JAMES K. GRANT ASSOCIATES
STRUCTURAL ENGINEERS + HISTORIC PRESERVATION

LEDYARD UP-DOWN SAWMILL

HISTORIC PROPERTY STRUCTURAL AND CONDITION ASSESSMENT

Ledyard Up-Down Sawmill
172 Iron Street
Ledyard, Connecticut

March 2, 2023, *Revisions April 14, 2023 (noted in blue text)*

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PREPARED FOR:

The Town of Ledyard, Connecticut

PREPARED BY:

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Cirrus Structural Engineering

The Architects

Thank you to the Town of Ledyard, The Ledyard Historic District Commission and the mill volunteers for assisting us with gathering information. It has been a pleasure to work with you.

Table of Contents

A. Introduction

B. General Description

C. Building Description

D. Noted Conditions and Recommendations

E. Structural Load Assessment

F. Architectural Accessibility and Fire Suppression

G. Summarized List with Priorities

H. Limitations

I. Appendix

   I. Representative Building Drawings

   II. The Architects Building Code Assessment re Access and Fire Protection memo and ramp sketch

   III. Clarence Welti Associates boring log

A. Introduction

This past fall (2022), our team performed investigations at the Ledyard Up and Down Sawmill Building on 172 Iron Street in Ledyard to evaluate the areas identified as being of concern/interest in the RFP process, as well as to assess the current structural condition and identify significant structural deficiencies.

Our team of preservation professionals includes structural preservation engineers James K. Grant, PE, Principal of James K. Grant Associates and Elizabeth Acly, PE of Cirrus Structural Engineering, architect Robert B. Hurd, AIA, of The Architects and Historic Mill Consultant Tom Kelleher from Old Sturbridge Village. The town also engaged Clarence Welti Associates to perform geotechnical borings to determine stability of soils.

For the purposes of this report, Iron Street is assumed to run in the east-west direction, with the mill located on the south side of the street. The main door is located on the west side facing the mill pond, and the large openings for material access to the mill structure are on the north elevation.

B. General Description

A detailed description and history of the Ledyard Up-Down Sawmill can be found on the site's website and will not be repeated in this report beyond the details necessary to convey the findings of the study.

The Up-Down Sawmill is listed on the National Register of Historic Places under the name of the "Main Sawmill" referencing the Main family who owned it from 1902 until the town of Ledyard purchased it in 1966. The building is also part of the locally listed Sawmill Historic District and is under the care of the Ledyard Historic District Commission.

***Description of the Ledyard Up-Down Sawmill** – 1972 narrative from National Register Nomination*

The structure retain(s) its original arrangement with a wide opening across the front through which saw logs could be rolled for placement upon the wooden saw carriage just inside. This passed upon rollers between two large upright timbers which carried the guides upon which the saw frame slid vertically. A timber hinged to the frame bottom connected it with a heavy cast iron fly wheel that was driven through a series of belts and pulleys by an iron water turbine set at the very bottom of the basement area, taking its water power from the pond through a large wooden forebay and penstock. At least 85 percent of the original machinery was found in place at the start of restoration, and missing portions can readily be fabricated.

At the present time, restoration has progressed so far that the dam, mill race, and foundation have been restored, the building frame has been repaired and squared up, the roof reshingled, and much of the exterior resided with board-and-batten. Most of the machinery has been demounted and set aside, for the whole supporting framework has shifted and settled to such a degree that everything was entirely out of line and patently impossible to operate. The turbine must be dug out of the thirty years' accumulation of washed-in sand and gravel that completely bury it, and put into usable condition. There is no apparent obstacle to the expectation that this old mill will once more run with all of the fascinating and rarely-seen moving parts of the original.

Relevant Construction History

1865	Approximate date of original construction of sawmill building with sash / up and down saw
1877-80	Israel Brown reopens sawmill after inheriting it, significant upgrades including circular saw and 1870's vintage cast iron Tyler water turbine

1937-38	Mill was repaired to some extent by Harry C.W. Main (perhaps after the Hurricane of 1938) after inheriting it from his father Horace W. Main upon his death.
1966	Town of Ledyard purchased the property after successful fundraising by the Ledyard Historical Society. Per the sawmill website, the mill was in poor condition including: • The south side of the building was collapsing; • The vertical board siding was failing; • Just a few years later the roof right above the sash sawmill was rotted enough to need to be covered with sheets of plywood and corrugated metal.
1966-75	Preservation and Restoration. Per the sawmill website: • The lean-to on the south side of the building was damaged beyond saving and was demolished; • The original sawmill building was repaired with timber framing replacements where needed and new roofing and siding; • By 1972, the south side lean-to was rebuilt; • By 1972, the pond was deepened and improvements made to accommodate the new use of the site as a town park complete with swimming beach; the spillway to the brook, the dam, and gate to control water flow into the mill were also repaired; stone stairs were added along the east elevation of the mill; • In 1973, a circular sawmill that was previously in the mill was purchased and returned to its former home; • The turbine was dug out the accumulated mud and debris of 30-plus years of freshets and dam breaches, removed and re-set; repairs and alignment were performed on the turbine and the framing that supports the shafts that power the up-down saw; • In 1974, a Lane shingle machine was donated and installed.
1970	Establishment of the local Sawmill Historic District administered by Ledyard Historic District Commission.
1972	The mill becomes a registered property on the National Register of Historic Places.
1975	The mill reopens within a new town park.
1976-80	Adjacent blacksmith shop building was reconstructed on original foundations after destruction of the original in the Hurricane of 1938.
1978-80	Gristmill purchased from Exeter, NH and addition in south-east corner of the building constructed to display it.
1982	Mill building sustained damage after June 1982 flooding of mill pond due to torrential rain. Some of foundation on west wall was rebuilt, and dam/berm along pond shore was rebuilt using reinforced concrete.
2017	Roof re-shingled with cedar shakes.
2000	Current steel penstock and tank were installed.

ca. 2012	Loft added in east portion of original mill building.
2021	Area to the northeast of the building was regraded to direct surface runoff to drain to the east of the east stairs rather than running down them.

C. Building Description

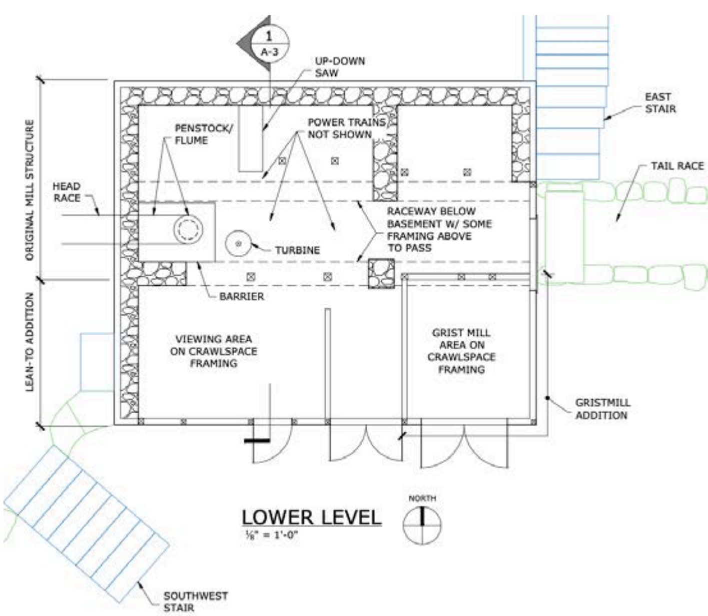
The mill appears to have been built into the banks of the brook, with the south and east sides of the building being roughly level with the main floor, and east and south levels walking out to the lower level. To the north, the site generally pitches toward upper level of the mill building. The stone raceway runs under the lower level of the mill from west to east, with the head between the upper level mill pond and raceway creating the pressure to power the turbine. Stone stairs on the east side and near the southwest corner of the building provide access from upper and lower levels on the exterior.

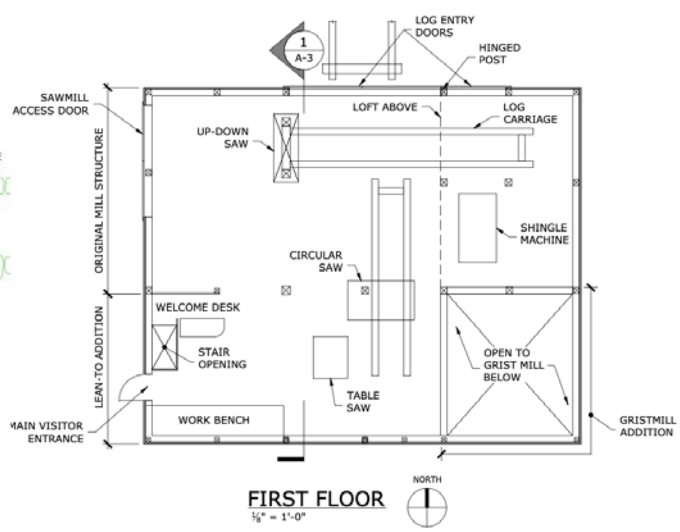
As noted in the Construction History above, the current mill building is made up of three parts. The first is the original mill building dating from the 1860s, which is a two-story gable roof structure constructed of 6 timber framed bays. The lower story is below grade and houses the raceway. The upper story houses a new loft at the east end.

The second part is a two-story lean-to on the south side of the original mill building. This structure is a replica constructed in the 1970’s to match the former lean-to that was too deteriorated to save. The roof line of the current lean-to is not an exact match to the original based on historic images. The lean-to is a 4-bay building constructed of heavy timber; the bays roughly matched the 4 western bays of the original building. Rafters are supported on the south slope of the original building.

The third part of the building is a 2-bay extension of the lean-to in the southeast corner of the building constructed in the 1980s to house the newly acquired gristmill.

The layout of the floors is shown in the Key Plans below:





Key Plans

The north, east and north end of the west foundation walls are constructed of dry-laid stone, but some areas of more recent mortar repairs are apparent in some areas.

The mill has board and batten siding and a cedar shingle roof.

D. Noted Conditions and Recommendations

The following sections describe the conditions noted on site assessment together with the recommendation for treatment. Note that many of the items identified below were included in the scope of assessment, while other were identified during the course of the project.

1. Foundation and Stairs along East End / Site Drainage.

   Description: The east exterior stone stairs provide access across the tailrace embankment. A small retaining wall extends north of the east mill wall to support the upper grade for the top 3 steps. Erosion has occurred below the bottom three steps allowing them to rotate out of place. The lowest step has settled into a significant hole. A substantial bulge and dampness are apparent in the masonry foundation wall of the mill at approximately the fourth step from the top. In 2021, the area just to the north of the stairs was regraded to create a small berm near the top of the stair and to direct site drainage to the southeast of the stairs.

