MEMORANDUM OF FINDINGS

TO: England, Thims & Miller, Inc.

FROM: Erik J. Olsen, P.E. EJO

DATE: 16 September 2020 (Revised November 2, 2020)

RE: THE SHIPYARDS, JACKSONVILLE
Flood Risk Assessment and Resiliency Guidance

Purpose of Professional Services

On behalf of the project Developer, Iguana Investments, Olsen Associates, Inc. (OAI) has been retained as a Subconsultant by their Project Engineer -- England, Thims & Miller, Inc. (ETM), to provide design guidance with respect to sea level rise, storm surge vulnerability, nuisance flooding and other dynamic phenomena (including waves) that could affect the future design and development of the SHIPYARDS site – located on the Northbank shorefront of the St. Johns River in downtown Jacksonville. The firm was retained at the *conceptual planning* stage for the SHIPYARDS project. As a result, this study provides a global analysis of site vulnerability, in lieu of specific guidance on yet to be decided individual project design elements or features which tentatively would be expected to include hotels, office and residential buildings, parking garages, restaurants, museums, etc. That is to say, the information included herein is intended to be used in the future by various design professionals to best address the issue of ensuring post-construction resiliency throughout the limits of the SHIPYARDS site over some defined "project life."

Project Site Riverfront Characteristics

Tides - The general area of interest fronts a portion of the Northbank of the St. Johns River (SJR) within the downtown City core and is nominally located between the Main Street and Isaiah D. Hart Bridge(s). The subject property shoreline is located at a major bend in the SJR where the channel orientation changes from N-S to E-W (see **Figure 1**). The site is both tidally influenced as well as subject to storm tides (*i.e.* surge) originating from the Atlantic Ocean, *as well as* from the N-S segment of the St. Johns River lying southward of the Fuller Warren Bridge extending into Clay County.

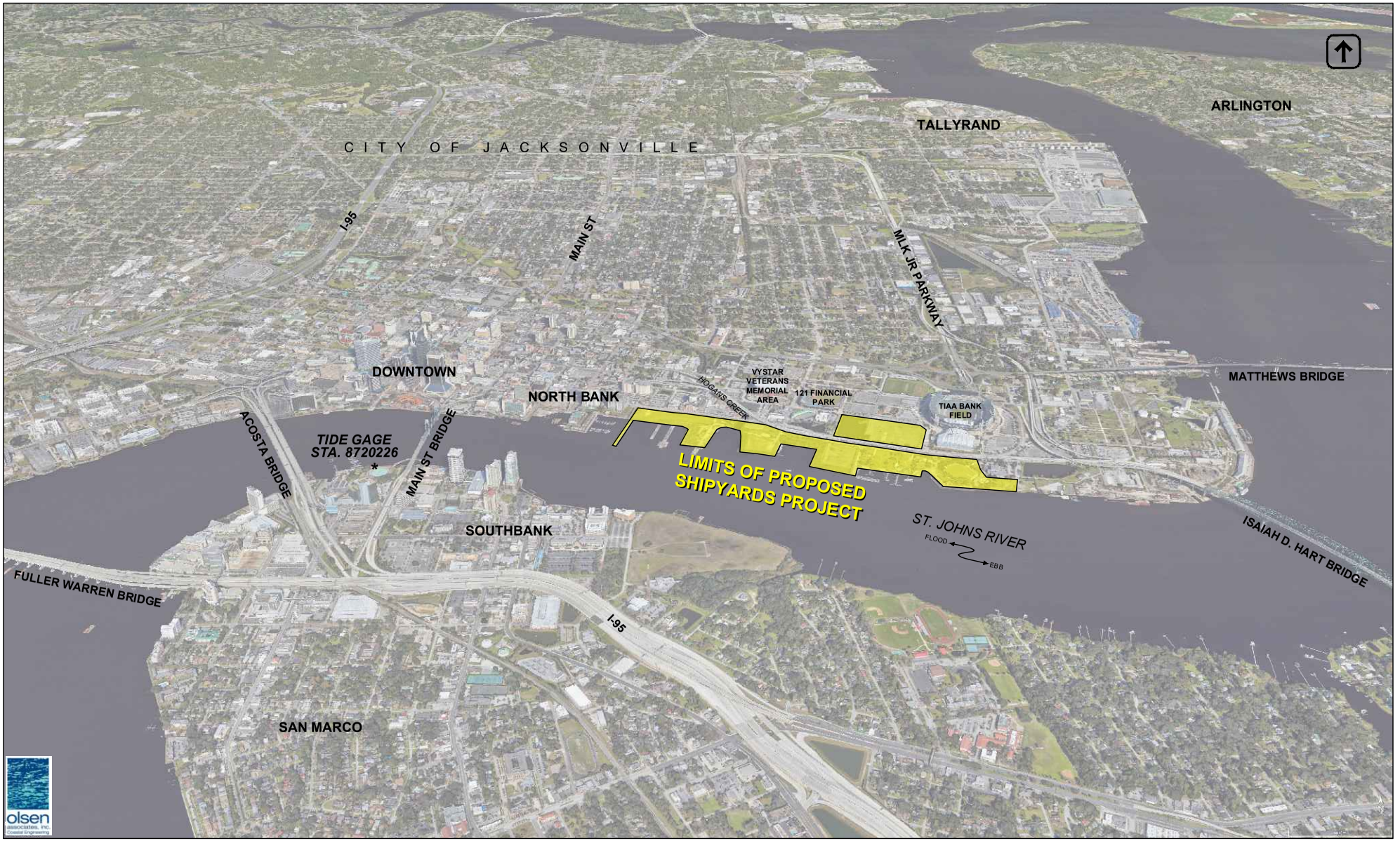
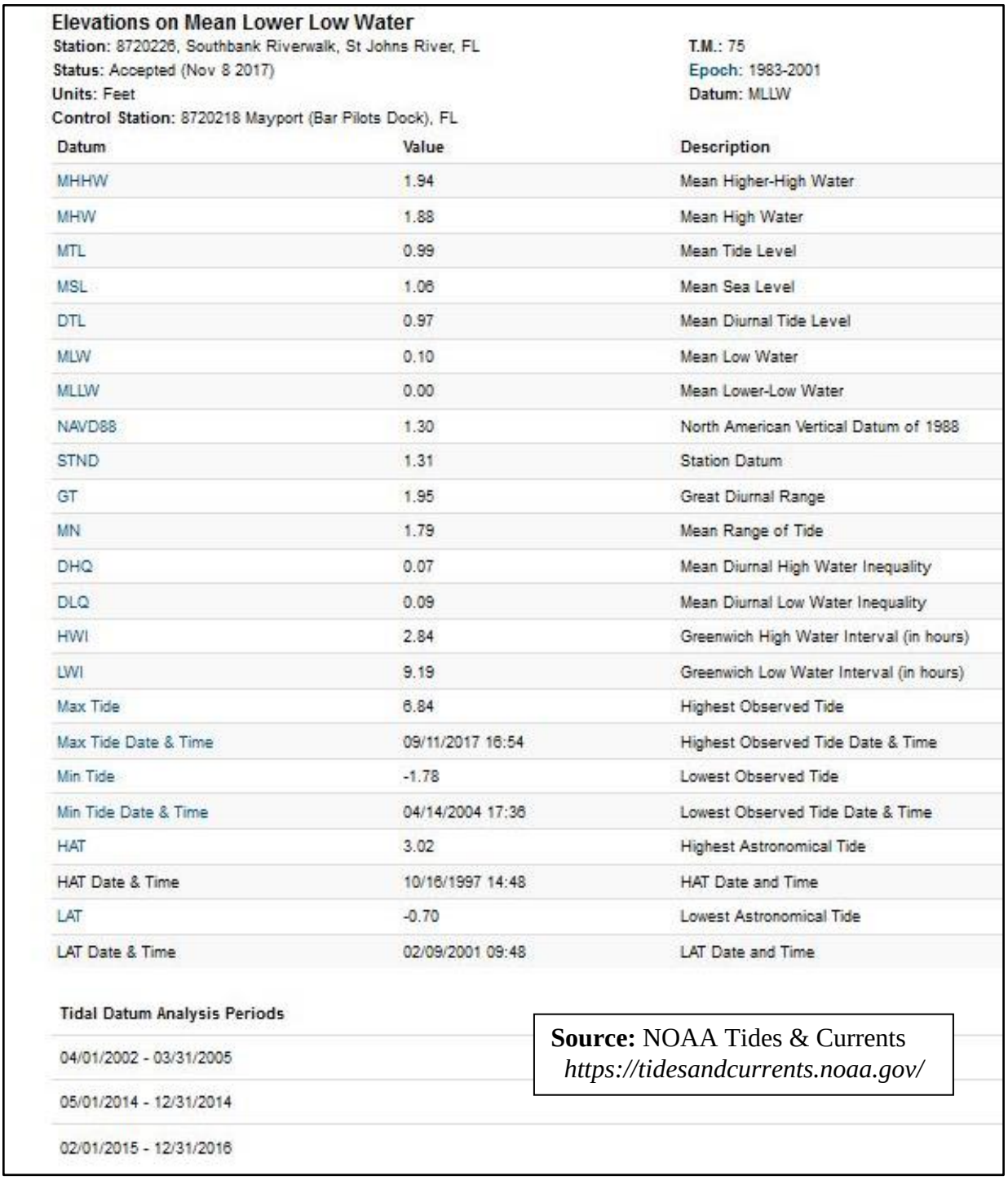


FIGURE 1
SHIPYARDS PROJECT LOCATION

The official elevation of Mean High Water (MHW) at the site is +.57 ft. (NAVD88). The average mean tide level (annually) is computed to be -.32 ft. (NAVD88), or .89 ft. below the elevation of average MHW. All computed tidal datums for the project site derive from a National Ocean & Atmospheric Administration (NOAA) recording tide gage located on the Southbank Riverwalk (Tidal Station 8720226) which is nominally about a mile away -- directly across from the proposed site. **Figure 2** presents a listing of the published datums for that gage which are *theoretically* associated with the SHIPYARDS riverfront property, but as will be addressed herein, *are not* necessarily suitable for purposes of planning and design.

Based upon multi-period record analyses by NOAA for the Southbank tidal datums gage, **Figure 3** demonstrates the astronomical (*only*) predicted tidal characteristics of the project riverfront locale for calendar year 2020. These tidal predictions by NOAA however do *not* include the effects of wind, waves, rainfall, tropical storms, or hurricanes, nor'easters, riverine fresh water discharge, or other factors affecting the actual day-to-day elevation of the river adjacent to the project site. For example, multi-day nor'easter events alone in N.E. Florida routinely super-elevate water levels within the subject section of the St. Johns River by 1 ft. or more *above* the predicted astronomical tides – often for days on end.

Irrespective of the "official significance" of the published tidal datums for Station 8720226, Southbank Riverwalk, such datum elevations *should not be utilized* for purposes of tailwater identification typically required for upland drainage structure design, or for the evaluation of future nuisance flooding phenomena. It can be demonstrated that the actual recorded water elevations for the Southbank Riverwalk tide gage can vary significantly from those analytically predicted. As an example, **Figure 4** is a depiction of analytically predicted vs. actual recorded water levels for the month of December 2019, at NOAA's Southbank gage. As such, recorded water levels in the latter part of the month exceeded those "predicted' -- by as much as +1.3 ft. Hence any datum analysis published by NOAA made for the Southbank tide gage is not necessarily relevant to future or even today's water level conditions and therefore *should not be relied upon for purposes of design for any project located within the City core waterfront*. This is particularly true for the design of conventional drainage infrastructure dependent upon tailwater elevations within the sole receiving body -- which is the SJR. This conclusion also applies to publicly accessible riverwalk amenities in close proximity to the river.



Elevations on Mean Lower Low Water

Station: 8720228, Southbank Riverwalk, St Johns River, FL
Status: Accepted (Nov 8 2017)
Units: Feet
Control Station: 8720218 Mayport (Bar Pilots Dock), FL

T.M.: 75
Epoch: 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW	1.94	Mean Higher-High Water
MHW	1.88	Mean High Water
MTL	0.99	Mean Tide Level
MSL	1.06	Mean Sea Level
DTL	0.97	Mean Diurnal Tide Level
MLW	0.10	Mean Low Water
MLLW	0.00	Mean Lower-Low Water
NAVD88	1.30	North American Vertical Datum of 1988
STND	1.31	Station Datum
GT	1.95	Great Diurnal Range
MN	1.79	Mean Range of Tide
DHQ	0.07	Mean Diurnal High Water Inequality
DLQ	0.09	Mean Diurnal Low Water Inequality
HWI	2.84	Greenwich High Water Interval (in hours)
LWI	9.19	Greenwich Low Water Interval (in hours)
Max Tide	6.84	Highest Observed Tide
Max Tide Date & Time	09/11/2017 16:54	Highest Observed Tide Date & Time
Min Tide	-1.78	Lowest Observed Tide
Min Tide Date & Time	04/14/2004 17:36	Lowest Observed Tide Date & Time
HAT	3.02	Highest Astronomical Tide
HAT Date & Time	10/16/1997 14:48	HAT Date and Time
LAT	-0.70	Lowest Astronomical Tide
LAT Date & Time	02/09/2001 09:48	LAT Date and Time

Tidal Datum Analysis Periods

04/01/2002 - 03/31/2005

05/01/2014 - 12/31/2014

02/01/2015 - 12/31/2016

Source: NOAA Tides & Currents
https://tidesandcurrents.noaa.gov/

Figure 2: Vertical datums for NOAA Tide Station 8720228 (Southbank Riverwalk, St. Johns River, FL). Values listed are relative to Mean Lower Low Water (MLLW).

