56th Street Alternative

Supplemental Concept-Level Economic Analysis

1 - Introduction and Alternative Description

This document presents results of a concept-level[1] incremental analysis of the 56th Street alternative relative to the 56th Street alternative, Illinois Street variation. The 56th St alternative, relative to the Illinois St variation, provides additional flood risk management benefit to the Riviera Club, Lift Station #507, and the commercial structures within the area North of 56th St, South of the intersection of Westfield Blvd and Illinois St, and West of high ground, approximately midway between Illinois St and Meridian St. This analysis will estimate the viability of this alternative on the basis of incremental costs incurred versus benefits accrued. As an incremental analysis, both costs and benefits considered reflect only the incremental increase in cost/benefits associated with the 56th St alternative over the Illinois St variation.

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) model was used to perform a risk-based analysis of damages for both conditions. All dollar values shown are in a 2013 price level. These were indexed from the 2011 price levels of the original analysis for even comparison to the most recent 2013 cost estimates using the ENR CCI. All discounting and amortization was done using the FY13 federal discount rate of 3.75%.

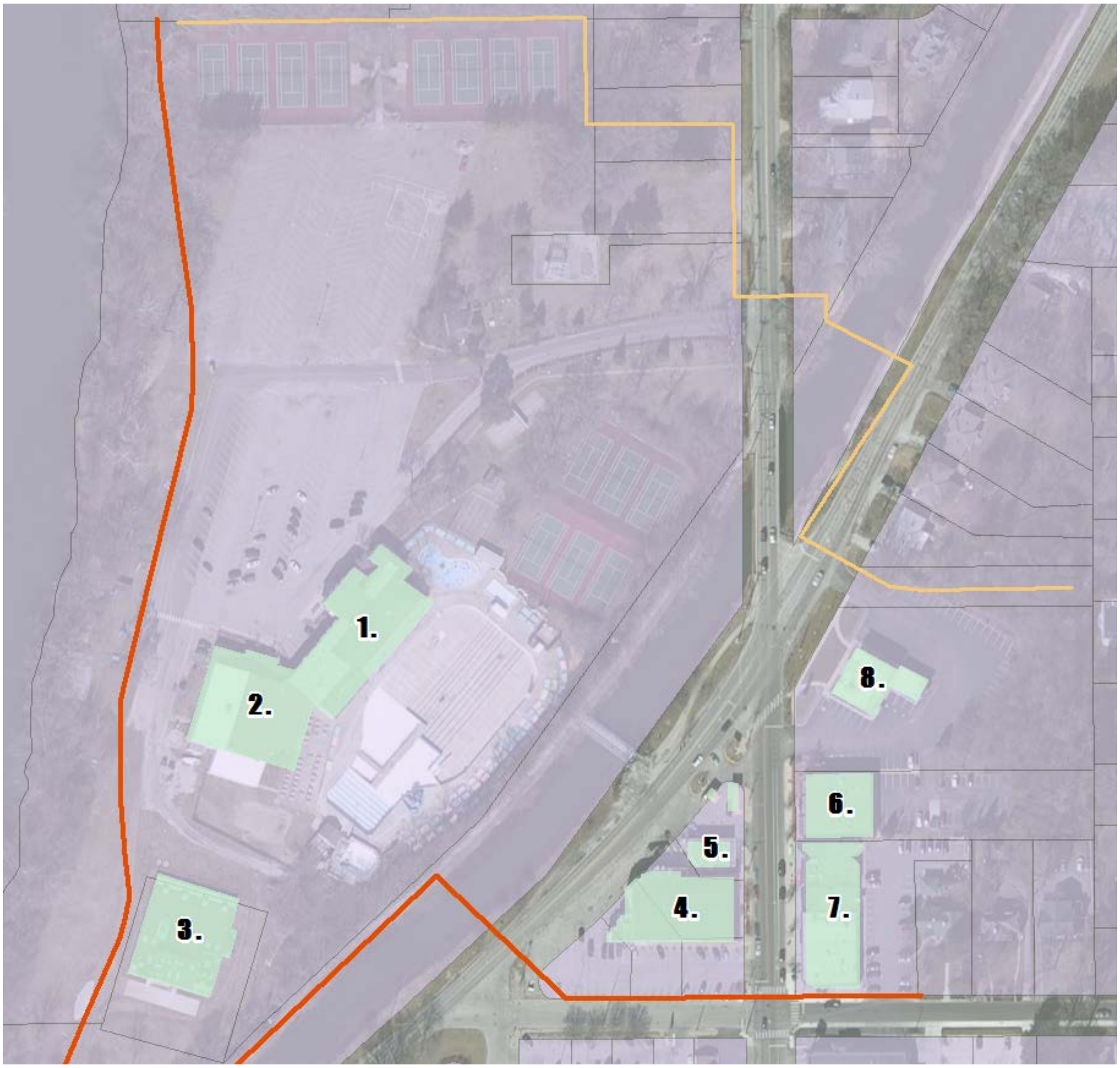
The following sections detail the data gathering, data processing, and modeling (providing a brief overview of the model's function), as well as a summary of analysis results.