   Analysis: A geotechnical boring was performed slightly northwest of the area during this project, and the soil material found to have suitable properties for bearing without the propensity for foundation settlement. Long standing issues with site drainage and gutter discharge onto the east exterior stairs are apparent based on information from the town and mill volunteers. The issues noted in the stairs and foundation wall are consistent with erosion that might occur due to washout of soils from water flowing through and below the affected components. The bulge in the foundation wall is likely caused by movement of the individual dry-laid stones in response to pressure from discharging gutter drainage water.

   Recommendation: In addition to managing gutter discharge water (see section below), and maintenance of recent site grading that now directs water to the southeast of the stairs, the authors recommend the resetting of the bottom 3 steps. In addition, some additional probing into the foundation wall is recommended to determine if the full thickness of it has bulged or just the outer stones below the gutter. Local rebuilding of the bulged stone might be considered, the extent to which can be determined by the further probing.


Images from the northeast show the uphill site grading at the stairs and overall.

Top: Overall view of damage; Bottom Left: Bulge in foundation wall; Bottom Right: Shifting and movement of bottom 3 steps due to erosion of soil below.

2. Gutters and Leaders.

   Description: The north eave has a wood V-gutter with wood brackets likely fastened to the rafter tails. This gutter was likely recently replaced with the roof in 2017 and based on the color, was likely constructed of rot-resistant western red cedar. The gutter terminates just shy of the edge of the edge of the building at the east and west ends and is open-ended without any obvious means for drainage water to be guided away from the building. The pitch of the gutter is not apparent by eye, but is intended to drain at both ends. At the east end the gutter is dumping water directly onto the stone coping of the retaining wall which slopes back to the rubble stone foundation. At the west end the water is dispersed onto grass/ground surface which appears to be level or pitch slightly back toward the building, and corresponding dampness and erosion of joints was noted on the interior of the wall in the basement. At the west end, the base of the board siding is heavily weathered, the corner batten has been replaced and the foundation stones appear washed out. Items 1 and 3 refer to further damage at the northeast corner that may have been caused by the free-flowing roof drainage.

   The south eave has a wood rectangular (box) gutter with steel hangers/supports. The gutter has an end cap at the west side and pitches to the east where a leader is present that is plumbed into an underground drain. Pea gravel is installed along the base of the south wall to assist with keeping water away from foundation and sills, but is overgrown with grass in some areas.

Both gutters were 1970s or later additions and do not appear in historic images prior to the restoration. The V-gutter (eave trough) is historically accurate; however, the box gutter is a twentieth century form and not accurate despite being easier to connect to a leader. The gutters do not appear to be lined.

Analysis: The wood V-gutter on the north side appears to be in good condition. Biological growth and general weathering appear on the south box gutter. The gutter pitches east, but dips down perhaps due to a missing bracket about 10' from east end. The gutters do not appear to be lined, which leaves them vulnerable to deterioration and a relatively short life-span. It is not known how the joints in the gutters are treated.

Recommendation: At the north gutter, the authors recommend adding a leader and below-grade drainage to the east end to manage flow of water away from the building on that side. A similar approach or at least a splash block should be considered on the west side. The south gutter is due for replacement relatively soon (within 5 years). In the meantime, the dip should be investigated and gutter re-supported as needed. A V-gutter shape should be considered when replacement occurs, along with linings and/or joint treatment. The leader should be tested to confirm that it is working.

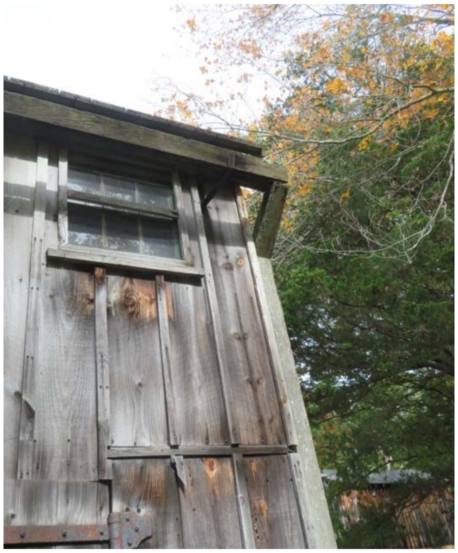
North gutter overall and profile of V-shape and bracket.

North gutter, west end; Left: grade where gutter is discharging; Right: inside face of foundation wall at northwest corner showing dampness and fungal growth on sill above.

North gutter, east end, showing deteriorated board siding and erosion in masonry.

South gutter showing dip (likely missing bracket) toward east end.

South gutter showing box gutter shape, weathering, biological growth and brackets.




South gutter, east end, showing wood box trim around metal leader transitioning to sub-surface drainage.

3. Framing Settlement at Northeast Corner of Building.

   Description: The floor pitches roughly 3.5" to the east in the NE corner of the building. The upper-level floor is framed with 8x8 beams at 4' on center spanning in the north-south direction with 2" decking spanning east-west between beams. The distance between the north wall and first beam is roughly 4' from the corner. The east basement wall is constructed of masonry north of the tail race, then transitions to timber frame over the tail race to the south corner. The end post of the timber frame portion sits on the north raceway wall, and appears to have dropped slightly as indicated by the gap between the top of the post and sill/beam above.

   Analysis: Movement in the foundation wall from the water issue noted in Item 1 is likely the main cause of the floor settlement; however, the irregular geometry of the stone walls made it difficult to directly correlate the two. It is also likely that the causes of the deflection are multifactorial and cumulative based on a number of issues observed including a shear crack at the east end of the northern-most beam. Based on the gutter discharge in the area and biological growth and deterioration of the siding, sill deterioration may also be a likely contributor, although not yet extensive. Some of the deflection may have also been caused by former beams and sills, which have now been replaced, but may not have been installed in flush / level condition. The deteriorated post base could also be contributing.

Exterior of northeast corner showing siding deterioration.

Recommendation: Once funds are raised to address the northeast corner, the authors recommend a holistic look at both further investigation and treatment, which might include local wall rebuilding, local sill replacement, post base repairs (dutchman) and beam hangers.

Left: Northeast corner from basement showing sill corner tenon (possibly bent); Right: East end of north beam show shear crack parallel with tenon (stress concentration).

Top: East wall post from south and west respectively; Bottom: gap between top of post and beam/sill.

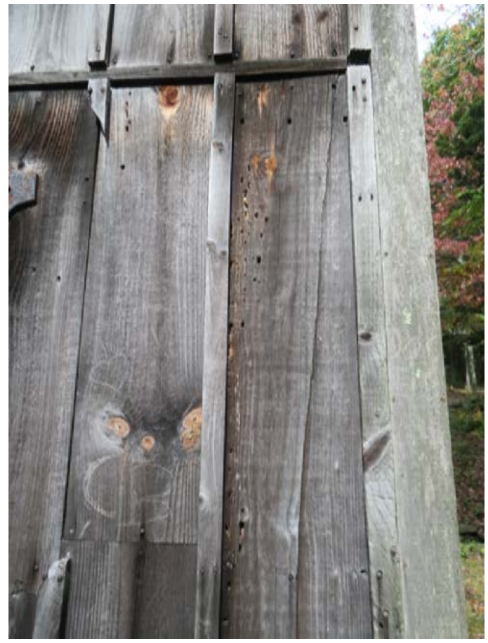
Left: Bottom of east wall post just above decking over raceway, post base is concealed below decking; Right: Deterioration of east end of decking sill over north wall of raceway looking east to gate to tail race, the post base is not apparent in this image but deterioration of deck sill is suggestive.

4. Sills and Post Bases.

   Description: Sills are mainly 7x7 or 8x8 in size. On the north, west, and partial east sides the sills bear on the full story battered stone foundation basement walls. On the south and southern part of the east walls, the sills appear to bear on a possibly shallow stone wall that projects approximately 3” above grade. It appears that all sills were replaced during the 1960s work or more recently, and most have mortise and tenon (corner) or half-lap (straight) timber frame joinery between pieces. All sills are in close proximity to grade; however, the installation of pea gravel along the south side may have been an attempt to protect them from undue ground moisture.

   Analysis: On the exterior, the only visible sign of sill deterioration is at the central part of the south elevation (lean-to portion) below the double doors. As viewed from the basement, where visible, sills do not show any obvious deterioration; however, black staining is apparent on the surfaces in northwest and southeast corners suggesting that damp conditions due to proximity to grade and/or gutter discharge is allowing for fungal growth on wood. Sills were installed on a solid bed of mortar which may prevent bottom of sills from drying encouraging deterioration. The lower level framing on the south side is also in close proximity to grade leaving it vulnerable to deterioration. A former termite infestation occurred in the grist mill area but was caught and treated. Evidence of termite borings in the boards in the southeast corner suggest that the corner post may have been attacked.

   Recommendation: A deeper investigation is recommended to determine sill damage at areas of known exposure to water, primarily at the corners. If siding work is planned in the next 5 years, sill investigation and repairs / replacements could be performed as part of that work.

Left: Termite damage at the grist mill frame; Right: tell-tale termite trails / holes at siding at the east end of the south elevation.


Siding and foundation below grist mill exterior doors. Siding nails have failed, but sill behind appears to be in good condition.

East end of joist in grist mill floor (crawlspace) showing black staining and close proximity to grade, but not visible deterioration.

Central double doors at south elevation (lean-to) showing siding deterioration and sill / threshold deterioration behind.

Northwest corner of sills from the basement showing black staining presumed to be fungal growth.

5. Integrity of East Loft Framing.

   Description: Created in the last few decades, the loft is located in the two east end bays of the structure. For purposes of this report, we'll refer to the framing lines as loft-west, loft-central, loft-east (also east wall of the building). The scope of the loft addition appears to include: retaining the roof tie-beam and extant middle post at loft-west, installation of a north-south support below the upper level framing to support the loft-west middle post, replacement of the tie-beam at loft-central and resetting into historic mortise joinery at end posts using mortises, adding a middle post at loft-central line, supplementing the north post at the loft-west line inset from north wall and hinged post, and addition of braces between posts and beams. The Town asked for our input regarding conformance of the framing with best practice, capacities, etc.

   Analysis: The "new" loft-central tie-beam was installed in two pieces, with a new post supporting the middle at the joint between the pieces. Steel plates and bolts were used to make connections at the top and bottom of the post in lieu of traditional joinery causing it to stand out as visually new. The plates in both locations are plain steel and not protected from corrosion, thus showing signs of surface rust. A lower level post was also added at the basement level, but it was offset a few inches from the upper post, and not directly stacked creating an eccentricity of load path and unintended bending stresses in the post and decking.

At loft-west, north end, a new post was added inside of the sill and is directly supported on the decking. A deflection in the deck is apparent along with simultaneous lifting of door sill, presumably from lifting of decking below.