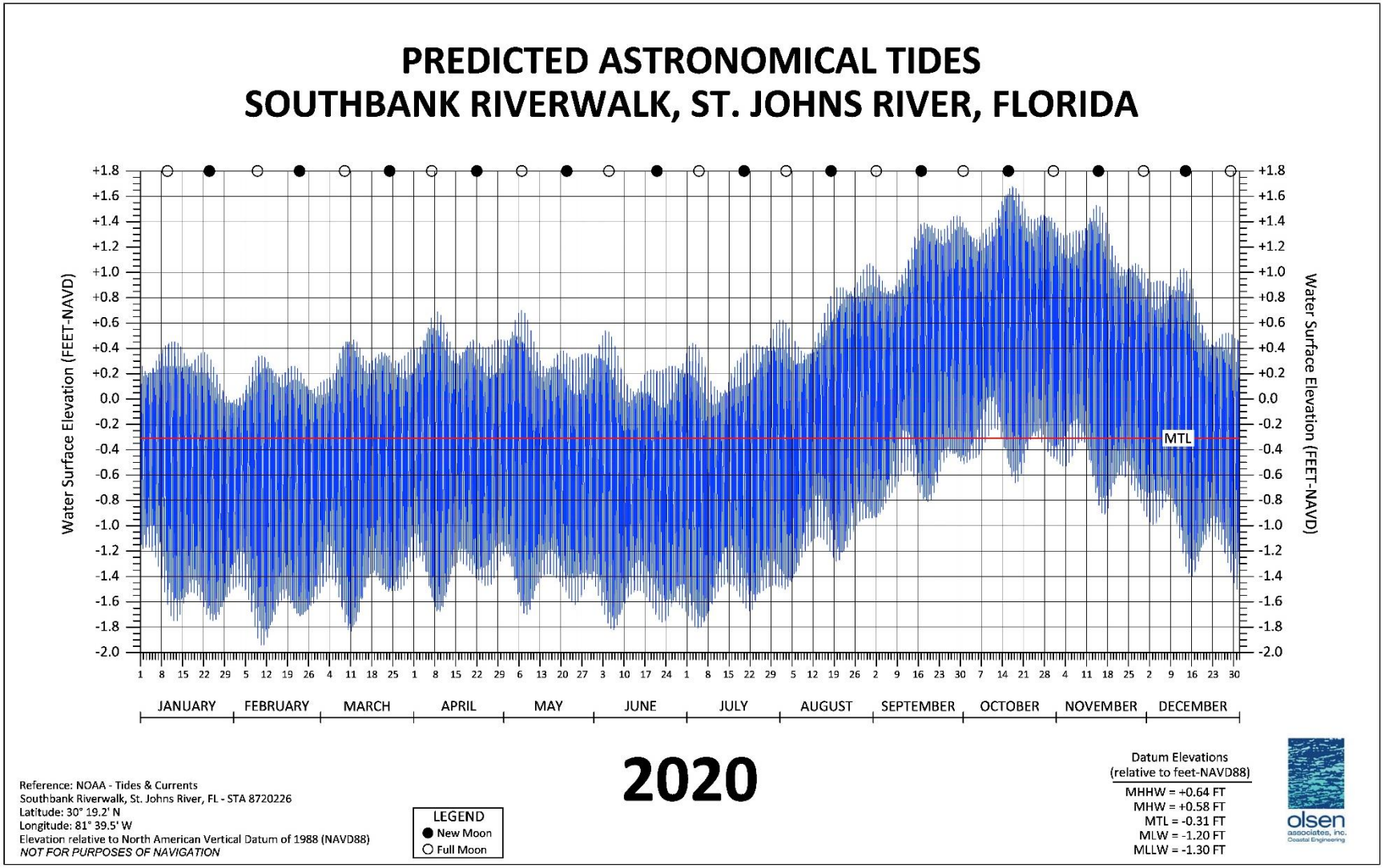


Figure 3: Southbank recording gauge – 2020 predicted tides.

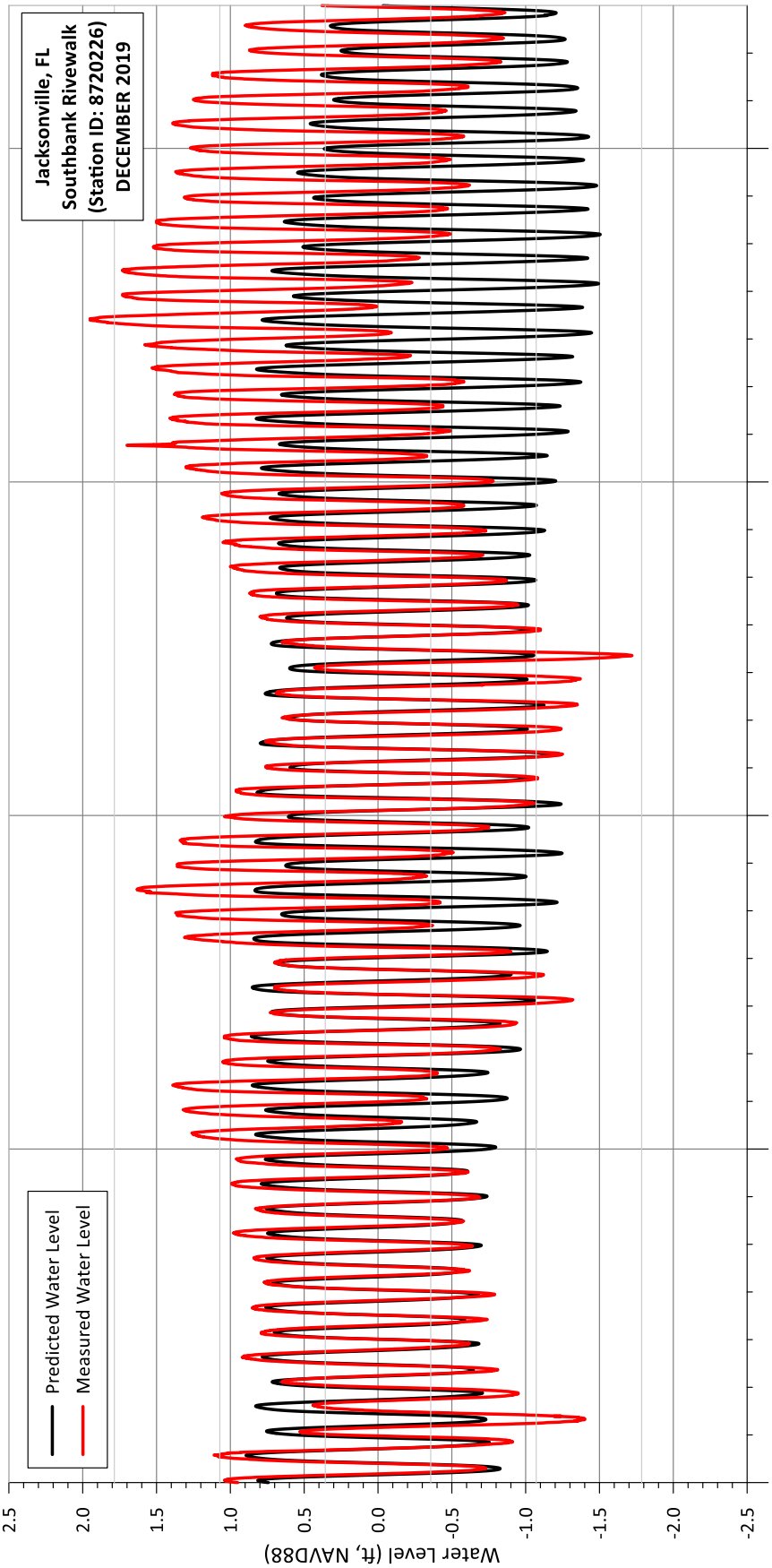


Figure 4:
Actual versus Predicted Tides (December 2019).

It is of importance to note that the annual seasonal occurrence of nor'easters is likewise concurrent with the fall months when naturally occurring astronomical tides in N.E. Florida are the highest of the year (see **Figure 3**). The cumulative effect of such higher water levels is often episodic "nuisance" flooding in areas of low elevation bordering the St. Johns River. At the present time, this mostly occurs in the vicinity of Hogan's Creek which crosses the SHIPYARDS project site. Nuisance flooding – as defined by NOAA is – "Flooding which causes public inconveniences such as frequent road closures, overwhelmed storm drains and compromised infrastructure." Nuisance flooding in certain riverfront areas within the City core will experience a future increase in frequency and magnitude due to sea level rise and continued St. Johns River Federal navigation project deepening by the U.S. Army Corps of Engineers. It should also be noted that Hurricane Season (July – November) is likewise concurrent with the highest naturally occurring astronomical tides of the year. This combination of events can further exacerbate the magnitude of major storm flooding when N.E. Florida is directly, or even indirectly influenced by Tropical Storm or Hurricane events.

Sea Level Rise (SLR) – The City of Jacksonville has recently (2020) adopted various recommendations of a special purpose Adaptation Action Area (AAA) Workgroup specific to future the development or redevelopment of riverfront areas within the COJ which may experience higher tides and storm surge due to a *two-foot rise* in sea level by the year 2060. To that end, a stated COJ objective in this regard is to "guide and regulate development and redevelopment to avoid or accommodate rising water due to flooding and the associated impacts of sea level rise". The Duval County areas bordering the St. Johns River subject to this new "standard" were defined (by mapping) as a Coastal High Hazard Area (CHHA). Virtually *all* of the SHIPYARDS site lies within the CHHA (see **Figure 5**).

In addition to future SLR anticipated as a result of Climate Change, the construction of the St. Johns River jetties beginning in the 1800's and the sequential multiple deepening's of the river for purposes of commercial navigation have improved the hydraulic efficiency of the River channel to the point that the downtown area is now subject to a fairly large tidal range *and* super elevated mean tide level. To that end, the Harbor Deepening Project presently under construction by the USACOE will (by their estimates) increase water levels downtown by as much as 0.2 ft. or more – *immediately* upon completion of construction. This is equivalent to almost 25 years of *gradual* water level rise – if one considers the *average annual* recorded increase in sea level rise over the last century within the SJR.

