Assessment of Vulnerability to Climate Change Effects on City of Las Vegas Urban Stormwater Infrastructure

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① Introduction

- As part of the Thriving Earth Exchange program, in the spring of 2016 the City of Las Vegas and the Southern Illinois University Carbondale began collaborating on a project that seeks to assess the city's current vulnerability to drought, extreme heat, and extreme precipitation patterns, as well as the response mechanisms that are already in place within its jurisdiction.
- The document analyzes a series of scenarios to assess to what extent the vulnerability of four Key Planning Areas will change in the long term (30-50 years), what city operations will be the most affected, and what mechanisms the City will need to put into place to adapt to such changes.
- As part of the vulnerability report, this study assessed the impacts of climate change in the existing stormwater system by assessing projected design storms.

② Objective

- To determine the future design depth using climate models projection with 27 different frequency analysis.
- To evaluate the existing stormwater infrastructures considering the future climate information.

③ Study Area and Data

- The Gowan Watershed is located within the Las Vegas Valley, and managed by the Clark County Regional Flood Control District.

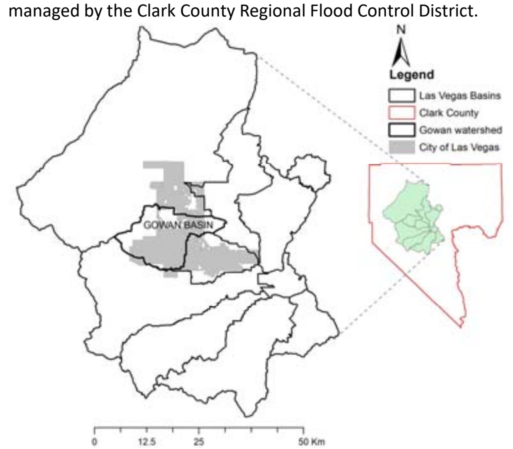

Figure 1: Map of Gowan watershed within Clark county

- The majority of this watershed lies within the City of Las Vegas
- Clark County maintains jurisdiction of the Gowan Watershed and is responsible for programming flood control funds.
- The total area of the Gowan Watershed is 216 km^2.
- Drainage facilities within the watershed consist primarily of detention basins connected by conveyance facilities.

④ Data and Model

- NARCCAP data
  - ➢ 13 combination of GCM & RCM paired climate models
  - ➢ Historic Data (1970-2000), Future Projection Data (2040-2070)
  - ➢ 50 km spatial resolution
- NARR data
  - ➢ Historic reanalyzed data (1979-2000)
  - ➢ 32 km spatial resolution
- Hydrological Model
  - ➢ Existing HEC-HMS model from Clark County Regional Flood Control District (CCRFCD)

⑤ Methodology

- Statistical method (Calculation of 6h 100y design storm)
  - ➢ best fitted among 27 different probability distributions.
- Delta change Method
  - ➢ An alternative of complex downscaling methods
- Hydrological Modeling
  - ➢ Using existing HEC-HMS Model (to convert the rainfall to runoff)

⑥ Results

Table 1: Best fit plot among 27 distributions for 13 different NARCCAP model data.

S.N.	Analysis	CRCM-CCSM	CRCM-CGCM3	ECP2-GFDL	HRM3-GFDL	HRM3-HADCM3	MM5I-CCSM	MM5I-HADCM3	REGCM3-CGCM3	REGCM3-GFDL	TMSL-CCSM	TMSL-GFDL	WRFG-CCSM	WRFG-CGCM3
1	Normal											□		□
2	Normal(L-Moments)						◊		□					
3	Log Normal		◊					○			○			
4	Galton													
5	Exponential									○				
6	Exponential (L-Moments)				○								□	
7	Gamma		●	●		◊		□						
8	Pearson III	◊						●						
9	Log Pearson III			□						●				
10	EV1-Max (Gumbel)													◊
11	EV2-Max					□●			○					○
12	EV1-Min (Gumbel)													
13	EV3-Min (Weibull)	□												
14	GEV-Max													
15	GEV-Min	●		◊							◊			
16	Pareto													
17	GEV-Max (L-Moments)								●				●	
18	GEV-Min (L-Moments)				●		●	◊			●	◊		●
19	EV1-Max (Gumbel, L-Moments)		○	○							□		◊	
20	EV2-Max (L-Moments)				□					□			○	
21	EV1-Min (Gumbel, L-Moments)													
22	EV3-Min (Weibull, L-Moments)						□					○●		
23	Pareto (L-Moments)				◊									
24	GEV-Max (Kappa Specified)	○				○			◊	◊				
25	GEV-Min (Kappa Specified)		□											
26	GEV-Max (Kappa Specified, L-Moments)													
27	GEV-Min (Kappa Specified, L-Moments)						○							