2 - Structure Inventory

The analysis area was delineated as the area that falls within the leveed area of the 56th St alternative, but that would not fall within the leveed area of the Illinois St variation. This includes the Riviera Club, Lift Station #507, and the commercial structures within the area North of 56th St, South of the intersection of Westfield Blvd and Illinois St, and West of high ground, approximately midway between Illinois St and Meridian St. The structure inventory is a dataset of properties within the analysis area, including all relevant data to be used as input parameters for the HEC-FDA analysis. The study area is shown in the figure below, with the structure inventory highlighted. The red line is a rough approximation of the 56th St alternative alignment, and the orange line a rough approximation of the Illinois St variation alignment.

[1] "Concept-Level" is used here to describe a level of effort considered to be lower intensity than a reconnaissance level analysis

Figure 1 – Map of Incremental Area



Structure data required for HEC-FDA analysis can be subdivided into four primary components; structure counts and locations within the floodplain (stream name and stationing corresponding to that used in the Hydraulic and Hydrologic (H&H) model), structure values and other characteristics, structure elevations, and susceptibility to flooding damages and the magnitude of those damages as represented by a depth-damage curve. The processes for developing these components are detailed below.

2.1 Structure Locations and Values

Structure footprints (as ArcGIS shapefiles) and detailed parcel data were obtained for the structures in the Butler Tarkington area from the Marion County Assessor's Office. Structure footprints provide the geospatial location of individual structures, as well as their first floor square footage. The parcel data was also geospatially referenced, and contains a significant amount of additional data on these structures, including improvement values.

Structure values from the parcel data were assessed values in 2011 price levels. Typical flood risk management analyses use depreciated structure replacement values, the value to replace the structure new, depreciated by effective age of the structure, rather than assessed values. Given the low level of intensity of this analysis, a valuation technique to arrive at depreciated replacement value was not employed, and assessed value was used instead.

The parcel data did not include structure value data on Lift Station #507. Per a review of estimated costs for similar lift stations, an estimated value of $500,000 for the structure itself was assumed, with the significant uncertainty represented by a standard deviation of $250,000. Content value, the value of the contained machinery and equipment, was assumed at twice the value of the structure itself.

2.2 Structure Elevations

The geospatial location of the identified 'primary' structure footprints are important for the association of individual structures to H&H input data, which is itself associated with stream stationing, and for the assignment of ground elevations to these structures. Ground elevations were assigned by overlaying these footprints over a digital elevation model (DEM) with five-foot grid cells obtained from the Indiana Geologic Survey. This DEM was converted from the NAVD88 to the NGVD29 vertical datum for compatibility with H&H model inputs already in the latter datum. Elevations were pulled from this DEM based on the centroid of each structure's footprint.