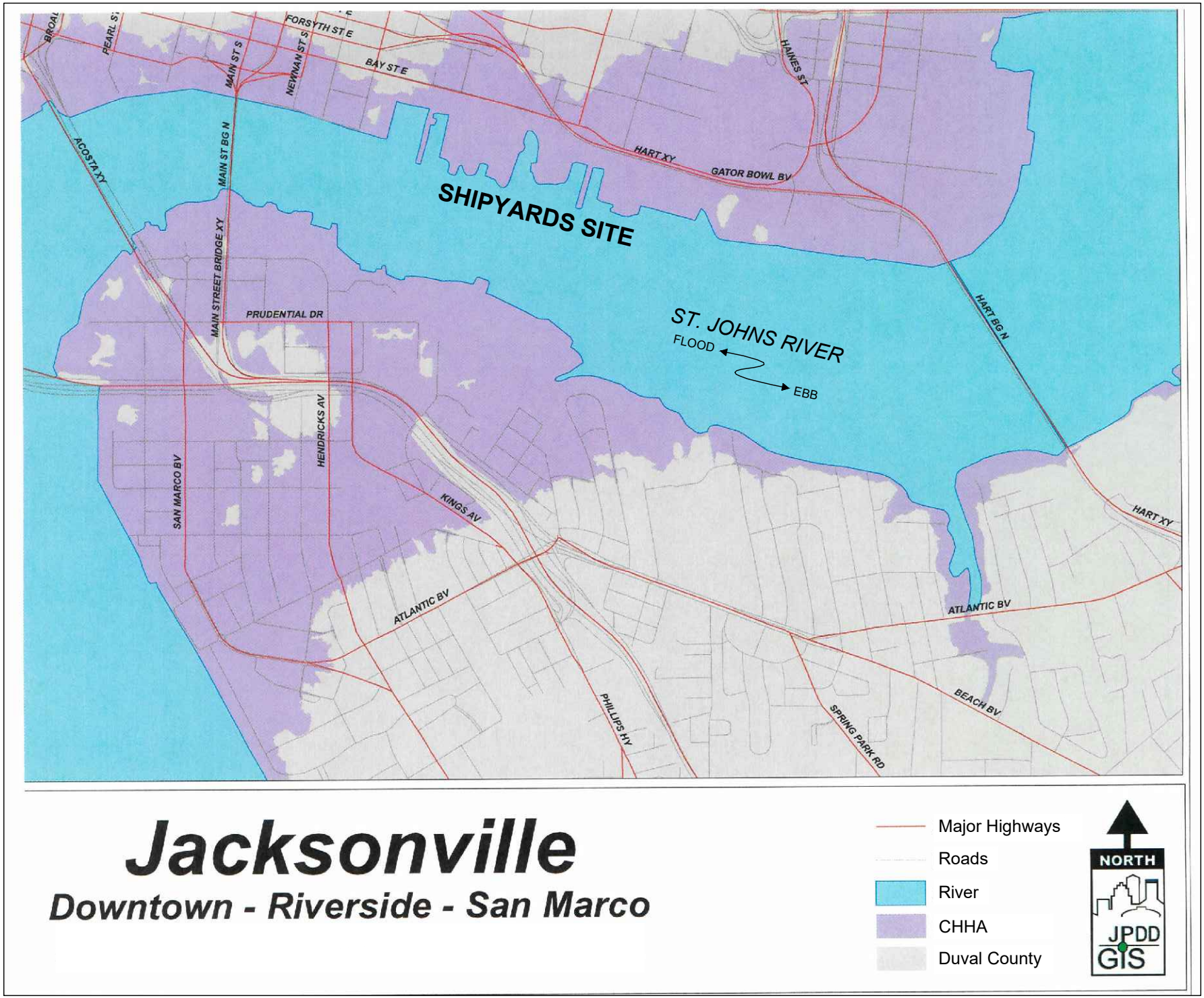

SHIPYARDS SITE
ST. JOHNS RIVER
FLOOD
EBB
FORSYTH ST E
BAY ST E
HAINES ST
HART XY
GATOR BOWL BV
ACOSTA XY
MAIN ST BG N
MAIN STREET BRIDGE XY
PRUDENTIAL DR
HART BG N
HENDRICKS AV
SAN MARCO BV
KINGS AV
ATLANTIC BV
PHILLIPS HY
SPRING PARK RD
BEACH BV
Jacksonville
Downtown - Riverside - San Marco
Major Highways
Roads
River
CHHA
Duval County
NORTH
JPDD
GIS

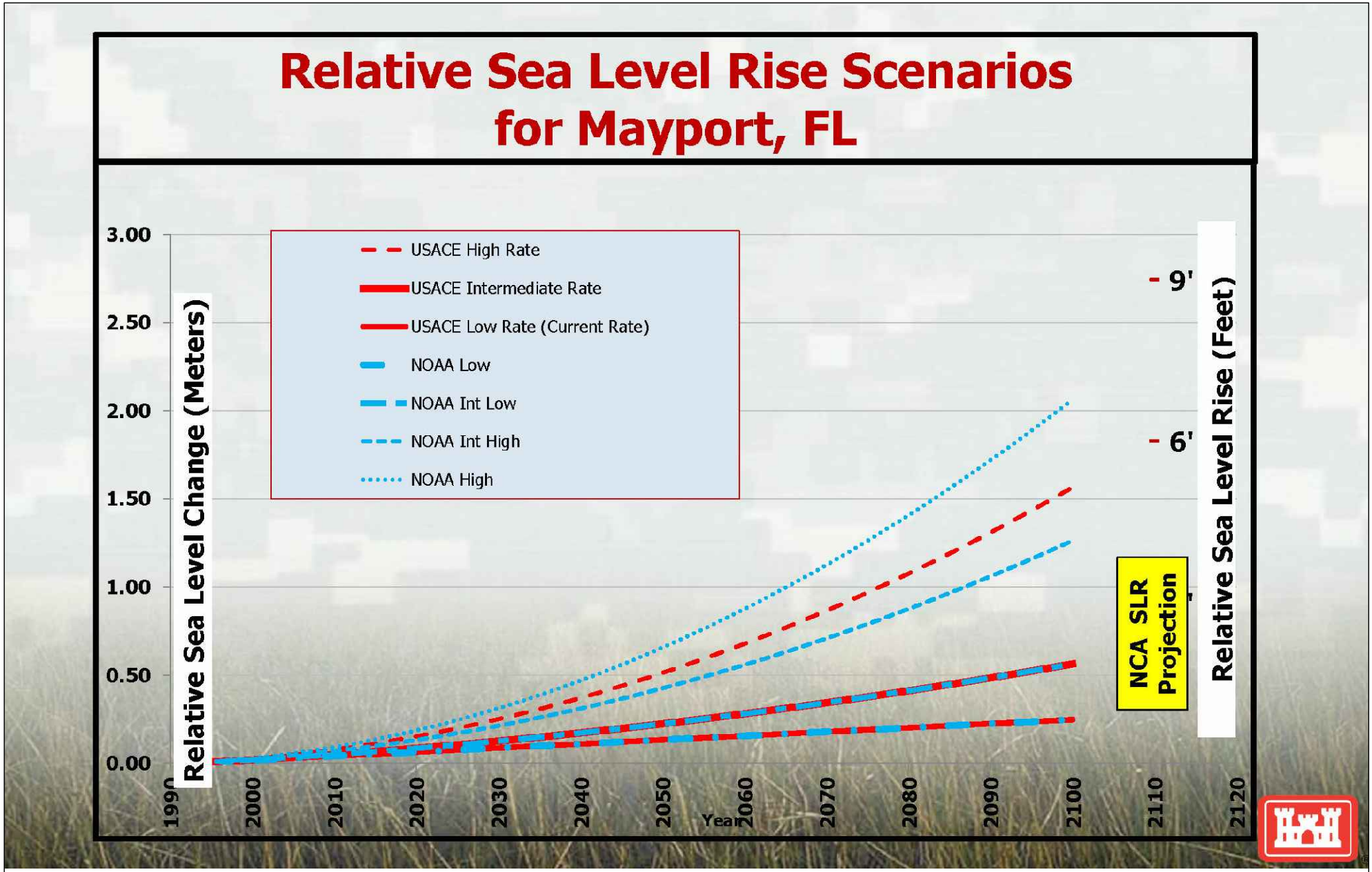
FIGURE 5

Irrespective of origin, there are three (3) issues of consequence that need to be considered with a continued probable increase in the mean annual water level of the St. Johns River. These include:

- An increase in upland flood vulnerability and spatial extent of storm induced inundation (due to several feet of additive surge over that which is predicted today by FEMA mapping – or other more reliable sources).
- Nuisance flooding due to the overbank flow of river water resulting from daily tidal fluctuations, and/or
- Nuisance flooding due to impedance of drainage infrastructure capacity resulting from increases in the elevation of tail waters within the abutting receiving body.

In addition to the recently codified COJ resiliency standard requiring the consideration (by 2060) of a 2 ft. SLR adaptation strategy for development within the CHHA, design professionals, owners and financing institutions must obviously consider site conditions and/or liabilities *beyond* just a 40 year horizon. In the recent past, predictions for the assessment of SLR were based upon the actual long-standing coastal tide gage records acquired over the last century. Conversely, with predictions of accelerated SLR due to Climate Change (predicted on the basis of numerical modeling), recently proffered design standards have typically been based upon predictions sourced from various governmental agencies (see **Figure 6**). Unfortunately, the variation in magnitude of such SLR predictions can vary significantly. The variations in SLR available for consideration by design professionals typically range from the long-term historical rate of about one ft. per century, to projected rates which can be interpreted as basically "catastrophic" in magnitude. The selection of a SLR factor relevant to the design life of a project such as the SHIPYARDS will ultimately require a risk assessment guided by the project owner or developer in the context of the best available data projections, plus some reasonable safety factor.

The longest-term recording NOAA tide gage for northeast Florida is located at Mayport, within the SJR just inside the SJR jetties. Tidal records for that gage document a historical rate of rise in water level from 1928 to present of .86 ft. (or about 1 ft. per century) (see **Figure 7**). Water level rise over time in the City core has been of similar magnitude due primarily to navigation channel deepening between downtown and the Atlantic Ocean. That is to say, over the last century or more, "the City of Jacksonville has literally invited the river downtown" – due to its long standing political support of continued improvements to the Federal Navigation Project.



US ARMY CORPS OF ENGINEERS | Jacksonville District

FIGURE 6

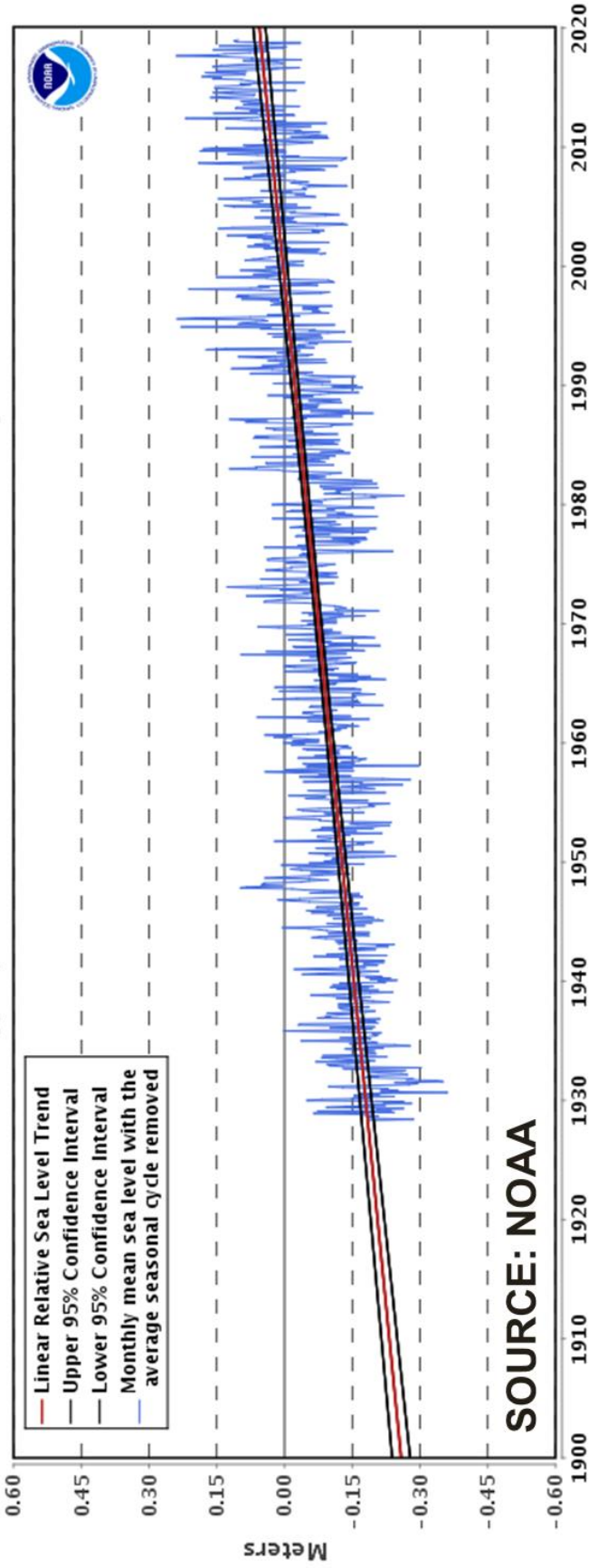


Figure 7: Mayport, Florida tide gage – historical sea level rise.

On face value the historically measured .9 ft. rise in sea level recorded at the Mayport gage over the last 92 years would appear to conflict with the selection of a COJ development adaptation strategy required planning for 2 ft. of SLR *over only the next 40 years*. But does it? Olsen Associates, Inc. has recently analyzed long-term tidal records for the Atlantic east coast Counties of Brevard and Palm Beach – at the request of local governmental clientele. In those areas, the evaluation of "shorter term" tide records spanning the last 20 years, mol have revealed potential Florida East Coast SLR trends well exceeding the historical "rule of thumb" assumption of an expected one ft. per century.