At loft-west, middle post, the north-south beam to support the post was hung from the adjacent east-west beams. While unconventional, the authors did not observe any obvious signs of distress at the beam or its connections.

Overall Loft and Loft-West support line. Left: Loft-West north bay showing replacement post; Right: Loft-West middle post with hung beam support below.

Recommendation: See Section E below for discussion of loft capacity. In addition, the authors recommend improving the connections noted above to meet industry standards in terms of strength and durability. To do this, we recommend that retrofit designs for each of the noted connections be developed by a preservation structural engineer (we'd be happy to provide this service) to ensure that load paths are safely transferred through the joint. Retrofits will likely include structural screws or bolts, galvanized or stainless steel hardware (concealed to the extent possible) and wood blocking or bracing. The designs will be shown on sketches with material specifications that can be bid out for the work or completed by town personnel or volunteers.

Loft-Central support line. Top: Middle post and beam connections at top; Middle: Middle post connection at bottom; Bottom: Beam connections into end post using historic joinery.

Loft-west, north post. Top: "new" offset post overall and zoomed in view at base supported by decking as well as deflection of deck board relative to adjacent one; Bottom: exterior view showing gap between door sill and skirt board suggesting lifting of door sill by decking.

6. First Floor Beams below Original Structure and Lean-To.

   Description: When the lean-to was added, a ledger type beam was constructed at upper level floor framing to support the north-south spanning floor joists of the lean-to. The supporting post was either moved, or it had already been installed to be roughly centered on the full sandwich of framing (lean-to ledger, vertical siding, original building north beam). The original building north beam is lap sliced over the post, and a bracket added to the post to support the offset load. A through-bolt was included in the connection to tie the multiple structural laminations together. A horizontal "crack" is apparent in original building north beam, on the east side of the lap splice.

   Just to the north and west of the area noted above, the main building joist shows a less severe horizontal "crack" at the connection into the beam aligned with the bottom of the tenon.

   Analysis: The "crack" at the north beam appears to have started as a natural wood check or possibly a shear crack (if the post was not directly below prior to the addition of the lean-to), but was amplified by the drilling of the through-bolt and possibly expansion forces of corrosion of the through-bolt.

The "crack" at the end of the main building joist is a classic presentation of "shear crack" which occurs due to a shear stress concentration at the mortise joint.

Recommendation: Similar to the previous item, we recommend that retrofit designs for both of the noted connections be developed by a preservation structural engineer to ensure that load paths are safely transferred through the joint. Retrofit designs will likely include vertical screws or bolts across the cracks, steel seat angles or hangers, and possibly epoxy injection.

Left: from the southwest showing ledge, board siding and original building sill/beam with deep vertical check, as well as ledger on post to support inner edge of beam; Right: from north showing bolted lap spice over post, split, and ledger on post.

Shear crack in original mill joist framing into the sill / beam (behind the conduit).

7. Fender Beam.

Description: The fender beam is a 12x10 timber beam spanning north-south parallel to the upper floor framing adjacent to it and supports the two vertical up-down saw guides. The north end of the fender beam bears on the exterior stone foundation wall and the frames into a post at the south end. A more-recent intermediate post with steel plate top connection was added to support the fender beam above the north raceway wall.

Analysis: The fender beam and end connections do not appear to show any signs of distress; however, the authors did not have adequate load information to perform a numerical analysis to check the capacity of the fender beam relative to its demand.

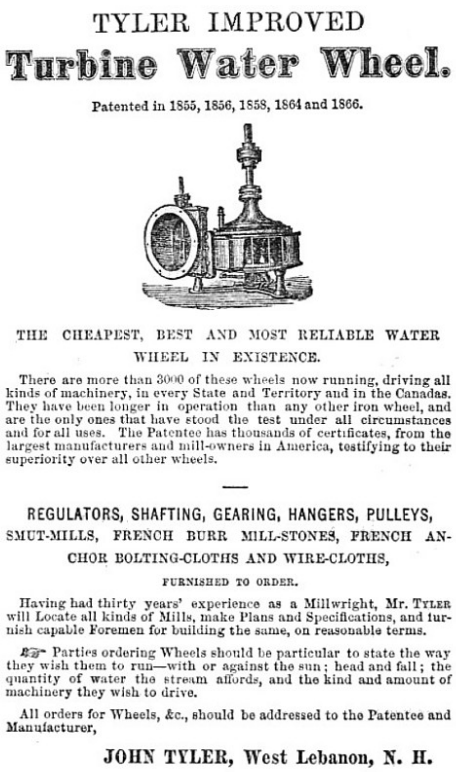
Recommendation: The authors would be happy to undertake a more rigorous analysis should it be desired.

Top: overall view of fender beam from the east showing two saw guides extending below; Middle: north end of fender beam; Bottom: south end of fender beam including newer intermediate post supported on north raceway wall below.

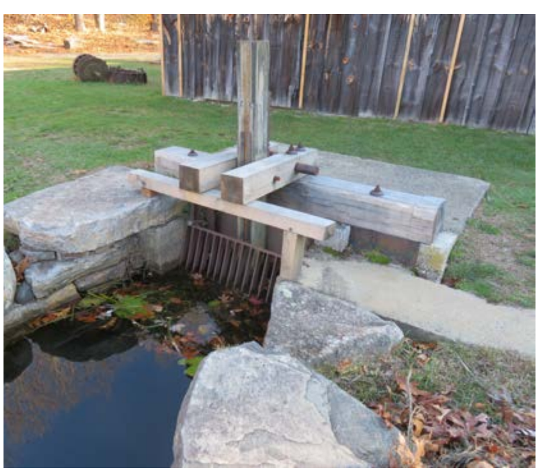
8. Penstock and Water Tank.

   Description: The existing steel penstock and water tank installed circa 1982 connects to a reinforced concrete culvert that travels below grade to the gate at the mill pond. The steel penstock is corroding and has been reinforced with strapping to hold it together. The town would like to replace it, but in a form more historically authentic.

   Analysis: Tom Kelleher (Historian, and Curator of Mechanical Arts) a nineteenth century mill expert from Old Sturbridge Village visited and advised the team about period appropriate options including historic forms constructed of wood (round and square) and iron flumes common at that time and shown in excerpts from historic catalogs provided by Tom. The discussion of the specifics mainly focused on the square wood option due to cost and longevity.

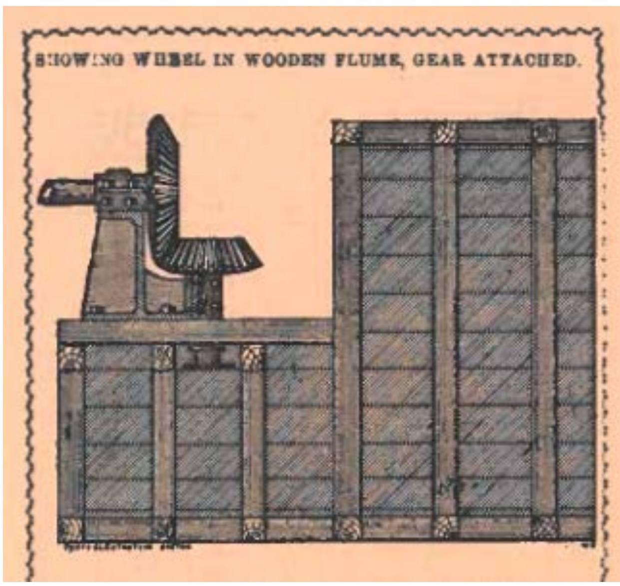


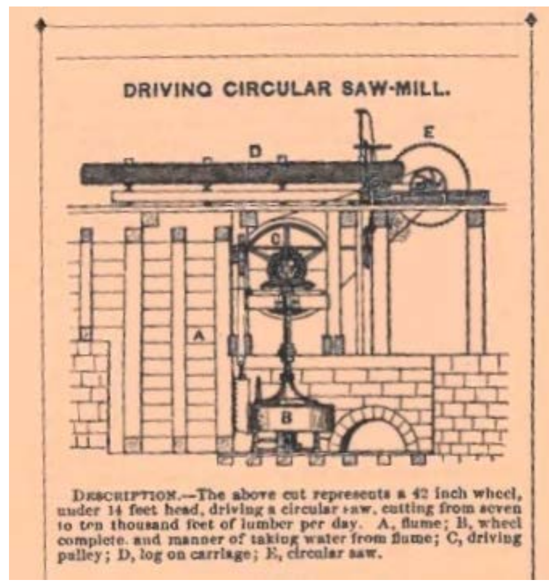
Left: 1870 advertisement for the Tyler Turbine; Right: Top of turbine in-situ.




Left: Gate at mill pond; Right: circa 1980s vertical tube and penstock with nylon tension straps reinforcing it.

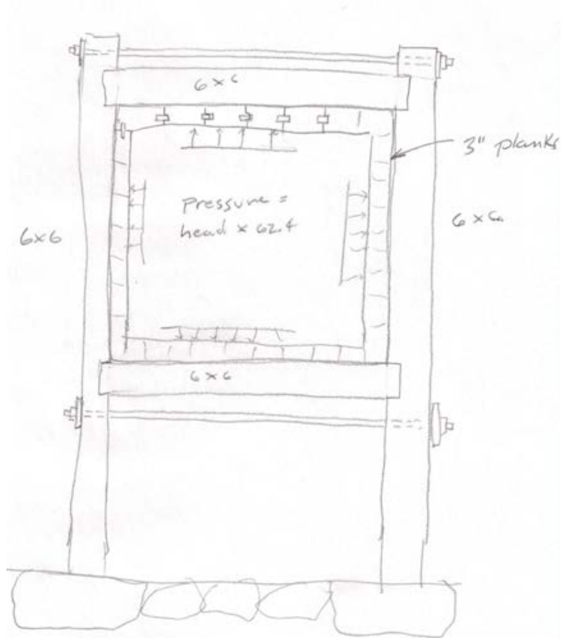

Left: investigation of the gate showing structure behind gate assembly; Right: concrete culvert between grate and penstock (penstock beyond). Both images courtesy of Ledyard Up-Down Sawmill Facebook page.





Eighteenth century turbine catalog diagrams showing arrangement of square wooded flumes. Images collected and provided by Tom Kelleher.

Recommendation: Per historic examples, the design concept that the group coalesced around is of a rectangular flume (penstock) constructed of 2" or 3" pressure-treated plank with groove edges connected with ¾" or 1" spline slightly oversized and lined with rubber to make it watertight. The planks would be braced by 4x4 (or bigger) frames every few feet with possible mortise and tenon joints. The frames could be wedged against the planks with shingles to pre-tension / pressurize against water pressure. The bottom of the interior of the flume / penstock would epoxy coated to extend its longevity. The downpipe connecting the flume to the turbine would also be square and of similar construction. We have provided a conceptual sketch of a cross-section through the flume of this assembly below. A full design is outside the scope of this project and would require exact head dimensions and detailed measurements of the area. Tom Kelleher suggests that making the supply 50% bigger than gate offers a less rigorous engineering analysis of the final design.