2.3 Structure Characteristics

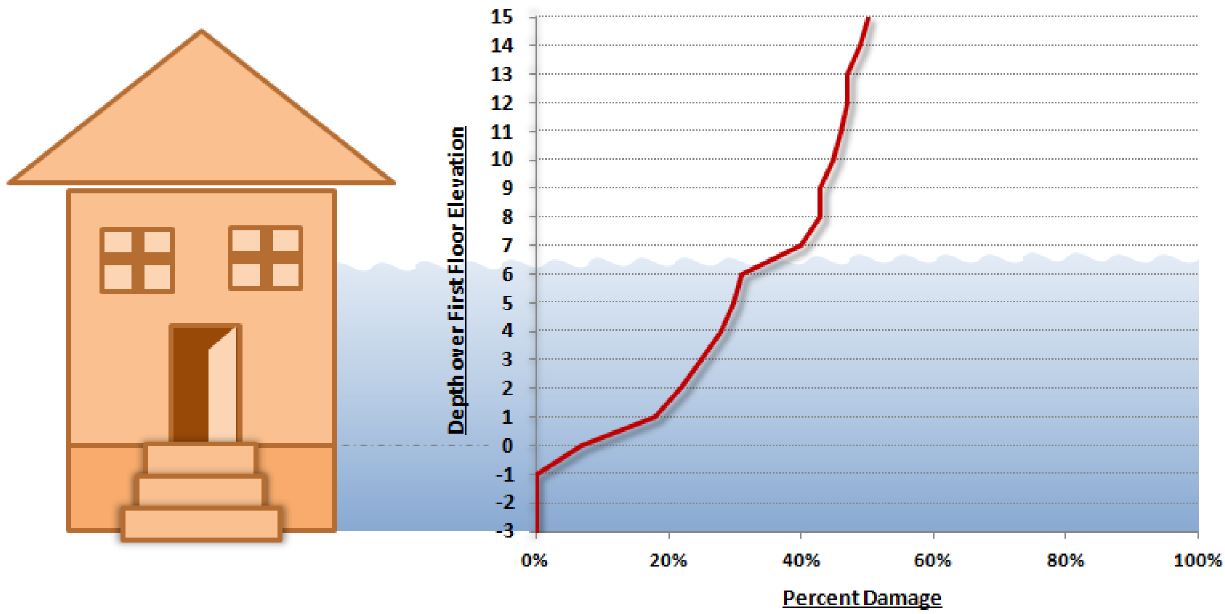
In addition to structure values and elevations, a number of other structure characteristics are critical for accurate estimation of flood damages. These include foundation heights (relative elevation of the structures first or ground floor over the ground elevation described above), structure class (residential/commercial/public), number of stories, and the presence or absence of a basement. Structure class information was available from the parcel data and from visual inspection using Google Street View. Foundation heights were also approximated using Street View for the structures East of the Canal. Site photographs of the Riviera Club and Lift Station #507 were used to assess approximate foundation height.

2.4 Depth-Damage Relationships

The structure class, presence of a basement, and number of stories estimated above are used to assign each structure a depth-damage relationship, or curve. Standardized non-residential depth-damage functions resulting from a March 2008 expert opinion elicitation on behalf of FEMA's Benefit Cost Analysis program and the USACE were used for this analysis.

Depth-damage curves essentially relate a flood depth, relative to the first floor elevation of a given structure, to a damage or economic loss represented as a percentage of that structure's value. Figure 2 below illustrates the concept of a depth-damage relationship for a single-story home without a basement. Two such curves exist for each structure, one describing the relationship between depth and structure damage, and the other depth and content damage –both represented as a percentage of structure value.

Figure 2 – Depth-Damage Example



3 - Hydraulic and Hydrologic Data

The second key component of flood damage analysis is how the flooding itself is modeled. Hydraulic and Hydrologic (H&H) data is used to estimate flood stages at structures for the eight analyzed probabilistically weighted flood scenarios. This process is summarized below.

3.1 Water Surface Profiles

H&H data was provided in the form of a water surface profile for one White River cross-section. This water surface profile relates stage and discharge to this stream station for a range of eight possible flood events, ranging from those with a nearly 100% chance of exceedance in a given year, to those with 0.2% exceedance chance (commonly referred to as a 500-year flood). Uncertainty around discharge exceedance probability (the chance in a given year of river flow exceeding a set amount, or "discharge") and stage discharge relationships (expected river stages associated with a given discharge) for this cross section is additionally incorporated into the HEC-FDA model. During HEC-FDA model runs, these input parameters are sampled from within the defined uncertainty ranges for each Monte Carlo iteration.