Note :- The symbol ○ and □ are used for Chi square test fit for present & future climate data while ◊ and ● are used for Kolmogorov Smirnov test fit for present & future climate data

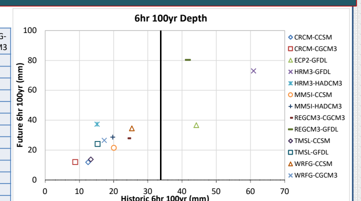

Figure 2: Scatter plot Historic Vs Future Design Depths

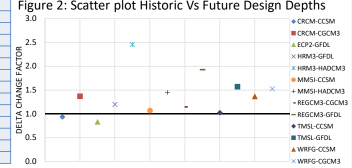

Figure 3: Delta change factors plot for NARCCAP models

Table 2: Historic & Future 6h-100y depths with delta change factor for NARCCAP models

Climate Model	Historic 6hr-100yr depth (mm)	Projected 6hr-100yr depth (mm)	Delta Change Factor
NARR	33.73	-	-
CRCM-CCSM	12.57	11.77	0.94
CRCM-CGCM3	8.75	11.99	1.37
ECP2-GFDL	44.18	36.58	0.83
HRM3-GFDL	60.92	72.94	1.20
HRM3-HADCM3	15.16	37.19	2.45
MM5I-CCSM	20.06	21.49	1.07
MM5I-HADCM3	19.75	28.57	1.45
REGCM3-CGCM3	24.25	27.76	1.14
REGCM3-GFDL	41.70	80.30	1.93
TMSL-CCSM	13.34	13.66	1.02
TMSL-GFDL	15.31	24.05	1.57
WRFG-CCSM	25.31	34.45	1.36
WRFG-CGCM3	17.27	26.38	1.53

Table 3: Hydrological modeling output for SUM5DB

Scenario	Peak Inflow (m^3/s)	Storage (m^3)	Change in elevation (m)	Peak Outflow (m^3/s)
Design	198.26	473656.00	8.23	60.96
Baseline	196.09	460088.04	8.26	61.06
CSC 1.14	235.23	479577.02	9.36	74.38
CSC 2.45	601.65	628211.36	10.82	546.48

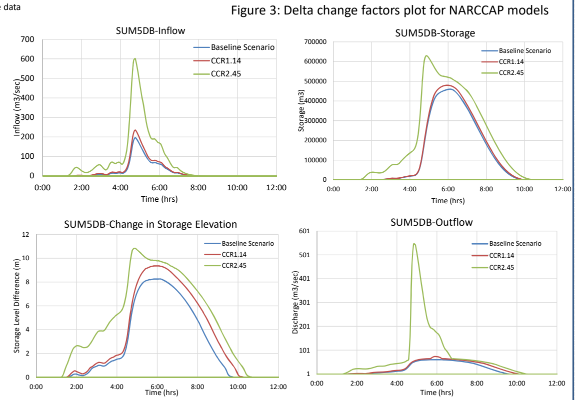

Figure 4: Hydrological Modeling outputs for Summerlin Detention Basin (SUM5DB) for different NARCCAP model scenarios.

⑦ Conclusion and Contribution

- Current flood control facilities may not be able to convey the projected flow due to changing climate.
- Different climate models are showing different future climate projection.
- There is an uncertainty in the future climate scenario, that warrants considering a range of the probable future scenarios during the planning process.
- Existing design standard needs to account for the effect of climate change.
- This study demonstrated a robust and simple method that accounts the effects of climate change on the urban stormwater infrastructure design.
- The results of this study can be helpful to engineers, water managers, policy makers, and decision makers to include the effects of climate change in the planning and design of stormwater facilities.

⑧ Recommendation

- Comparison of the climate change factors with the recently observed storms.
- Assessment of the effectiveness of different techniques available for attenuation the peak flows.
- More finer horizontal resolution climate model data may be used to exclude the probable downscaling error.

⑨ Acknowledgement

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⑩ References

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