Conceptual Design of Flume Replacement, Cross-Section

9. Stone Tail Race.

   Description: A significant bulge is present in the dry laid stone tail race wall just to the east of the exterior stair. As part of its function, the wall also retains the earth behind the channel of the tail race.

   Analysis: The bulge is located at the most downstream end of the water flow and damage described in Item 1 and is likely caused by the same drainage path from the water pressure that builds up behind the wall.

   Recommendation: The condition could lead to instability and should be addressed. The most effective solution is to locally rebuild the wall in a plumb condition. This would also allow the opportunity to excavate behind the wall and improve drainage by adding a curtain drain wrapped with filter fabric. Weep holes through the wall could also be added to ensure overflow drainage in case the curtain drain becomes clogged in the future. Installing struts across the tailrace could provide temporary stabilization and/or a lower cost but less effective alternative to rebuilding.

North tailrace wall showing bulge in dry laid masonry

10. Stair at West End / Site Drainage.

    Description: Similar to the east side drainage and erosion issues noted in Items 1 and 9, the west side exhibits similar but milder conditions. Erosion was observed along the foundation wall and above the stair along with displacement of the dry-laid stone retaining wall and stone steps.

    Analysis: Unlike the west side, the pitch of the grade on this side of the building is less severe. Floods from the adjacent pond on several occasions in the last decade have been noted when water breached the pond and onto the strip of land between pond and mill building. On these occasions, water flowed into the basement at the southwest corner of the building and caused damage. It is possible that the noted erosion is caused by both land drainage and prior flooding.

    Recommendation: Excavating below this area to improve drainage by adding a curtain drain wrapped with filter fabric would prevent continued damage due to erosion, particularly if the accessibility / ramp project is undertaken. The drain would need to be routed to drain away from the building, which could prove to be a significant project. Weep holes through the wall could also be added to ensure overflow drainage in case the curtain drain becomes clogged in the future.

Erosion at west side of building, to north and south of door threshold

Displacement of steps and dry laid retaining wall at lower level below eroded areas above

11. Exterior Siding.

Description: The exterior of the mill is sided with vertical wood board and batten siding of variable heights/lengths and batten spacing. The species of the wood is unknown. Generally, boards are ¾" to 1" thick and battens ¾" to 1" (x 1¾"). The boards are nailed at the sills, eave / rake beams, and intermediate horizontal wall girts. The gap between boards (covered by the batten) allows them room for seasonal contraction.

At the north and south walls the boards extend the full height of the elevation. At the west gable end elevation, the boards run in two lengths with an overlapping joint around the eave line. The east elevation is similar to the west at the upper level; however, a third board length is added at the basement level at the south end (primarily grist mill addition). Rather than overlap, the joint between the upper and lower level boards in this location is formed as a butt joint with a horizontal batten between lengths. At the gable ends with multiple board lengths, the battens do not vertically line up at all locations.

Some battens have been replaced. The base of the boards are warped in areas and exhibit checks or rot in spots. Some cracks/checks are located at areas of nails or where metal tube railings (at the west side south corner) are fastened into the siding. The boards are also generally weathered and discolored.

Analysis: The durability and longevity of siding depends on many factors including wood species used for siding, whether it is treated, and installation techniques. In general, pine has the shortest lifespan of 20+ years (as it is least water and rot resistant), fir is a better option lasting 30+ years, cedar or redwood 75+ years, and cypress at 100+ years. Siding that is left untreated is more vulnerable to weather damage, particularly when it is a lower quality wood species. Typically, paint will last longer on smooth, edge-grained surfaces while penetrating stains or preservative treatments may work better for rough-sawn lumber. Treatment applications should include vertical surfaces of the siding as well as the horizontal end-grains.

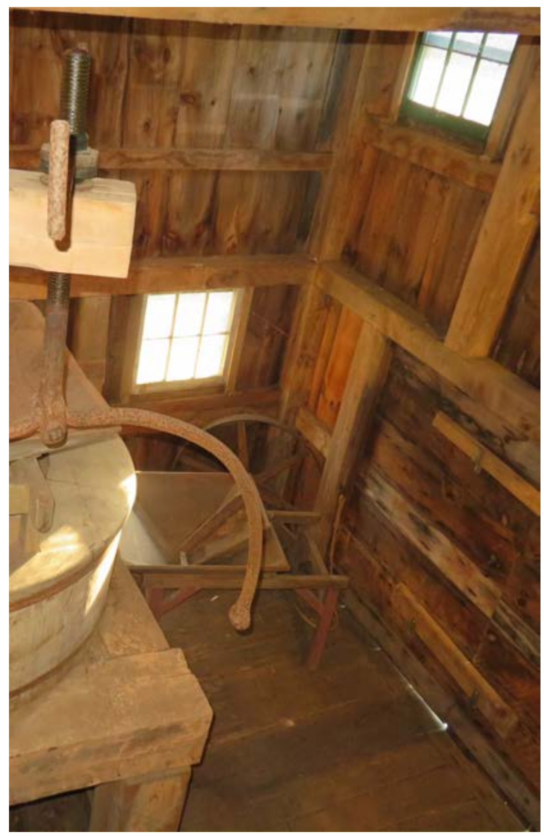
There are several construction details that may have led to premature deterioration of the siding. One of the most significant is the extension of the siding all the way to the ground, resulting in the exposure end grains of the wood making it susceptible to moisture absorption, warping and deterioration. Other details such as the vertical stacking of the boards without intermediary flashing and space for movement is similarly resulting in absorption of moisture via the end grains and deterioration at these locations. The horizontal "batten" at the butt joint details is essentially acting as a shelf for rain water, which is then absorbed by the siding above and below.

Recommendation: Short term treatment would involve the removal and replacement of any deteriorated sections of siding, and treatment of end grains via sanding and application of preservative treatment. It would also include removal and replacement of the horizontal batten, and if possible the addition of a Z-flashing along the upper surface of the horizontal batten to allow for any moisture that gets behind the siding above to drain out.

For a long term repair, it is recommended that the existing siding be removed and replaced with new wood batten siding, using at least either a pressure treated pine or cedar, and following industry recommended batten siding installation practices. This includes components such as the addition of a water table at the base and Z-flashing along the top. If stacking wood batten siding vertically, it is recommended that a Z-flashing be installed at the upper termination and a space of ¼" left before another piece of siding installed above.

Additional details for water management off the wooden envelope components such as drip edges at sills and flashings above windows would also help alleviate the water load on the siding and therefore prolong its lifespan. These are further discussed in the next section.

West and south elevations.



Left: Exterior of east elevation; Right: interior of south east corner showing horizontal girts and board supports.


Left: Overlapped detail at board joints on west elevation; Right: Butt joint detail at board joints on grist mill portion of east elevation.

Biological growth, weathering, deterioration and replacement battens (shown at northwest corner).

12. Windows.

Description: Existing wood windows are a mix of 2/2 and 3/3 single glazed wood sashes that are typically fixed in place. Some of the windows have plexiglass nailed to the interior where they had previously broken mainly at the lean-to on south elevation. Many of the windows have an exterior mounted wood frame with metal screens. The wood sashes vary in vintages which is evident by the variety of styles of muntins.

The window frames appear to be set directly between the siding including the wood sills that appear to be mounted to the exterior of the siding, not set on the frame. There do not appear to be any metal head flashings incorporated above the windows and sills do not possess flashings or drip edges.

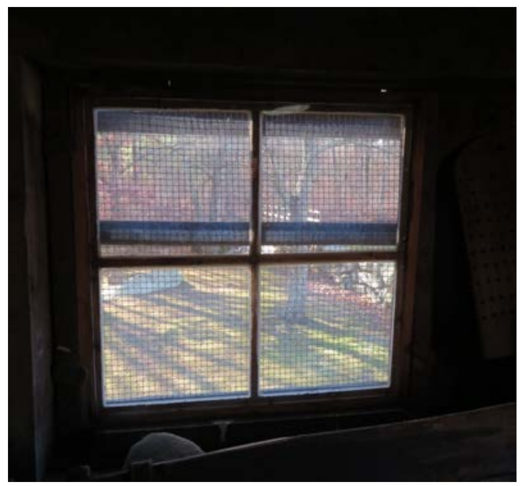
The town noted that the windows were mainly salvaged from other locations and set into new openings to provide light for the museum, and don't necessarily accurately reflect the historic sawmill.

Analysis: Peeling paint and areas of failed glazing putty are visible, but overall the sashes appear to be in fair condition. Some of the exterior mounted wood frames have cracks/checks and the wood is dried out in areas. Similarly, the wood sills show deep weathering, especially at the limits where the end grains are exposed, and sky-facing surfaces exhibit heavy cracking in many areas suggesting that wood fibers are separating due to deterioration from exposure to the elements.

Recommendation: Based on the observed conditions of the windows and sashes, it is recommended that the exterior window frames and associated components most susceptible to moisture be repaired/replaced. Where possible, replacement elements such as new wood sills should incorporate drip edges and be sloped to shed water. In conjunction with this work, additional elements such as flashings at the window heads should be integrated to reduce the potential of future deterioration of these elements. If done properly, these elements could be done discretely and without disrupting the historic appearance.

With respect to the window sashes, it seems that there are two options for window sash restoration: one option (least invasive) is to restore all the existing sashes (historic and non-historic) via maintenance repairs such as replacement of failed glazing putty, repair of wood defects, and repainting. The second option is to further review the existing windows to identify the various vintages of the windows, and identify which (if any) windows may be original/fall into the Mill's period of historic significance. These windows would then be the prototype and all non-appropriate windows would be removed and replaced with appropriate historic replicas to match these.

As part of the window work it is recommended that the existing interior plexiglass enclosures and exterior wood mounted screens be reviewed to assess need for these elements, and whether they should be reinstalled, replaced or omitted in the future.

Interior view; Left: painted salvaged window in grist mill addition; Right: south lean-to window with plexiglass replacement


Exterior original mill window with wood mounted screen. Sill is weathered with dry end grain.

E. Structural Load Assessment

The floor decking and beams of the main floor and loft of the sawmill were documented and framing plans drawn for the purpose of calculating the allowable loads which may be superimposed on the floors. To account for the possible mix of wood species, conservative values for allowable stresses were assumed in the analysis. The decking used for both the main floor and the loft averages approximately 2 full inches in thickness, and beams as noted in relevant areas below.