4 - HEC-FDA Analysis

The US Army Corps of Engineers requires the use of risk-based analysis for evaluating flood damages and flood damage reduction measures, as described in ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies. A risk-based analysis accounts for uncertainty in the stage-flow relationships, discharge -exceedance probability relationships, stage-damage relationships, structure characteristics, and other categories for which uncertainty exists. This procedure further integrates them into an economic analysis for with and without-project conditions and a performance analysis for flood reduction measures. These computations were performed for this analysis using the HEC-FDA software package, version 1.2.4.

5 - Analysis Results

HEC-FDA model results are presented as "expected annual damages" or EAD. These do not represent the damages expected to occur in a given year, but rather the probability weighted damages of the range of analyzed flood events. For this analysis, a 50-year analysis period was used.

5.1 Without-Project Condition

Without-project condition EAD for this analysis represents the annualized value of the range of potential flood damages given the Illinois St variation. These damages are only those that would occur to structures that would be protected in the with-project (56th St) condition, but are not protected by the Illinois St variation. Expected annual flood damages are shown below in Figure 3. Note that all dollar values are in 1,000's.

Figure 3 – Without-Project EAD[2]

Illinois St Alignment
Expected Annual Damage by Damage Categories and Plans
for Analysis Year 2011
(Damage in $1,000's)

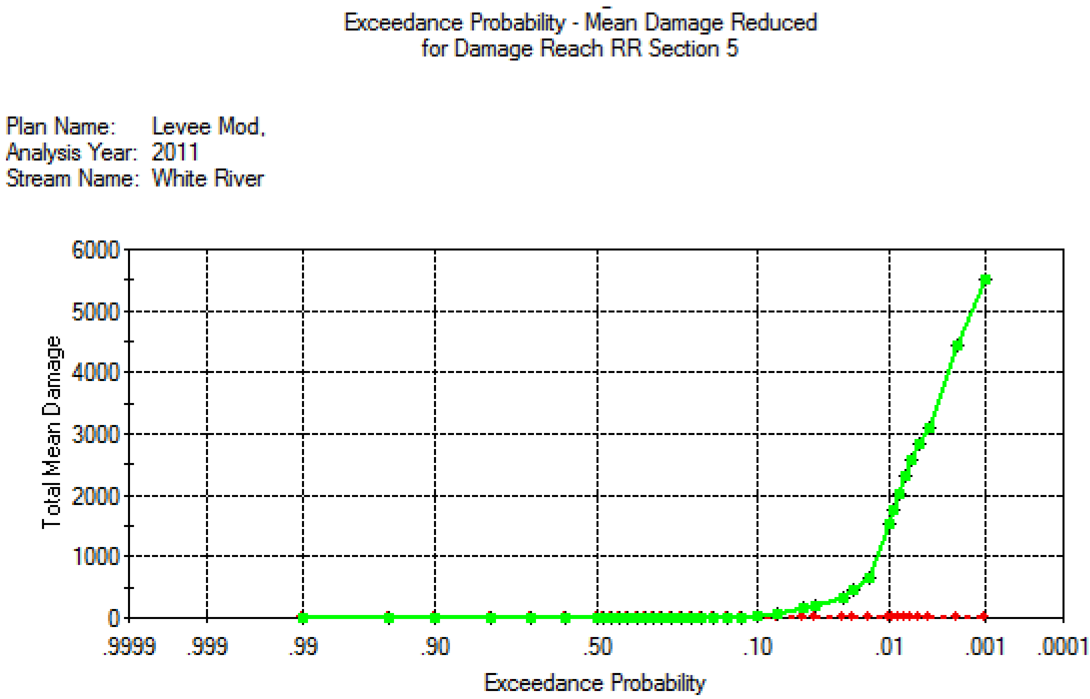
Plan Name	Damage Categories					Total Damage
	Commercial	Mobile Home	Multifamily	Public	Single Family	
Without	33.71	0.00	0.00	16.76	0.00	50.47

5.2 With-Project Condition

With-project condition EAD represents annualized flood damages to structures given the 56th St alternative. Damages reduced in the with-project condition are illustrated in the following screen capture from FDA. The green curve represents damages (y-axis) in the without-project condition; the red curve represents damages in the with-project condition. The x-axis is exceedance probability (the probability that damages will equal or exceed those shown on the y-axis in a given year). The incremental damage reductions (benefits) of the 56th St alternative would, conceptually speaking, be the area between these without-project curves and the with-project curves (the integration of these curves does not produce EAD – these curves are approximate and do not account for uncertainty).