As a direct result, OAI has recently evaluated the Mayport, Florida Tide Gage records in a similar manner – in an effort to corroborate the global observations of many east coast communities that they have been experiencing higher water levels throughout each calendar year. Not unexpectantly, what the firm found was a clear significant increase in the rate of annual rise in the mean water level when one evaluated just measured tidal data for the last *20 years*. The results of that assessment are presented in **Table 1**. Simplistically, if one evaluates the last *20 years* of record, it can be calculated that the temporal rate of SLR (for just that period) has increased by 230% over the known historical (92 year) long-term rate. Although the probable accuracy of predictions can be expected to decline with "shorter term" records, similar analyses of the *15-year* and *10-year* records (to 2020) imply increases in SLR of 300% and 400% respectively -- relative to the cumulative long-term record of .9 ft./century. Although such computations are accurate – for the shorter term period of record – their probability of occurrence in the future is statistically less reliable. That is to say, additional future data is required to verify such short-term trends. None-the-less, these findings do fall in line with certain numerically modeled Climate Change predictions, as well as corroborate the qualitative observations of various coastal communities that mean water levels, associated out-of-bank flooding and drainage induced upland flooding events have increased over the last decade or more. In the City of Jacksonville, the frequency of occurrence of nuisance flooding events in the historical neighborhoods of San Marco and Riverside/Avondale is well documented and considered to be directly attributable to an ever increasing elevation of the mean daily water level of the SJR.

Nuisance Flooding – As noted above, increases in SLR have (and are expected to continue to) exacerbate nuisance flooding along the banks of the St. Johns River in Jacksonville. For riverfront sites within the City core, as well as its historical neighborhoods located southward

Table 1

SLR Summary – Mayport Tide Gage

Time Frame	SLR – Rate [2]	Interval of Analysis (years)	Multiple of LT
1929 – 2020[1]	.872 ft./century	90	1.0
1985 – 2020	1.29 ft./century	35	1.5
1990 – 2020	1.24 ft./century	30	1.4
1995 – 2020	1.22 ft./century	25	1.4
2000 – 2020	2.02 ft./century	20	2.3
2005 – 2020	2.64 ft./century	15	3.0
2010 – 2020	3.74 ft./century	10	4.3

[1] LT – Long term period of record.

[2] **Appendix A** includes the individual analysis for each rate of SLR predicted herein.

thereof, present day nuisance flooding has essentially two (2) origins which can occur separately, or in combination:

- Direct overtopping of seawalls or bulkheads during periods of extremely high waters within the St. Johns River, in addition to the back-flow of river waters (through drainage structures) to low-lying residential streets. In such areas, upland storm drain inverts are lower than bulkhead caps so that river levels back up storm drains and flooding occurs well before the seawall is overtopped. However, with the predicted levels of SLR which must now be taken into consideration for waterfront development, physical overtopping of waterfront structures may *not* always be the secondary impact that it is today in certain areas of the City.

- The upland ponding of water – principally on roadways – which can be extensive during rain events due to the impedance of suitable rates of drainage to the river through existing (and often significantly outdated and poorly maintained) COJ culvert systems – during periods of super-elevated water levels in the receiving body (*i.e*. the SJR).

Along the SHIPYARDS project shoreline, existing waterfront structures include an assortment of bulkheads, wharfs, or piers of varying age, condition, elevation and design configuration. Many have exceeded their usefulness or design life and warrant replacement as part of an overall project plan of improvement. Surveyed cap elevations of existing waterfront structures vary from about +3 to +7 ft. NGVD88, mol, (see **Exhibit 1**). For most conceptual project plans presented to-date, a future "riverwalk" proximate to the SJR is a reoccurring design theme due to the stated desire of the COJ to ensure future public access to and along the downtown riverfront.

At the present time, nuisance flooding is not currently a major threat to the utilization of the SHIPYARDS site except in the vicinity of Hogans Creek where overbank flooding during periods of high water in the SJR is known to frequently occur. None-the-less, in consideration of an increase in SLR of +2 ft., *or more*, nuisance flooding could become a factor which affects the waterfront perimeter of the project site – depending upon the absolute elevation and nature of waterfront structural improvements which are ultimately implemented --- including a riverwalk.

For consideration by the owner, developers, project engineers and the COJ, OAI has provided a series of Nomographs which predict the annual number, or frequency of overtopping of waterfront structures in the City core as a function of wall or pier top elevation (relative to NAVD88), for varying magnitudes of SLR expected over time. The SLR scenarios presented vary between 1 ft. and 4 ft. The computation of frequency of occurrence of overtopping is based upon the "probability of maximum annual water levels" developed from actual tide records measured over time at the Southbank Gage (Sta. 8720226) between January 2015 and November 2019. Two summary Nomographs (at differing scales) are included as **Figure 8** and **Figure 9**. "Threshold" as defined therein is the elevation of the bulkhead cap, or wharf deck located along any segment of the downtown City core waterfront including the SHIPYARDS site. Expanded views of *individual* SLR vs. Cap Elevation scenarios are included within **Appendix B** to this document. Is should be noted that each occurrence of overtopping depicts a "*still water level*". They do *not* therefore include the additive effects of wind waves, ship or boat wake, etc. Safety considerations for a publicly accessible riverwalk, or recreational areas in close proximity to the SJR should take into account the probable occurrence of such phenomena.

Storm Surge – Extreme water elevations due to storm surge within the St. Johns River resulting from Hurricane or Tropical Storms present the greatest threat to the development and functionality of the SHIPYARDS site – particularly given the predictable additive effects of Sea Level Rise. Recently updated Duval County Flood Insurance Rate Maps (FIRM's) by FEMA and the formal adoption of those results by the COJ can be shown to underestimate the probability of future flood threat throughout the site of interest. As shown by **Figure 10**, which is an excerpt from FIRM Map 12031C0367J, the effective 100-Year Base Flood Elevation (BFE) for the site as a whole is predicted to be +4 ft. NAVD88. Minor increases along the site's waterfront depict an AE Zone elevation of +5 ft. NAVD88 – the difference being due to one ft. of expected wave height at the river boundary. The effective elevation of the 500-yr flood zone appears to be +6 ft. NAVD88. The Flood Hazard Zones associated with the November, 2018 updated FIRM's for Duval County essentially result from the standardized modeling protocol used for such analyses which originate with numerically modeled open coast storm surge elevations. The latter are propagated up the St. Johns River throughout the southernmost limits of Duval County. As expected, probabilistic storm surge elevations computed by FEMA decrease from those predicted at the mouth of the SJR within the Atlantic Ocean as they are mapped inland toward the City Core.

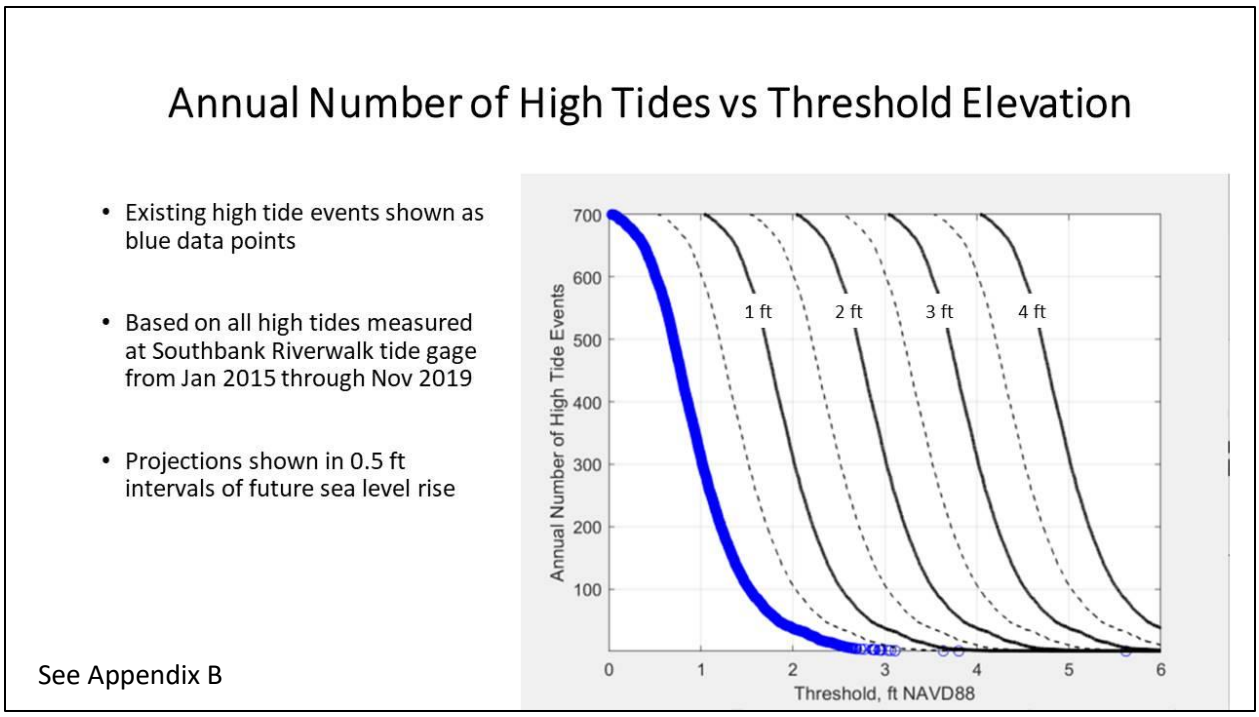
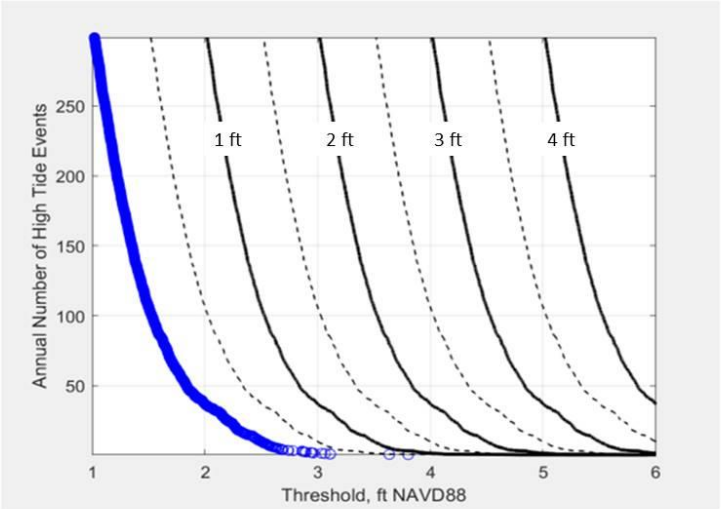


FIGURE 8 NOMOGRAPH FOR PURPOSES OF PREDICTING NUISANCE FLOODING CAUSED BY OVERTOPPING OF WATERFRONT BULKHEAD

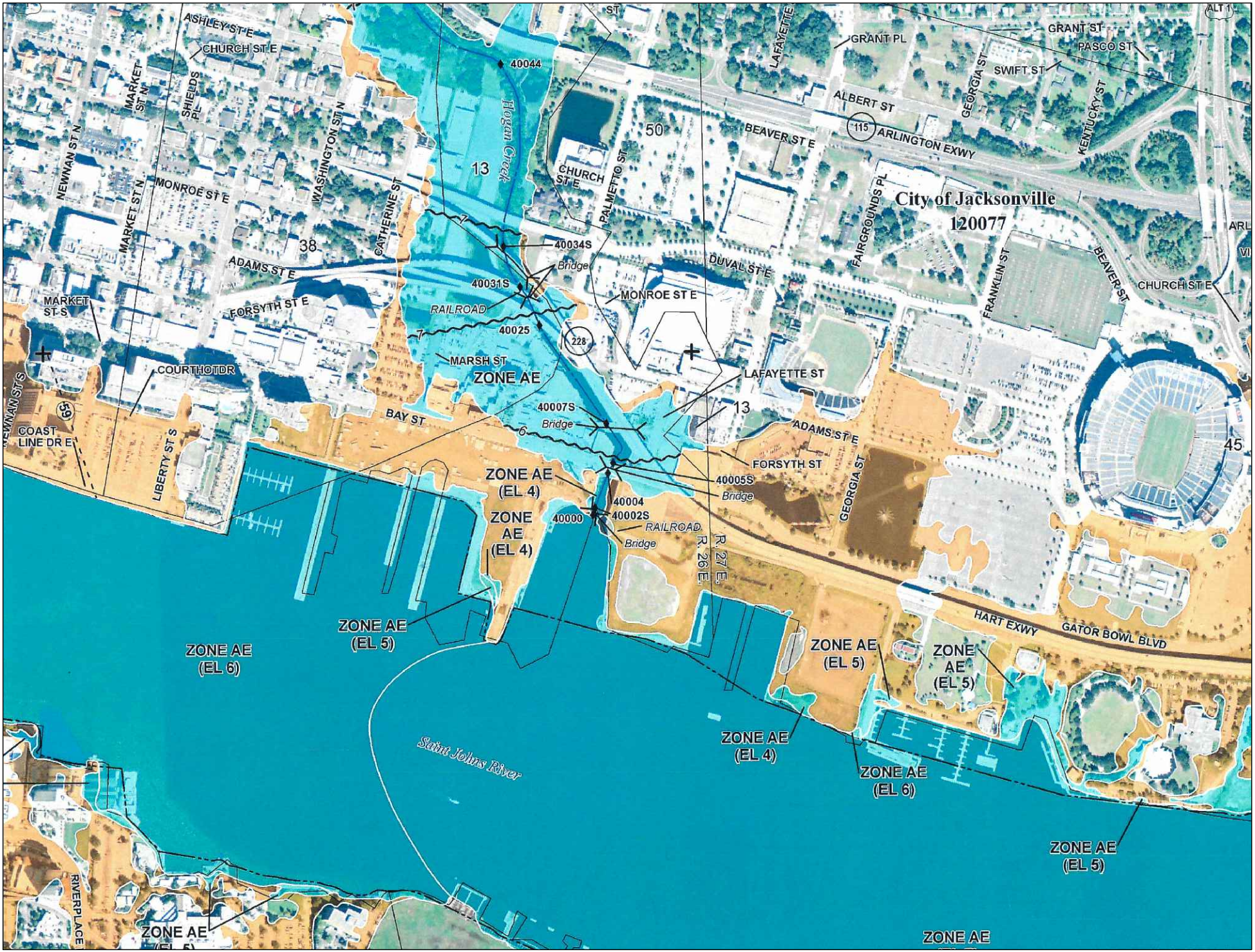
- Expanded view of previous graph
- Can be applied to any threshold
- Example:

  For 4 ft NAVD flood threshold, and for 2.5 ft of future sea level rise, dashed curve shows just over 100 flood events per year



See Appendix B

FIGURE 9 NOMOGRAPH FOR PURPOSES OF PREDICTING NUISANCE FLOODING CAUSED BY OVERTOPPING OF WATERFRONT BULKHEAD



MAP NO. (203)1C0359J (NOV 2018)

FIGURE 10:
FIRM FOR SHIPYARDS PROJECT SITE

It is now a matter-of-record that out-of-bank flooding experienced during Hurricane Irma in the fall of 2017 demonstrated that the recently adopted 100-year Base Flood Elevations for the Northbank of the St. Johns River extending from at least the City core southward were exceeded by approximately 2 to 3 ft. It can therefore be reliably concluded that existing FIRM's for that area should *not be utilized for purposes of design*. The reasoning behind the conclusions and opinions stated herein that the most recent FEMA published elevations are incorrect can be summarized as follows:

1. Hurricane Irma was *less than* a Category 1 storm when it affected Jacksonville in the fall of 2017. FEMA predictions are based upon a 100-year event (annual probability of occurrence of 1%). Although there is no actual "equivalency", a Category 3 storm would normally be considered to be statistically "*about*" a 100-year event, mol.

2. Documented flood elevations along both shorelines of the St. Johns River from the Matthews Bridge southward were equal to, or exceeded the measured storm of record which was H. Dora in 1964 -- since that time an assumed Category 2 or 3 storm.

3. H. Irma traversed Duval County via a path which was essentially central to the State. Its wind field therefore was synonymous for some period of time with the N-S alignment of the SJR within southern Duval County, and

4. Last but not least, it is a matter of record that storm effects – such as those experienced during H. Irma – are *not* specifically modeled by FEMA in their standardized methodology for coastal counties – irrespective of the existence of a major riverine component such as the St. Johns River. Rather, the FEMA modeling protocol for Duval County simulates statistically derived storm surge elevations in the Atlantic Ocean and propagates the resultant water levels up the river throughout the countywide study area. Hence, they do *not* specifically replicate storm events such as that experienced with H. Irma and should therefore be considered to be an *unreliable* source of design guidance in the development of the SHIPYARDS site considered herein, as well as the City core waterfront in general.

Documented upland water level elevations in proximity to the SHIPYARDS Lot J (surveyed post-Irma) were measured at +5.65 ft. NGVD88 – or +1.65 above the FEMA predicted 100-year storm event, and just slightly less than the FEMA probabilistic 500-year event. The measured 5.65 ft. elevation was determined to be synonymous with the maximum water level elevation measured during the storm at the Southbank Tide Gage. As noted previously, H. Irma was less than a Cat 1 event as it approached Jacksonville from the south. For comparison, a measured still water elevation of +7 ft. NAVD88 was measured within a parking garage fronting the SJR located at St. Vincent's Hospital in Riverside several miles to the west.

Had H. Irma been a Category 2 or 3 event, it is probable that water levels experienced within the SJR would have been significantly higher. It is therefore reasonable to conclude that the existing FIRM map elevations for the SHIPYARDS site should *not* be utilized for purposes of planning or design. It is a recommendation of this assessment that the COJ should fund a third-party *special purpose* flood vulnerability study for the City core based upon storm tracks similar to H. Irma. Without the benefit of such a numerical modeling exercise, one can only "*estimate*" the actual vulnerability of the SHIPYARDS site to a Category 3 (or 100-year) storm event which traverses the center of the State. Any modeling performed should evaluate both today's conditions, as well as multiple future SLR scenarios.

SHIPYARDS – Planning and Design Considerations

Storm Surge – The most recent FIRM for the subject site predicts Base Flood Elevations (BFE) of +4 ft. and +6 ft. NAVD88 for probabilistic 100-year and 500-year storm surge events, respectively. Neither is recommended for purposes of design due to documented shortcomings in the numerical modeling protocols utilized by FEMA for the prediction of storm surge within the segment of the SJR under consideration. Measured upland still water levels on the site during H. Irma in 2017 were approximately +5.65 ft. NAVD88, or about 1.7 ft. above the 100-year BFE predicted by FEMA. Due to the fact that H. Irma was slightly less than a Cat. 1 storm event for Duval County, greater water levels would be experienced for a self-similar Cat. 2 or Cat. 3 storm event. Until additional numerical modeling is performed – as recommended herein – it is proffered that a defacto 100-year (annual probability occurrence of .01) *BFE of +7 ft. NAVD88 be adopted for the subject site, at a minimum.* Note – it is entirely possible that a 100-year recommended BFE greater than +7 ft., could result subsequent to more rigorous special purpose surge analysis.

Sea Level Rise – Although the recently adopted resiliency "standard" of +2 ft. of SLR by year 2060 has been recently instituted by the COJ, other considerations associated with project financing, insurance, operational impacts, etc. would suggest a longer time frame and probable further increases in the mean water level within the SJR over time. A final selection of same will ultimately be the responsibility of the owner/developers – as long as such parameters exceed whatever COJ standards are in effect at the time. For purposes of both discussion and sensitivity analysis associated with costing, future business operational considerations, lending or insurance interests, etc. – Sea Level Rise scenarios of +2, +3 and +4 ft. are addressed herein. For example, assuming a +7 ft. NAVD88 probable BFE for today, future BFE's would be +9 ft., +10 ft. and +11 ft. for SLR increases of +2, +3 and +4 ft., respectively. Such BFE's are essentially "still water" and do *not* account for either wind waves generated over the site during the storm event, or waves entering the site from the SJR. Hence, there are two (2) maximum flood elevation conditions to consider for the SHIPYARDS site – upland and waterfront.

Wave Height Projections - Along the project waterfront, due to both a limited fetch as well as some level of protection afforded by abutting bridges to the East and West, a storm related wave height of 2 ft., mol would be expected. Where a 2 ft. wave exists, the associated wave crest elevation would be equal to the BFE plus 1.8 ft. This wave height would carry inland from the river for some distance – beyond the seawardmost bulkhead line – whenever the storm induced water level exceeds the bulkhead cap, pier deck, or ground elevation, by about 2.6 ft. Eventually, wave transmission toward the upland would dissipate due to landscaping, structural interference, etc. For the remainder of the SHIPYARDS site, it is recommended that future BFE's should be increased by an estimated one (1) ft. to account for locally generated wind waves during a storm event when water depths exceed 1.5 ft. above existing (or improved) grade.

Nuisance Flooding –

The overtopping of existing and/or future shoreline waterfront structures (bulkheads, piers, etc.) due to astronomical tides (*alone*) will eventually occur with increased mean water levels in the SJR resulting from global SLR. The Nomographs included herein (see **Appendix B**) allow project planners and designers to estimate the frequency (number of times annually) that riverine water levels will exceed the cap or top elevation of a bulkhead, pier, etc. For example, if the cap elevation of a project improved bulkhead is set at elevation +5 ft. NAVD88, approximately 40 overtopping events per year would occur concurrent with a +3 ft. SLR. However, if the cap elevation was set at 5.5 ft. NAVD88, approximately 10 overtopping events per year are predicted. Under either scenario, those *estimates are conservative* since they do *not* include

wind waves or boat wake. Note – the easternmost extent of the SHIPYARDS site is in close proximity to a staging area for working tugs and barges – both of which can produce substantial shore-directed ship wake.

An obvious site element which could serve to reduce or "live with" such nuisance flooding along the SJR waterfront – other than increased bulkhead elevations – is by raising the developed upland grade – or potentially the elevation of a continuous shore-parallel riverwalk feature (see **Figure 11**).

Site Drainage – A typically under-appreciated and misunderstood side effect of a continuous long-term rise in the mean water level of the SJR due to sea level rise is the direct adverse effect that a super-elevated St. Johns River has upon site drainage. Also often ignored are the similar significant additive changes in seasonal water level due to nor'easters, rain events, riverine freshwater flow, etc. One need only consider the present day drainage issues facing the historical neighborhoods of San Marco, Riverside/Avondale, and Ortega to understand the ever-evolving extent of upland acreages (residential and commercial) within the COJ where gravity dependent drainage systems are (or have become) non-functional during certain rainfall events. To that end, it is incumbent upon the SHIPYARDS development team to *not* commit to the "sins of the past" by failing to consider the continuous rise in the elevation of the receiving body for all site drainage, i.e. the St. Johns River. As of this date, the COJ has no appropriate codes or requirements which direct developers in the design of drainage systems which would be considered "resilient" in accordance with the phenomena addressed by this report. Hence, it is incumbent upon the SHIPYARDS project development team to further the State-of-the-Art with respect to ensuring positive drainage from the project site under both normal day-to-day conditions, as well as after a major storm event. Again, all of this is dependent upon a complete understanding of the elevation of the project's sole receiving body – the SJR – which often times continues to be super-elevated for days after a major storm or rain event. Initially, all of this would imply a site drainage system which is *not based upon conventional gravity dependent discharge* – unless proven suitable under all expected operational conditions. It would also argue for the elimination of sub-grade water detention vaults which are expected to fail to perform due to SJR tailwater elevations – in many cases even under today's (2020) conditions.

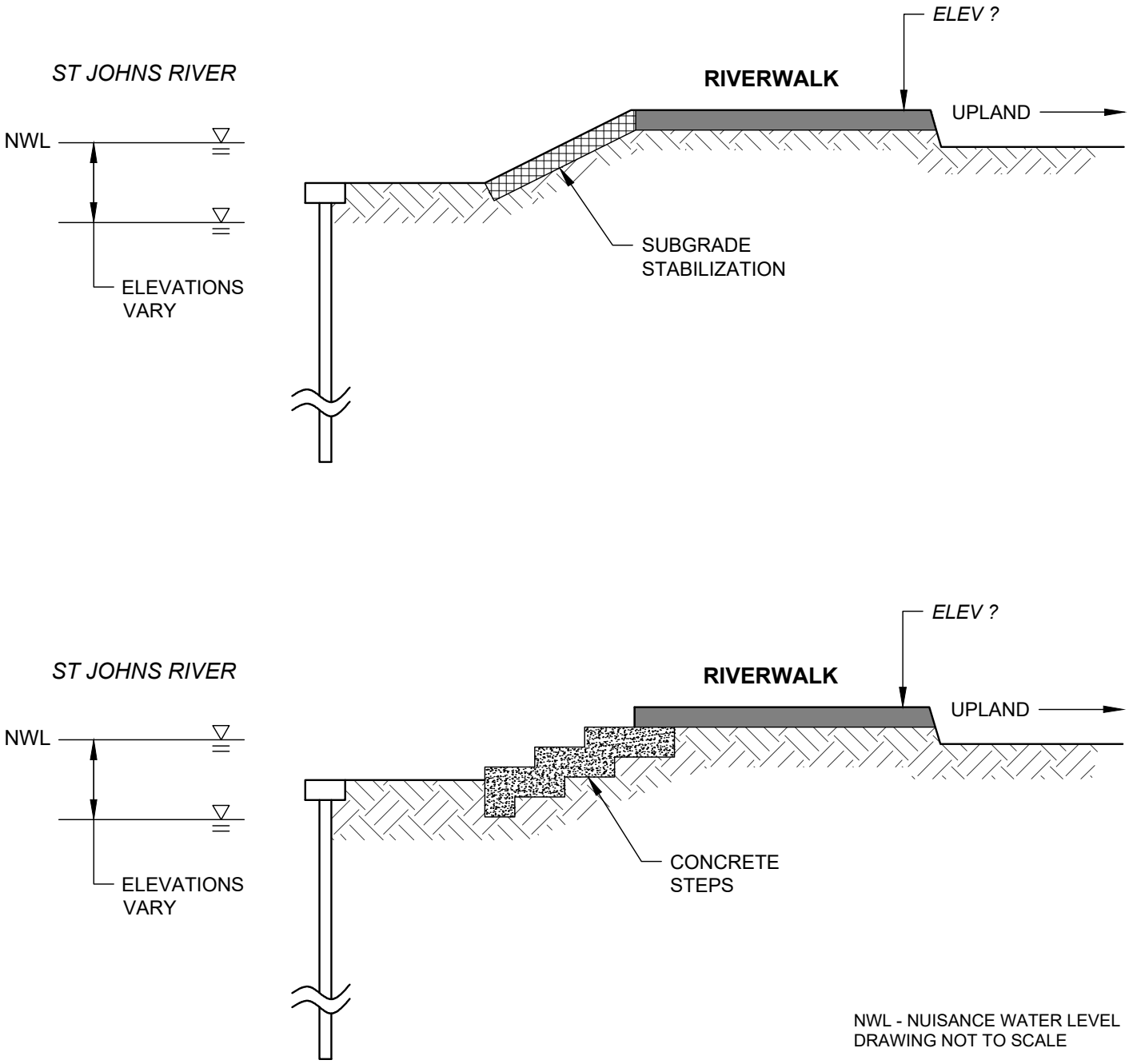


FIGURE 11:
POTENTIAL USE OF RIVERWALK TO REDUCE FUTURE IMPACTS OF HIGH-FREQUENCY NUISANCE FLOODING.