1. Loft:

   Decking: The longest deck span occurs in the loft at 7'-2" but the loft beams were found to be the limiting component there.

   Beams: The 8" x 8" loft beams, with a maximum span of 10'-10", have a live load capacity of 60 psf. In practical terms, this would allow stacking of 8 more layers of 2" planks on top of the existing planks throughout the entire loft.

2. Northwest Area (over penstock area near up-down saw):

   Decking: On the main floor, the maximum deck span is 5'-6". For that span, the decking is capable of supporting over 100 pounds per square foot (psf), which is the live load capacity required for assembly use, such as auditoriums and dance floors.

   Beams: This area is framed with 10x10 beams or larger and can be rated for over 100 psf. There is a multitude of heavy timber floor framing in this area, all well connected and in very good condition.

3. Lean-To (the floor of the southwest area, which is an addition to the original mill):

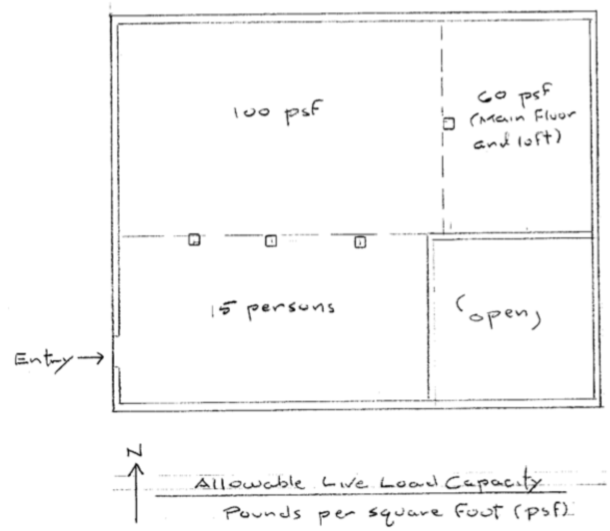
   Decking: With short spacing between joists, the decking has significantly more capacity than the beams.

   Beams: This area is framed with 6x6 floor beams @ 30" o.c. spanning 15 feet. The allowable floor live load here is just over 30 psf, which in terms of the building code, is suitable only for second floor bedrooms in one and two family dwellings. The allowable load for this area, however, is determined by deflection limits, not weight. A 30 psf live load would result in a deflection of more than 2 inches and would be very bouncy. Because of this, an occupancy limit of 15 persons in this area should be posted. The live load capacity of the floor can be increased to 60 psf by adding a center beam of (2) 1¾" x 9½" LVLs spanning from the stair opening east to the grist mill with one 6x6 post at the center and a 6x6 post under each end. The beam can be raised up flush with the joists so it only projects 3½" below the joists.

4. Northeast Area / Shingle Machine

   In the northeast area of the main floor, where the floor beams are 8" x 8" at 48" o.c., the allowable live load is approximately 60 psf, which, for reference, is about the same as office floor loading with some allowance for partition loads. This area includes the heavy, cast iron framed, shingle machine, however, which adds a heavy, undetermined weight to the floor. It occupies a footprint of about 5 feet x 5 feet. At 60 psf, the machine should weigh no more than 1500 lbs to stay within the allowable load. The machine likely weighs at least double that. If we were to assume that the effective supporting floor area extends one foot beyond the foot print, or 7' x 7', the maximum load allowed would be almost 3000 lbs. Presently, the floor supports the machine but there is some deflection of the two beams directly under it, indicating that they may be overstressed. We recommend that additional support be added by adding posts beneath each of the beams. If the supports are added, the south east area could be rated for a 60 psf live load.

When the saw mill is open to the public, a total occupancy limit for the building of 20 persons seems to be a reasonable limit to assure that the northwest area is not loaded excessively while still allowing a reasonable number of observers for demonstrations. See graphic representation of areas below.



F. Architectural Accessibility and Fire Suppression

The Ledyard Up-and-Down Sawmill (the Sawmill) was restored during the second half of the twentieth century and serves currently as a museum operated by volunteers. During the restoration, no provisions were made either for access by those with physical challenges or for fire protection other than the placement of fire extinguishers with the building. Since Section 303.1.1 of CSBS-2022 allows that small buildings may be classified as B-Business occupancies, we recommend so classifying the Sawmill.

Chapter 11 of the Connecticut State Building Code (CSBC-2022) exempts stories above and below the 'street floor', regardless of occupancy, if they contain fewer than 3,000 square feet of total gross floor area; however, the 'street floor' must be designed, renovated, or altered to provide the desired accessibility [Section 1103.2.15.2].

Further, CSBC-2022 requires an accessible route between the parking area of the site and the accessible building entrance [Section 1104.1]. Assuming the existing compacted gravel path between the parking lot and the mill site will meet the standards for grading, materials, and finishes required for wheelchair access, we recommend installation of a new pathway to the upper level of the mill building from the existing compacted gravel path.

Finally, CSBC-2022 requires an accessible entrance to the publicly accessed space(s) within the building [Section 1105.1]. We recommend creation of an accessible entrance at and through the existing entry door at the southwest corner of as outlined below and on the attached sketch.

We suggest that the proposed access pathway be laid out at a width of 48" to 60" between the existing compacted gravel path and the west façade of the Sawmill as delineated on the attached sketch. Further, we suggest that the pathway be constructed using a 2" thick bituminous concrete wearing course topped with 1" of washed aggregate (pea stone matching the gravel native to the area) on a minimum 6" deep compacted gravel base to provide a uniform travel surface for those visitors using wheelchairs and/or walling aids.

The Sawmill itself has two levels both of which can be entered at grade; however, the primary visitor entrance is at the upper level on the west façade of the Sawmill diagonally opposite the inlet for the head race. The existing grade at the entrance is roughly 12" or 13" below the upper floor level. Because the lower level houses the works of the up-and-down saw as well as other millworks machinery and equipment, the upper level provides an excellent vantage point for visitors to view the Sawmill operations. With that in mind, we suggest installation of an entry platform set above the existing grade and flush with the upper floor connected to a modest bridge ramp which will descend 6" vertically toward the existing grade (a slope of 8%).

To meet the existing grade, we suggest a slightly raised path matching the character of the new pathway described above with a maximum slope of 5% and extended to the new pathway as necessary to meet existing grade. Given the apparent elevation of the existing grade, we anticipate that the raised path will extend for between 72" and 90".

Finally, to complete the accessible entrance, we recommend widening the primary visitor entrance to maintain a full 32" clear as required by Section 1010.1.1 of CSBC-2022. This will require trimming down the door jamb post on the west side by a few inches, which will not likely impact its ability to carry the light load imposed on it.

Chapter 9 of CSBC-2022 does not require automated sprinkler systems in B-Business occupancies. Given that the water pressure required for a 'wet' sprinkler system will exceed available water supply sources and that cost of installing and maintaining a 'dry' sprinkler system will impose a fiscal burden on the property, we recommend installation of a monitored security system with fire alarm capabilities along with enhancement and continued maintenance of the existing fire extinguishers.

G. Summarized List

We have developed the rough order of magnitude budget pricing for the repair work identified in this report:

Penstock replacement - $25,000

Sitework, tailrace wall stabilization, resetting the settled sidewalk ramp, new ramp to the exterior door, gutter/downspout replacement and split beam repairs - $75,000.

We had mentioned the option of doing "dendrochronology" on the historic structural timbers to better identify when the mill was constructed. Should this work / project be desired, we recommend budgeting about $5,000 for it.

H. Limitations

The analysis and recommendations in this report are based upon data obtained from limited field observations. These observations are limited to the visual assessment of exposed elements on the building. If discrepancies, unforeseen conditions or undesirable conditions more extensive than originally thought become evident in the field, it will be necessary to re-evaluate the recommendations contained in this report.

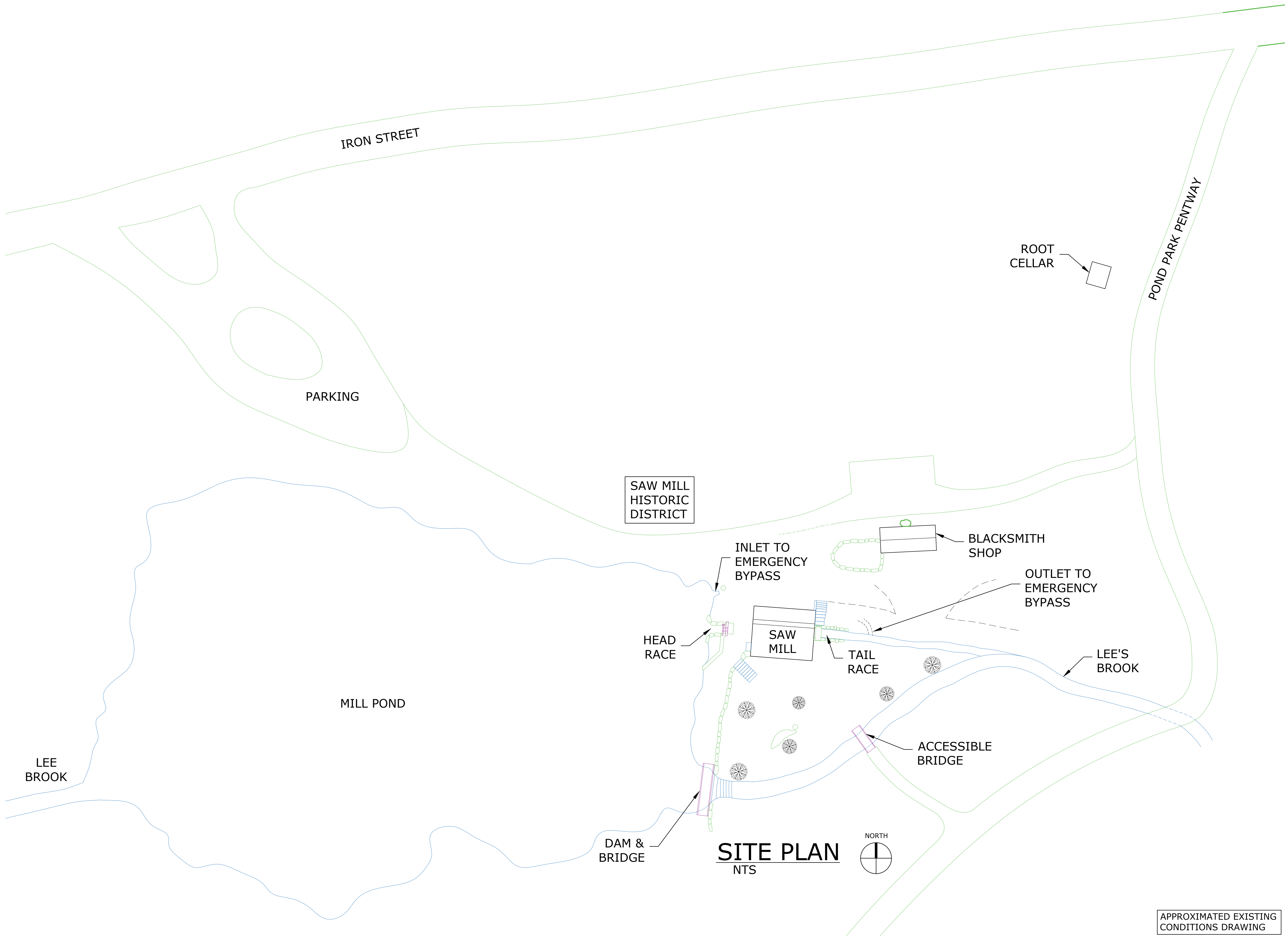
The information provided in this report is not suitable for construction. It is for planning, and budgeting purposes only. Should the Owner decide to move forward with any of the work recommended in this report, we strongly suggest that Bid and Construction Documents be developed, and Construction Administration performed under the guidance of a qualified consultant. We would be delighted to assist you in these efforts.

I. Appendix

I. Representative Building Drawings, including roof and floor framing sketches

II. The Architects Building Code Assessment re Access and Fire Protection memo and ramp sketch

III. Clarence Welti Associates boring log



SITE PLAN
NTS

CIRRUS

James K. Grant Associates
Structural Engineering
Historic Preservation
P.O. BOX 235, 30 DEPOT ST.
COLLINSVILLE, CT. 06022
860 693 8403

NAME: Ledyard Up-Down Sawmill

ADDRESS: Sawmill Park
172 Iron St
Ledyard, CT 06339

REVISIONS

#	DATE	DESCRIPTION

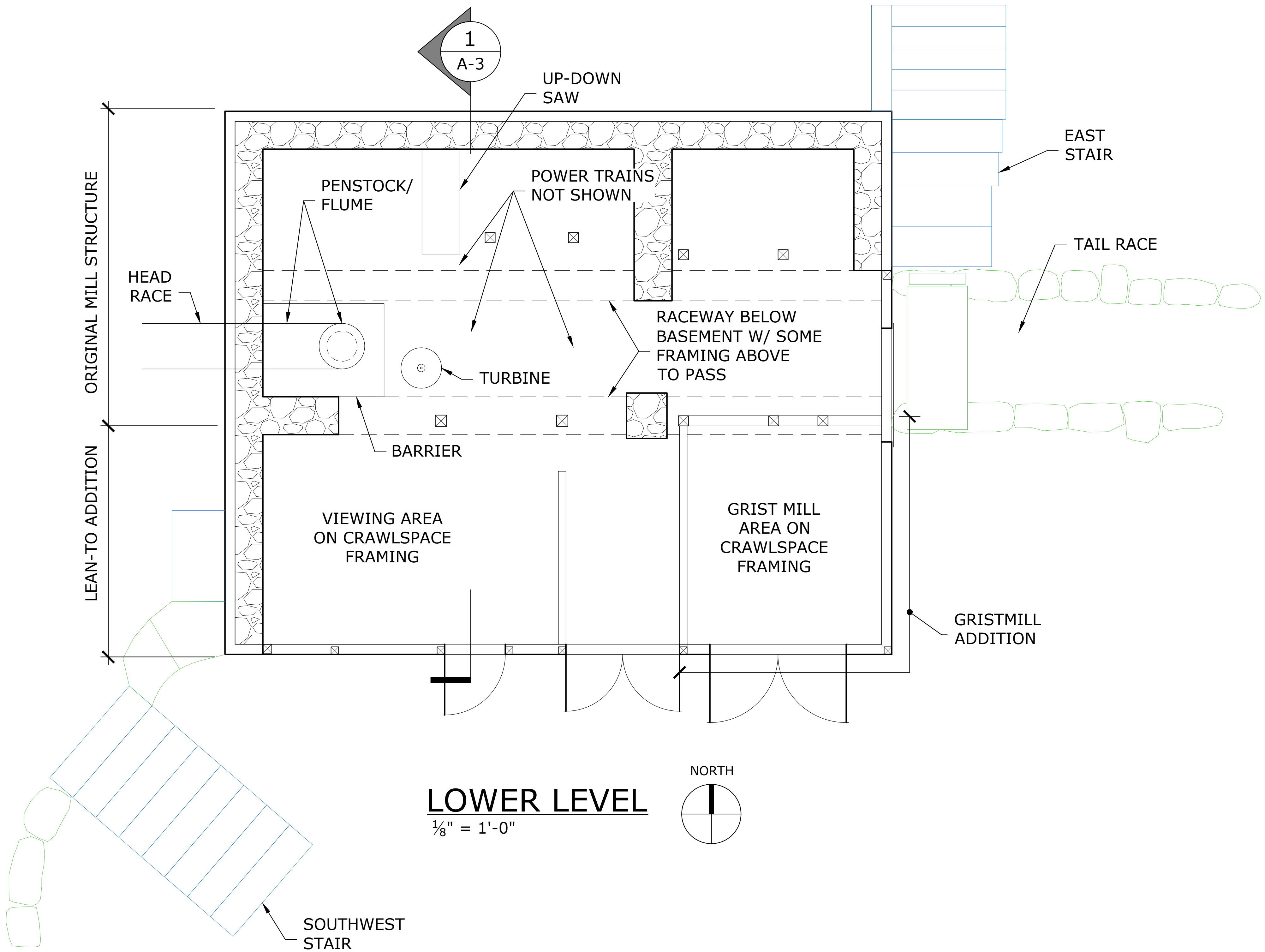
Drawn By:	Checked By:
PAN	EWA

Date of Issue: January 16, 2022

Drawing Title: SITE PLAN

Scale: As Noted @ 11x17

Drawing No: S-1



LOWER LEVEL
⅛" = 1'-0"

APPROXIMATED EXISTING
CONDITIONS DRAWING

James K. Grant Associates
Structural Engineering
Historic Preservation

P.O. BOX 235, 30 DEPOT ST.
COLLINSVILLE, CT. 06022
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REVISIONS

#	DATE	DESCRIPTION

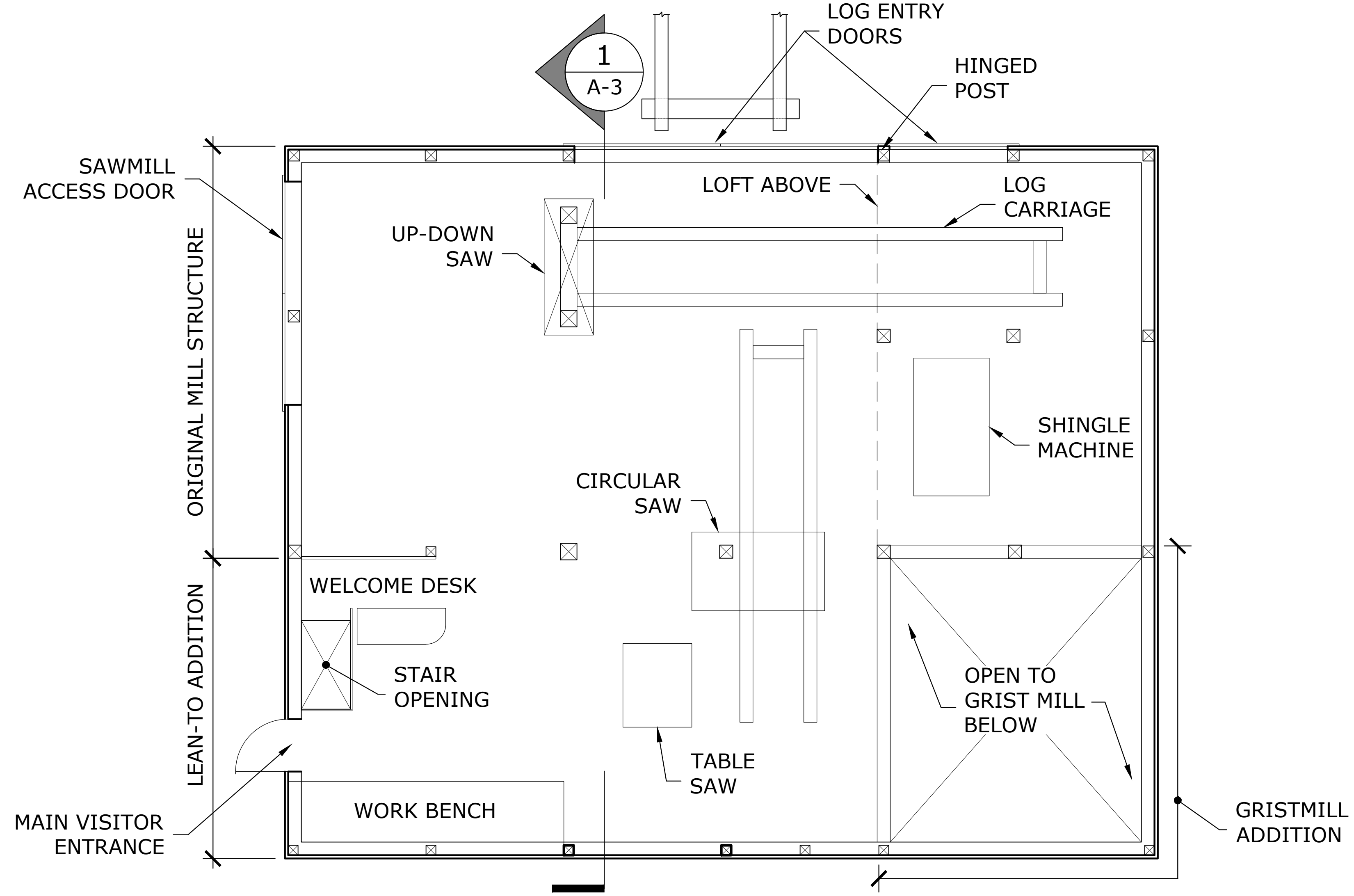
Drawn By:	Checked By:
PAN	EWA

Date of Issue: January 16, 2022

Drawing Title: LOWER LEVEL PLAN

Scale: As Noted @ 11x17

Drawing No: A-1



FIRST FLOOR

$\frac{1}{8}$" = 1'-0"

NORTH

APPROXIMATED EXISTING CONDITIONS DRAWING

James K. Grant Associates
Structural Engineering
Historic Preservation

P.O. BOX 235, 30 DEPOT ST.
COLLINSVILLE, CT. 06022
860 693 8403

NAME: Ledyard Up-Down Sawmill

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Ledyard, CT 06339

REVISIONS		
#	DATE	DESCRIPTION

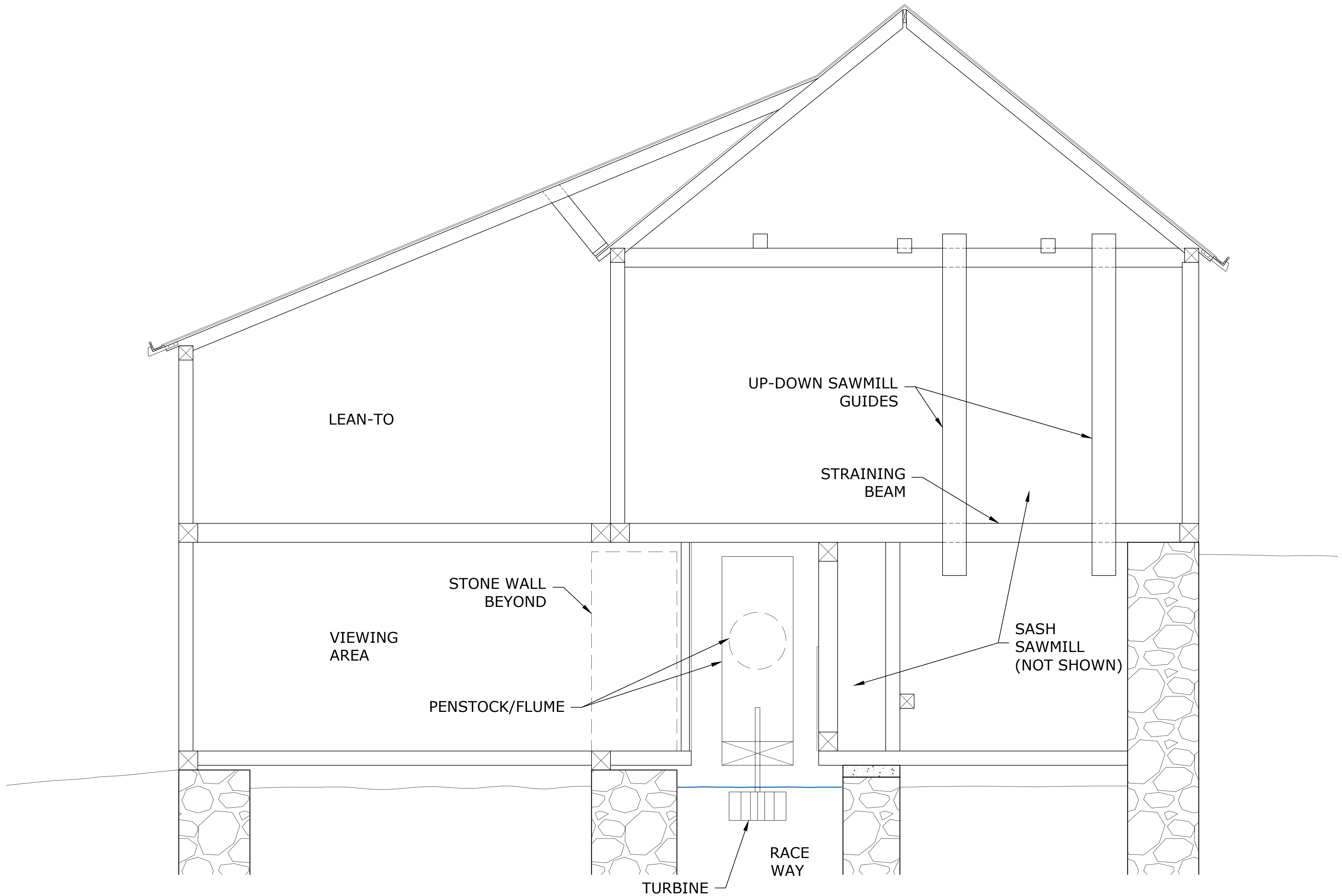
Drawn By:	Checked By:
PAN	EWA

Date of Issue: January 16, 2022

Drawing Title: FIRST FLOOR PLAN

Scale: As Noted @ 11x17

Drawing No: A-2



1 A-3 BUILDING SECTION
¼" = 1'-0"   LOOKING WEST

APPROXIMATED EXISTING CONDITIONS DRAWING

James K. Grant Associates
Structural Engineering
Historic Preservation

P.O. BOX 235, 30 DEPOT ST.
COLLINSVILLE, CT. 06022
860 693 8403

NAME: Ledyard Up-Down Sawmill

ADDRESS: Sawmill Park
172 Iron St
Ledyard, CT 06339

REVISIONS		
#	DATE	DESCRIPTION

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Date of Issue: January 16, 2022	
Drawing Title: BUILDING SECTION	
Scale: As Noted @ 11x17	
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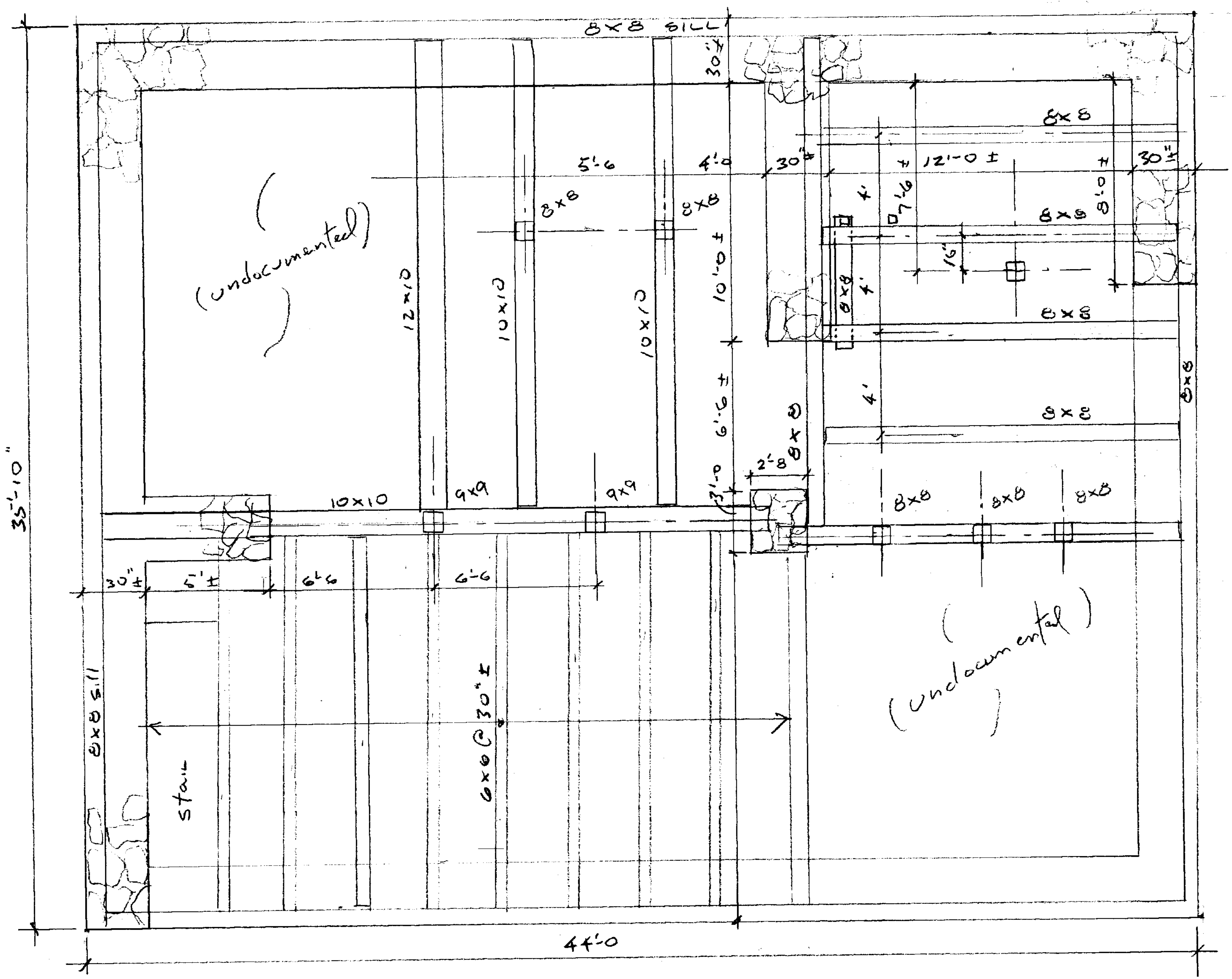
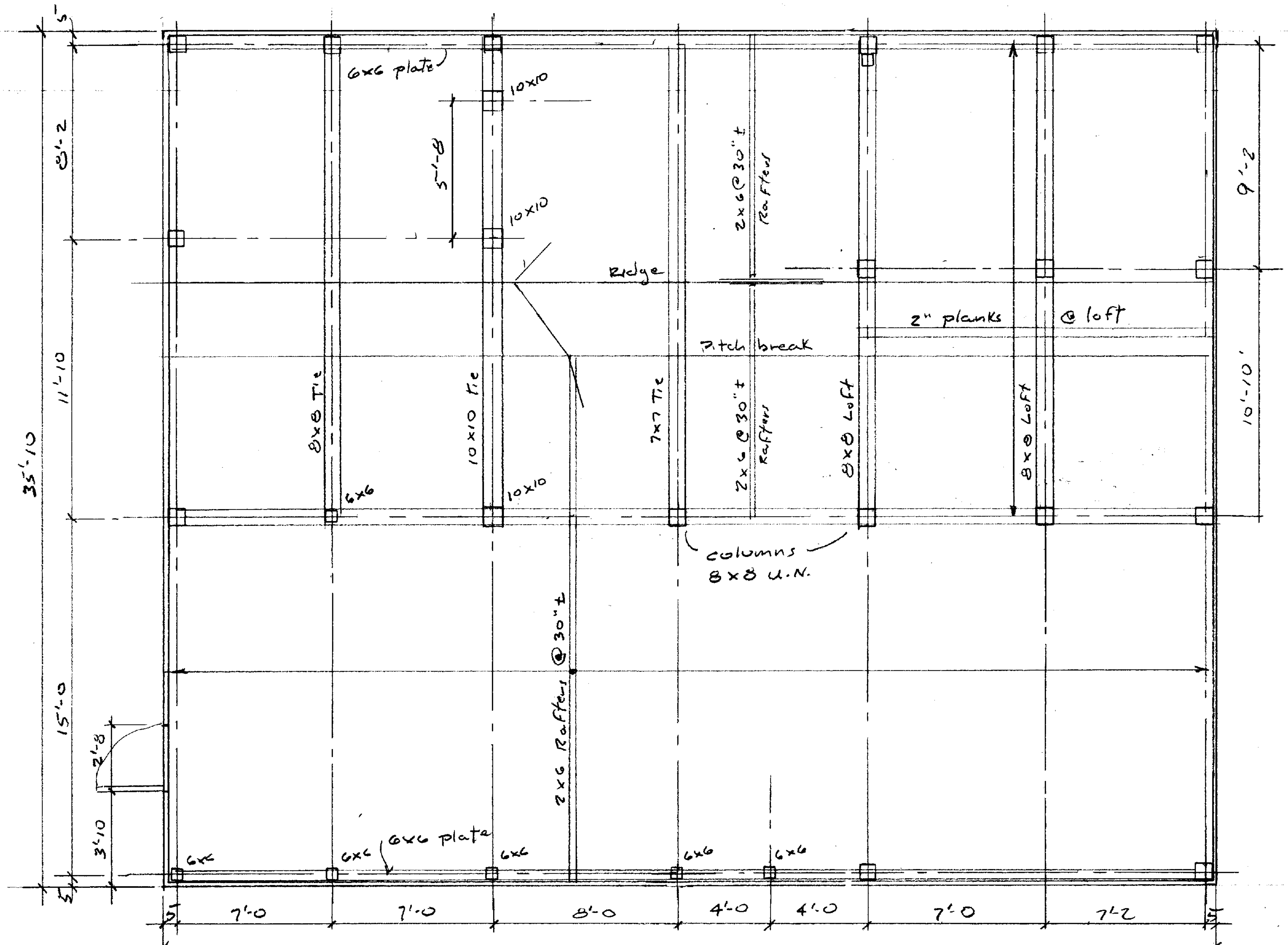


FLOOR FRAMING



ROOF & LOFT FRAMING

The Architects

56 Arbor Street
Hartford, CT 06106
Tel: 860-232-2707
Fax: 860-232-2722

Robert B. Hurd, AIA
Architect

MEMORANDUM

DATE: December 8, 2022

TO: Elizabeth Acly, PE – Principal Engineer
Cirrus Structural Engineering LLC
19A Woodland Terrace
Columbia, CT 06237

FROM: THE ARCHITECTS – Robert B. Hurd, AIA

RE: Ledyard Up-and-Down Sawmill
Building Code Assessment re Access and Fire Protection

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THE ARCHITECTS
THE INTEGRITY. THE ABILITY. THE EXPERIENCE

The Architects

56 Arbor Street
Hartford, CT 06106
Tel: 860-232-2707
Fax: 860-232-2722

Robert B. Hurd, AIA
Architect

DATE: December 8, 2022
TO: Elizabeth Acly, PE – Principal Engineer
Cirrus Structural Engineering LLC

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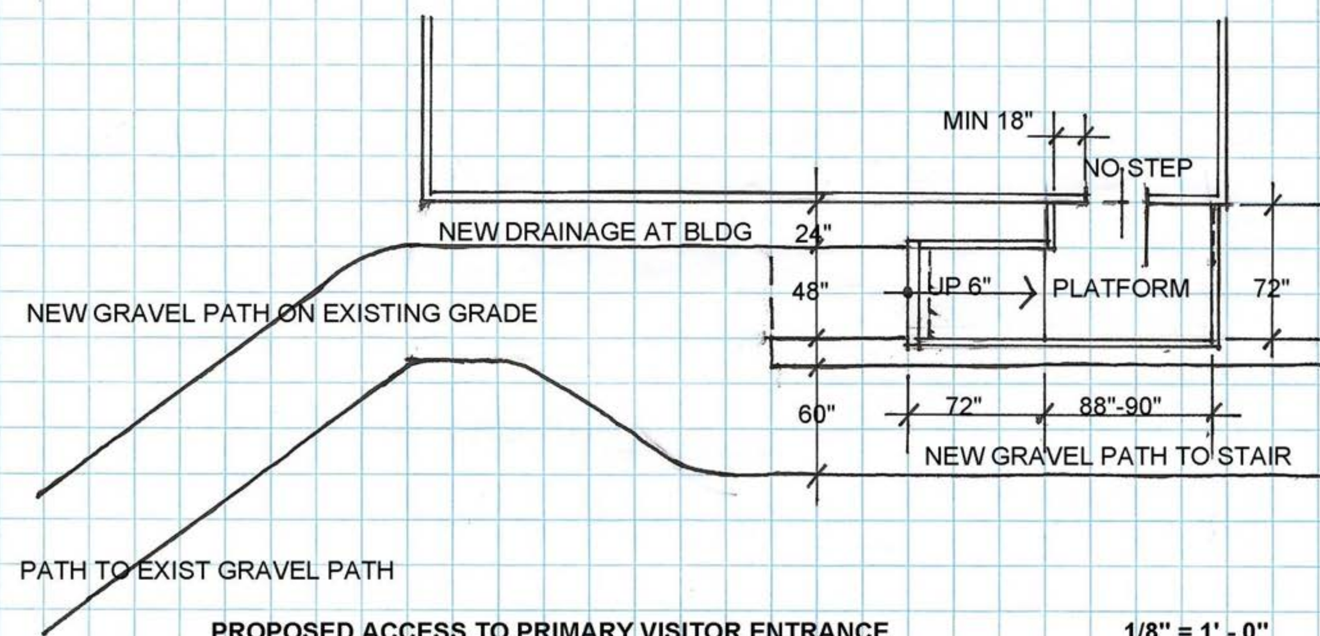
Please feel free to contact me with questions about these recommendations.

Cc: Sawmill file

THE ARCHITECTS
THE INTEGRITY. THE ABILITY. THE EXPERIENCE



PROPOSED ACCESS TO PRIMARY VISITOR ENTRANCE **1/8" = 1' - 0"**

DESCRIPTION - ACCESS TO PRIMARY VISITOR ENTRANCE

THE PROPOSED ACCESSIBLE ENTRANCE PATHWAY WILL CONSIST OF THE FOLLOWING:

1. NEW 48" TO 60" WIDE PATH ON EXISTING GRADE USING WASHED AGGREGATE (PEA GRAVEL MATCHING NATIVE STONE) LAID OVER A BITUMINOUS CONCRETE PATH ON EXISTING GRADE BETWEEN THE EXISTING GRAVEL PATH TO THE PARKING AREA.
2. THE PATH WILL CONTINUE PAST THE ACCESSIBLE ENTRANCE TO THE TOP OF THE EXISTING STONE STAIR.
3. THE 48" WIDE ACCESSIBLE PATH WILL RISE AS REQUIRED (ESTIMATED AT 2" TO 3" VERTICALLY) TO MEET THE BASE OF THE BRIDGE RAMP.
4. THE 48" WIDE BRIDGE RAMP WILL RISE A MAXIMUM OF 6" VERTICALLY TO REACH THE NEW ENTRY PLATFORM AT THE EXISTING ENTRANCE TO THE UPPER LEVEL OF THE SAWMILL.
5. BOTH THE BRIDGE RAMP AND THE ENTRY PLATFORM WILL HAVE 4" HIGH x 4" WIDE CURBS ALONG THEIR EDGES.
6. EXISTING GRADE BELOW THE BRIDGE RAMP AND THE ENTRY PLATFORM WILL REMAIN UNDISTURBED ALLOWING THE NATURAL FLOW OF WATER AWAY FROM THE FOUNDATION OF THE SAWMILL.
7. FINALLY, THE PROJECT WILL INCLUDE A 24" WIDE x 24" TO 48" DEEP DRAINAGE SYSTEM ALONG THE FACE OF THE SAWMILL TO REDIRECT THE OCCASIONAL FLOOD WATERS WHEN THE MILL POND OVERFLOWS.

PREPARED BY: ROBERT B HURD, AIA - ARCHITECT 12/8/2022

PROJ. NO.:
DWG. NO.:

PROPOSED ACCESS TO PRIMARY VISITOR ENTRANCE
LEDYARD UP-AND-DOWN SAWMILL
FOR: TOWN OF LEDYARD - LEDYARD HISTORIC DISTRICT COMMISSION

SCALE: AS NOTED
DATE: DEC. 8, 2022

REVISIONS:

THE ARCHITECTS

ROBERT B. HURD,
56 ARBOR STREET
HARTFORD, CT 06106
TEL: (860) 232-2707
LICENSED IN CONNECTICUT, NEW YORK AND RHODE ISLAND


UP-DOWN SAWMILL
172 IRON STREET, LEDYARD, CT
TEST BORING LOCATION
CLARENCE WELTI ASSOCIATES, INC.
11/11/22
9.5'
BORING B-1
10'

CLARENCE WELTI ASSOC., INC. P.O. BOX 397 GLASTONBURY, CONN 06033	CLIENT JAMES K. GRANT ASSOCIATES	PROJECT NAME UP-DOWN SAW MILL LOCATION 172 IRON STREET, LEDYARD, CT

	AUGER	CASING	SAMPLER	CORE BAR.
TYPE	HSA		SS	NQ
SIZE I.D.	3.75"		1.375"	2.0"
HAMMER WT.			140lbs	
HAMMER FALL			30"	

OFFSET
LINE & STA.
N. COORDINATE
E. COORDINATE

SURFACE ELEV.
HOLE NO. B-1

GROUND WATER OBSERVATIONS
AT 9.0 FT. AFTER 0 HOURS
AT FT. AFTER HOURS

START DATE 11/11/22
FINISH DATE 11/11/22

DEPTH	SAMPLE NO.	BLOWS/6"	DEPTH	A	STRATUM DESCRIPTION + REMARKS	ELEV.
0	1	4-3-4-2	0.0'-2.0'		BR.FINE-CRS.SAND, SOME GRAVEL, TRACE SILT - FILL	
						2.0
	2	3-2-3-2	2.0'-4.0'		BR.FINE-CRS.SAND, SOME SILT, LITTLE GRAVEL - FILL	
						4.5
5	3	4-12-22-33	4.0'-6.0'		BR.FINE-CRS.SAND, SOME GRAVEL & COBBLES, LITTLE SILT & BOULDERS	
					CORED BOULDERS	
					RUN #1 9.8' - 14.8' RECOVERED 18"	
10	4	33-60	9.0'-9.6'			
15	5	12-6-7	14.0'-15.5'			
						18.5
					CORED BEDROCK -	
20					RUN #2 18.5' - 23.5' RECOVERED 60"	
						23.5
					BOTTOM OF BORING @ 23.5'	
25						
30						
35						

LEGEND: COL. A:
SAMPLE TYPE: D=DRY A=AUGER C=CORE U=UNDISTURBED PISTON S=SPLIT SPOON
PROPORTIONS USED: TRACE=0-10% LITTLE=10-20% SOME=20-35% AND=35-50%

DRILLER: J. BREWER
INSPECTOR:

SHEET 1 OF 1 HOLE NO. B-1