depth	ft	Dmax	0.75
	Average Bankfull Depth	ft	Davg	*0.50*
	Floodprone Depth	ft	Dfp	1.5
	Bankfull Width	ft	Wbkf	5.5
	Floodprone Width	ft	Wfp	30.0
	Width/Depth Ratio	-	W/D	*11.00*
	Entrenchment Ratio	-	ER	*5.45*
	Bankfull Area	sqft	Abkf	2.75
	Sinuosity	-	k	1.226
	Meander Belt Width	ft	MBW	18.0
	Belt Width Ratio	-	MBW/Wbkf	*3.27*
	Meander Length	ft	ML	40.0
	Meander Length Ratio	-	ML/Wbkf	*7.27*
	Radius of Curvature	ft	Rc	12.5
	Radius of Curvature Ratio	-	Rc/Wbkf	*2.27*
	Pool Length	ft	Lp	16.22
	Pool Length Ratio	-	Lp/Wbkf	*2.95*
	Pool to Pool Spacing	ft	P2P	24.52
	Pool Spacing Ratio	-	P2P/Wbkf	*4.46*
Calculated Values	Stream Length	ft	SL	1204
	Stream Slope	ft/ft	Slope	*0.00946*
	Valley Slope	ft/ft	VS	0.01160
	Valley Length	ft	VL	982.5
	Invert In	ft	INVin	47.70
	Invert Out	ft	INVout	36.31
	Bankfull Wetted Perimeter	ft	P	5.85
	Bankfull Hydraulic Radius	ft	Rh	*0.47*
	Bankfull Manning's n	-	n	0.035
	Bankfull Velocity	fps	V	*2.50*
	Bankfull Flow	cfs	Q	*6.87*
	Floodprone Wetted Perimeter	ft	Pfp	30.4
	Floodprone Area	sqft	Afp	18.4
	Floodprone Hydraulic Radius	ft	RHfp	*0.60*
	Floodprone Velocity	fps	Vfp	*1.72*
	Floodprone Manning's n	-	nfp	0.06
	Floodprone Flow	cfs	Qfp	*31.6*
	High Flow Wetted Perimeter	ft	P50	39.6
	High Flow Area	sqft	A50	44.3
	High Flow Hydraulic Radius	ft	RH50	*1.12*
	High Flow Manning's n	-	n50	0.08
	High Flow Velocity	fps	V50	*2.16*
	High Flow	cfs	Q50	*95.4*

Full Flow Wetted Perimeter	ft	P100	48.7
Full Flow Area	sqft	A100	76.9
Full Flow Hydraulic Radius	ft	RH100	*1.58*
Full Flow Manning's n	-	n100	0.09
Full Flow Velocity	fps	V100	*2.41*
Full Flow	cfs	Q100	*185.4*
Low Flow Wetted Perimeter	ft	Plf	2.95
Low Flow Area	sqft	Alf	0.27
Low Flow Hydraulic Radius	ft	RHlf	*0.09*
Low Flow Manning's n	-	nlf	0.035
Low Flow Velocity	fps	Vlf	*0.84*
Low Flow	cfs	Qlf	*0.23*
Bankfull Stable Particle - Rosgen	in	RDbkf	2.49
Low Flow Stable Particle - Rosgen	in	RDlf	0.70
Floodprone Stable Particle - Rosgen	in	RDfp	2.80
Full Flow Stable Particle - Rosgen	in	RD100	5.68
Bankfull Stable Particle - LWM	in	LDbkf	0.88
Low Flow Stable Particle - LWM	in	LDlf	0.15
Floodprone Stable Particle - LWM	in	LDfp	1.05
Full Flow Stable Particle - LWM	in	LD100	2.85

06 November 2018

Watershed Modeling for Hodgson Brook

Hodgson Brook is a highly urbanized stream system which passes through the Pease Tradeport, starting in Newington, and ending at North Mill Pond in Portsmouth. Traditional methods for predicting peak stream flows based on watershed characteristics alone (from nearby stream gages, using drainage-area weighting, from regional regression equations, SCS method, etc.) are very likely to produce results without great accuracy. Most traditional methods for predicting peak flows work best on less impacted, more natural systems or on smaller watershed sizes. Hodgson Brook at the Iron Rail Parcel has a watershed which has been extremely impacted by urbanization, and flows underground through almost one mile of storm sewer before daylighting downstream from the project site. In order to better predict expected peak flows and floodwater elevations at the site and its surroundings, a more appropriate method for analyzing urban watersheds was chosen; the EPA's Storm Water Management Model (SWMM). This program is freely available for use[1], and is meant to model urban hydrology and hydraulics in greater detail than traditional peak flow calculations. The program is able to use a wealth of information (infiltration rates, weather, real-time precipitation, stormwater infrastructure, ponding, etc.) to better calculate (by means of methods more appropriate for culverts: dynamic wave, kinematic wave, accounting for surcharge) – among other things – flow rates and water elevations.

Though SWMM is able to calculate flows and water elevations more precisely, it is most appropriate to check and calibrate the model against observations for the results to be accurate. As with any model, precision can almost be guaranteed, but only with calibration data can the results be assumed accurate. Upon completion of a calibrated existing conditions model, proposed conditions may be modeled using site development plans. Results between the two models may then be compared, and results for the proposed model used for planning purposes.

Before creating the existing conditions model, it was known that there was almost no existing data to which a model could be calibrated. There are no stream gages along the stream, and little historic verbal observations were recounted[2]. It was also anticipated that the time of concentration for this site would be fairly small – most likely less than 30 minutes – meaning that both calculation time steps and precipitation distributions (historic, modeled, and monitored) would have to be less than that interval in order to accurately calibrate the model (one to 10 minutes, for example). Planning for these two key constraints for modeling, flows and elevations were monitored at three locations along the system, and

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[1] https://www.epa.gov/water-research/storm-water-management-model-swmm

[2] Verbal observations might include generalizations about locations within the watershed. Statements such as "I've never seen flows overtop that road," or "That field floods all the time," or "The water in our building was knee-deep during the flood of '86" are useful for analyzing historic modeling results. If the modeled results poorly reflect such observations, the model may be tweaked to better reflect reality, even if such accounts are quite general in their nature.

the storm occurring during the monitoring period were obtained in 5-minute recorded intervals. These two correlating sources of information could thus be used to calibrate a SWMM model for the existing site conditions.

Among the purposes driving the creation of a watershed model for the site are planning for flows and water elevations at key locations along the system. Modeling the design scenario provides a confirmation that any pertinent proposed infrastructure performs as it is intended. The results from the proposed model may also be compared to past conditions, both to make observations on the relative performance of the system from past to future, and to ensure no adverse conditions are created resulting from the proposed project.

Among the initial efforts to develop a conceptual plan for modeling was to define points of interest, and the limits to which the model would extend. Members of the design team met with project reviewers (the city, the city's third-party reviewer, and the PDA – referred to as the Reviewers) during a 9/25/18 meeting in Portsmouth. During the meeting, it was a general consensus of the Reviewers that flood flows at the wetland behind Martin's Point, adjacent to the ball fields at Tony Rahn park, would be managed by the wetland system there and on downstream. This was considered, for modeling purposes, as the terminal point for the analysis. Therefore, any potential adverse impacts resulting from the project would be expected to occur somewhere between this location and immediately downstream from the project site. In that stretch, only two potential impact locations were identified; the swale at the outlet of the project site, adjacent to Goose Bay Drive (referred to as the GBSwale), and the wetland adjacent to Corporate Drive ending at the Pease Wastewater Treatment Facility (referred to as the PWTFDrive). Other key locations in which the Reviewers were interested included the upstream- and downstream-most ends of the project site. For reference, an image depicting some of these key locations may be seen in Figure 2, with the project subwatersheds delineated in Figure 1.

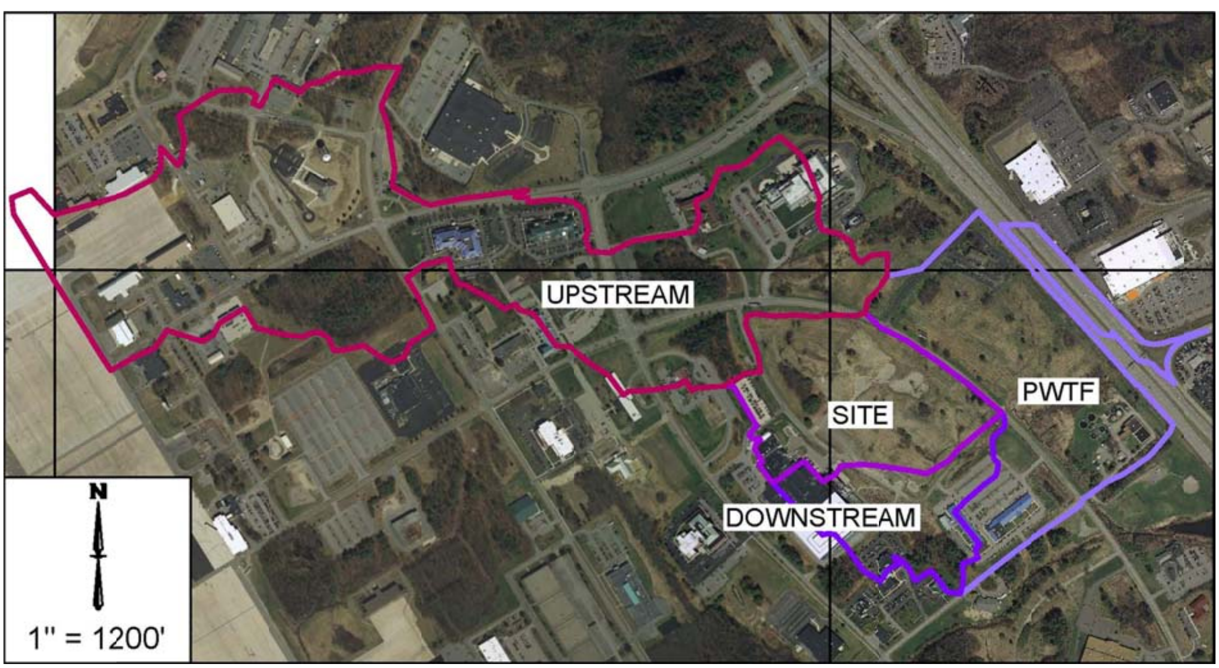

Figure 1 - Subwatersheds defined for the model

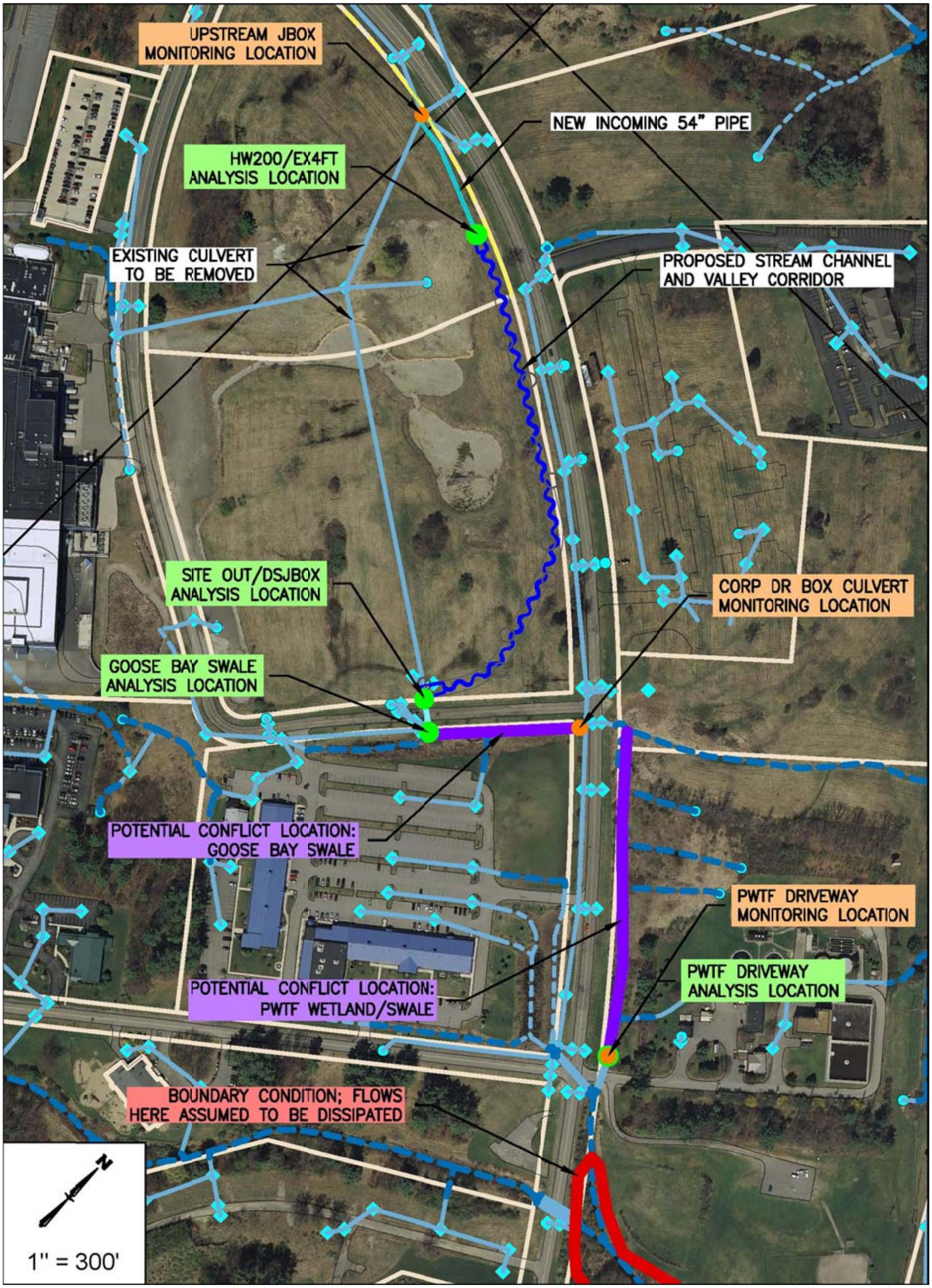

Figure 2 – Referenced Model Locations

The model of the Hodgson Brook watershed upstream from the PWTF Driveway was segmented into four subwatersheds, defined by key locations described previously. These four subwatersheds are identified (from upstream to downstream) as: Upstream, Site, Downstream, and PWTF, with the subwatershed outlets being located at the upstream junction box on the site, the downstream junction box at the site, the box culvert passing Hodgson Brook beneath Corporate Drive, and the PWTF Driveway, respectively (see Figure 1). Each subwatershed was chosen for specific reasons; the Upstream, Downstream, and PWTF subwatersheds may all be calibrated to monitoring data collected at each of their outlets, and the Site subwatershed contains the entire project site, where modeled conditions may be compared between the Existing and Proposed site conditions.

In order to calibrate the watershed model, monitoring was performed from 9/10 to 10/16 (37 days) at three locations: the upstream junction box, the inlet to the Corporate Drive box culvert, and at the PWTF driveway. At each of these locations, flows and water stages were recorded during low-flow and runoff conditions, for a multitude of flow depths. Flows were measured by stream gaging – using a cross section and a flow meter and following USAFS procedures for the 0.6-depth method – conducted during six storms over the span of the monitoring period. In addition to flow monitoring, pressure transducers were placed at the upstream junction box and the PWTF driveway, set to take readings every minute, which provided near-constant water elevations for 21 of the days. The stream gaging data was used to create a rating curve at each location; the measured flows and synoptic transducer water depths (converted to water surface elevations -WSELs) data was plotted best-fitting regression trendlines[3] were fitted to the data to obtain equations that then transformed the 1-minute transducer water elevations into observed hydrographs. Only two pressure transducers were available, therefor the hydrograph at the Corporate Drive box culvert was estimated, using concurrent readings between the three sites. In total, monitoring data was collected for nine storms during this time frame.

Recognizing that the watershed is highly responsive to rainfall, precipitation observations were necessary in as small a time step as possible. Larger time steps, especially those greater than the estimated 30-minute Upstream watershed time of concentration, result in poor model calibration. No nearby officially-managed rain gages were discovered to provide rainfall data in a time step less than one hour; three NOAA weather stations that are currently operational were discovered nearby – two in Durham and one on Pease – but all recorded data at hourly time steps. There is a long-term record by a weather station in Durham with 15-minute data, but only up until the year 2013, and another one which is currently operational and has (not very easily obtainable) minute weather observations – and was considered for use, but ultimately was abandoned in favor of another solution.

With the assumption that the time of concentration at the site was likely to be very short, and having only nine storms occurring during the monitoring phase, having an accurate rainfall distribution at a minimum time step was considered to be overly important for each storm. It was discovered that community-collected precipitation amounts in 5-minute intervals are publicly available; the data is

[3] It is necessary in some instances to use more than one trendline; as water levels increase, the conditions which govern the amount of flow are not always the same. For example, at the Corporate Drive box culvert, monitored flows at water levels below the top of the culvert are well described by one trendline – when they reach the crown and higher, they are better described by another trendline, as flows begin to enter the field to the south east.

collected by private enthusiasts and published by a weather company, Weather Underground (WU). Dozens of weather stations are located near to the site, of which six stations – forming a circle encompassing the site – were chosen to help determine storm precipitation hyetographs during the monitoring events. The location of the six WU stations may be seen in Figure 3, along with the other five mentioned weather stations, and a list of the all the mentioned rain gages relevant information about each may be found in Table 1.

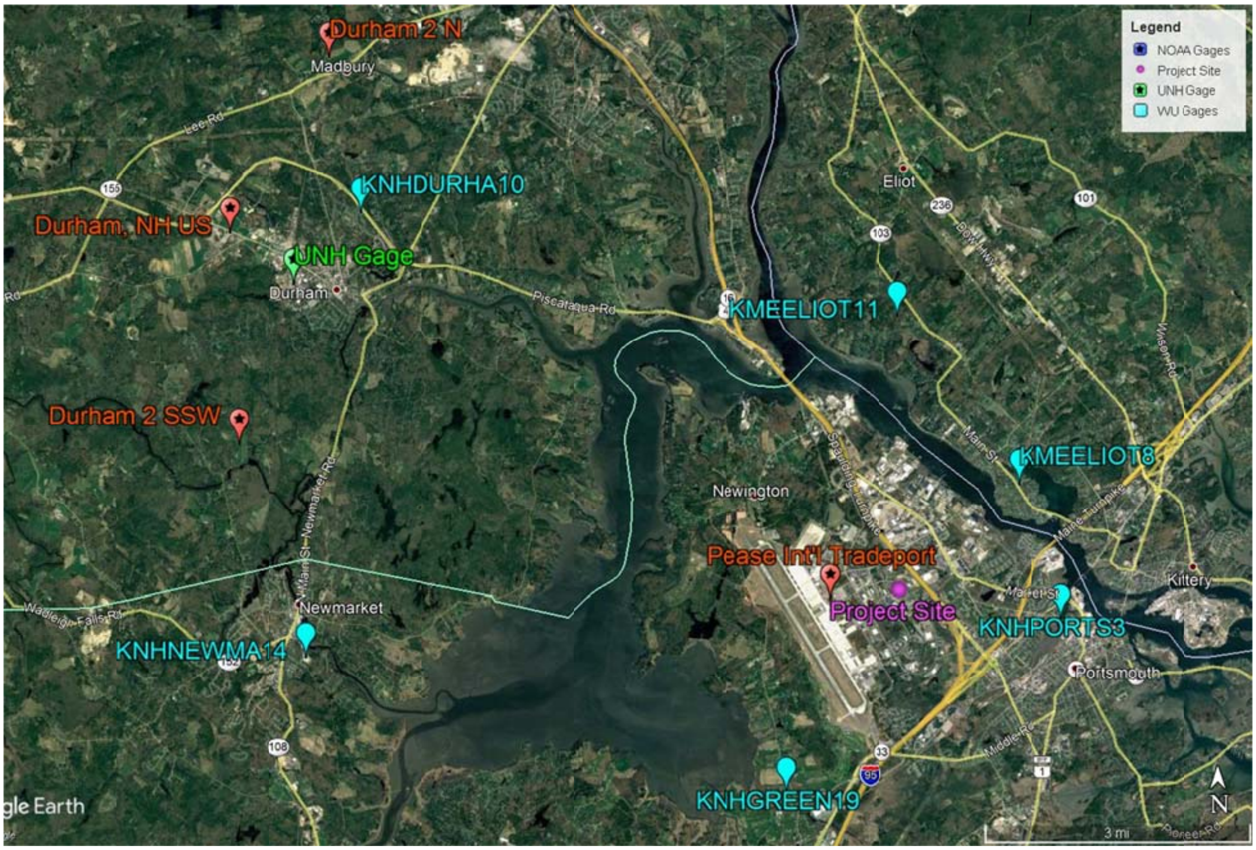

Figure 3 - Rain Gage Locations

The goal for using the amateur-collected rainfall observations was to obtain as accurate an account of the distribution of the rain occurring during each of the monitored storms. These weather stations record data every 5-minutes. For several purposes, more than one of these gages were used; no one gage was located within the model watershed, therefore many were used to more accurately represent site conditions. Also, as these are privately-owned stations, bias by any one station – if used alone – would pose issues with the accuracy of the calibrated model, and with overall credibility. In theory, a sample of individual data points (in this case, the gages) selected from a population (the true storm characteristics at the site) should represent the true average of the population, within a certain degree of probability. The larger the sample size, the more likely it is to accurately represent the population. For this reason, to make up for the lack of watershed rainfall data, the closest six WU gages surrounding the watershed were chosen. Though these may individually have slight inconsistencies from storm to storm, especially given that they are dispersed in their locations, when processed and accounted for as a group, the expectation is that they produce the most representative and relevant storm characteristics as possible.

Table 1 - Reference Rain Gages

Owner/ Publisher	Gage ID	Description	Municipality	State	Time Step (min)	Period of Record	Distance to Site (mi)	Direction from Site
WU	KNHDURHA10	Littlehale Rd	Durham	NH	5	9/10-10/16	7.4	NW
WU	KNHNEWMA14	Fire Department	Newmarket	NH	5	9/10-10/16	6.8	W
WU	KNHGREEN19	Airport	Greenland	NH	5	9/10-10/16	2.62	SSW
WU	KNHPORTS3	Maplewood Ave	Portsmouth	NH	5	9/10-10/16	1.85	E
WU	KMEELIOT8	Spinney Creek	Eliot	ME	15	9/10-10/16	1.78	NE
WU	KMEELIOT11	Sunset Hill	Eliot	ME	5	9/10-10/16	3.06	N
NOAA	99999954794	Durham 2 N	Madbury	NH	60	2001-Current	8.75	NW
NOAA	99999954795	Durham 2 SSW	Durham	NH	60	2001-Current	7.6	WNW
NOAA	72605504743	Pease Int'l Tradeport	Portsmouth	NH	60	2006-Current	0.8	W
NOAA	COOP:272174	Durham, NH US	Portsmouth	NH	15	1971-2013	8.53	WNW
UNH	CR1000	UNH Weather Station	Durham	NH	60	2000-Current	7.62	WNW

In order to confirm the reliability of the crowdsourced data, a number of checks were performed to determine, with a degree of confidence, the consistency of the WU gages against officially-published data. This was all determined by correlating the WU data to the hourly data collected at the Pease and Durham rain gages. The totals – both by hourly increments and storm totals – were analyzed for the departure between each increment and each storm. So long as the storm totals and hourly amounts were within reasonable similarity (approximately +/-15% for an overall performance, though the further away a WU gage was from a reference gage, the more lenient the range was considered to be), the gage records were considered acceptable for use. Ultimately, the six WU gages in Table 1 were considered to be reasonable surrogates for determining each of the storm distributions.

It is important to note that the WU gages were only used to develop each monitoring reference storm's *rainfall distribution*; ultimately the total storm rainfall amounts were defined using the NOAA gage at Pease. As this gage is very close to the site, and is an official source of QA/QC'd data, this was considered the most appropriate source for total rainfall. The community-supplied data was merely a method to interpret a the hyetograph for each storm; both the time and interval rainfalls were made dimensionless. The rainfall amounts at each gage in 5-minute intervals were divided by the total recorded rainfall at each gage to yield dimensionless rainfall each 5-minute period. The recording time was also converted to dimensionless time, with the storm peaks, beginnings, and ends made relative to all others. Since the relative location of each gage combined with the variable nature of the actual storm rainfall distribution results in differences between each gage's rainfall distribution, an optimization was run to determine suitable weighting factors for each of the six reference WU gages, and how much each should contribute to the final calculated unit hyetograph for the site. This was done by weighting each gage by a factor, resulting in a weighted average record for the site. This was optimized by comparing the produced storm distribution calculated from the WU gages to that of the hourly record for the Pease NOAA gage. The goal was to weight each gage in such a manner that the produced rainfall record for the site matched the hourly amount of rainfall at the Pease NOAA gage. The result was that no one calculated/weighted storm was off by more than 0.02" when compared hourly, and the total precipitation during the monitoring period for both the calculated data set and the NOAA set matched within a hundredth of an inch. For reference, the total rainfall amounts recorded by the NOAA Pease gage may be found for the calibration events appear in Table 2, and total 7.09 inches.

Table 2 - Storms Occurring During Monitoring Period with Storm Total Rainfall[4]

Storm Date in 2018	Total Rainfall (in)
10-Sep	1.36
18-Sep	2.76
25-Sep	0.61
26-Sep	0.65
27-Sep	0.07
28-Sep	0.02
1-Oct	0.15
2-Oct	0.42
3-Oct	0.17
11-Oct	0.73
16-Oct	0.15

The idea behind this method was that, while the WU data may not be subject to official QA/QC, any individual errors or inaccuracies should hopefully be countered by the sheer quantity of data. This method of using community-supplied data – while uncommon – is not without justification. Even federal agencies support the method; NOAA divisions, including the NCDC and NWS, support and reference the non-profit Community Collaborative Rain, Hail & Snow Network (CoCoRaHS). Furthermore, the WU data was only used to create a more appropriate rainfall account, at a smaller time step which was necessary in order to better calibrate the SWMM watershed model. Even then, this data was referenced against the hourly data collected on Pease, with storm totals being defined by the Pease NOAA gage. It was these storm totals which were used to transform the unit precipitation record back into 5-minute rainfall depths.

In total, stream gaging and flow stages were collected during six storms (9/10, 9/12, 9/18 and Hurricane Florence remnants, 10/2, 10/11, and 10/16). The pressure transducers monitored conditions during an

[4] Though 11 storms are shown in Table 2, two of them produced almost no runoff (those on 9/28 and 10/1), and therefore no monitored field observations were recorded during those storms. These storms were modeled, however, to ensure that little to no runoff was modeled as a result of those events.

additional three storms (9/25, 9/26, and 9/27). Using the observed flows and stages, the continuous transducer data was calibrated, and a hydrograph spanning the 37 days of monitoring was created.

Concurrent with the monitoring, all necessary modeling input was collected. The city provided their GIS database, which included many important features such as impervious surfaces and infrastructure locations. While the database had a wealth of infrastructure information, most of the data was limited to X and Y coordinates, and infrastructure types (catch basins, pipes, manholes, stream, etc.). There was very little useable data regarding infrastructure dimensions or elevations. This data was thus collected in the field; manholes were opened, pipe materials were noted, sizes were recorded, and elevations were collected using a laser level and known elevations. LiDAR data obtained from NHGRANIT was also used to create topography of the watershed, accurate to 0.5 feet.

With all of the required information collected and processed, an existing condition watershed model was built in SWMM. Using the monitoring data at the three locations (as well as the generalized observations), the model was then calibrated against this data by adjusting selected parameters within acceptable their tolerances. The model was considered calibrated to an acceptable degree when the modeled peak flow rates, time to peaks, and total runoff volumes were all within 15% of the monitored conditions, which was almost entirely achieved (several of the storms had one of the calculated amounts outside the 15% limits – however, none of these amounts were off by greater than 25%).

With the calibrated existing conditions model, several other scenarios could be created using long-term gaged precipitation, design precipitation, and proposed conditions: the three modeled scenarios thereby named Long Term Existing, Design Storm Existing, and Proposed models. The results for the three models were then compared, and used to analyze longer-term flows and water stages. The Long Term Existing conditions model was created using 15-minute gaged precipitation collected by the NOAA gage in Durham (Durham NH, US) and the existing conditions of the watershed. While not considered precise enough to use for the calibration storms, this weather station in Durham is suitable to use as a long-term historic record. While variations might be quite large over the short span of the monitoring period, the 41 years of historic data was considered to be more than accurate enough to be employed as a surrogate for the Lonza site. The results from this Historic model are useful to estimate flows may have resulted in the recent past for the watershed as it exists today. With respect to instream flows, it is common to develop statistics based upon observed, historic peak or average daily flows. The Durham rain gage had 41 years of data, spanning 1971 to 2013, with a total of 3,078 days during which some rain was recorded. This long-term rainfall record was used as input to the SWMM model and the resulting runoff (flows) was calculated to yield a 41-year hydrograph. With this hydrograph, low flow and peak flow statistics were computed. A common practice in determining peak flows occurring at annual rates is to use a Log-Pearson Type 3 (LP3) analysis of the peak flow during each year of the historic data set. This was done on the Historic modeled peak flows incoming to the site, the results of which may be found in Table 4.

The Design Storm Existing conditions model was then created to analyze the results for the commonly used design storm precipitation. Design storm precipitation in New Hampshire is obtained from the Northeast Regional Climate Center's (NRCC) Extreme Precipitation in New England and New York website (http://precip.eas.cornell.edu/). Precipitation totals determined by the NRCC reflect continually-adjusted climate rainfall amounts at specified return periods. Since the NRCC precipitation amounts are used for design purposes, a correlation to historic results may not be effective. For reference, the long-term existing record storm totals (as well as the historic peak storm intensities), ranked using the Weibull method, may be found alongside the design precipitations (shown for the 24-hour total) given by the NRCC, in Table 3.

Table 3 – Peak Rainfall Rates and Total Amounts by Return Period for the NOAA Durham, NH US Gage and NRCC Design Storms

Return Period	Long Term Record Peak Rate	Peak Rate by SCS Type 3 Distribution of the NRCC Totals	Long Term Record Total Rainfall	NRCC Design Precipitation
Yrs	in/hr	in/hr	in	in
1	2.05	2.56	1.80	2.65
2	2.52	3.09	2.40	3.20
5	3.35	3.91	3.04	4.05
10	5.61	4.69	3.50	4.85
25	11.99	5.94	4.23	6.15
50	14.78	7.11	5.86	7.36
100	-	8.52	-	8.82

Of note, the NRCC total precipitation amounts needed to be transformed into a hyetograph representing the rainfall distribution over the 24-hour span for which the totals are shown. To do this, the standard SCS Type 3 rainfall distribution was used. This yields a design storm totaling the precipitation amounts, distributed throughout a 24-hour period – from which peak intensities for each of the storms could be determined, and compared to the historic data. These may be found in Table 1. Caution should be exercised in comparing the rainfall amounts by return periods between the two sources, as the long-term precipitation values were generated using a Weibull ranking, while the NRCC uses more advanced statistical modeling and prediction methods. Since there were only 41 years of historic precipitation amounts, predictions beyond the 50-year were not made.

Table 4 - Peak Flow Results at the Upstream Point of Analysis

Analysis Method / Return Period (years)	Long Term Existing Model	LP3 Predictions for Long Term Results	Design Storm Existing Conditions Model	Proposed Conditions Model
100-yr	-	175.87	205.59	174.68
50-yr	174.63	158.38	181.99	157.61
25-yr	159.96	140.81	162.64	144.23
10-yr	140.24	112.69	143.88	130.93
5-yr	88.74	87.40	136.66	124.73
2-yr	61.28	52.14	107.16	99.33
1-yr	43.27	34.04	73.08	73.13
1"	-	-	13.71	13.76

Finally, a Proposed conditions model was created, using the design for the site to update the Site watershed and infrastructure in the model[5], and the same NRCC design precipitation described above.

Ultimately, the results from the Proposed conditions model are used for all design purposes pertaining to site drainage infrastructure – stormwater basins, the stream design[6], culverts, etc. The results from the Design Storm Existing conditions model, while not used for any design purposes, are useful to demonstrate the reduced impacts of the Proposed conditions. By comparing the two models, conclusions may be made with respect to flows and water elevations: *do peak flows increase?*, *does flooding occur more frequently?*, *are floodwater elevations increased?*, etc. Results by storm events for select model conditions and/or analysis methods may be found in the following sections: each section being defined by the point-of-analysis location (reference Figure 2 for each location). Notes and remarks specific to each location and to each analysis method are detailed as well, to provide context and a brief summary.

It should also be noted that the model was calibrated to the previously-described storms . The nine storms provided excellent data with which to refine the model to a high degree. Although the range of these storm depths were very representative of common events, none were in the range of the design storm totals: the remnants of Hurricane Florence produced a storm in the amount of 2.76" with a peak intensity during the storm of about 2.4 in/hr, resulting in a peak flow at the upstream end of the site of roughly 55 cfs, which is on par with the estimated 2-year return period flow for peaks resulting from the Long Term Existing model, and below the 1-year Design Storm Existing model peak flow. The model performs extremely well for the smaller, more frequent storms. Although no design storms occurred during the monitoring period, it is assumed that the SWMM model yields an accurate representation of the resulting runoff characteristics for those storms.