Summary

A summary of the major conclusions and recommendations made by this **Memorandum of Findings** are as follows:

- Except for the delineation of an official Mean High Water datum for the City Core, all other datums associated with NOAA Tidal Station 8720226 (located on the Southbank) are irrelevant for purposes of project design, planning and permitting.

- The COJ has recently adopted a development or redevelopment standard that necessitates consideration of a +2 ft. Sea Level Rise (SLR) by 2060 within the St. Johns River (SJR). The SHIPYARDS site in its entirety is mapped as a Coastal High Hazard Area within which this standard now applies.

- The longest period recording tide gage for the St. Johns River (1928 – Present) is located at Mayport. The average SLR rise at this gage over the period of record is approximately .9 ft. (or about 1 ft. per century). Recent analyses of the most recent 20-years of record indicate *potential* rates of SLR 300-400% greater than the long term average.

- Nuisance flooding within certain sections of the COJ exists today in many of the historical neighborhoods lying southward of the City Core. Future overtopping of existing or replacement bulkheads associated with the SHIPYARDS site can be analytically predicted as a function of structure elevation and effective elevation of future water levels with the St. Johns River due to SLR (see **Appendix B**).

- Nuisance flooding due to impedance of existing and future gravity drainage infrastructure in the City core is predictable based upon the continuing increase in tailwater elevation due to SLR with the SJR.

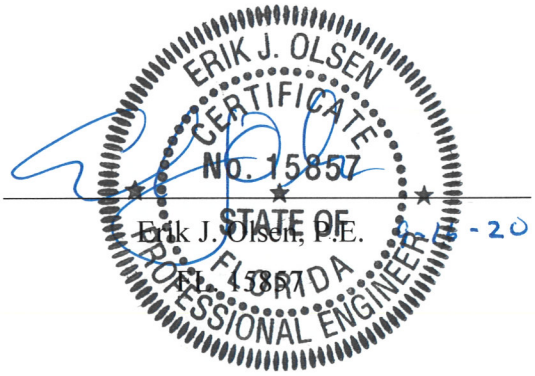
- Recently published (2018) Flood Insurance Rate Maps (FIRM's) adopted by the COJ do not adequately represent an accurate vulnerability to major flood events at the SHIPYARDS site for the probabilistic 100 or 500 year storm. As a result, the present day FIRM(s) should not be utilized for purposes of design or planning.

- A minimum Base Flood Elevation (BFE) for a 100-year event of +7 ft. NAVD88 is proposed, but subject to a recommended special purpose modeling study of hurricane vulnerability with the St. Johns River southward of the City core.

- Considering SLR scenarios of +2, +3, and +4 ft. will necessitate BFE(s) of +9, +10 and +11 ft. (NAVD88), respectively.

- Wave heights expected to increase water levels above a selected project BFE are +2 ft. along the project waterfront and +1 ft. throughout the site upland.

- It is proffered that expected future water levels within the SJR (due to progressive SLR) will obfuscate the typical implementation of conventional gravity dependent drainage infrastructure.



Erik J. Olsen, P.E.
FL 15857

2-13-20

REPORT ACRONYMS

AAA – Adaptation Action Area

BFE – Base Flood Elevation

CAT – Category (of hurricane storm strength as used herein)

CHHA – Coastal High Hazard Area

COJ – City of Jacksonville (Florida)

ETM – England, Thims & Miller, Inc.

FEMA – Federal Emergency Management Administration

FIRM – Flood Insurance Rate Map

H – Hurricane

LT – Long-term

MHW – Mean High Water

NAVD88 – North American Vertical Datum (1988)

NOAA – National Ocean & Atmospheric Administration

OAI – Olsen Associates, Inc.