[2] Values shown are in 2011 price levels from the initial model runs. These have been indexed to 2013 price levels using the ENR-CCI

Figure 4 – Reach 4 Mean Damage Reduction Plot



5.3 Expected Annual Damages

Table 1 and Table 2 below display the HEC-FDA model results as expected annual damages in the without-project and with-project conditions, as well as project benefits (without-project EAD minus with-project EAD), and the uncertainty around these benefits.

Table 1 – Expected Annual Damages

Without-Project Condition	$53,043
With- Project Condition	$1,387
Damage Reduction (Benefits)	**$51,655**

Given the uncertainty around input parameters, this benefit estimate is, likewise, uncertain. To best capture the likelihood of project feasibility, the uncertainty of benefit estimates should be illustrated. Table 2 below roughly approximates this uncertainty; each value in the right-hand column indicates the damage reductions, or benefits, which have the probability of being exceeded shown in the left-hand column. So for example, there is a 25% chance that the 56th St alternative could provide annualized incremental benefits greater than $69,617 in value (and likewise a 75% chance that it will provide benefits less than this value).

Table 2 – Percent Chance Damage Reductions Exceed Indicated Values

75%	$14,461
50%	$34,314
25%	$69,617

5.4 Annualized Implementation Costs

As stated earlier, the costs used in this analysis reflect only the incremental costs necessary to implement the 56th St alternative over the Illinois St variation. These incremental costs, including interest during construction (IDC), were annualized over the 50-year analysis period (at a discount rate of 3.75%) for comparison to expected annual benefits. Total costs, interest during construction, and the annualized value of these costs are shown in Table 3 below.

Table 3 – Implementation Costs

Total Cost	$1,478,000
Interest During Construction	$172,588
Total Cost w/ IDC	$1,650,588
Annualized Costs	**$73,574**

5.5 Benefit-Cost Ratios

The results of a benefit-cost analysis can be displayed in two ways: as a single net benefits number (benefits minus costs) and as a benefit-cost ratio (BCR). Net benefits are typically used to select and scale a recommended course of action from an array of alternatives within the context of a single study or analysis. Benefit-cost ratios are used as a metric to test the viability of a proposed course of action; a benefit-cost ratio greater than one indicates that every dollar invested will yield in excess of 1 dollar of benefit to the nation. A benefit-cost ratio less than one indicates that every dollar invested will yield less than one dollar in benefit.

Benefit-cost ratios are computed using the annualized costs and annualized damage reductions associated with the alternative or plan analyzed. The (concept-level) incremental benefit-cost ratio for the 56th St alternative *over* the Illinois St variation then would be:

$$\frac{\$51,655}{\$73,574} = 0.7$$

Using the uncertainty parameters shown in Table 2 above, we can extrapolate the *range* of possible benefit-cost ratios given uncertainty around project benefits (note this does not incorporate cost uncertainty, essentially assuming costs are certain). This is shown in Table 4 below:

Table 4 – Percent Chance BCR's Exceed Indicated Values

75%	$\frac{\$14,461}{\$73,574}$	= 0.2
50%	$\frac{\$34,314}{\$73,574}$	= 0.47
25%	$\frac{\$69,617}{\$73,574}$	= 0.95

It should be noted that the uncertainty represented by these ranges does not fully encompass the uncertainty around model results and thus benefit-cost ratios or net benefits, especially in the case of a concept level analysis such as this one. These benefit-cost ratios are intended only to depict a *likely range* of outcomes.

In summary, the additional $1.48 million required for the 56th St alternative over the Illinois St variation would likely not be met or exceeded by the associated reduction in annualized flood damages to the incrementally protected area.