Overall, by implementing the green infrastructure, daylighting the culvert, and creating a geomorphically designed stream; the proposed site conditions will result with reduced peak flows, reduced runoff volumes, and reduced water surface elevations compared to existing site conditions. Additionally, it may be said that upon the completion of the project, flooding is not expected to occur more frequently than it has in the past, anywhere along the modeled reach of the system. When analyzed for the design storms, the proposed conditions are expected to reduce the rate of flooding. These results are most affected by the proposed stormwater basins and restored stream corridor – both of which will supply infiltration and flow attenuation.

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[5] Included in the Proposed conditions model are three Green Infrastructure stormwater basins which will manage all the stormwater on the site, and the removed 4' culvert which is to, in part, daylight into a restored section of stream corridor.

[6] There is a caveat here: the stream restoration ultimately uses the results from the Long Term Existing model to help define the flows which will be expected at what return periods, which help geomorphically design the stream. However, for reference and site design purposes, the results from the Proposed model are shown and used in the AOT permit.

Results at the Upstream End of the Project Site

At the upstream end of the project site there exists a large concrete vault, with three 3-foot diameter culverts which pass Hodgson Brook and other areas under Corporate Drive, as well as a 4-foot diameter culvert as an outlet from the vault. For the Historic and Existing models, this is the location where results are shown. Proposed conditions have the 4-foot diameter culvert removed almost in its entirety (only 11 feet of the culvert are to remain), where it will flow into a proposed junction box (PDMH203) along with the outlet from the proposed Subsurface Gravel Wetland 2 (GW2). A proposed 4.5-foot diameter culvert will then carry the flows parallel to Corporate Drive and daylight into the proposed restored stream corridor. Results shown in this section reflect the flows coming in to the site, at the existing junction box (Figure 4).

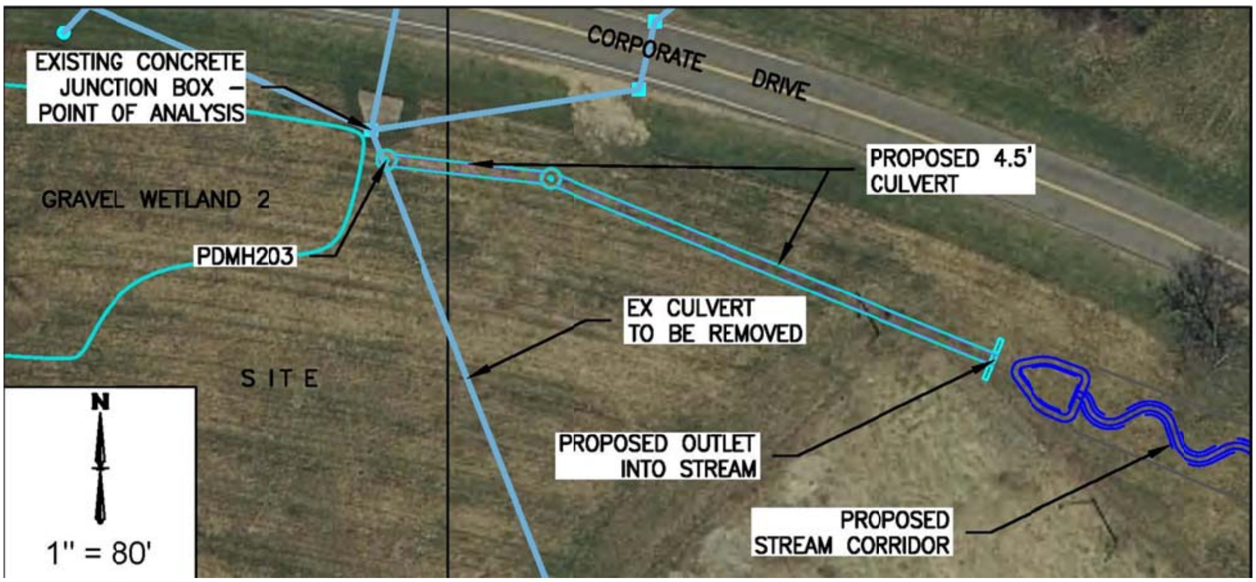


Figure 4 – Upstream Point of Analysis References

In Table 4, the results for storm peak flow events by various methods are presented however should not be compared without some context. The flows in the second column, for the Long Term Existing model, represent the results calculated in SWMM for the 41 years of long-term precipitation data, obtained from the NOAA Durham, NH US gage. The peak flows for each return period in this column reflect the flows calculated using the Weibull method, which determines a probability of exceedance based on the annual ranked peak flows, then determining a return period from those probabilities (the exact peak flows for the return periods shown were interpolated/extrapolated from the Weibull-ranked flows). The peak flows shown in the third column reflect a more robust statistical analysis of the results from the Long Term Existing model. Peak flows calculated by the Long Term Existing model were processed using the LP3 analysis method. These results are probably more accurate in saying, based on 'observed' long-term data, these are most likely the flows which may occur at these rates. The peak flows shown in the final two columns are the results which the model calculated using the NRCC design precipitation, for the Existing and Proposed models. The design precipitation was given for the return periods shown, and from these storms, these would be the expected flows.

Looking at the results, perhaps the most notable comparison is that of the peak flows calculated between the Design Storm Existing and Proposed models. Flows are calculated to be slightly higher during the less-frequent storms, should the current existing conditions remain. This is likely resulting from several factors, most of which are due to effects of the proposed infrastructure downstream from the existing junction box. Under existing conditions, there is almost no downstream storage – neither is there any upstream for quite a ways. Proposed conditions have the pipe quickly outletting into the proposed PDMH203, where the outlet is a larger culvert, which then outlets into the restored stream. Even though proposed conditions have an additional flow coming in from GW2, these flows were only calculated to be about 30 cfs during the 100-yr event, and are not enough to cause more strain on the upstream junction box performance compared to the existing conditions. The presence of the stream corridor also likely helps to lower the energy slope up through this location, as the wide valley will provide a much lower water elevation than the existing culvert, which has a maximum rise before it begins to act under pressure-flow conditions.

Results at the Downstream End of the Project Site

At the downstream end of the project site under existing conditions, the 4-foot diameter culvert passing Hodgson Brook through the site outlets into a large concrete box vault where it is then passed through three 42”x29” CMP culverts beneath Goose Bay Drive. Also existing are two catch basins in the field, which drain site flows into the concrete box. All this infrastructure is set to be removed as part of the project, with only the three CMP culverts remaining, just cut slightly shorter. Long-term observations[7] at the downstream end of the culverts, in the Goose Bay Swale, it was found that there is a nearly-constant pool of water at about an elevation of 36.1’.

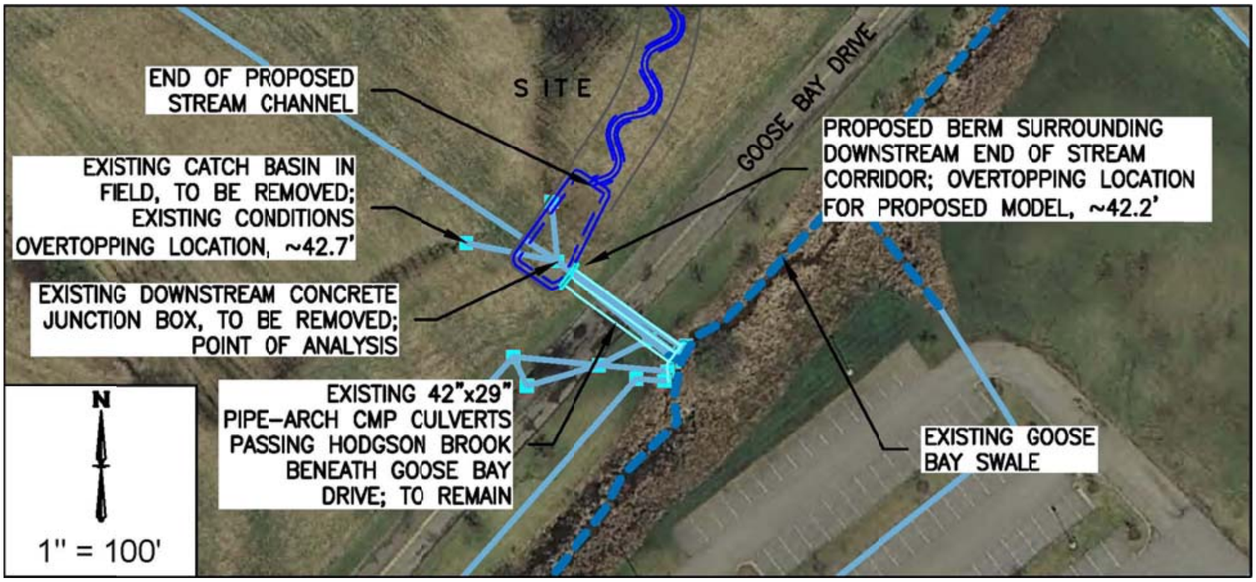


Figure 5 - Downstream Site Point of Analysis References

As detailed in the results section for the upstream end of the site, the peak flows shown in Table 5 reflect the modeled results with their respective return periods (an LP3 analysis was not performed on the Historic modeled flows here, as the flows were found to be nearly identical, the same may be said for the LP3 analysis). The relative difference in peak flows from Proposed to Existing conditions may be seen in the final column. Again, the peak flows in the Design Storm Existing model do show that flows at this location are expected to be larger, should the existing conditions remain, when compared to the Proposed model results. These peak flows are the same values observed at the inlet for the Design Storm Existing model, which makes sense, as the system is almost entirely closed in its current manner. Interestingly, the peak flows from the Proposed model are calculated to be reduced slightly when compared to the flows incoming to the site – even though flows are added upstream from this location from the three stormwater systems. This is due to the increased storage provided by the restored stream and the stormwater systems, in conjunction with the timing of the peak flow rates relative to the upstream incoming flows and those leaving the stormwater basins.

[7] Over the span of the project, many observations have been taken which include the model calibration monitoring performed in the past 6 weeks, to surveying of the GBSwale done in the spring of 2016. It is from this long-term set of observations from which an overall estimation of the ‘dry’ condition WSEL has been approximated.

Table 5 - Peak Flow Results at the Downstream Point of Analysis

Analysis Method / Return Period (years)	Long Term Existing Model	Design Storm Existing Conditions Model	Proposed Conditions Model	Difference PRO-EX
100-yr	-	205.59	173.04	-33
50-yr	174.63	181.99	157.56	-24
25-yr	159.96	162.64	144.17	-18
10-yr	140.24	143.88	130.86	-13
5-yr	88.74	136.66	124.64	-12
2-yr	61.28	107.16	95.93	-11
1-yr	43.27	73.08	70.33	-2.8
1"	-	13.71	11.86	-1.8

Perhaps of greater interest at this location may be the peak flood stages which are calculated for each of the storms. The modeled results for these peak water surface elevations may be found in Table 6. Under existing conditions – which apply to the Historic and Existing models – flooding occurs when flows surcharge up through the two catch basins in the field. The same is not true for the Proposed model; as the junction box and the catch basins are to be removed, flooding shall occur under the proposed scenario when water reaches the top of the proposed berm surrounding the restored stream. The results for the Existing and Historic models may thus be compared directly to each other, but the results from the Proposed model is misleading, as flooding here occurs at a different elevation.

Table 6 - Peak Water Surface Elevations at the Inlet to the Triple Pipe-Arch Culverts Out of the Site

Analysis Method / Return Period (years)	Long Term Existing Model	Design Storm Existing Conditions Model	Proposed Conditions Model
100-yr	-	44.04	42.80
50-yr	43.26	43.61	42.71
25-yr	43.06	43.28	42.60
10-yr	42.84	42.97	42.35
5-yr	40.95	42.80	42.13
2-yr	39.83	41.45	40.05
1-yr	39.07	40.34	39.30
1"	-	37.70	37.28

As the flooding elevations vary from existing to proposed conditions, it may be most useful to compare the water stage relative to each scenario's flooding elevation. For the Historic and Existing models, this occurs at about an elevation of 42.7 ft MSL. For the Proposed model, flooding occurs over the top of the proposed bermat an elevation of about 42.2 ft MSL'. This is lower than existing because…The peak flood stages corresponding to the design storms may be found in Table 7.

Table 7 - Peak Water Surface Elevations Above Overtopping Elevation

Analysis Method / Return Period (years)	Long Term Existing Model	Design Storm Existing Conditions Model	Proposed Conditions Model	Difference PRO-EX
100-yr	-	1.34	0.60	-0.75
50-yr	0.56	0.91	0.51	-0.41
25-yr	0.36	0.58	0.40	-0.19
10-yr	0.14	0.27	0.15	-0.12
5-yr	-	0.10	-	-
2-yr	-	-	-	-
1-yr	-	-	-	-
1"	-	-	-	-

The relative difference in total depth of water above the flood stage from the Proposed and the Existing model may be found in the final column. The proposed conditions show that flood depths are expected to be reduced compared to the Existing model, and even a reduction in expected frequency of flooding, though compared to Historic conditions.

Results at the Goose Bay Swale, Downstream from the Site

Immediately downstream from the site, the three pipe-arch culverts pass Hodgson Brook under Goose Bay Drive into a swale which runs adjacent to the road before being passed under Corporate Drive by a box culvert. The swale here has flows incoming from the southwest in addition to those coming from the site. The field to the east of the outlets is relatively low compared to the road surfaces surrounding it. The box culvert is the primary outlet for the swale here however during larger flow events water ponds in the field, flowing over the driveway to the southeast before overtopping anywhere else – Goose Bay Drive, Corporate Drive, the parking lot to the south, etc. While being updated as part of the project, this culvert setting is set to remain almost the same from existing to proposed conditions. The primary concern at this point of analysis has been voiced as; does the project impact flows and water stages in a manner which may cause the swale to become full enough to cause flooding over Goose Bay Drive?

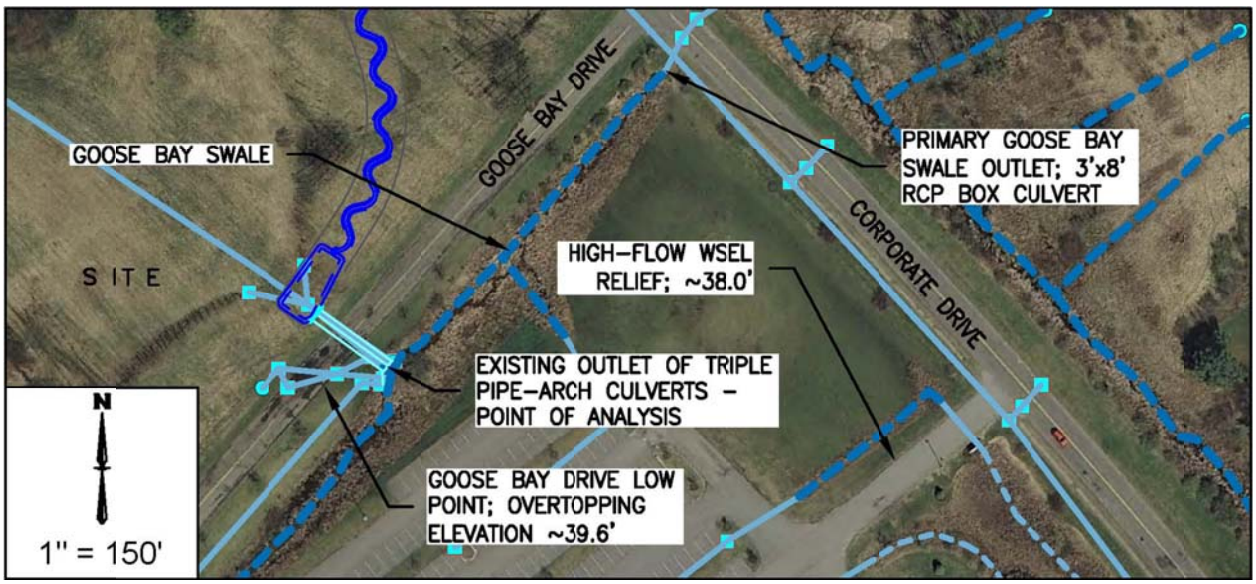


Figure 6 - Goose Bay Swale (Downstream from Site) Point of Analysis References

The lowest point in Goose Bay Drive, adjacent to the swale, is located almost above the three pipe-arches; this elevation is about 39.6 ft NAVD88. Flood stages would therefore have to overtop this elevation in order to flood the road. This is not expected to ever occur at this location because the driveway to the east has a low point of about 38.0 ft MSL. Flooding will occur for 1.5 feet over that driveway before ever overtopping Goose Bay Drive.

The most important result at this location is relative to flooding – how much and how often might it occur. The calculated peak flood elevations for each of the three models are shown in Table 8. As the lowest road elevation was assumed to remain constant, the values may be compared to one another. The final column represents the difference in the calculated peak flood elevations from the Proposed model to the Existing.

As shown, the proposed conditions are expected to improve the flooding conditions relative to the Existing model, and are about on par with the Historic model. It is interesting to see that for all three models, the driveway downstream is expected to overtop, on average, every year. This was not ever observed as the correct estimation for an actual frequency – none was really ever given. With the lack of calibration data for this location, this type of possible modeling error is to be expected. However, though the rate of return of flooding at that driveway may be slightly off, the frequencies from one model to another may be compared with confidence. Proposed conditions are not calculated to flood the driveway, or Goose Bay Drive any more frequently than historically. Furthermore, using the same design storms, the peak flooding depth above the driveway is projected to be reduced. This is due to the fact that while the peak flows are somewhat on the same magnitude between the Design Storm Existing and Proposed models, there is likely a greater volume of total runoff coming from upstream under existing conditions. This, plus the attenuation of the flows provided by the proposed site, reduce the peak flow timing and the amount of required storm volume routing required by the field and swale.

Table 8 - Peak Water Surface Elevations in the Goose Bay Swale, Downstream from the Site

Analysis Method / Storm Event	Long Term Existing Model	Design Storm Existing Conditions Model	Proposed Conditions Model	Difference PRO-EX
100-yr	-	40.28	38.83	-1.46
50-yr	38.26	39.85	38.76	-1.09
25-yr	38.24	39.52	38.69	-0.83
10-yr	38.20	39.21	38.56	-0.65
5-yr	38.16	39.04	38.43	-0.61
2-yr	38.13	38.69	38.27	-0.42
1-yr	38.11	38.47	38.19	-0.28
1"	-	37.70	37.27	-0.44

McGraw-Edison

DESCRIPTION

The Galleon™ LED luminaire delivers exceptional performance in a highly scalable, low-profile design. Patented, high-efficiency AccuLED Optics™ system provides uniform and energy conscious illumination to walkways, parking lots, roadways, building areas and security lighting applications. IP66 rated and UL/cUL Listed for wet locations.

Catalog #		Type
Project		
Comments		Date
Prepared by		

GLEON
GALLEON LED

1-10 Light Squares
Solid State LED

AREA/SITE LUMINAIRE

SPECIFICATION FEATURES

Construction
Extruded aluminum driver enclosure thermally isolated from Light Squares for optimal thermal performance. Heavy-wall, die-cast aluminum end caps enclose housing and die-cast aluminum heat sinks. A unique, patent pending interlocking housing and heat sink provides scalability with superior structural rigidity. 3G vibration tested and rated. Optional tool-less hardware available for ease of entry into electrical chamber. Housing is IP66 rated.

Optics
Patented, high-efficiency injection-molded AccuLED Optics technology. Optics are precisely designed to shape the distribution maximizing efficiency and application spacing. AccuLED Optics create consistent distributions with the scalability to meet customized application requirements. Offered standard in 4000K (+/- 275K) CCT 70 CRI. Optional 3000K, 5000K and 6000K CCT.

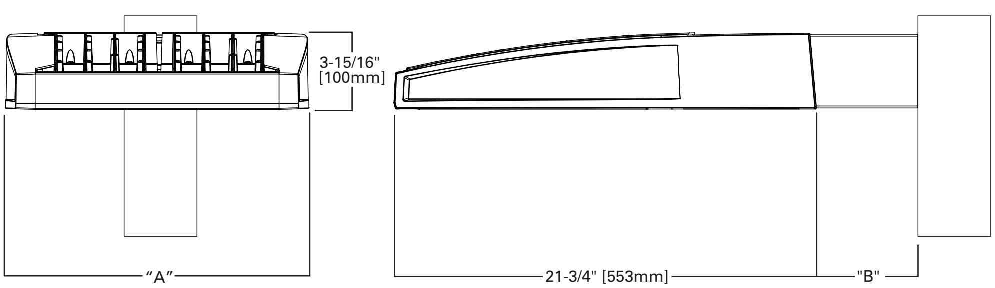
Electrical
LED drivers are mounted to removable tray assembly for ease of maintenance. 120-277V 50/60Hz, 347V 60Hz or 480V 60Hz operation. 480V is compatible for use with 480V Wye systems only. Standard with 0-10V dimming. Shipped standard with Eaton proprietary circuit module designed to withstand 10kV of transient line surge. The Galleon LED luminaire is suitable for operation in -40°C to 40°C ambient environments. For applications with ambient temperatures exceeding 40°C, specify the HA (High Ambient) option. Light Squares are IP66 rated. Greater than 90% lumen maintenance expected at 60,000 hours. Available in standard 1A drive current and optional 600mA, 800mA and 1200mA drive currents (nominal).

Mounting
STANDARD ARM MOUNT: Extruded aluminum arm includes internal bolt guides allowing for easy positioning of fixture during mounting. When mounting two or more luminaires at 90° and 120° apart, the EA extended arm may be required. Refer to the arm mounting requirement table. Round pole adapter included. For wall mounting, specify wall mount bracket option. QUICK MOUNT ARM: Adapter is bolted directly to the pole. Quick mount arm slide into place on the adapter and is secured via two screws, facilitating quick and easy installation. The versatile, patent pending, quick mount arm accommodates multiple drill patterns ranging from 1-1/2” to 4-7/8”. Removal of the door on the quick mount arm enables wiring of the fixture without having to access the driver compartment. A knock-out enables round pole mounting.

Finish
Housing finished in super durable TGIC polyester powder coat paint, 2.5 mil nominal thickness for superior protection against fade and wear. Heat sink is powder coated black. Standard housing colors include black, bronze, grey, white, dark platinum and graphite metallic. RAL and custom color matches available.

Warranty
Five-year warranty.

DIMENSIONS



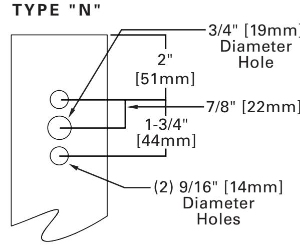
DIMENSION DATA

Number of Light Squares	"A" Width	"B" Standard Arm Length	"B" Optional Arm Length [1]	Weight with Arm (lbs.)	EPA with Arm [2] (Sq. Ft.)
1-4	15-1/2" (394mm)	7" (178mm)	10" (254mm)	33 (15.0 kgs.)	0.96
5-6	21-5/8" (549mm)	7" (178mm)	10" (254mm)	44 (20.0 kgs.)	1.00
7-8	27-5/8" (702mm)	7" (178mm)	13" (330mm)	54 (24.5 kgs.)	1.07
9-10	33-3/4" (857mm)	7" (178mm)	16" (406mm)	63 (28.6 kgs.)	1.12

NOTES: 1. Optional arm length to be used when mounting two fixtures at 90° on a single pole. **2.** EPA calculated with optional arm length.

DRILLING PATTERN

TYPE "N"



CERTIFICATION DATA

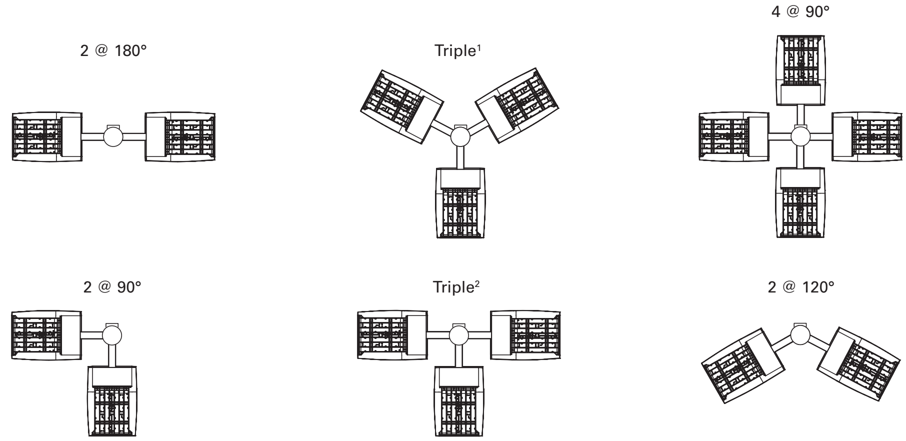
UL/cUL Wet Location Listed
ISO 9001
LM79 / LM80 Compliant
3G Vibration Rated
IP66 Rated
DesignLights Consortium™ Qualified*

ENERGY DATA

Electronic LED Driver
>0.9 Power Factor
<20% Total Harmonic Distortion
120V-277V 50/60Hz
347V & 480V 60Hz
-40°C Min. Temperature
40°C Max. Temperature
50°C Max. Temperature (HA Option)

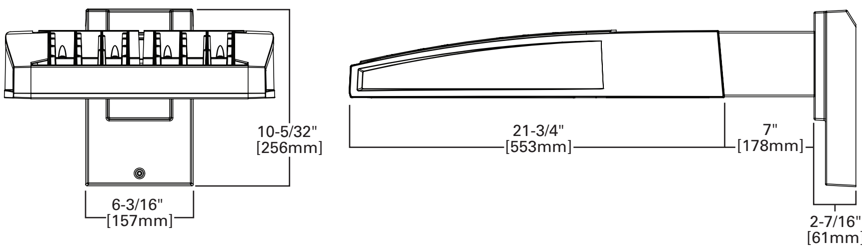
ARM MOUNTING REQUIREMENTS

Configuration	90° Apart	120° Apart
GLEON-AF-01	7" Arm (Standard)	7" Arm (Standard)
GLEON-AF-02	7" Arm (Standard)	7" Arm (Standard)
GLEON-AF-03	7" Arm (Standard)	7" Arm (Standard)
GLEON-AF-04	7" Arm (Standard)	7" Arm (Standard)
GLEON-AF-05	10" Extended Arm (Required)	7" Arm (Standard)
GLEON-AF-06	10" Extended Arm (Required)	7" Arm (Standard)
GLEON-AF-07	13" Extended Arm (Required)	13" Extended Arm (Required)
GLEON-AF-08	13" Extended Arm (Required)	13" Extended Arm (Required)
GLEON-AF-09	16" Extended Arm (Required)	16" Extended Arm (Required)
GLEON-AF-10	16" Extended Arm (Required)	16" Extended Arm (Required)

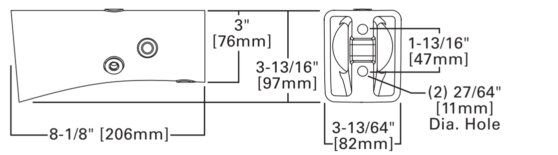


NOTES: 1 Round poles are 3 @ 120°. Square poles are 3 @ 90°. **2** Round poles are 3 @ 90°.

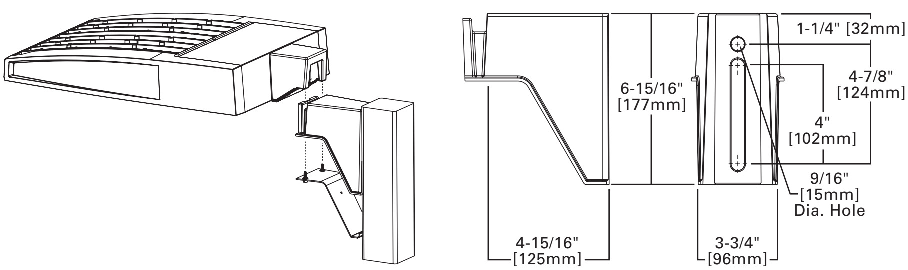
STANDARD WALL MOUNT

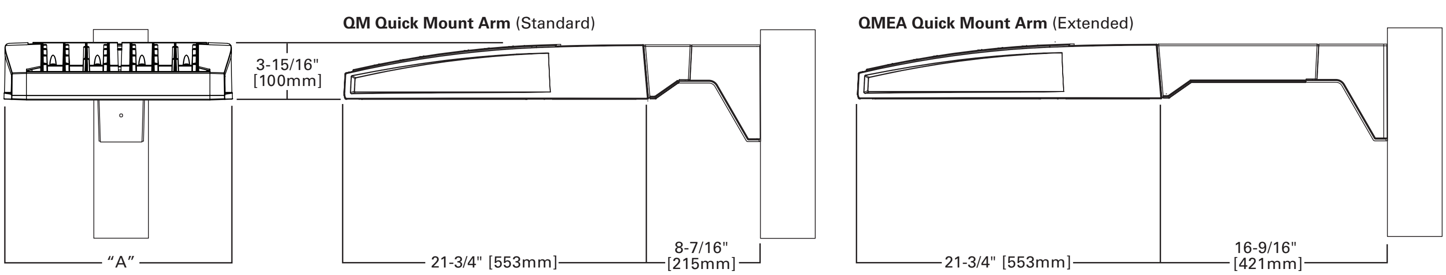


MAST ARM MOUNT



QUICK MOUNT ARM (INCLUDES FIXTURE ADAPTER)



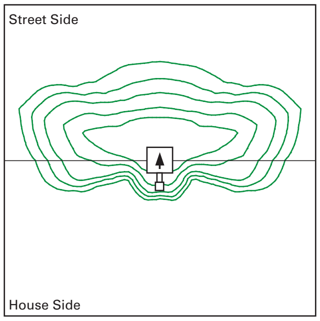


QUICK MOUNT ARM DATA

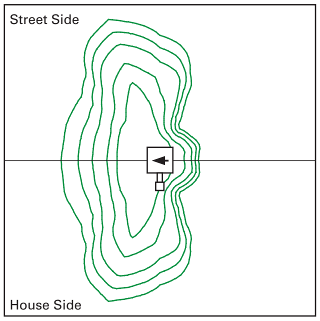
Number of Light Squares [1,2]	"A" Width	Weight with QM Arm (lbs.)	Weight with QMEA Arm (lbs.)	EPA (Sq. Ft.)
1-4	15-1/2" (394mm)	35 (15.91 kgs.)	38 (17.27 kgs.)	
5-6 [3]	21-5/8" (549mm)	46 (20.91 kgs.)	49 (22.27 kgs.)	1.11
7-8	27-5/8" (702mm)	56 (25.45 kgs.)	59 (26.82 kgs.)	

NOTES: 1 QM option available with 1-8 light square configurations. **2** QMEA option available with 1-6 light square configurations. **3** QMEA arm to be used when mounting two fixtures at 90° on a single pole.

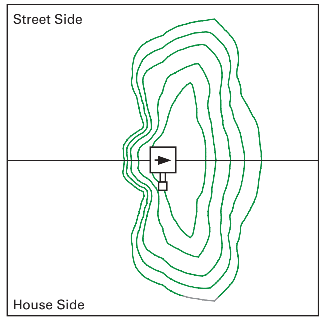
OPTIC ORIENTATION



Standard



Optics Rotated Left @ 90° [L90]

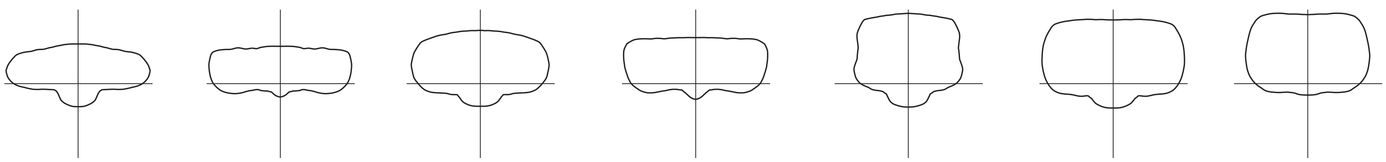


Optics Rotated Right @ 90° [R90]

OPTICAL DISTRIBUTIONS

Asymmetric Area Distributions

T2 (Type II) · **SL2** (Type II with Spill Control) · **T3** (Type III) · **SL3** (Type III with Spill Control) · **T4FT** (Type IV Forward Throw) · **T4W** (Type IV Wide) · **SL4** (Type IV with Spill Control)



Asymmetric Roadway Distributions

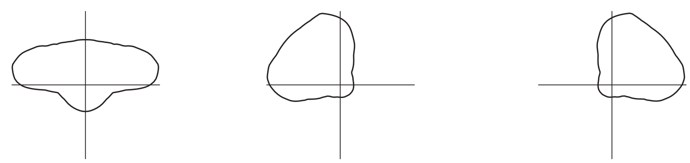
RW (Rectangular Wide Type I) · **T2R** (Type II Roadway) · **T3R** (Type III Roadway)

Symmertric Distributions

5NQ (Type V Square Narrow) · **5MQ** (Type V Square Medium) · **5WQ** (Type V Square Wide)

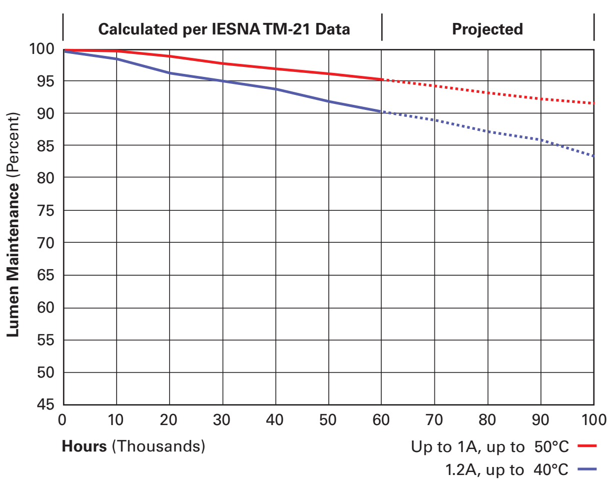
Specialized Distributions

AFL (Automotive Frontline) · **SLL** (90° Spill Light Eliminator Left) · **SLR** (90° Spill Light Eliminator Right)



LUMEN MAINTENANCE

Drive Current	Ambient Temperature	TM-21 Lumen Maintenance (60,000 Hours)	Projected L70 (Hours)
Up to 1A	Up to 50°C	> 95%	416,000
1.2A	Up to 40°C	> 90%	205,000



LUMEN MULTIPLIER

Ambient Temperature	Lumen Multiplier
0°C	1.02
10°C	1.01
25°C	1.00
40°C	0.99
50°C	0.97

Eaton
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Specifications and dimensions subject to change without notice.

NOMINAL POWER LUMENS (1.2A)

Number of Light Squares		1	2	3	4	5	6	7	8	9	10
Nominal Power (Watts)		67	129	191	258	320	382	448	511	575	640
Input Current @ 120V (A)		0.58	1.16	1.78	2.31	2.94	3.56	4.09	4.71	5.34	5.87
Input Current @ 208V (A)		0.33	0.63	0.93	1.27	1.57	1.87	2.22	2.52	2.8	3.14
Input Current @ 240V (A)		0.29	0.55	0.80	1.10	1.35	1.61	1.93	2.18	2.41	2.71
Input Current @ 277V (A)		0.25	0.48	0.70	0.96	1.18	1.39	1.69	1.90	2.09	2.36
Input Current @ 347V (A)		0.20	0.39	0.57	0.78	0.96	1.15	1.36	1.54	1.72	1.92
Input Current @ 480V (A)		0.15	0.30	0.43	0.60	0.73	0.85	1.03	1.16	1.28	1.45
Optics											
T2	4000K/5000K Lumens	6,709	13,111	19,562	25,848	32,026	38,325	45,324	51,355	57,286	63,424
	3000K Lumens	5,939	11,606	17,316	22,881	28,349	33,925	40,121	45,459	50,710	56,143
	BUG Rating	B1-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
T2R	4000K/5000K Lumens	7,122	13,919	20,769	27,442	34,000	40,687	48,117	54,519	60,816	67,333
	3000K Lumens	5,939	11,606	17,316	22,881	28,349	33,925	40,121	45,459	50,710	56,143
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5
T3	4000K/5000K Lumens	6,838	13,363	19,939	26,346	32,642	39,062	46,196	52,343	58,388	64,646
	3000K Lumens	6,053	11,829	17,650	23,321	28,895	34,578	40,893	46,334	51,685	57,225
	BUG Rating	B1-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
T3R	4000K/5000K Lumens	6,990	13,660	20,382	26,931	33,368	39,930	47,223	53,506	59,686	66,081
	3000K Lumens	6,188	12,092	18,042	23,839	29,537	35,346	41,802	47,364	52,834	58,495
	BUG Rating	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5
T4FT	4000K/5000K Lumens	6,878	13,440	20,055	26,499	32,832	39,289	46,464	52,646	58,726	65,020
	3000K Lumens	6,088	11,897	17,753	23,457	29,063	34,779	41,130	46,602	51,984	57,556
	BUG Rating	B1-U0-G2	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
T4W	4000K/5000K Lumens	6,789	13,267	19,795	26,156	32,408	38,781	45,864	51,967	57,968	64,180
	3000K Lumens	6,010	11,744	17,523	23,153	28,688	34,329	40,599	46,001	51,313	56,812
	BUG Rating	B1-U0-G2	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
SL2	4000K/5000K Lumens	6,697	13,088	19,529	25,804	31,970	38,259	45,245	51,267	57,186	63,315
	3000K Lumens	5,928	11,585	17,287	22,842	28,300	33,867	40,051	45,382	50,621	56,046
	BUG Rating	B1-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
SL3	4000K/5000K Lumens	6,837	13,361	19,936	26,342	32,639	39,057	46,189	52,336	58,380	64,636
	3000K Lumens	6,052	11,827	17,647	23,318	28,892	34,573	40,887	46,328	51,678	57,216
	BUG Rating	B1-U0-G2	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
SL4	4000K/5000K Lumens	6,496	12,695	18,943	25,029	31,011	37,110	43,886	49,727	55,470	61,414
	3000K Lumens	5,750	11,238	16,768	22,156	27,451	32,850	38,848	44,018	49,102	54,364
	BUG Rating	B1-U0-G2	B1-U0-G3	B2-U0-G4	B2-U0-G4	B2-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
5NQ	4000K/5000K Lumens	7,052	13,781	20,564	27,171	33,664	40,285	47,641	53,981	60,215	66,669
	3000K Lumens	6,242	12,199	18,203	24,052	29,799	35,660	42,172	47,784	53,302	59,015
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4
5MQ	4000K/5000K Lumens	7,182	14,034	20,942	27,671	34,284	41,027	48,518	54,975	61,323	67,896
	3000K Lumens	6,358	12,423	18,538	24,494	30,348	36,317	42,948	48,664	54,283	60,102
	BUG Rating	B3-U0-G1	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G5	B5-U0-G5	B5-U0-G5
5WQ	4000K/5000K Lumens	7,201	14,073	20,998	27,744	34,375	41,136	48,648	55,121	61,487	68,077
	3000K Lumens	6,374	12,457	18,587	24,559	30,429	36,414	43,063	48,793	54,428	60,262
	BUG Rating	B3-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G5	B5-U0-G5	B5-U0-G5	B5-U0-G5
SLL/SLR	4000K/5000K Lumens	6,009	11,741	17,519	23,148	28,681	34,321	40,589	45,990	51,301	56,798
	3000K Lumens	5,319	10,393	15,508	20,491	25,388	30,381	35,929	40,710	45,412	50,278
	BUG Rating	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5
RW	4000K/5000K Lumens	6,989	13,657	20,378	26,925	33,360	39,921	47,211	53,494	59,672	66,066
	3000K Lumens	6,187	12,089	18,039	23,834	29,530	35,338	41,791	47,353	52,822	58,482
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G4
AFL	4000K/5000K Lumens	7,014	13,706	20,452	27,023	33,481	40,066	47,383	53,688	59,888	66,306
	3000K Lumens	6,209	12,133	18,104	23,921	29,637	35,466	41,943	47,525	53,013	58,694
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G4	B4-U0-G4	B4-U0-G4

* Nominal data for 70 CRI.

NOMINAL POWER LUMENS (1A)

Number of Light Squares		1	2	3	4	5	6	7	8	9	10
Nominal Power (Watts)		59	113	166	225	279	333	391	445	501	558
Input Current @ 120V (A)		0.51	1.02	1.53	2.03	2.55	3.06	3.56	4.08	4.6	5.07
Input Current @ 208V (A)		0.29	0.56	0.82	1.11	1.37	1.64	1.93	2.19	2.46	2.75
Input Current @ 240V (A)		0.26	0.48	0.71	0.96	1.19	1.41	1.67	1.89	2.12	2.39
Input Current @ 277V (A)		0.23	0.42	0.61	0.83	1.03	1.23	1.45	1.65	1.84	2.09
Input Current @ 347V (A)		0.17	0.32	0.50	0.64	0.82	1.00	1.14	1.32	1.50	1.68
Input Current @ 480V (A)		0.14	0.24	0.37	0.48	0.61	0.75	0.91	0.99	1.12	1.28
Optics											
T2	4000K/5000K Lumens	6,116	11,951	17,833	23,563	29,195	34,937	41,317	46,814	52,221	57,817
	3000K Lumens	5,414	10,579	15,786	20,858	25,843	30,926	36,574	41,440	46,226	51,180
	BUG Rating	B1-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
T2R	4000K/5000K Lumens	6,493	12,688	18,932	25,015	30,994	37,090	43,863	49,699	55,439	61,380
	3000K Lumens	5,748	11,231	16,759	22,143	27,436	32,832	38,828	43,994	49,075	54,334
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5
T3	4000K/5000K Lumens	6,234	12,181	18,176	24,017	29,756	35,609	42,111	47,715	53,225	58,930
	3000K Lumens	5,518	10,783	16,089	21,260	26,340	31,521	37,277	42,237	47,115	52,165
	BUG Rating	B1-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
T3R	4000K/5000K Lumens	6,372	12,453	18,580	24,550	30,418	36,400	43,048	48,776	54,409	60,239
	3000K Lumens	5,640	11,023	16,447	21,732	26,926	32,221	38,106	43,177	48,163	53,324
	BUG Rating	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5
T4FT	4000K/5000K Lumens	6,270	12,252	18,282	24,156	29,929	35,815	42,356	47,992	53,534	59,271
	3000K Lumens	5,550	10,845	16,183	21,383	26,493	31,703	37,494	42,483	47,388	52,467
	BUG Rating	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5
T4W	4000K/5000K Lumens	6,189	12,094	18,045	23,844	29,543	35,352	41,809	47,372	52,843	58,506
	3000K Lumens	5,479	10,706	15,973	21,107	26,151	31,294	37,009	41,934	46,777	51,790
	BUG Rating	B1-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G4	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
SL2	4000K/5000K Lumens	6,105	11,931	17,803	23,522	29,144	34,877	41,245	46,734	52,130	57,717
	3000K Lumens	5,404	10,561	15,759	20,822	25,798	30,873	36,510	41,369	46,145	51,091
	BUG Rating	B1-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5	B4-U0-G5
SL3	4000K/5000K Lumens	6,233	12,180	18,174	24,013	29,753	35,604	42,106	47,708	53,218	58,921
	3000K Lumens	5,517	10,782	16,088	21,256	26,337	31,517	37,272	42,231	47,109	52,157
	BUG Rating	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5
SL4	4000K/5000K Lumens	5,922	11,572	17,268	22,816	28,269	33,829	40,006	45,330	50,566	55,984
	3000K Lumens	5,242	10,244	15,286	20,197	25,024	29,945	35,413	40,126	44,761	49,557
	BUG Rating	B1-U0-G2	B1-U0-G3	B2-U0-G3	B2-U0-G4	B2-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
5NQ	4000K/5000K Lumens	6,429	12,563	18,746	24,768	30,688	36,723	43,429	49,208	54,891	60,775
	3000K Lumens	5,691	11,121	16,594	21,925	27,165	32,507	38,443	43,559	48,590	53,798
	BUG Rating	B2-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4
5MQ	4000K/5000K Lumens	6,547	12,794	19,090	25,224	31,253	37,400	44,228	50,114	55,902	61,893
	3000K Lumens	5,795	11,325	16,898	22,328	27,665	33,106	39,151	44,361	49,484	54,788
	BUG Rating	B3-U0-G1	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G5	B5-U0-G5
5WQ	4000K/5000K Lumens	6,564	12,828	19,141	25,291	31,336	37,499	44,347	50,248	56,051	62,058
	3000K Lumens	5,810	11,355	16,944	22,388	27,739	33,194	39,256	44,480	49,616	54,934
	BUG Rating	B3-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G5	B5-U0-G5	B5-U0-G5	B5-U0-G5
SLL/SLR	4000K/5000K Lumens	5,478	10,703	15,970	21,102	26,145	31,286	37,001	41,924	46,765	51,777
	3000K Lumens	4,849	9,474	14,137	18,679	23,144	27,694	32,753	37,111	41,396	45,833
	BUG Rating	B1-U0-G2	B1-U0-G3	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
RW	4000K/5000K Lumens	6,371	12,449	18,576	24,544	30,411	36,392	43,037	48,764	54,396	60,225
	3000K Lumens	5,640	11,020	16,443	21,726	26,920	32,214	38,096	43,166	48,151	53,311
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4
AFL	4000K/5000K Lumens	6,394	12,494	18,644	24,634	30,521	36,524	43,194	48,942	54,593	60,444
	3000K Lumens	5,660	11,060	16,504	21,806	27,017	32,331	38,235	43,323	48,326	53,505
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G2	B3-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G3	B4-U0-G4	B4-U0-G4

* Nominal data for 70 CRI.

NOMINAL POWER LUMENS (800MA)

Number of Light Squares		1	2	3	4	5	6	7	8	9	10
Nominal Power (Watts)		44	85	124	171	210	249	295	334	374	419
Input Current @ 120V (A)		0.39	0.77	1.13	1.54	1.90	2.26	2.67	3.03	3.39	3.80
Input Current @ 208V (A)		0.22	0.44	0.62	0.88	1.06	1.24	1.50	1.68	1.87	2.12
Input Current @ 240V (A)		0.19	0.38	0.54	0.76	0.92	1.08	1.30	1.46	1.62	1.84
Input Current @ 277V (A)		0.17	0.36	0.47	0.72	0.83	0.95	1.19	1.31	1.42	1.67
Input Current @ 347V (A)		0.15	0.24	0.38	0.49	0.63	0.77	0.87	1.01	1.15	1.52
Input Current @ 480V (A)		0.11	0.18	0.29	0.37	0.48	0.59	0.66	0.77	0.88	0.96
Optics											
T2	4000K/5000K Lumens	4,941	9,656	14,408	19,038	23,588	28,227	33,382	37,823	42,191	46,713
	3000K Lumens	4,374	8,547	12,754	16,852	20,880	24,987	29,550	33,481	37,347	41,350
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B4-U0-G5	B4-U0-G5
T2R	4000K/5000K Lumens	5,246	10,251	15,296	20,211	25,041	29,966	35,439	40,154	44,791	49,592
	3000K Lumens	4,644	9,074	13,540	17,891	22,166	26,526	31,371	35,544	39,649	43,899
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5
T3	4000K/5000K Lumens	5,037	9,842	14,685	19,404	24,041	28,770	34,024	38,551	43,003	47,612
	3000K Lumens	4,459	8,712	12,999	17,176	21,281	25,467	30,118	34,125	38,066	42,146
	BUG Rating	B1-U0-G1	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5
T3R	4000K/5000K Lumens	5,148	10,061	15,011	19,835	24,576	29,409	34,780	39,408	43,959	48,669
	3000K Lumens	4,557	8,906	13,288	17,558	21,755	26,033	30,787	34,884	38,913	43,082
	BUG Rating	B1-U0-G2	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
T4FT	4000K/5000K Lumens	5,066	9,899	14,770	19,516	24,181	28,936	34,221	38,774	43,252	47,888
	3000K Lumens	4,484	8,763	13,074	17,276	21,405	25,614	30,292	34,323	38,287	42,390
	BUG Rating	B1-U0-G2	B1-U0-G2	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
T4W	4000K/5000K Lumens	5,000	9,771	14,579	19,264	23,869	28,562	33,779	38,274	42,694	47,269
	3000K Lumens	4,426	8,649	12,905	17,052	21,129	25,283	29,901	33,880	37,793	41,843
	BUG Rating	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B4-U0-G5	B4-U0-G5
SL2	4000K/5000K Lumens	4,933	9,639	14,383	19,005	23,547	28,178	33,324	37,758	42,118	46,632
	3000K Lumens	4,367	8,532	12,732	16,823	20,844	24,943	29,498	33,423	37,283	41,279
	BUG Rating	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B4-U0-G5	B4-U0-G5
SL3	4000K/5000K Lumens	5,036	9,841	14,683	19,401	24,039	28,766	34,019	38,546	42,997	47,605
	3000K Lumens	4,458	8,711	12,997	17,174	21,279	25,464	30,114	34,121	38,061	42,140
	BUG Rating	B1-U0-G2	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
SL4	4000K/5000K Lumens	4,784	9,350	13,951	18,434	22,840	27,332	32,323	36,624	40,854	45,232
	3000K Lumens	4,235	8,277	12,349	16,318	20,218	24,194	28,612	32,420	36,164	40,039
	BUG Rating	B1-U0-G2	B1-U0-G3	B1-U0-G3	B2-U0-G4	B2-U0-G4	B2-U0-G5	B2-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
5NQ	4000K/5000K Lumens	5,194	10,150	15,145	20,011	24,794	29,670	35,088	39,757	44,349	49,102
	3000K Lumens	4,598	8,985	13,406	17,714	21,948	26,264	31,060	35,193	39,258	43,465
	BUG Rating	B2-U0-G1	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G3	B5-U0-G3
5MQ	4000K/5000K Lumens	5,290	10,337	15,424	20,380	25,250	30,217	35,734	40,489	45,165	50,006
	3000K Lumens	4,683	9,150	13,653	18,040	22,351	26,748	31,632	35,841	39,980	44,265
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G4
5WQ	4000K/5000K Lumens	5,304	10,365	15,465	20,434	25,318	30,297	35,830	40,597	45,286	50,139
	3000K Lumens	4,695	9,175	13,690	18,088	22,411	26,819	31,717	35,936	40,087	44,383
	BUG Rating	B3-U0-G1	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G5	B5-U0-G5
SLL/SLR	4000K/5000K Lumens	4,426	8,648	12,903	17,049	21,124	25,278	29,894	33,872	37,784	41,832
	3000K Lumens	3,918	7,655	11,422	15,092	18,699	22,376	26,462	29,983	33,446	37,030
	BUG Rating	B1-U0-G2	B1-U0-G2	B2-U0-G3	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5	B3-U0-G5
RW	4000K/5000K Lumens	5,147	10,058	15,009	19,830	24,570	29,402	34,771	39,399	43,949	48,658
	3000K Lumens	4,556	8,903	13,286	17,554	21,749	26,027	30,779	34,876	38,904	43,072
	BUG Rating	B2-U0-G1	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G3	B5-U0-G4
AFL	4000K/5000K Lumens	5,166	10,095	15,063	19,903	24,659	29,509	34,898	39,542	44,108	48,835
	3000K Lumens	4,573	8,936	13,334	17,618	21,828	26,121	30,892	35,003	39,044	43,229
	BUG Rating	B1-U0-G1	B1-U0-G1	B2-U0-G2	B2-U0-G2	B3-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G3

* Nominal data for 70 CRI.

Eaton
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Specifications and
dimensions subject to
change without notice.

NOMINAL POWER LUMENS (600MA)

Number of Light Squares		1	2	3	4	5	6	7	8	9	10
Nominal Power (Watts)		34	66	96	129	162	193	226	257	290	323
Input Current @ 120V (A)		0.30	0.58	0.86	1.16	1.44	1.73	2.03	2.33	2.59	2.89
Input Current @ 208V (A)		0.17	0.34	0.49	0.65	0.84	0.99	1.14	1.30	1.48	1.63
Input Current @ 240V (A)		0.15	0.30	0.43	0.56	0.74	0.87	1.00	1.13	1.30	1.43
Input Current @ 277V (A)		0.14	0.28	0.41	0.52	0.69	0.81	0.93	1.04	1.22	1.33
Input Current @ 347V (A)		0.11	0.19	0.30	0.39	0.49	0.60	0.69	0.77	0.90	0.99
Input Current @ 480V (A)		0.08	0.15	0.24	0.30	0.38	0.48	0.53	0.59	0.71	0.77
Optics											
T2	4000K/5000K Lumens	4,029	7,874	11,749	15,525	19,235	23,019	27,222	30,844	34,406	38,093
	3000K Lumens	3,566	6,970	10,400	13,743	17,027	20,376	24,097	27,303	30,456	33,720
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G4
T2R	4000K/5000K Lumens	4,278	8,360	12,474	16,482	20,421	24,437	28,900	32,745	36,527	40,441
	3000K Lumens	3,787	7,400	11,042	14,590	18,077	21,632	25,582	28,986	32,334	35,798
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4
T3	4000K/5000K Lumens	4,107	8,026	11,976	15,824	19,605	23,461	27,746	31,438	35,068	38,827
	3000K Lumens	3,636	7,105	10,601	14,007	17,354	20,768	24,561	27,829	31,042	34,370
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5
T3R	4000K/5000K Lumens	4,198	8,205	12,242	16,175	20,041	23,982	28,363	32,137	35,848	39,689
	3000K Lumens	3,716	7,263	10,837	14,318	17,740	21,229	25,107	28,448	31,733	35,133
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5
T4FT	4000K/5000K Lumens	4,131	8,072	12,045	15,915	19,719	23,597	27,907	31,620	35,272	39,052
	3000K Lumens	3,657	7,145	10,662	14,088	17,455	20,888	24,703	27,990	31,223	34,569
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5
T4W	4000K/5000K Lumens	4,077	7,968	11,889	15,710	19,465	23,292	27,546	31,212	34,816	38,547
	3000K Lumens	3,609	7,053	10,524	13,906	17,230	20,618	24,384	27,629	30,819	34,122
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G2	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5	B3-U0-G5
SL2	4000K/5000K Lumens	4,022	7,861	11,729	15,498	19,202	22,979	27,175	30,791	34,347	38,028
	3000K Lumens	3,560	6,959	10,383	13,719	16,998	20,341	24,055	27,256	30,404	33,662
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G3	B2-U0-G3	B3-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5
SL3	4000K/5000K Lumens	4,106	8,025	11,974	15,821	19,603	23,458	27,742	31,433	35,064	38,821
	3000K Lumens	3,635	7,104	10,599	14,005	17,353	20,765	24,557	27,824	31,039	34,364
	BUG Rating	B1-U0-G1	B1-U0-G2	B2-U0-G3	B2-U0-G3	B2-U0-G3	B3-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5
SL4	4000K/5000K Lumens	3,902	7,624	11,377	15,033	18,626	22,289	26,359	29,867	33,316	36,886
	3000K Lumens	3,454	6,749	10,071	13,307	16,488	19,730	23,333	26,438	29,491	32,651
	BUG Rating	B1-U0-G2	B1-U0-G2	B1-U0-G3	B1-U0-G3	B2-U0-G4	B2-U0-G4	B2-U0-G4	B2-U0-G5	B3-U0-G5	B3-U0-G5
5NQ	4000K/5000K Lumens	4,236	8,277	12,351	16,319	20,219	24,196	28,614	32,422	36,166	40,042
	3000K Lumens	3,750	7,327	10,933	14,446	17,898	21,418	25,329	28,700	32,014	35,445
	BUG Rating	B2-U0-G1	B3-U0-G1	B3-U0-G2	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G2	B5-U0-G3	B5-U0-G3
5MQ	4000K/5000K Lumens	4,314	8,429	12,578	16,619	20,591	24,641	29,141	33,019	36,832	40,779
	3000K Lumens	3,819	7,461	11,134	14,711	18,227	21,812	25,796	29,228	32,604	36,098
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4
5WQ	4000K/5000K Lumens	4,325	8,452	12,611	16,664	20,646	24,707	29,219	33,106	36,930	40,888
	3000K Lumens	3,828	7,482	11,163	14,751	18,276	21,871	25,865	29,305	32,690	36,194
	BUG Rating	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G4	B5-U0-G4	B5-U0-G4	B5-U0-G4
SLL/SLR	4000K/5000K Lumens	3,609	7,052	10,522	13,903	17,226	20,613	24,378	27,622	30,812	34,114
	3000K Lumens	3,195	6,242	9,314	12,307	15,248	18,247	21,579	24,451	27,275	30,198
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G3	B2-U0-G3	B2-U0-G3	B2-U0-G4	B3-U0-G4	B3-U0-G4	B3-U0-G5	B3-U0-G5
RW	4000K/5000K Lumens	4,197	8,202	12,239	16,171	20,036	23,977	28,356	32,129	35,839	39,680
	3000K Lumens	3,715	7,260	10,834	14,315	17,736	21,224	25,101	28,441	31,725	35,125
	BUG Rating	B2-U0-G1	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2	B5-U0-G3	B5-U0-G3	B5-U0-G3
AFL	4000K/5000K Lumens	4,213	8,232	12,284	16,230	20,109	24,064	28,459	32,246	35,969	39,824
	3000K Lumens	3,729	7,287	10,874	14,367	17,800	21,301	25,192	28,544	31,840	35,252
	BUG Rating	B1-U0-G1	B1-U0-G1	B2-U0-G2	B2-U0-G2	B2-U0-G2	B3-U0-G2	B3-U0-G3	B3-U0-G3	B3-U0-G3	B3-U0-G3

* Nominal data for 70 CRI.

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1121 Highway 74 South
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Specifications and dimensions subject to change without notice.

CONTROL OPTIONS

0-10V (DIM)
This fixture is offered standard with 0-10V dimming driver(s). The DIM option provides 0-10V dimming wire leads for use with a lighting control panel or other control method.

Photocontrol (P, R and PER7)
Optional button-type photocontrol (P) and photocontrol receptacles (R and PER7) provide a flexible solution to enable "dusk-to-dawn" lighting by sensing light levels. Advanced control systems compatible with NEMA 7-pin standards can be utilized with the PER7 receptacle.

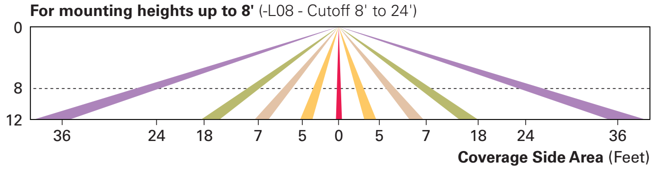
After Hours Dim (AHD)
This feature allows photocontrol-enabled luminaires to achieve additional energy savings by dimming during scheduled portions of the night. The dimming profile will automatically take effect after a "dusk-to-dawn" period has been calculated from the photocontrol input. Specify the desired dimming profile for a simple, factory-shipped dimming solution requiring no external control wiring. Reference the After Hours Dim supplemental guide for additional information.

Dimming Occupancy Sensor (MS/DIM-LXX, MS/X-LXX and MS-LXX)
These sensors are factory installed in the luminaire housing. When the MS/DIM-LXX sensor option is selected, the occupancy sensor is connected to a dimming driver and the entire luminaire dims when there is no activity detected. When activity is detected, the luminaire returns to full light output. The MS/DIM sensor is factory preset to dim down to approximately 50 percent power with a time delay of five minutes. The MS-LXX sensor is factory preset to turn the luminaire off after five minutes of no activity. The MS/X-LXX is also preset for five minutes and only controls the specified number of light engines to maintain steady output from the remaining light engines.

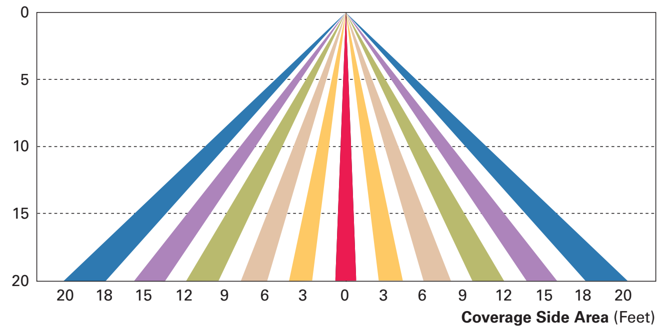
These occupancy sensors includes an integral photocell that can be activated with the FSIR-100 accessory for "dusk-to-dawn" control or daylight harvesting - the factory preset is OFF. The FSIR-100 is a wireless tool utilized for changing the dimming level, time delay, sensitivity and other parameters.

A variety of sensor lens are available to optimize the coverage pattern for mounting heights from 8'-40'.

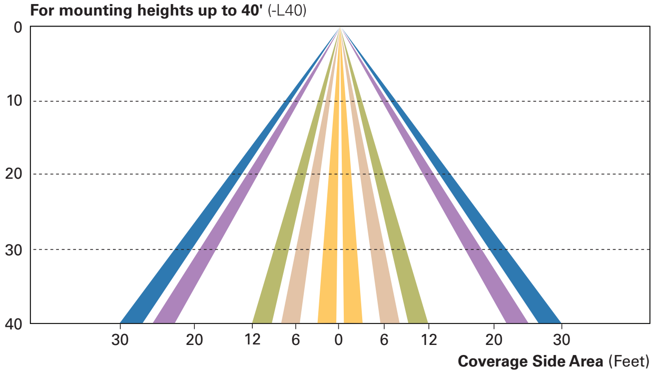
For mounting heights up to 8' (-L08 - Cutoff 8' to 24')



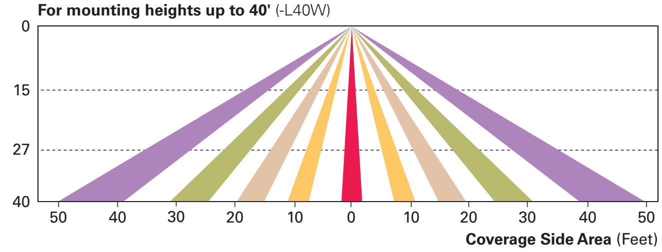
For mounting heights up to 20' (-L20)



For mounting heights up to 40' (-L40)



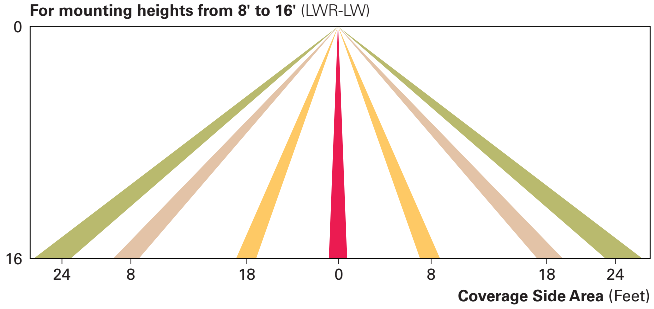
For mounting heights up to 40' (-L40W)



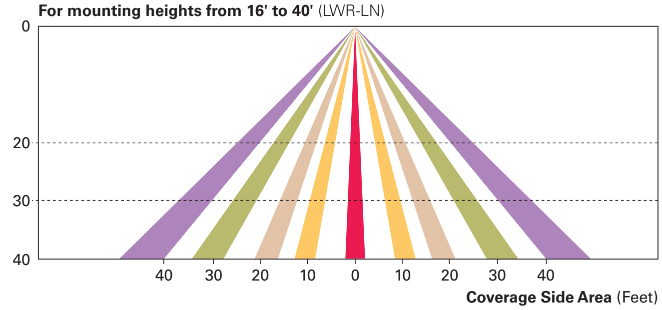
LumaWatt Wireless Control and Monitoring System (LWR-LW and LWR-LN)
The LumaWatt system is a peer-to-peer wireless network of luminaire-integral sensors for any sized project. Each sensor is capable of motion and photo sensing, metering power consumption and wireless communication. The end-user can securely create and manage sensor profiles with browser-based management software. The software will automatically broadcast to the sensors via wireless gateways for zone-based and individual luminaire control. The LumaWatt software provides smart building solutions by utilizing the sensor to provide easy-to-use dashboard and analytic capabilities such as improved energy savings, traffic flow analysis, building management software integration and more.

For additional details, refer to the LumaWatt product guides.

For mounting heights from 8' to 16' (LWR-LW)



For mounting heights from 16' to 40' (LWR-LN)



ORDERING INFORMATION

Sample Number: GLEON-AF-04-LED-E1-T3-GM-QM

Product Family [1, 2]	Light Engine	Number of Light Squares [3]	Lamp Type	Voltage	Distribution	Color	Mounting
GLEON=Galleon	**AF**=1A Drive Current	**01**=1 **02**=2 **03**=3 **04**=4 **05**=5 **06**=6 **07**=7 [4] **08**=8 [4] **09**=9 [5] **10**=10 [5]	**LED**=Solid State Light Emitting Diodes	**E1**=120-277V **347**=347V [6] **480**=480V [6, 7]	**T2**=Type II **T2R**=Type II Roadway **T3**=Type III **T3R**=Type III Roadway **T4FT**=Type IV Forward Throw **T4W**=Type IV Wide **5NQ**=Type V Narrow **5MQ**=Type V Square Medium **5WQ**=Type V Square Wide **SL2**=Type II w/Spill Control **SL3**=Type III w/Spill Control **SL4**=Type IV w/Spill Control **SLL**=90° Spill Light Eliminator Left **SLR**=90° Spill Light Eliminator Right **RW**=Rectangular Wide Type I **AFL**=Automotive Frontline	**AP**=Grey **BZ**=Bronze **BK**=Black **DP**=Dark Platinum **GM**=Graphite Metallic **WH**=White	**[Blank]**=Arm for Round or Square Pole **EA**=Extended Arm [8] **MA**=Mast Arm Adapter [9] **WM**=Wall Mount **QM**=Quick Mount Arm (Standard Length) [10] **QMEA**=Quick Mount Arm (Extended Length) [11]

Options (Add as Suffix)	Accessories (Order Separately)
7030=70 CRI 3000K [12] **8030**=80 CRI 3000K [13] **7050**=70 CRI 5000K [12] **7060**=70 CRI 6000K [12] **600**=Drive Current Factory Set to Nominal 600mA [14] **800**=Drive Current Factory Set to Nominal 800mA [14] **1200**=Drive Current Factory Set to Nominal 1200mA [14, 15] **F**=Single Fuse (120, 277 or 347V. Must Specify Voltage) **FF**=Double Fuse (208, 240 or 480V. Must Specify Voltage) **2L**=Two Circuits [16, 17] **DIM**=External 0-10V Dimming Leads **P**=Button Type Photocontrol (120, 208, 240 or 277V. Must Specify Volatage) **PER7**=NEMA 7-PIN Twistlock Photocontrol Receptacle **R**=NEMA Twistlock Photocontrol Receptacle **AHD145**=After Hours Dim, 5 Hours [18] **AHD245**=After Hours Dim, 6 Hours [18] **AHD255**=After Hours Dim, 7 Hours [18] **AHD355**=After Hours Dim, 8 Hours [18] **HA**=50°C High Ambient [19] **MS/DIM-L08**=Motion Sensor for Dimming Operation, Maximum 8' Mounting Height [20, 21] **MS/DIM-L20**=Motion Sensor for Dimming Operation, 9' - 20' Mounting Height [20, 22] **MS/DIM-L40**=Motion Sensor for Dimming Operation, 21' - 40' Mounting Height [20, 23] **MS/DIM-L40W**=Motion Sensor for Dimming Operation, 21' - 40' Mounting Height (Wide Range) [20, 24] **MS/X-L08**=Bi-Level Motion Sensor, Maximum 8' Mounting Height [20, 21, 25] **MS/X-L20**=Bi-Level Motion Sensor, 9' - 20' Mounting Height [20, 22, 25] **MS/X-L40**=Bi-Level Motion Sensor, 21' - 40' Mounting Height [20, 23, 25] **MS/X-L40W**=Bi-Level Motion Sensor, 21' - 40' Mounting Height (Wide Range) [20, 24, 25] **MS-L08**=Motion Sensor for ON/OFF Operation, Maximum 8' Mounting Height [20, 21] **MS-L20**=Motion Sensor for ON/OFF Operation, 9' - 20' Mounting Height [20, 22] **MS-L40**=Motion Sensor for ON/OFF Operation, 21' - 40' Mounting Height [20, 23] **MS-L40W**=Motion Sensor for ON/OFF Operation, 21' - 40' Mounting Height (Wide Range) [20, 24] **LWR-LW**=LumaWatt Wireless Sensor, Wide Lens for 8' - 16' Mounting Height [26] **LWR-LN**=LumaWatt Wireless Sensor, Narrow Lens for 16' - 40' Mounting Height [26] **L90**=Optics Rotated 90° Left **R90**=Optics Rotated 90° Right **MT**=Factory Installed Mesh Top **TH**=Tool-less Door Hardware **LCF**=Light Square Trim Plate Painted to Match Housing [27] **HSS**=Factory Installed House Side Shield [28] **CE**=CE Marking [29]	**OA/RA1016**=NEMA Photocontrol Multi-Tap - 105-285V **OA/RA1027**=NEMA Photocontrol - 480V **OA/RA1201**=NEMA Photocontrol - 347V **OA/RA1013**=Photocontrol Shorting Cap **OA/RA1014**=120V Photocontrol **MA1252**=10kV Surge Module Replacement **MA1036-XX**=Single Tenon Adapter for 2-3/8" O.D. Tenon **MA1037-XX**=2@180° Tenon Adapter for 2-3/8" O.D. Tenon **MA1197-XX**=3@120° Tenon Adapter for 2-3/8" O.D. Tenon **MA1188-XX**=4@90° Tenon Adapter for 2-3/8" O.D. Tenon **MA1189-XX**=2@90° Tenon Adapter for 2-3/8" O.D. Tenon **MA1190-XX**=3@90° Tenon Adapter for 2-3/8" O.D. Tenon **MA1191-XX**=2@120° Tenon Adapter for 2-3/8" O.D. Tenon **MA1038-XX**=Single Tenon Adapter for 3-1/2" O.D. Tenon **MA1039-XX**=2@180° Tenon Adapter for 3-1/2" O.D. Tenon **MA1192-XX**=3@120° Tenon Adapter for 3-1/2" O.D. Tenon **MA1193-XX**=4@90° Tenon Adapter for 3-1/2" O.D. Tenon **MA1194-XX**=2@90° Tenon Adapter for 3-1/2" O.D. Tenon **MA1195-XX**=3@90° Tenon Adapter for 3-1/2" O.D. Tenon **FSIR-100**=Wireless Configuration Tool for Occupancy Sensor [20] **GLEON-MT1**=Field Installed Mesh Top for 1-4 Light Squares **GLEON-MT2**=Field Installed Mesh Top for 5-6 Light Squares **GLEON-MT3**=Field Installed Mesh Top for 7-8 Light Squares **GLEON-MT4**=Field Installed Mesh Top for 9-10 Light Squares **GLEON-QM**=Quick Mount Arm Kit **GLEON-QMEA**=Quick Mount Extended Arm Kit **LS/HSS**=Field Installed House Side Shield [28, 30]

NOTES:
1. Customer is responsible for engineering analysis to confirm pole and fixture compatibility for all applications. Refer to our white paper WP513001EN for additional support information.
2. DesignLights Consortium™ Qualified. Refer to www.designlights.org Qualified Products List under Family Models for details.
3. Standard 4000K CCT and minimum 70 CRI.
4. Not compatible with extended quick mount arm (QMEA).
5. Not compatible with standard quick mount arm (QM) or extended quick mount arm (QMEA).
6. Requires the use of an internal step down transformer when combined with sensor options. Not available with sensor at 1200mA. Not available in combination with the HA high ambient and sensor options at 1A.
7. Only for use with 480V Wye systems. Per NEC, not for use with ungrounded systems, impedance grounded systems or corner grounded systems (commonly known as Three Phase Three Wire Delta, Three Phase High Leg Delta and Three Phase Corner Grounded Delta systems).
8. May be required when two or more luminaires are oriented on a 90° or 120° drilling pattern. Refer to arm mounting requirement table.
9. Factory installed.
10. Maximum 8 light squares.
11. Maximum 6 light squares.
12. Extended lead times apply. Use dedicated IES files for 3000K, 5000K and 6000K when performing layouts. These files are published on the Galleon luminaire product page on the website.
13. Extended lead times apply. Use dedicated IES files for 3000K, 5000K and 6000K when performing layouts. These files are published on the Galleon luminaire product page on the website.
14. 1 Amp standard. Use dedicated IES files for 600mA, 800mA and 1200mA when performing layouts. These files are published on the Galleon luminaire product page on the website.
15. Not available with HA option.
16. 2L is not available with MS, MS/X or MS/DIM at 347V or 480V. 2L in AF-02 through AF-04 requires a larger housing, normally used for AF-05 or AF-06. Extended arm option may be required when mounting two or more fixtures per pole at 90° or 120°. Refer to arm mounting requirement table.
17. Not available with LumaWatt wireless sensors.
18. Requires the use of P photocontrol or the PER7 or R photocontrol receptacle with photocontrol accessory. See After Hours Dim supplemental guide for additional information.
19. 50°C lumen maintenance data applies to 600mA, 800mA and 1A drive currents.
20. The FSIR-100 configuration tool is required to adjust parameters including high and low modes, sensitivity, time delay, cutoff and more. Consult your lighting representative at Eaton for more information.
21. Approximately 22' detection diameter at 8' mounting height.
22. Approximately 40' detection diameter at 20' mounting height.
23. Approximately 60' detection diameter at 40' mounting height.
24. Approximately 100' detection diameter at 40' mounting height.
25. Replace X with number of Light Squares operating in low output mode.
26. LumaWatt wireless sensors are factory installed only requiring network components RF-EM-1, RF-GW-1 and RF-ROUT-1 in appropriate quantities. See www.eaton.com/lighting for LumaWatt application information.
27. Not available with house side shield (HSS).
28. Only for use with SL2, SL3, SL4 and AFL distributions. The Light Square trim plate is painted black when the HSS option is selected.
29. CE is not available with the LWR, MS, MS/X, MS/DIM, P, R or PER7 options. Available in 120-277V only.
30. One required for each Light Square.

McGraw-Edison

DESCRIPTION

The Galleon™ wall LED luminaire's appearance is complementary with the Galleon area and site luminaire bringing a modern architectural style to lighting applications. Flexible mounting options accommodate wall surfaces in both an upward and downward configuration. The Galleon family of LED products deliver exceptional performance with patented, high-efficiency AccuLED Optics™, providing uniform and energy conscious lighting for parking lots, building and security lighting applications.

Catalog #		**Type**
Project		
Comments		**Date**
Prepared by		

SPECIFICATION FEATURES

Construction
Driver enclosure thermally isolated from optics for optimal thermal performance. Heavy wall aluminum housing die-cast with integral external heat sinks to provide superior structural rigidity and an IP66 rated housing. Overall construction passes a 1.5G vibration test to ensure mechanical integrity. UPLIGHTING: Specify with the UPL option for inverted mount uplight housing with additional protections to maintain IP rating.

Optics
Choice of thirteen patented, high-efficiency AccuLED Optics. The optics are precisely designed to shape the distribution maximizing efficiency and application spacing. AccuLED Optics create consistent distributions with the scalability to meet customized application requirements. Offered standard in 4000K (+/- 275K) CCT and minimum 70 CRI. Optional 3000K, 5000K and 6000K CCT. Greater than 90% lumen maintenance expected at 60,000 hours. Available in standard 1A drive current and optional 1200mA, 800mA, and 600mA drive currents.

Electrical
LED drivers are mounted for ease of maintenance. 120-277V 50/60Hz, 347V or 480V 60Hz operation. 480V is compatible for use with 480V Wye systems only. Drivers are provided standard with 0-10V dimming. An optional Eaton proprietary surge protection module is available and designed to withstand 10kV of transient line surge. The Galleon Wall LED luminaire is suitable for operation in -30°C to 40°C ambient environments. For applications with ambient temperatures exceeding 40°C, specify the HA (High Ambient) option. Emergency egress options for -20°C ambient environments and occupancy sensor available.

Mounting
Gasketed and zinc plated rigid steel mounting attachment fits directly to 4” j-box or wall with the Galleon Wall “Hook-N-Lock” mechanism for quick installation. Secured with two captive corrosion resistant black oxide coated allen head set screws which are concealed but accessible from bottom of fixture.

Finish
Housing finished in super durable TGIC polyester powder coat paint, 2.5 mil nominal thickness for superior protection against fade and wear. Standard colors include black, bronze, grey, white, dark platinum and graphite metallic. RAL and custom color matches available. Consult the McGraw-Edison Architectural Colors brochure for the complete selection.

Warranty
Five-year warranty.

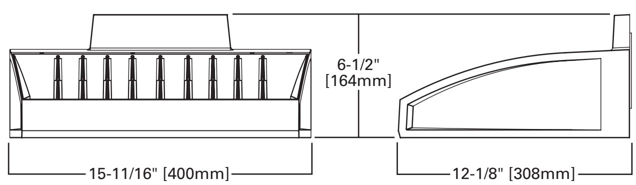
GWC GALLEON WALL LUMINAIRE

1-2 Light Squares

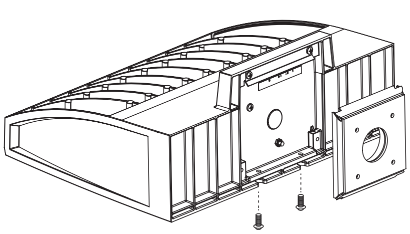
Solid State LED

WALL MOUNT LUMINAIRE

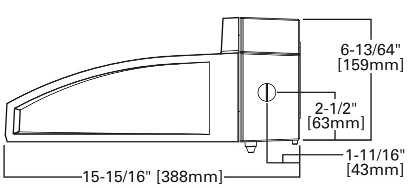
DIMENSIONS



HOOK-N-LOCK MOUNTING



BATTERY BACKUP AND THRU-BRANCH BACK BOX



CERTIFICATION DATA
UL/cUL Listed
LM79 / LM80 Compliant
IP66 Housing
ISO 9001
DesignLights Consortium™ Qualified*

ENERGY DATA
Electronic LED Driver
>0.9 Power Factor
<20% Total Harmonic Distortion
120-277V/50 & 60Hz, 347V/60Hz, 480V/60Hz
-30°C Minimum Temperature
40°C Ambient Temperature Rating

SHIPPING DATA
Approximate Net Weight:
27 lbs. (12.2 kgs.)

POWER AND LUMENS

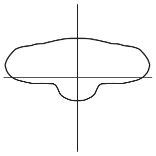
Number of Light Squares		1				2			
Drive Current		600mA	800mA	1.0A	1.2A	600mA	800mA	1.0A	1.2A
Nominal Power (Watts)		34	44	59	67	66	85	113	129
Input Current @ 120V (A)		0.30	0.39	0.51	0.58	0.58	0.77	1.02	1.16
Input Current @ 208V (A)		0.17	0.22	0.29	0.33	0.34	0.44	0.56	0.63
Input Current @ 240V (A)		0.15	0.19	0.26	0.29	0.30	0.38	0.48	0.55
Input Current @ 277V (A)		0.14	0.17	0.23	0.25	0.28	0.36	0.42	0.48
Input Current @ 347V (mA)		0.11	0.15	0.17	0.20	0.19	0.24	0.32	0.39
Input Current @ 480V (mA)		0.08	0.11	0.14	0.15	0.15	0.18	0.24	0.30
Optics									
T2	4000K/5000K Lumens	4,110	5,040	6,238	6,843	8,031	9,849	12,190	13,373
	3000K Lumens	3,638	4,461	5,522	6,057	7,109	8,718	10,791	11,838
	BUG Rating	B1-U0-G1	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B2-U0-G2	B2-U0-G2	B2-U0-G2
T3	4000K/5000K Lumens	4,189	5,138	6,359	6,975	8,187	10,039	12,425	13,630
	3000K Lumens	3,708	4,548	5,629	6,174	7,247	8,887	10,999	12,065
	BUG Rating	B1-U0-G1	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B2-U0-G2	B2-U0-G2	B2-U0-G2
T4FT	4000K/5000K Lumens	4,214	5,167	6,395	7,016	8,233	10,097	12,497	13,709
	3000K Lumens	3,730	4,574	5,661	6,211	7,288	8,938	11,062	12,135
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B2-U0-G3	B2-U0-G3
T4W	4000K/5000K Lumens	4,159	5,100	6,313	6,925	8,127	9,966	12,336	13,532
	3000K Lumens	3,682	4,515	5,588	6,130	7,194	8,822	10,920	11,979
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B2-U0-G2	B2-U0-G2	B2-U0-G3	B2-U0-G3
SL2	4000K/5000K Lumens	4,102	5,032	6,227	6,831	8,018	9,832	12,170	13,350
	3000K Lumens	3,631	4,454	5,512	6,047	7,098	8,703	10,773	11,817
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B2-U0-G2	B2-U0-G3	B2-U0-G3
SL3	4000K/5000K Lumens	4,188	5,137	6,358	6,974	8,186	10,038	12,424	13,628
	3000K Lumens	3,707	4,547	5,628	6,173	7,246	8,886	10,998	12,064
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G3	B2-U0-G3	B2-U0-G3
SL4	4000K/5000K Lumens	3,980	4,880	6,040	6,626	7,776	9,537	11,803	12,949
	3000K Lumens	3,523	4,320	5,347	5,865	6,883	8,442	10,448	11,462
	BUG Rating	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G3	B1-U0-G3	B2-U0-G3
5NQ	4000K/5000K Lumens	4,321	5,298	6,558	7,193	8,443	10,353	12,814	14,057
	3000K Lumens	3,825	4,690	5,805	6,367	7,474	9,164	11,343	12,443
	BUG Rating	B2-U0-G1	B2-U0-G1	B2-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G2	B3-U0-G2
5MQ	4000K/5000K Lumens	4,400	5,396	6,678	7,326	8,598	10,544	13,050	14,315
	3000K Lumens	3,895	4,777	5,911	6,485	7,611	9,334	11,552	12,672
	BUG Rating	B3-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2
5WQ	4000K/5000K Lumens	4,412	5,410	6,695	7,345	8,621	10,572	13,085	14,354
	3000K Lumens	3,906	4,789	5,926	6,502	7,631	9,358	11,583	12,706
	BUG Rating	B3-U0-G1	B3-U0-G1	B3-U0-G2	B3-U0-G2	B3-U0-G2	B4-U0-G2	B4-U0-G2	B4-U0-G2
SLL/SLR	4000K/5000K Lumens	3,681	4,515	5,588	6,129	7,193	8,821	10,917	11,976
	3000K Lumens	3,258	3,997	4,946	5,425	6,367	7,808	9,664	10,601
	BUG Rating	B1-U0-G1	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G2	B1-U0-G3	B1-U0-G3	B2-U0-G3
RW	4000K/5000K Lumens	4,281	5,250	6,498	7,129	8,366	10,259	12,698	13,930
	3000K Lumens	3,790	4,647	5,752	6,311	7,406	9,081	11,240	12,331
	BUG Rating	B2-U0-G1	B2-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G1	B3-U0-G2	B3-U0-G2

* Nominal lumen data for 70 CRI. BUG rating for 4000K/5000K. Refer to IES files for 3000K BUG ratings.

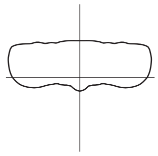
OPTICAL DISTRIBUTIONS

Asymmetric Area Distributions

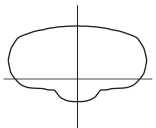
T2
(Type II)



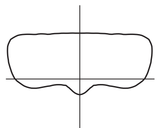
SL2
(Type II with Spill Control)



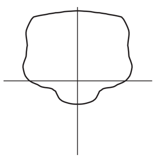
T3
(Type III)



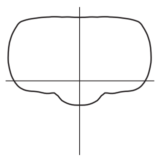
SL3
(Type III with Spill Control)



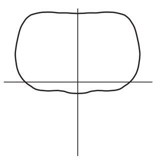
T4FT
(Type IV Forward Throw)



T4W
(Type IV Wide)

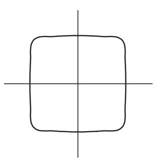


SL4
(Type IV with Spill Control)

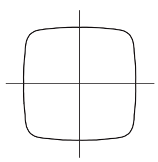


Symmertric Distributions

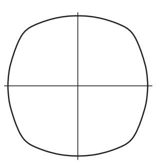
5NQ
(Type V Square Narrow)



5MQ
(Type V Square Medium)

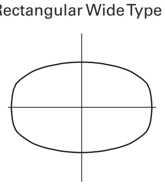


5WQ
(Type V Square Wide)

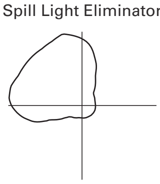


Specialized Distributions

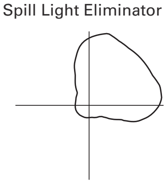
RW
(Rectangular Wide Type I)



SLL
(90° Spill Light Eliminator Left)

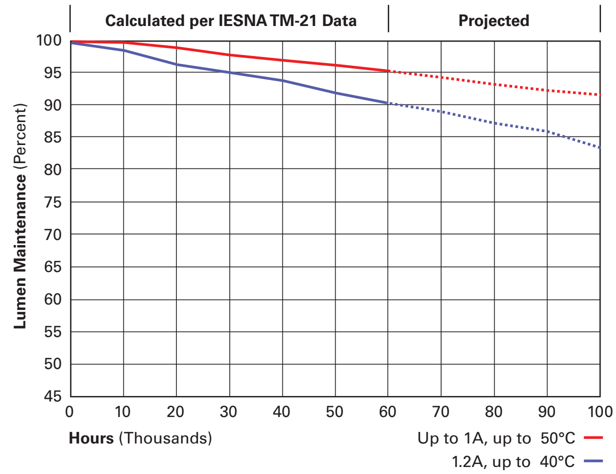


SLR
(90° Spill Light Eliminator Right)



LUMEN MAINTENANCE

Drive Current	Ambient Temperature	TM-21 Lumen Maintenance (60,000 Hours)	Projected L70 (Hours)
Up to 1A	Up to 50°C	> 95%	> 416,000
1.2A	Up to 40°C	> 90%	> 205,000



LUMEN MULTIPLIER

Ambient Temperature	Lumen Multiplier
0°C	1.02
10°C	1.01
25°C	1.00
40°C	0.99
50°C	0.97

Eaton
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.eaton.com/lighting

Specifications and dimensions subject to change without notice.

CONTROL OPTIONS

0-10V
This fixture is offered standard with 0-10V dimming driver(s). The DIM option provides 0-10V dimming wire leads for use with a lighting control panel or other control method.

Photocontrol (P, R and PER7)
Optional button-type photocontrol (P) and photocontrol receptacles (R and PER7) provide a flexible solution to enable “dusk-to-dawn” lighting by sensing light levels. Advanced control systems compatible with NEMA 7-pin standards can be utilized with the PER7 receptacle.

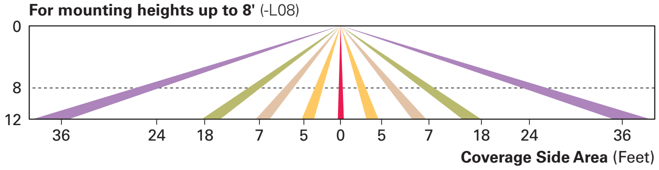
After Hours Dim (AHD)
This feature allows photocontrol-enabled luminaires to achieve additional energy savings by dimming during scheduled portions of the night. The dimming profile will automatically take effect after a “dusk-to-dawn” period has been calculated from the photocontrol input. Specify the desired dimming profile for a simple, factory-shipped dimming solution requiring no external control wiring. Reference the After Hours Dim supplemental guide for additional information.

Dimming Occupancy Sensor (MS/DIM-LXX and MS-LXX)
These sensors are factory installed in the luminaire housing. When the MS/DIM-LXX sensor option is selected, the occupancy sensor is connected to a dimming driver and the entire luminaire dims when there is no activity detected. When activity is detected, the luminaire returns to full light output. The MS/DIM sensor is factory preset to dim down to approximately 50 percent power with a time delay of five minutes. The MS-LXX sensor is factory preset to turn the luminaire off after five minutes of no activity. The MS/X-LXX is also preset for five minutes and only controls the specified number of light engines to maintain steady output from the remaining light engines.

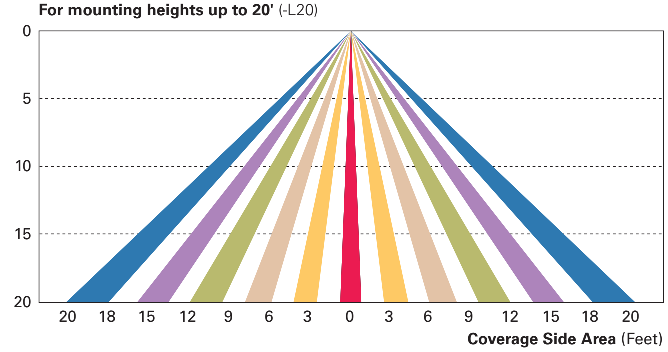
These occupancy sensors includes an integral photocell that can be activated with the FSIR-100 accessory for “dusk-to-dawn” control or daylight harvesting - the factory preset is OFF. The FSIR-100 is a wireless tool utilized for changing the dimming level, time delay, sensitivity and other parameters.

A variety of sensor lens are available to optimize the coverage pattern for mounting heights from 8’-40’.

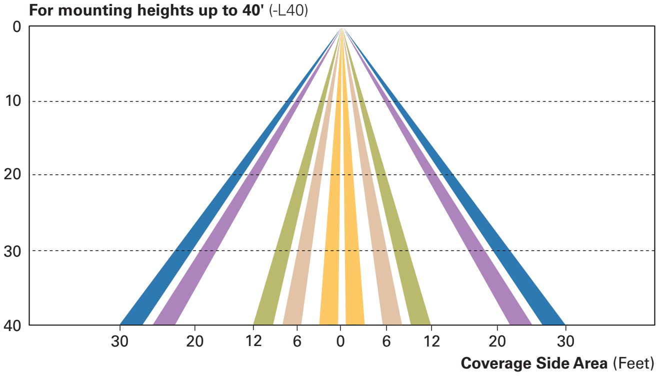
For mounting heights up to 8' (-L08)



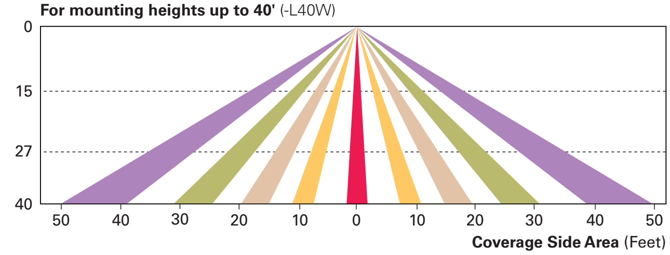
For mounting heights up to 20' (-L20)



For mounting heights up to 40' (-L40)



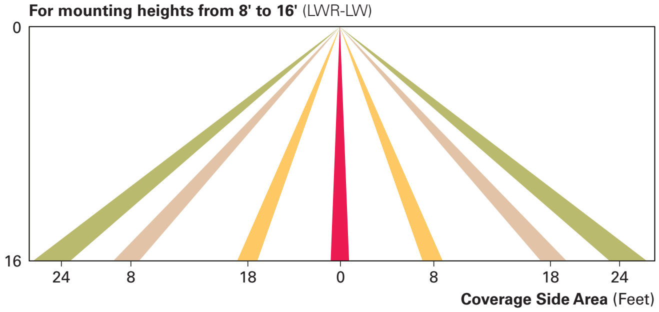
For mounting heights up to 40' (-L40W)



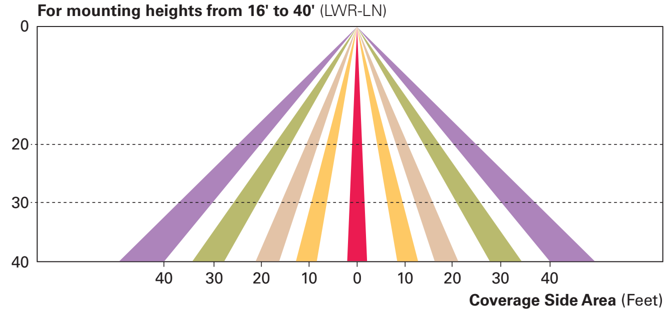
LumaWatt Wireless Control and Monitoring System (LWR-LW and LWR-LN)
The LumaWatt system is a peer-to-peer wireless network of luminaire-integral sensors for any sized project. Each sensor is capable of motion and photo sensing, metering power consumption and wireless communication. The end-user can securely create and manage sensor profiles with browser-based management software. The software will automatically broadcast to the sensors via wireless gateways for zone-based and individual luminaire control. The LumaWatt software provides smart building solutions by utilizing the sensor to provide easy-to-use dashboard and analytic capabilities such as improved energy savings, traffic flow analysis, building management software integration and more.

For additional details, refer to the LumaWatt product guides.

For mounting heights from 8' to 16' (LWR-LW)



For mounting heights from 16' to 40' (LWR-LN)



Eaton
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Specifications and dimensions subject to change without notice.

ORDERING INFORMATION

Sample Number: GWC-AF-02-LED-E1-T3-GM

Product Family [1]	Light Engine	Number of Light Squares [2]	Lamp Type	Voltage	Distribution	Color	Mounting Options
GWC=Galleon Wall	**AF**=1A Drive Current	**01**=1 **02**=2 [3]	**LED**=Solid State Light Emitting Diodes	**E1**=120-277V **347**=347V [4] **480**=480V [4, 5]	**T2**=Type II **T3**=Type III **T4FT**=Type IV Forward Throw **T4W**=Type IV Wide **SL2**=Type II w/Spill Control **SL3**=Type III w/Spill Control **SL4**=Type IV w/Spill Control **SLL**=90° Spill Light Eliminator Left **SLR**=90° Spill Light Eliminator Right **RW**=Rectangular Wide Type I **5NQ**=Type V Square Narrow **5MQ**=Type V Square Medium **5WQ**=Type V Square Wide	**AP**=Grey **BZ**=Bronze **BK**=Black **DP**=Dark Platinum **GM**=Graphite Metallic **WH**=White **CC**=Custom Color [6]	**[BLANK]**=Surface Mount

Options (Add as Suffix)	**Accessories** (Order Separately)
7030=70 CRI / 3000K [7] **8030**=80 CRI / 3000K [7] **7050**=70 CRI / 5000K [7] **7060**=70 CRI / 6000K [7] **600**=Drive Current Factory Set to 600mA **800**=Drive Current Factory Set to 800mA **1200**=Drive Current Factory Set to 1200mA [8] **F**=Single Fused (120, 277 or 347V. Must Specify Voltage) **FF**=Double Fused (208, 240 or 480V. Must Specify Voltage) **10K**=10kV Surge Module **DIM**=0-10V Dimming Leads [9, 10] **DALI**=DALI Driver [11] **HA**=50°C High Ambient [12] **UPL**=Uplight Housing [13] **BBB**=Battery Pack with Back Box [3, 8, 9, 14] **CWB**=Cold Weather Battery Pack with Back Box [3, 8, 9, 14] **P**=Button Type Photocontrol (120, 208, 240 or 277V. Must Specify Voltage) **R**=NEMA Twistlock Photocontrol Receptacle **PER7**=NEMA 7-PIN Twistlock Photocontrol Receptacle [15] **AHD145**=After Hours Dim, 5 Hours [16] **AHD245**=After Hours Dim, 6 Hours [16] **AHD255**=After Hours Dim, 7 Hours [16] **AHD355**=After Hours Dim, 8 Hours [16] **MS-LXX**=Motion Sensor for On/Off Operation [17, 18, 19] **MS/DIM-LXX**=Motion Sensor for Dimming Operation [17, 18, 19] **LWR-LW**=LumaWatt Wireless Sensor, Wide Lens for 8' - 16' Mounting Height [19, 20, 21] **LWR-LN**=LumaWatt Wireless Sensor, Narrow Lens for 16' - 20' Mounting Height [19, 20, 21] **L90**=Optics Rotated 90° Left **R90**=Optics Rotated 90° Right **MT**=Factory Installed Mesh Top **LCF**=Light Square Trim Plate Painted to Match Housing [22] **HSS**=Factory Installed House Side Shield [23] **CE**=CE Marking and Small Terminal Block [24]	**OA/RA1013**=Photocontrol Shorting Cap **OA/RA1016**=NEMA Photocontrol - Multi-Tap 105-285V **OA/RA1201**=NEMA Photocontrol - 347V **OA/RA1027**=NEMA Photocontrol - 480V **MA1252**=10kV Circuit Module Replacement **MA1059XX**=Thru-branch Back Box (Must Specify Color) **FSIR-100**=Wireless Configuration Tool for Occupancy Sensor [17] **LS/HSS**=Field Installed House Side Shield [23, 25]

NOTES:
1. DesignLight Consortium™ Qualied. Refer to www.designlights.org Qualified Products List under Family Models for details.
2. Standard 4000K CCT and minimum 70 CRI.
3. Two light squares with BBB or CWB options limited to 25°C, 120-277V only.
4. Requires the use of a step down transformer. Not available in combination with sensor options at 1200mA.
5. Only for use with 480V Wye systems. Per NEC, not for use with ungrounded systems, impedance grounded systems or corner grounded systems (commonly known as Three Phase Three Wire Delta, Three Phase High Leg Delta and Three Phase Corner Grounded Delta systems).
6. Custom colors are available. Setup charges apply. Paint chip samples required. Extended Lead times apply.
7. Extended lead times apply. Use dedicated IES files when performing layouts.
8. Not available with HA option.
9. Cannot be used with other control options.
10. Low voltage control lead brought out 18” outside fixture.
11. Only availble with BBB or CWB in single light square. HA option available for single light square only. Limited to 1A and below.
12. Not available with 1200, UPL, BBB and CWB options. Available for single light square only.
13. Not available with SL2, SL3, SL4, HA, BBB, CWB, R, or PER7 options.
14. Operates a single light square only. Cold weather option operates -20°C to +40°C, standard 0°C to +40°C. Backbox is non-IP rated.
15. Compatible with standard 3-PIN photocontrols, 5-PIN or 7-PIN ANSI controls.
16. Requires the use of P photocontrol or the PER7 or R photocontrol receptacle with photocontrol accessory. See After Hours Dim supplemental guide for additional information.
17. The FSIR-100 configuration tool is required to adjust parameters including high and low modes, sensitivity, time delay, cutoff and more. Consult your lighting representative at Eaton for more information.
18. Replace LXX with mounting height in feet for proper lens selection (e.g., L8=8’ mounting height). L8, L20, L40, and L40W are available options.
19. Includes integral photosensor.
20. LumaWatt wireless sensors are factory installed requiring network components in appropriate quantities. See www.eaton.com/lighting for LumaWatt application information.
21. Bronze sensor is shipped with Bronze fixtures. White sensor shipped on all other housing color options.
22. Not available with HSS option.
23. Only for use with SL2, SL3 and SL4 distributions. The light square trim plate is painted black when the HSS option is selected.
24. CE is not available with the 1200, DALI, LWR, MS, MS/DIM, P, R or PER7 options. Available in 120-277V only.
25. One required for each light square.