SJR – St. Johns River

SLR – Sea Level Rise

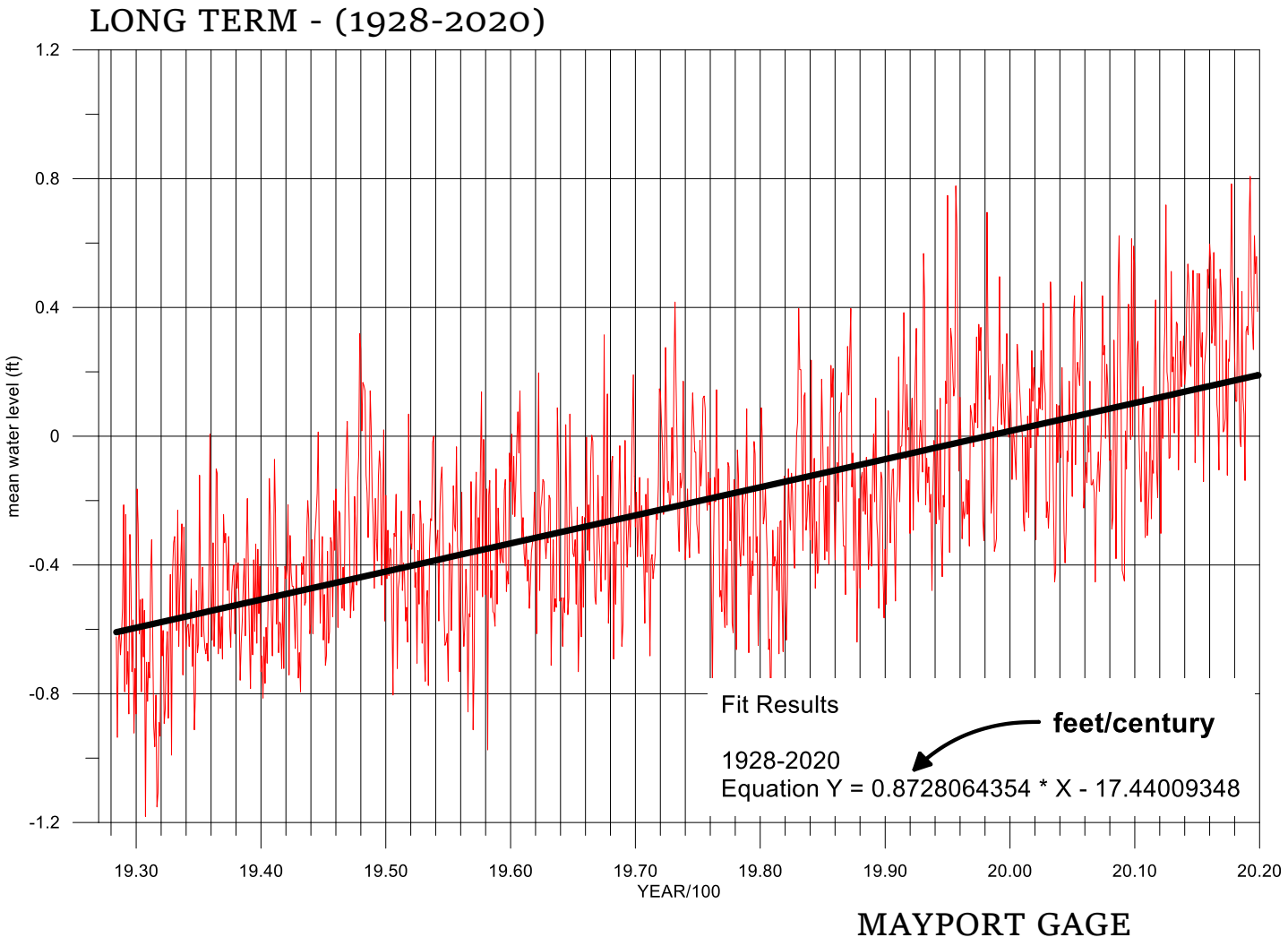
USACOE – U.S. Army Corps of Engineers

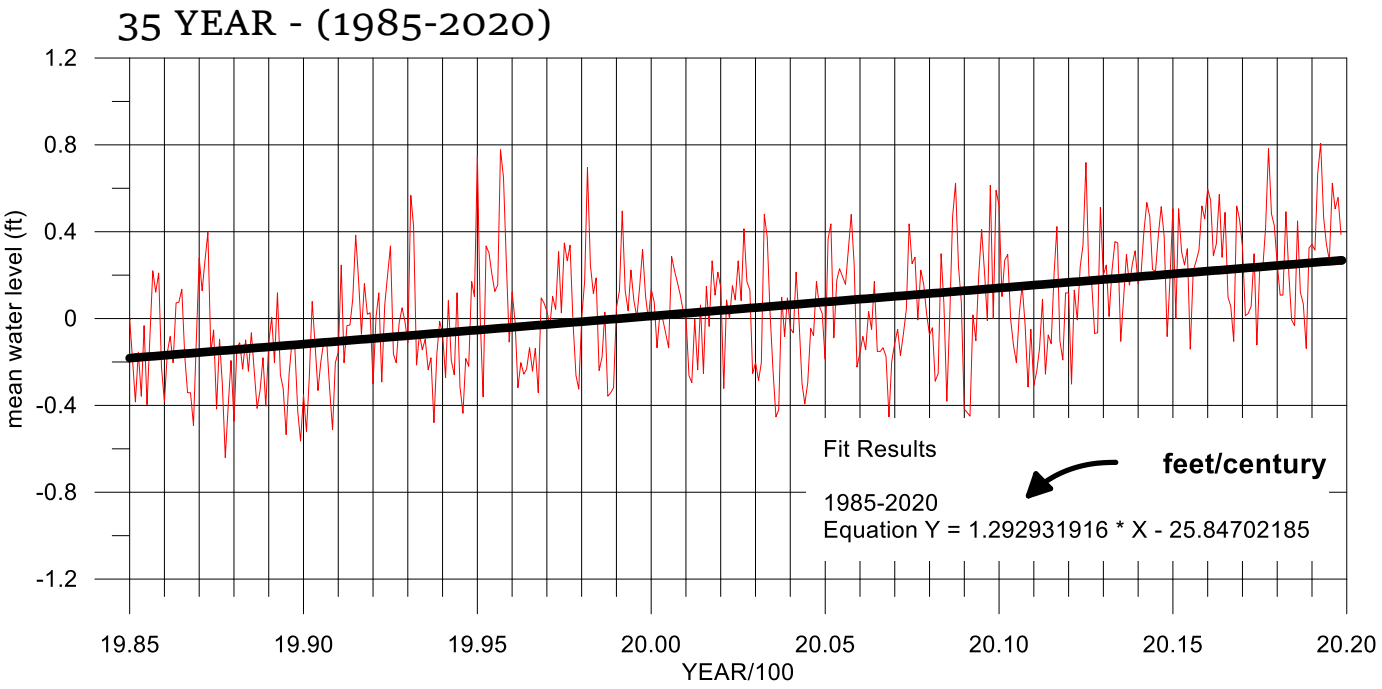
APPENDIX A

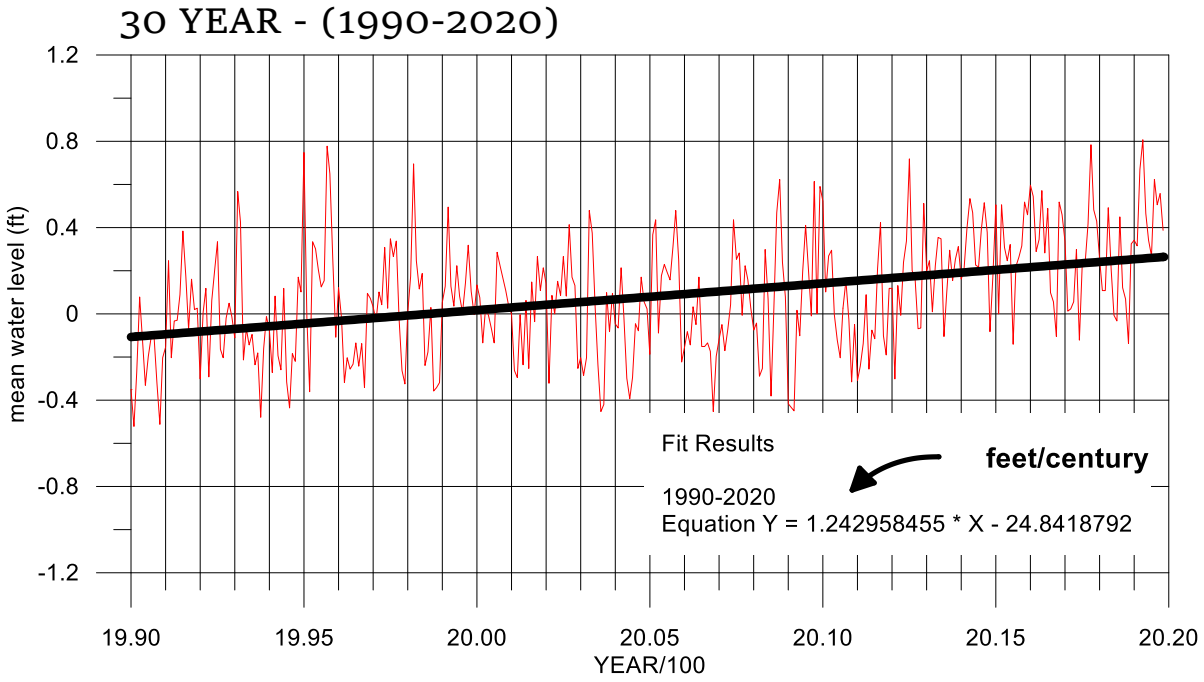
SEA LEVEL RISE PROJECTIONS

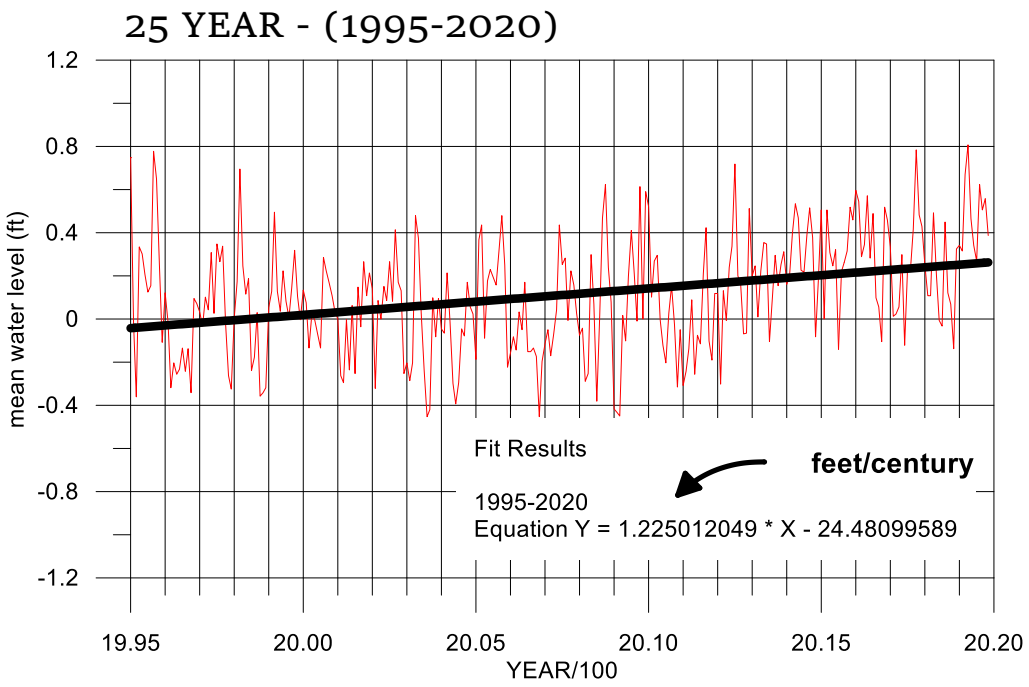
1928 – 2020

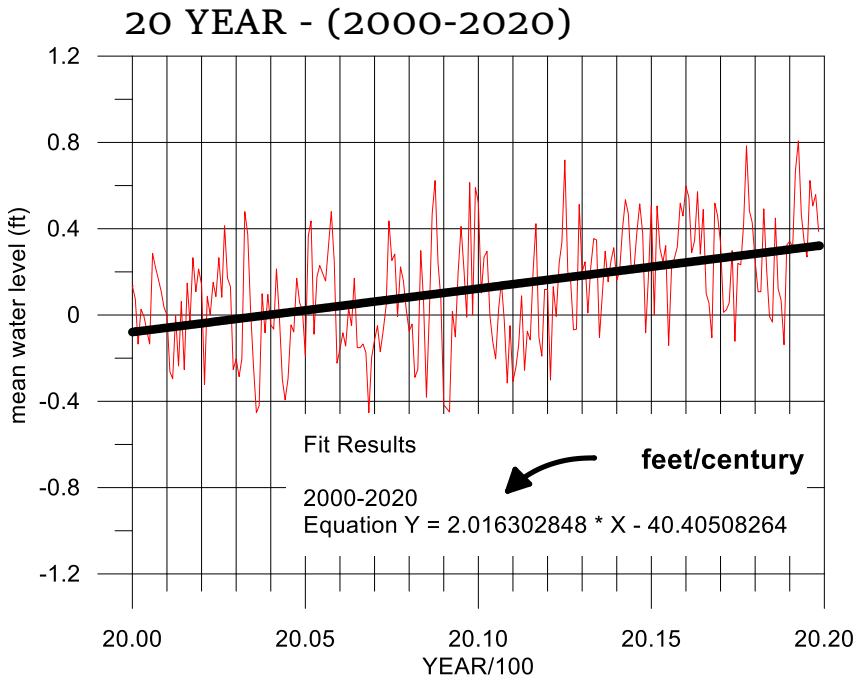
MAYPORT, FLORIDA GAGE

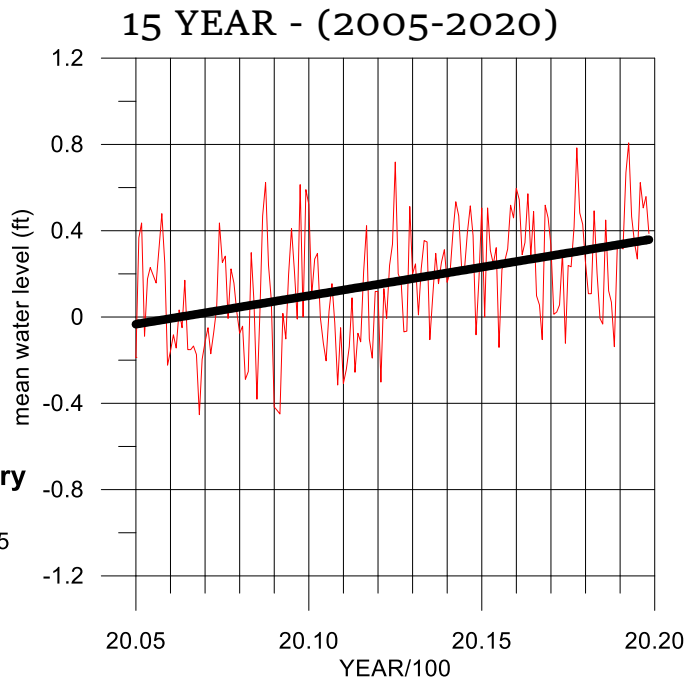

LONG TERM - (1928-2020)
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
mean water level (ft)
19.30
19.40
19.50
19.60
19.70
19.80
19.90
20.00
20.10
20.20
YEAR/100
Fit Results
feet/century
1928-2020
Equation Y = 0.8728064354 * X - 17.44009348
MAYPORT GAGE


35 YEAR - (1985-2020)
mean water level (ft)
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
19.85
19.90
19.95
20.00
20.05
20.10
20.15
20.20
YEAR/100
Fit Results
feet/century
1985-2020
Equation Y = 1.292931916 * X - 25.84702185


30 YEAR - (1990-2020)
mean water level (ft)
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
19.90
19.95
20.00
20.05
20.10
20.15
20.20
YEAR/100
Fit Results
feet/century
1990-2020
Equation Y = 1.242958455 * X - 24.8418792


25 YEAR - (1995-2020)
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
mean water level (ft)
Fit Results
feet/century
1995-2020
Equation Y = 1.225012049 * X - 24.48099589
19.95
20.00
20.05
20.10
20.15
20.20
YEAR/100

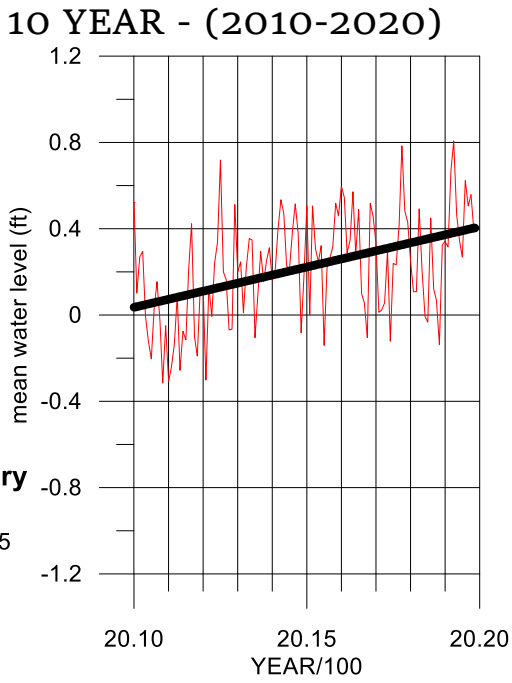

20 YEAR - (2000-2020)
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
mean water level (ft)
Fit Results
feet/century
2000-2020
Equation Y = 2.016302848 * X - 40.40508264
20.00
20.05
20.10
20.15
20.20
YEAR/100



Fit Results

2005-2020
Equation Y = 2.643297185 * X - 53.03154075

feet/century



Fit Results

2010-2020
Equation Y = 3.737578042 * X - 75.08970775

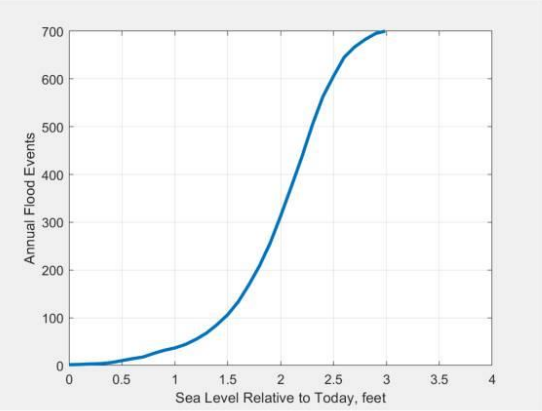
feet/century

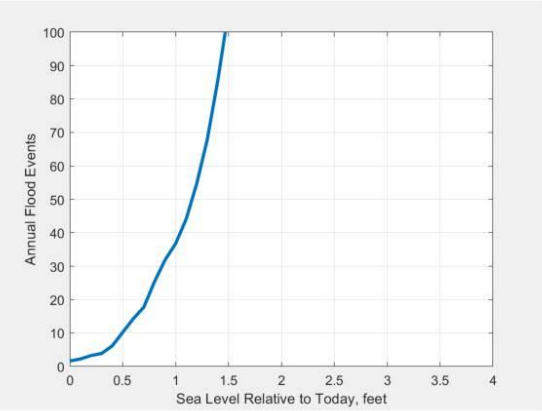
APPENDIX B

OVERTOPPING NOMOGRAPHS

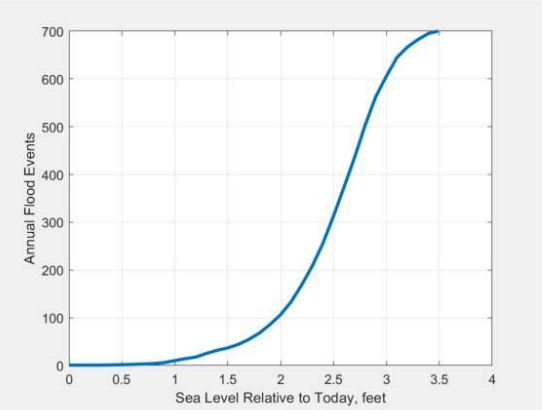
(SLR vs. Bulkhead Cap Elevation)

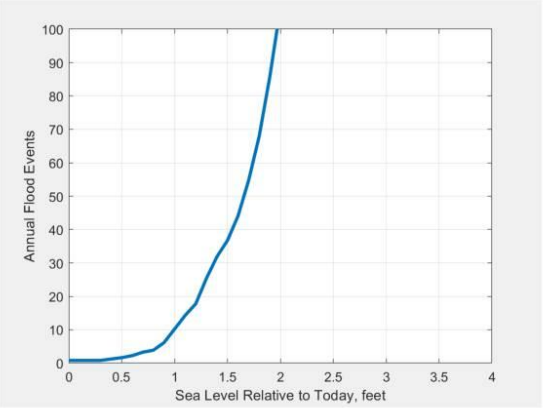
Threshold 3 ft NAVD



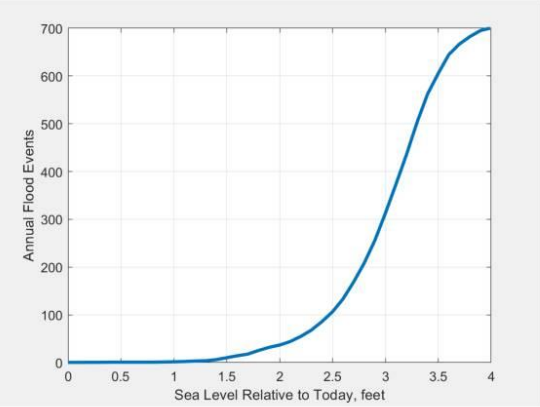


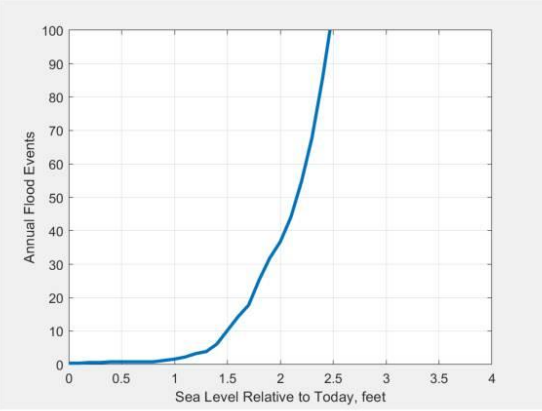
Threshold 3.5 ft NAVD



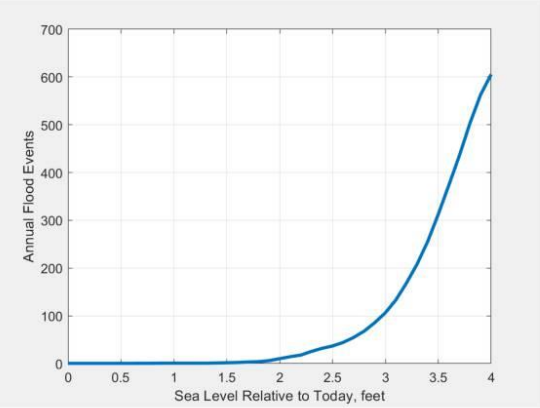


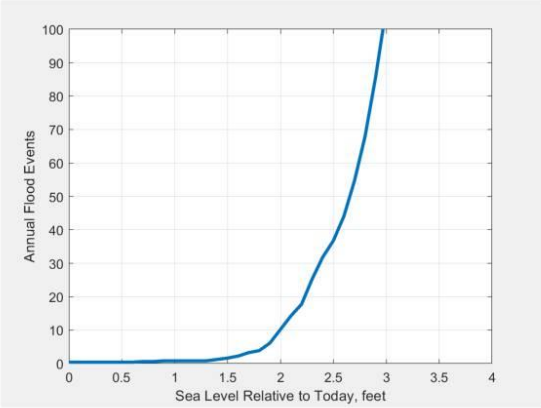
Threshold 4 ft NAVD



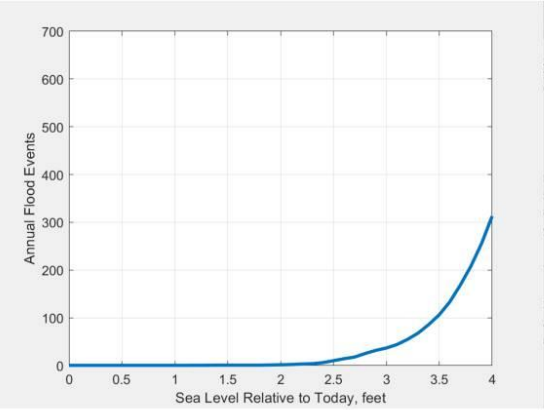


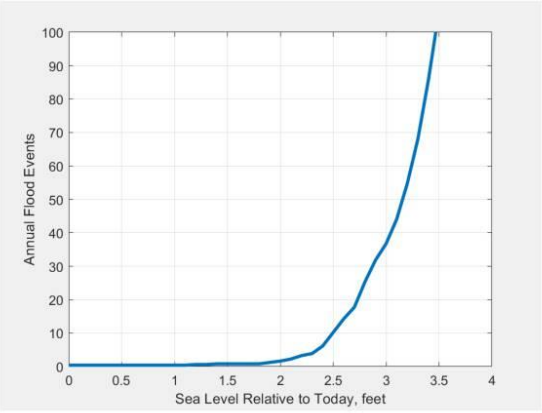
Threshold 4.5 ft NAVD



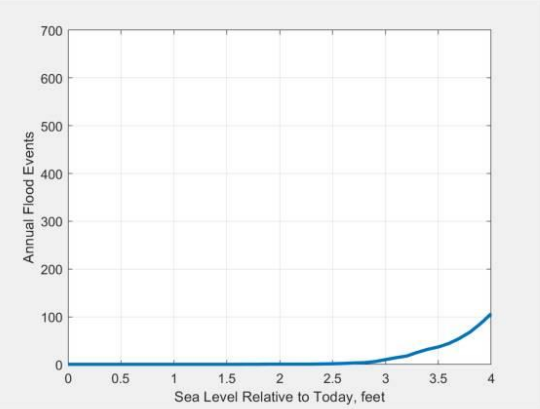


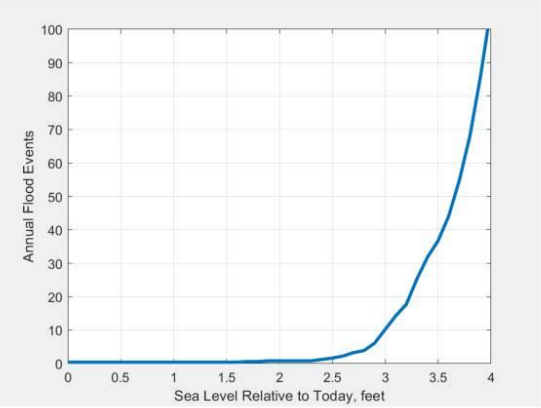
Threshold 5.0 ft NAVD



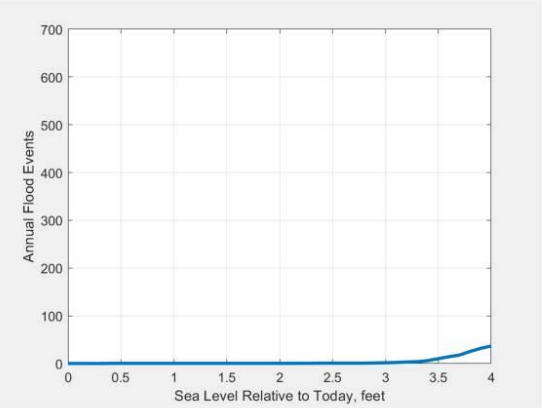


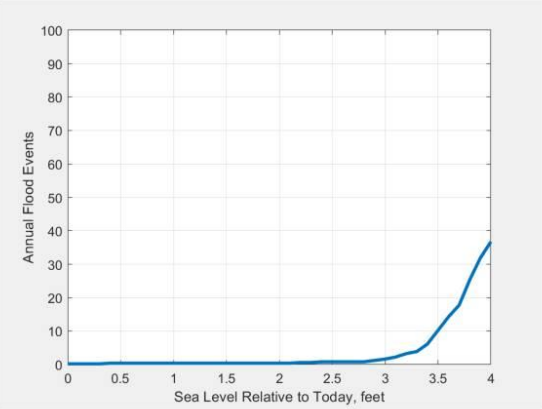
Threshold 5.5 ft NAVD



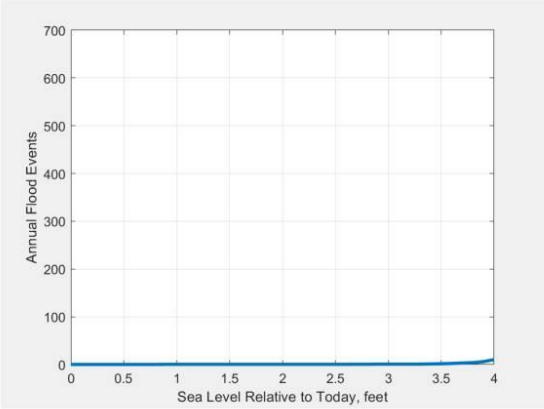


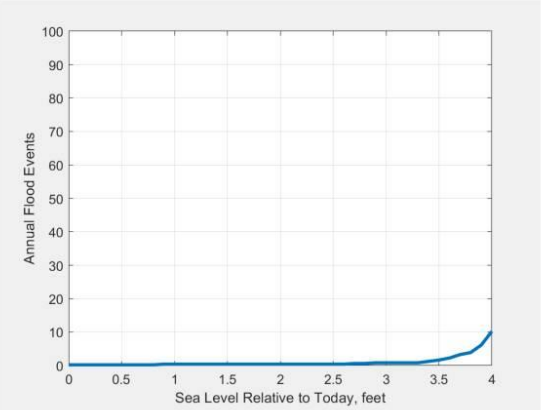
Threshold 6 ft NAVD



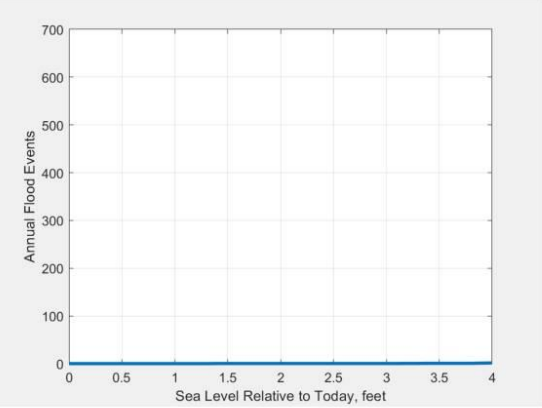


Threshold 6.5 ft NAVD





Threshold 7 ft NAVD



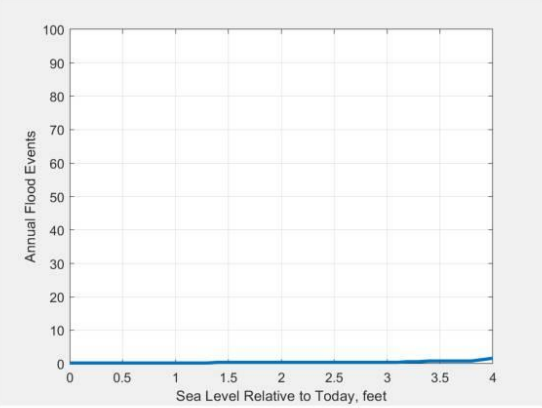


EXHIBIT 1

BULKHEAD CAP SURVEY

England, Thims & Miller, Inc.

Map Dated 9/15/2020

SHIPYARD BULKHEAD

DRAWING NUMBER 1

England-Thims & Miller, Inc.
14775 Old St. Augustine Road
Jacksonville, FL 32258
TEL: (904) 642-8990
FAX: (904) 646-9485
REG - 2584 LC - 0000316

VISION ▪ EXPERIENCE ▪ RESULTS

ETM NO.	19-094
DRAWN BY:	R.D.C.
DESIGNED BY:	
CHECKED BY:	G.V.K.
DATE:	8-19-2020

REVISIONS:

PLANS PREPARED UNDER THE DIRECTION OF: