INDOT Traffic Forecasting Tool

Online R-Based Version

presented to

Southeast Florida Model Users Group

Presented by

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March 15, 2019

THE CORRADINO GROUP

Engineers • Planners • Program Managers • Environmental Scientists

Helping communities since 1970

TFT Introduction

- **A customized R application to facilitate INDOT's long range traffic forecasting activities at project level**
- **Earlier TFT– developed in 2006.**
- **Existing TFT v3.0 – developed in 2017**
  - **GISDK based post-processor**
  - **TransCAD license required to use the post-processor**
  - **Input data in native TransCAD format (DBD, BIN)**
  - **Up to 15 links for analysis at a time**
  - **Reports & graphs in BIN format**

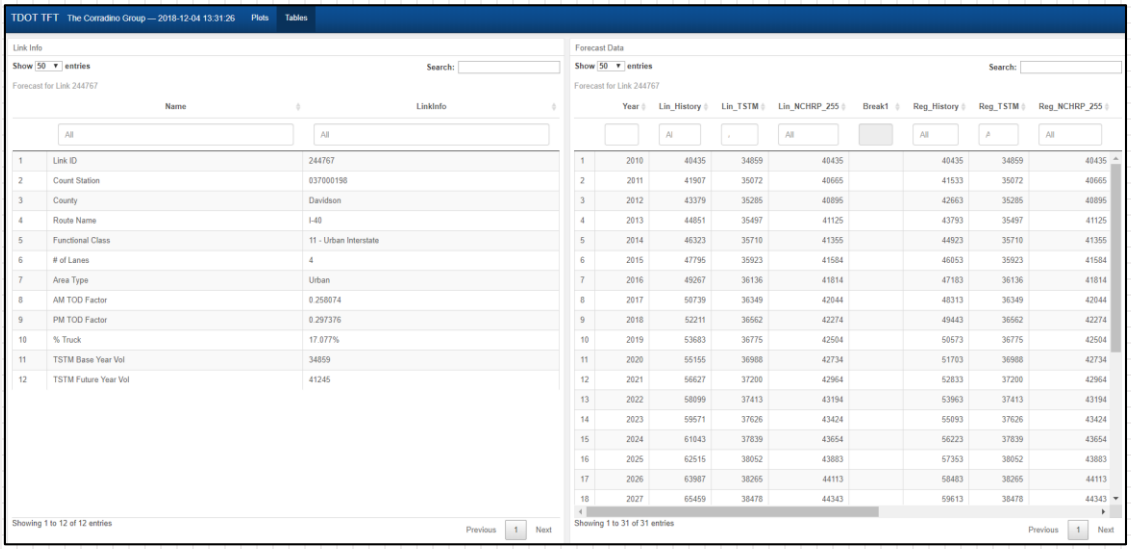
TFT Introduction (Cont.)

- **TFT v4.0 (for this presentation) – This is currently a working version and INDOT hasn't made decision regarding the official final version**
  - Interactive online tool
  - Easy to access and use by every individual with access to internet
  - Customized base year & future year for analysis
  - Latest traffic counts throughout Indiana
  - Utilization of the latest ISTDM
  - Various traffic forecasting methods
  - Analysis of multiple links at a time (No limit)
  - Enhanced output visualization (powered by R)
- **Minimizes staff requirements, reduces potential method & calculation errors**
- **Evolved version based on tools for Kentucky and Tennessee**

TFT Introduction (Cont.)

Why R ?

- **An open-source & emerging programming language for travel demand modeling**
- **Efficient data management of multiple links at a time**
- **Powerful graphing capability for better output visualization**
- **“Live” graphs**
- **.HTML output files – extremely convenient for info dissemination**

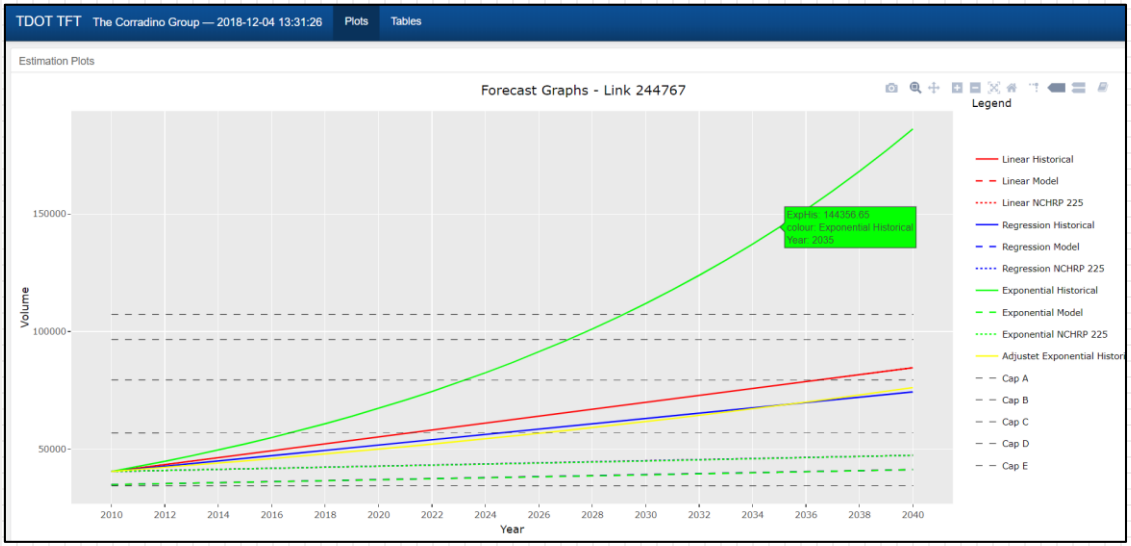


	Name	LinkInfo
1	Link ID	244767
2	Count Station	037000198
3	County	Davidson
4	Route Name	I-40
5	Functional Class	11 - Urban Interstate
6	# of Lanes	4
7	Area Type	Urban
8	AM TOD Factor	0.258074
9	PM TOD Factor	0.297376
10	% Truck	17.077%
11	TSTM Base Year Vol	34859
12	TSTM Future Year Vol	41245

Showing 1 to 12 of 12 entries

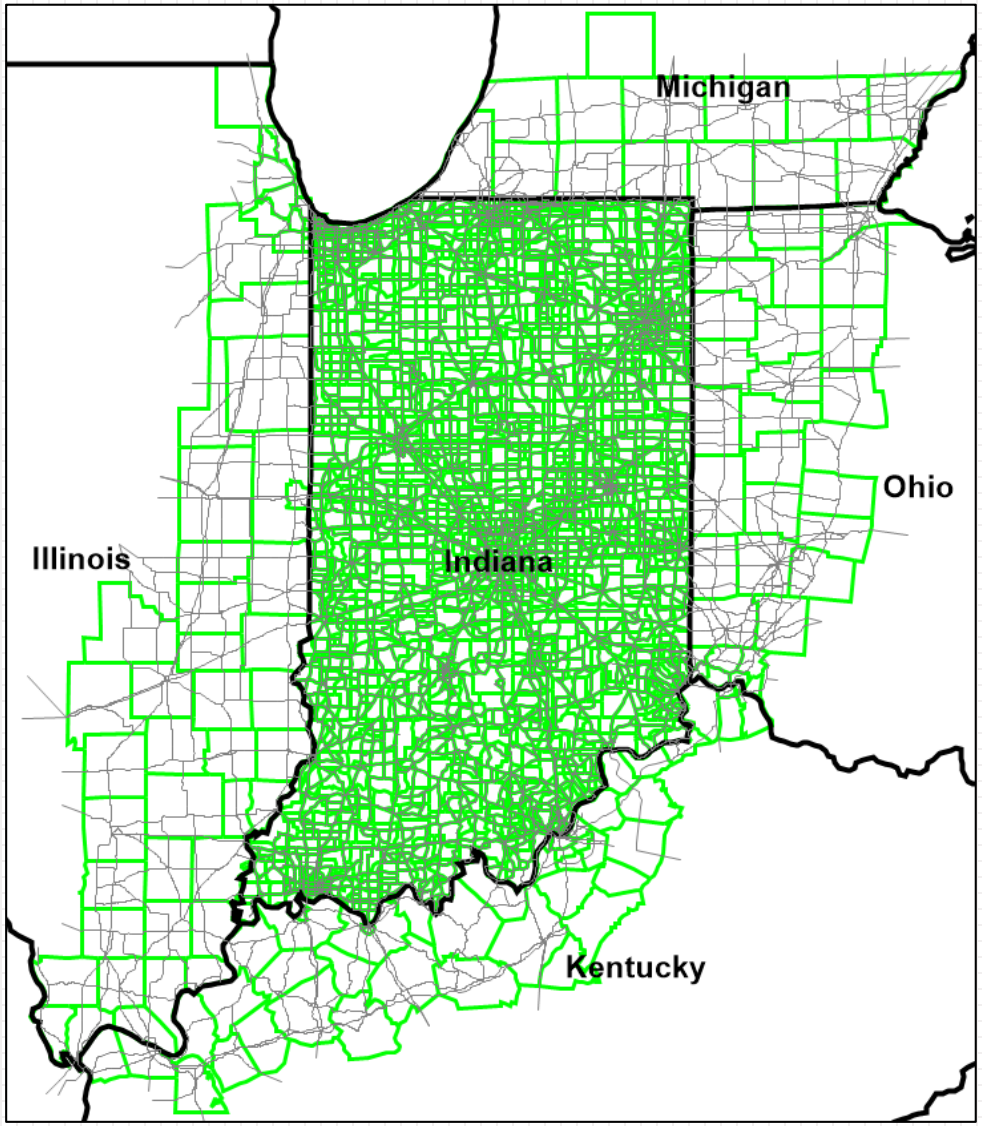
	Year	Lin_History	Lin_TSTM	Lin_NCHRP_255	Break1	Reg_History	Reg_TSTM	Reg_NCHRP_255
1	2010	40435	34859	40435		40435	34859	40435
2	2011	41907	35072	40665		41533	35072	40665
3	2012	43379	35285	40895		42663	35285	40895
4	2013	44851	35497	41125		43793	35497	41125
5	2014	46323	35710	41355		44923	35710	41355
6	2015	47795	35923	41584		46053	35923	41584
7	2016	49267	36136	41814		47183	36136	41814
8	2017	50739	36349	42044		48313	36349	42044
9	2018	52211	36562	42274		49443	36562	42274
10	2019	53683	36775	42504		50573	36775	42504
11	2020	55155	36988	42734		51703	36988	42734
12	2021	56627	37200	42964		52833	37200	42964
13	2022	58099	37413	43194		53963	37413	43194
14	2023	59571	37626	43424		55093	37626	43424
15	2024	61043	37839	43654		56223	37839	43654
16	2025	62515	38052	43883		57353	38052	43883
17	2026	63987	38265	44113		58483	38265	44113
18	2027	65459	38478	44343		59613	38478	44343

Showing 1 to 31 of 31 entries



ISTDM 8*

- 4-step model (TransCAD 7)
- Coverage – entire IN + partial IL, KY, MI, OH
- 4,915 zones & 61,410 links
- Modes
  - auto, freight, LD transit
  - tolling
- Model years 2015 – 2045 with 10-year increment



* This version is currently under development and the specific info provided here might change

Traffic Data

- INDOT's Traffic Count Database System (TCDS)
- Use recent data (2001 – 2015)
- Tag INDOT's Traffic Section & count stations GIS layers to ISTDM 8 network
- Cover all segments of state owned roads

Forecasting Fundamentals

- **Traffic Estimation/Forecast Methods**
  - Linear
  - Regression
  - Exponential (Annual Growth Factor)
  - Adjusted Exponential (Indiana Traffic Growth Profile)
  - NCHRP 255 Calibration Procedure: average of difference and growth factor methods.

  Used Data
  - 2001 – 2015 traffic counts (as many as 15 data points per location)
  - ISTDM8 model volume (2 data points per location – base year & future year)

- **Capacity Estimation (by Level of Service)**

Linear Model

$$P_t = P_b + s(t - b)$$

Where,

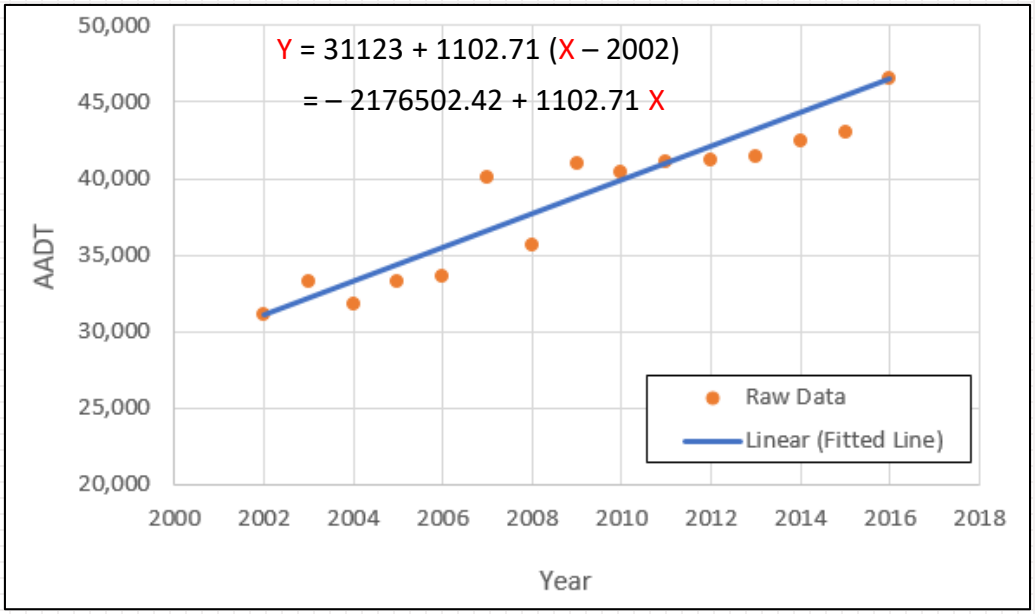
P_b = traffic volume in year b

P_t = traffic volume in year t

s = annual growth increment, which is defined as $s = \frac{P_t - P_b}{t - b}$

Year	AADT
2002	31,123
2003	33,288
2004	31,753
2005	33,231
2006	33,611
2007	40,087
2008	35,688
2009	41,020
2010	40,435
2011	41,041
2012	41,246
2013	41,455
2014	42,447
2015	42,998
2016	46,561

$$s = \frac{46561 - 31123}{2016 - 2002} = 1102.71$$



Regression Model

$$\widehat{P_t} = a + b \times t$$

Where,

$\widehat{P_t}$ = traffic volume in year t

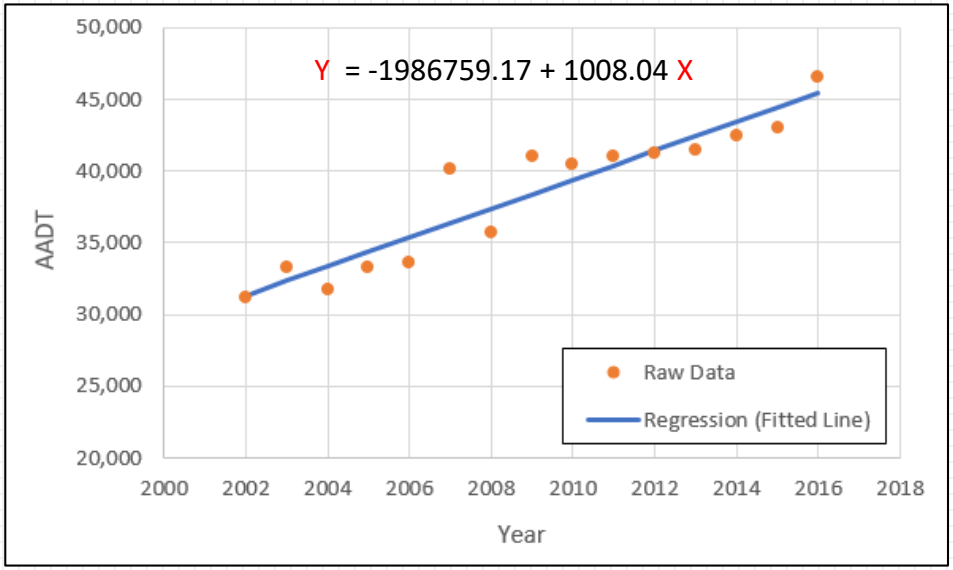
a = intercept

b = slope

Year	AADT
2002	31,123
2003	33,288
2004	31,753
2005	33,231
2006	33,611
2007	40,087
2008	35,688
2009	41,020
2010	40,435
2011	41,041
2012	41,246
2013	41,455
2014	42,447
2015	42,998
2016	46,561

$$a = -1986759.17$$

$$b = 1008.04$$



Exponential Model

$$P_t = P_b \times (1 + r)^{t-b}$$

Where,

P_b = traffic volume in year b

P_t = traffic volume in year t

r = annual growth rate, which is defined as $r = \left(\frac{P_t}{P_b}\right)^{\frac{1}{t-b}} - 1$

$$r = \left(\frac{46561}{31123}\right)^{\frac{1}{2016-2002}} - 1 = 2.92\%$$

Year	AADT
2002	31,123
2003	33,288
2004	31,753
2005	33,231
2006	33,611
2007	40,087
2008	35,688
2009	41,020
2010	40,435
2011	41,041
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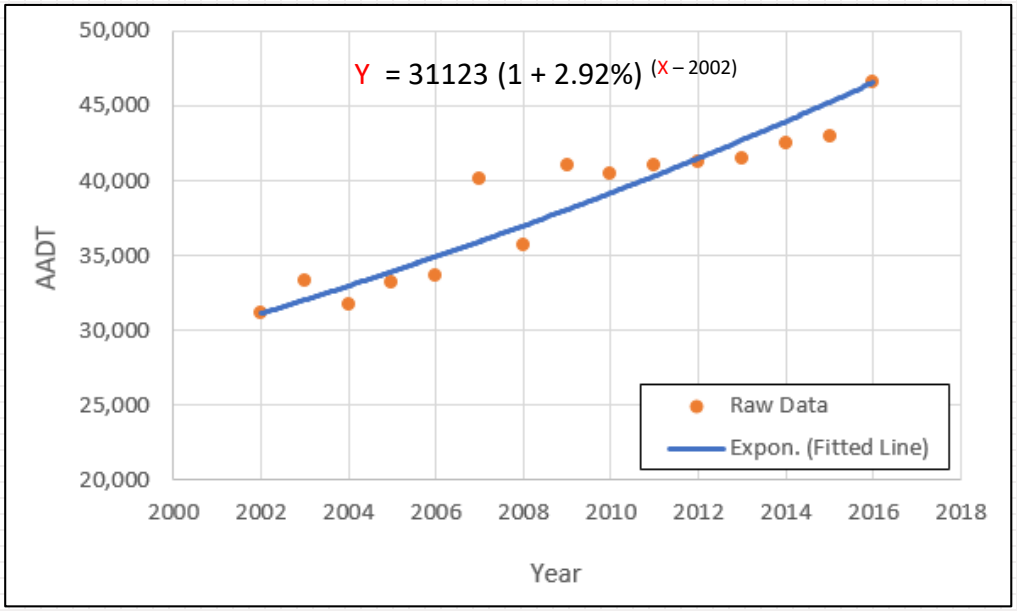


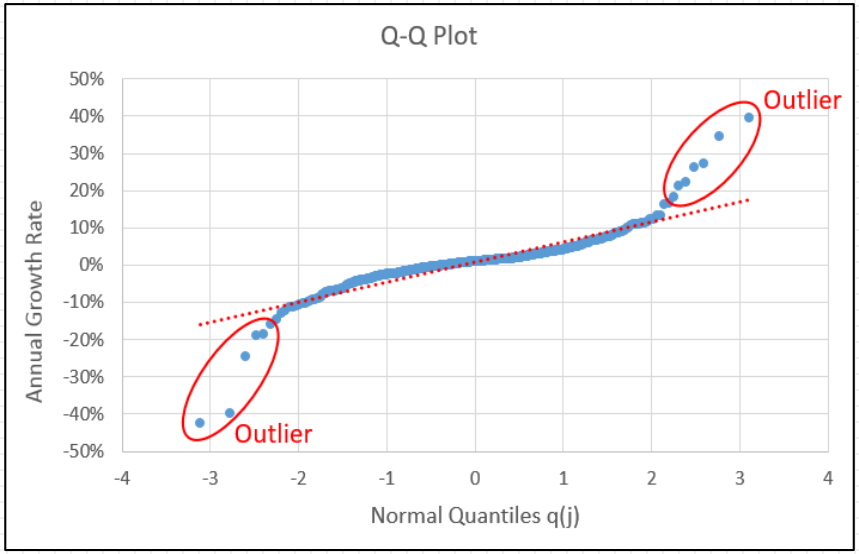
Indiana Traffic Growth Profile

- **Sometimes, it's necessary to adjust abnormal annual growth rate for long range traffic forecasting, due to raw data deficiency**
  - **Insufficient historical counts**
  - **Significant short-term variations caused by transient local event (e.g., land use development, new roadway projects)**

Indiana Traffic Growth Profile

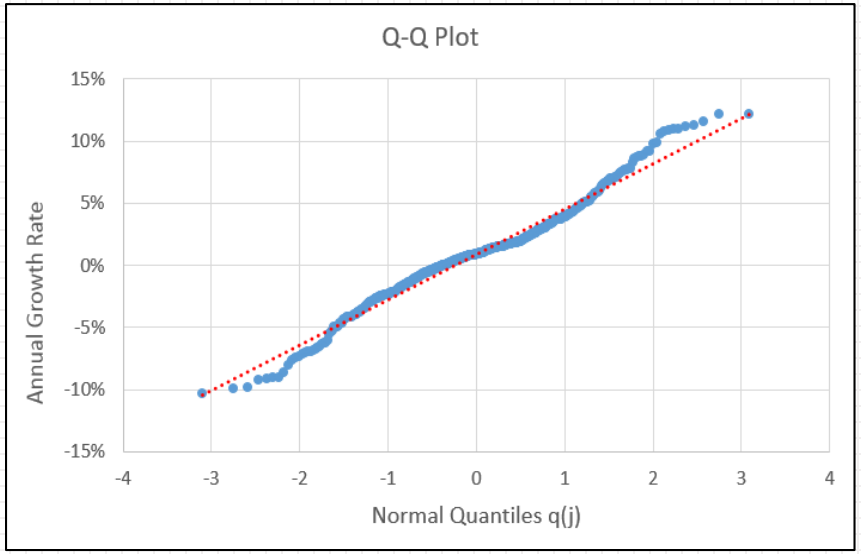
- **Use Q-Q plot to filter outliers (normally distributed data should follow a straight line with correlation coef. = 1.0).**
- **Find & delete the outliers from the analysis (Excel-based).**

Example: Rural Interstate (raw data)



correlation coef. = 0.89

Example: Rural Interstate (cleaned data)



correlation coef. = 0.99

Indiana Traffic Growth Profile (cont.)

Cleaned Data

Functional Classification	Rural			Urban		
	99% CI - Lower	Mean	99% CI - Upper	99% CI - Lower	Mean	99% CI - Upper
1 - Interstate	0.46%	0.88%	1.31%	1.04%	1.28%	1.52%
2 - Other Freeway or Expressway	0.88%	1.89%	2.90%	0.59%	1.13%	1.67%
3 - Other Principal Arterial	0.07%	0.26%	0.46%	-0.02%	0.13%	0.29%
4 - Minor Arterial	-0.08%	0.08%	0.25%	0.45%	0.57%	0.70%
5 - Major Collector	-0.06%	0.02%	0.10%	0.07%	0.33%	0.60%
6 - Minor Collector	-1.61%	-0.61%	0.39%	0.57%	0.84%	1.11%
7 - Local	-1.39%	-0.56%	0.26%	1.01%	1.44%	1.87%

Indiana Traffic Growth Profile (cont.)

Cleaned Data

Functional Classification	Rural			Urban		
	99% CI - Lower	Mean	99% CI - Upper	99% CI - Lower	Mean	99% CI - Upper
1 - Interstate	0.46%	0.88%	1.31%	1.04%	1.28%	1.52%
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6 - Minor Collector	-1.61%	-0.61%	0.39%	0.57%	0.84%	1.11%
7 - Local	-1.39%	-0.56%	0.26%	1.01%	1.44%	1.87%

vs.

Raw Data

Functional Classification	Rural			Urban		
	Min	Mean	Max	Min	Mean	Max
1 - Interstate	-42.53%	0.83%	39.31%	-34.31%	1.21%	33.52%
2 - Other Freeway or Expressway	-10.65%	1.89%	14.98%	-46.94%	0.54%	41.54%
3 - Other Principal Arterial	-26.08%	-0.22%	23.11%	-65.92%	-0.06%	57.37%
4 - Minor Arterial	-64.81%	0.00%	33.51%	-65.32%	0.33%	46.55%
5 - Major Collector	-58.93%	-0.50%	62.66%	-79.46%	0.35%	112.86%
6 - Minor Collector	-32.24%	-0.46%	68.87%	-46.31%	-1.29%	17.75%
7 - Local	-56.53%	-1.26%	45.97%	-52.38%	-0.07%	10.66%

Indiana Traffic Growth Profile (cont.)

Cleaned Data

Functional Classification	Rural			Urban		
	99% CI - Lower	Mean	99% CI - Upper	99% CI - Lower	Mean	99% CI - Upper
1 - Interstate	0.46%	0.88%	1.31%	1.04%	1.28%	1.52%
2 - Other Freeway or Expressway	0.88%	1.89%	2.90%	0.59%	1.13%	1.67%
3 - Other Principal Arterial	0.07%	0.26%	0.46%	-0.02%	0.13%	0.29%
4 - Minor Arterial	-0.08%	0.08%	0.25%	0.45%	0.57%	0.70%
5 - Major Collector	-0.06%	0.02%	0.10%	0.07%	0.33%	0.60%
6 - Minor Collector	-1.61%	-0.61%	0.39%	0.57%	0.84%	1.11%
7 - Local	-1.39%	-0.56%	0.26%	1.01%	1.44%	1.87%

$$GF_{adj} = \begin{cases} CI_{99\%,l}, & if\ GF < CI_{99\%,l} \\ GF, & if\ CI_{99\%,l} \leq GF \leq CI_{99\%,u} \\ CI_{99\%,u}, & if\ GF > CI_{99\%,u} \end{cases}$$

NCHRP 255 Adjustment Procedure

- **Ratio adjustment** $$A_{ratio} = \frac{COUNT}{A_b} \times A_f$$
- **Difference adjustment** $$A_{difference} = (COUNT - A_b) + A_f$$
- **Final adjustment** $$RA_f = \frac{A_{ratio} + A_{difference}}{2}$$

where:

$COUNT = base\ year\ traffic\ count$

$A_b = base\ year\ model\ volume$

$A_f = future\ year\ model\ volume$

$A_{ratio} = future\ year\ volume\ based\ on\ ratio\ adjustment$

$A_{difference} = future\ year\ volume\ based\ on\ difference\ adjustment$

$RA_f = final\ adjusted\ future\ year\ volume$

Capacity Estimation (by LOS)

- **LOS E Capacity:**
  - ISTDM8 daily capacity estimates
- **LOS A-D Capacity**
  - LOS E Capacity × reduction factor
  - Reduction factor: Highway Capacity Manual (HCM) Level of Service criteria by facility type & speed
  - Widely used by Indiana Department of Transportation (INDOT)

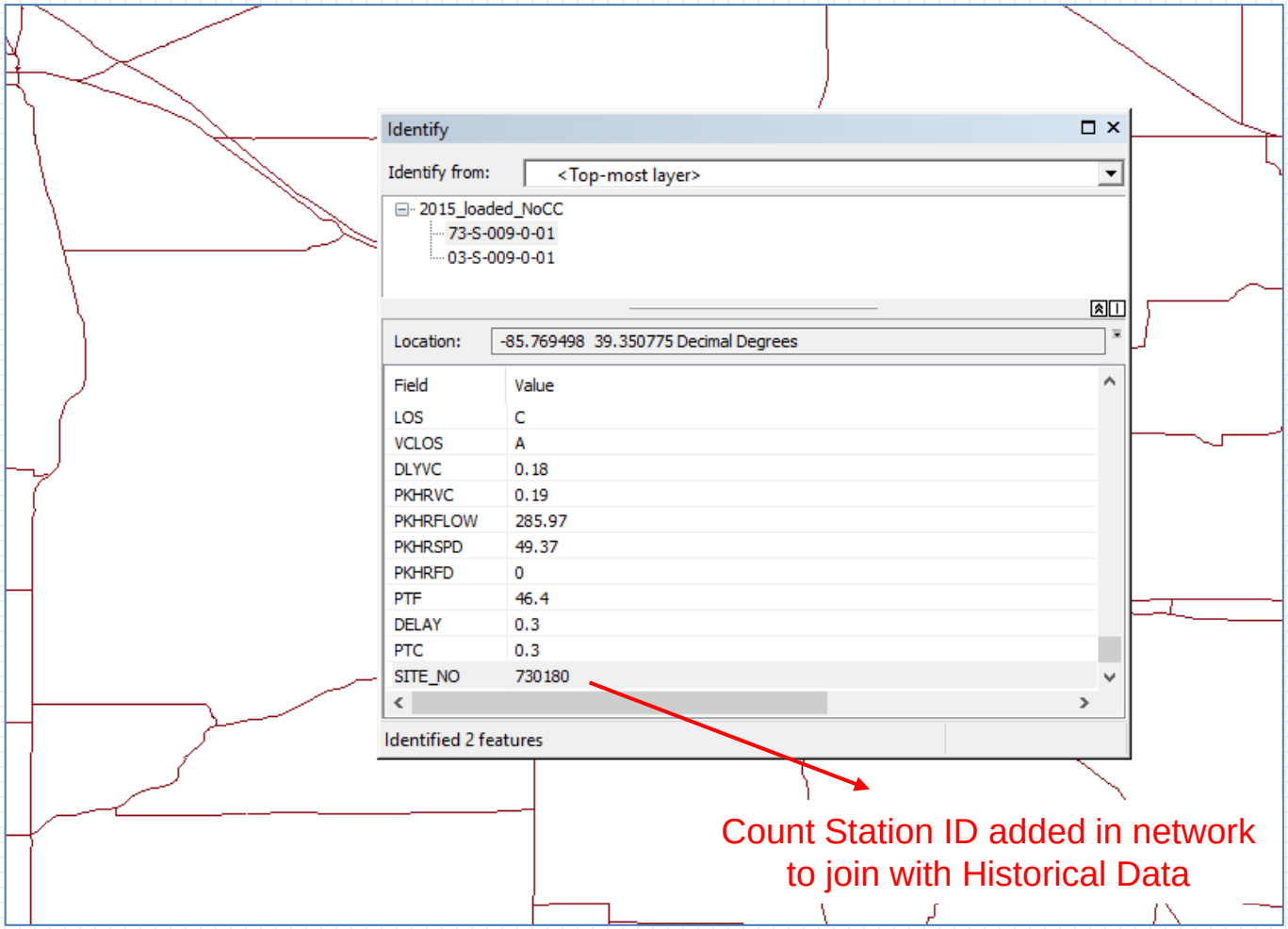
```
if joins.S_FClass = 1 or joins.S_FClass = 11 then do   // factype = "freeway"
   joins.DCAP_E = joins.S_AB_DailyCap + joins.S_BA_DailyCap
   linkspd = (joins.AB_FFS + joins.BA_FFS)/2
   LANES = (joins.AB_LANES + joins.BA_LANES)
   if linkspd >= 70 then do
      joins.DCAP_A = joins.DCAP_E * 0.32
      joins.DCAP_B = joins.DCAP_E * 0.53
      joins.DCAP_C = joins.DCAP_E * 0.74
      joins.DCAP_D = joins.DCAP_E * 0.90
      end
   if linkspd >= 65 and linkspd < 70 then do
      joins.DCAP_A = joins.DCAP_E * 0.30
      joins.DCAP_B = joins.DCAP_E * 0.50
      joins.DCAP_C = joins.DCAP_E * 0.71
      joins.DCAP_D = joins.DCAP_E * 0.89
      end
   if linkspd >= 60 and linkspd < 65 then do
      joins.DCAP_A = joins.DCAP_E * 0.29
      joins.DCAP_B = joins.DCAP_E * 0.47
      joins.DCAP_C = joins.DCAP_E * 0.68
      joins.DCAP_D = joins.DCAP_E * 0.88
      end
   if linkspd < 60 then do
      joins.DCAP_A = joins.DCAP_E * 0.27
      joins.DCAP_B = joins.DCAP_E * 0.44
      joins.DCAP_C = joins.DCAP_E * 0.64
      joins.DCAP_D = joins.DCAP_E * 0.85
      end
   end
```

Data

- All the required data is deployed to the hosting server along with the R scripts and related files
- The files are not visible to the users
- Any changes needed should be made by the admin and then redeployed to the hosting server

Data (cont.)

- **ISTDM8 Loaded Network (Base Years) – shapefiles**



Data (cont.)

- **Historical Data – CSV file**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Location_ID	2001_ADT	2002_ADT	2003_ADT	2004_ADT	2005_ADT	2006_ADT	2007_ADT	2008_ADT	2009_ADT	2010_ADT	2011_ADT	2012_ADT	2013_ADT	2014_ADT	2015_ADT	AREATYPE_MS2	FC	factor_K	Base_Trk_Pct	
12622	60700	0	0	0	0	0	0	0	0	0	3906	3922	3922	4031	4071	4095	1	5	0.102952	0.078877	
12623	459302	0	0	0	0	0	0	0	0	3495	0	0	4009	3961	4048	4095	2	3	0.12503	0.065934	
12624	880160	0	0	0	0	0	0	0	0	3711	0	0	3841	3964	4019	4095	1	4		0.160195	
12625	971685	0	0	0	0	0	0	0	0	0	0	3091	3119	3082	3919	4095	2	1	0.09875	0.021001	
12626	R76W106	0	0	0	0	0	0	0	0	0	0	0	0	0	4007	4095	2	5	0.11975	0.081319	
12627	270946	0	0	0	0	0	0	0	0	0	0	4453	4449	4387	4008	4096	2	4	0.106287		
12628	370072	5040	0	0	0	0	0	0	0	0	0	4413	4444	4586	4650	4096	1	3	0.096436	0.352783	
12629	660074	0	0	0	0	0	0	0	0	0	0	5302	5339	5510	4020	4096	1	4	0.086567	0.139404	
12630	290821	0	0	0	0	0	0	0	0	4377	0	0	4025	3969	4009	4097	2	4		0.025384	
12631	250121	0	4460	0	0	0	0	0	0	0	0	4021	4017	3961	4011	4099	2	3	0.087759	0.131983	
12632	740835	5530	0	0	0	0	0	0	0	0	4704	4723	4723	4756	4075	4099	1	5	0.104295	0.05416	
12633	82W092	0	0	0	0	0	0	0	0	0	0	0	0	0	4012	4100	2	5	0.117398		
12634	10180	0	0	0	0	0	0	0	0	0	4023	4027	4055	3969	4025	4101	1	3	0.088435	0.290417	
12635	620100	0	4150	0	0	0	0	0	0	0	0	3820	3847	3970	4026	4102	1	3		0.153096	
12636	978424	0	0	0	0	0	0	0	0	0	0	0	3683	3639	3925	4102	2	1	0.092484	0.013164	
12637	49W683	0	0	0	0	0	0	0	0	0	0	0	0	3842	3927	4104	2	2	0.11999		
12638	640454	0	0	0	0	0	0	0	0	3464	0	0	3299	3253	3286	4104	2	3	0.100634	0.038012	
12639	920310	0	4140	0	0	0	0	0	0	0	4028	4032	4060	3971	4027	4104	1	4	0.105263	0.116959	
12640	R43162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4104	2	4	0.09576	0.072612	
12641	130261	0	4340	0	0	0	0	4040	0	3771	0	0	4013	4041	4081	4105	1	5		0.224361	
12642	U20137	0	0	0	0	0	0	0	0	0	0	0	0	0	4017	4105		4	0.106298	0.056516	
12643	10W314	0	0	0	0	0	0	0	0	0	0	0	0	3979	4019	4107	2	4	0.103544	0.051863	
12644	18W254	0	0	0	0	0	0	0	0	0	0	0	0	3979	4019	4107	2	4	0.105052	0.03774	
12645	975124	0	0	0	0	0	0	0	0	4410	0	0	4708	4652	4754	4107	2	1	0.087899	0.27441	
12646	50122	0	0	0	0	0	0	0	0	0	3494	3557	3553	3980	4020	4108	2	4	0.089196	0.061831	
12647	35W148	0	0	0	0	0	0	0	0	0	0	0	0	3980	4020	4108	2	4	0.094221	0.417965	
12648	45W317	0	0	0	0	0	0	0	0	0	0	0	4039	3982	4022	4110	2	4		0.06618	
12649	640231	0	0	3370	0	0	0	0	0	3126	0	0	3537	3487	3522	4110	2	4	0.118735	0.059854	

HistoricalData

- AADT counts for the most recent 15 years (2001, 2002 … 2015)

Count Station ID

K- Factor

Area Type and Functional Classification

Truck Percentage

Data (cont.)

- **Future year total volumes by link ID – CSV file**

A	B
ID	Tot_Flow
28574	16101.43
28580	2035.799
28586	2035.799
28644	16101.43
28738	4085.333
29380	16101.43
29405	9425.651
29437	13975.56
29526	2035.799
29541	11939.76
29547	11701.58
29564	2732.19
29583	2732.19
29606	9425.651
29631	2732.19
29732	10009.78

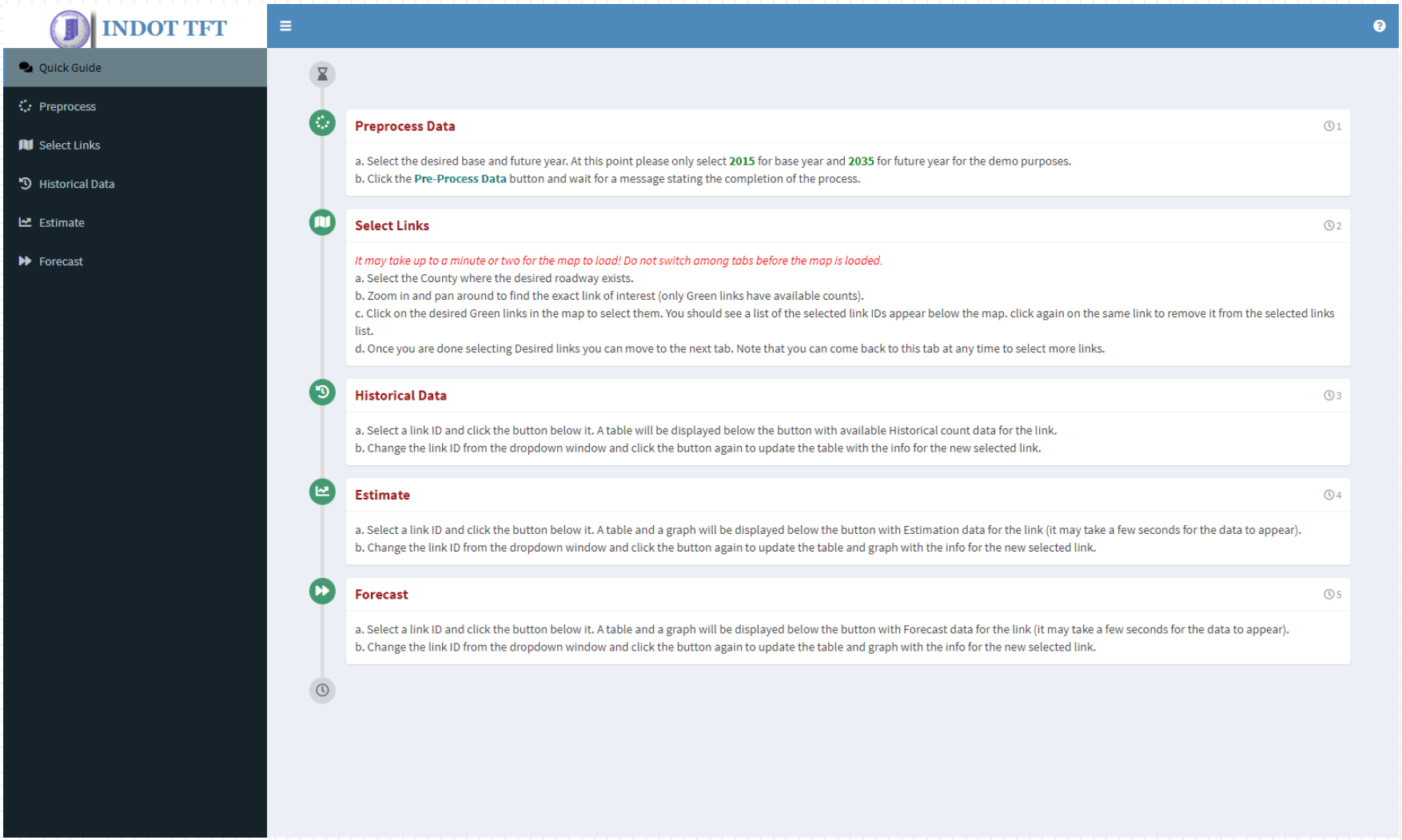
Network Link ID

Total Volume

Online TFT Application Tabs

“Quick Guide” Tab

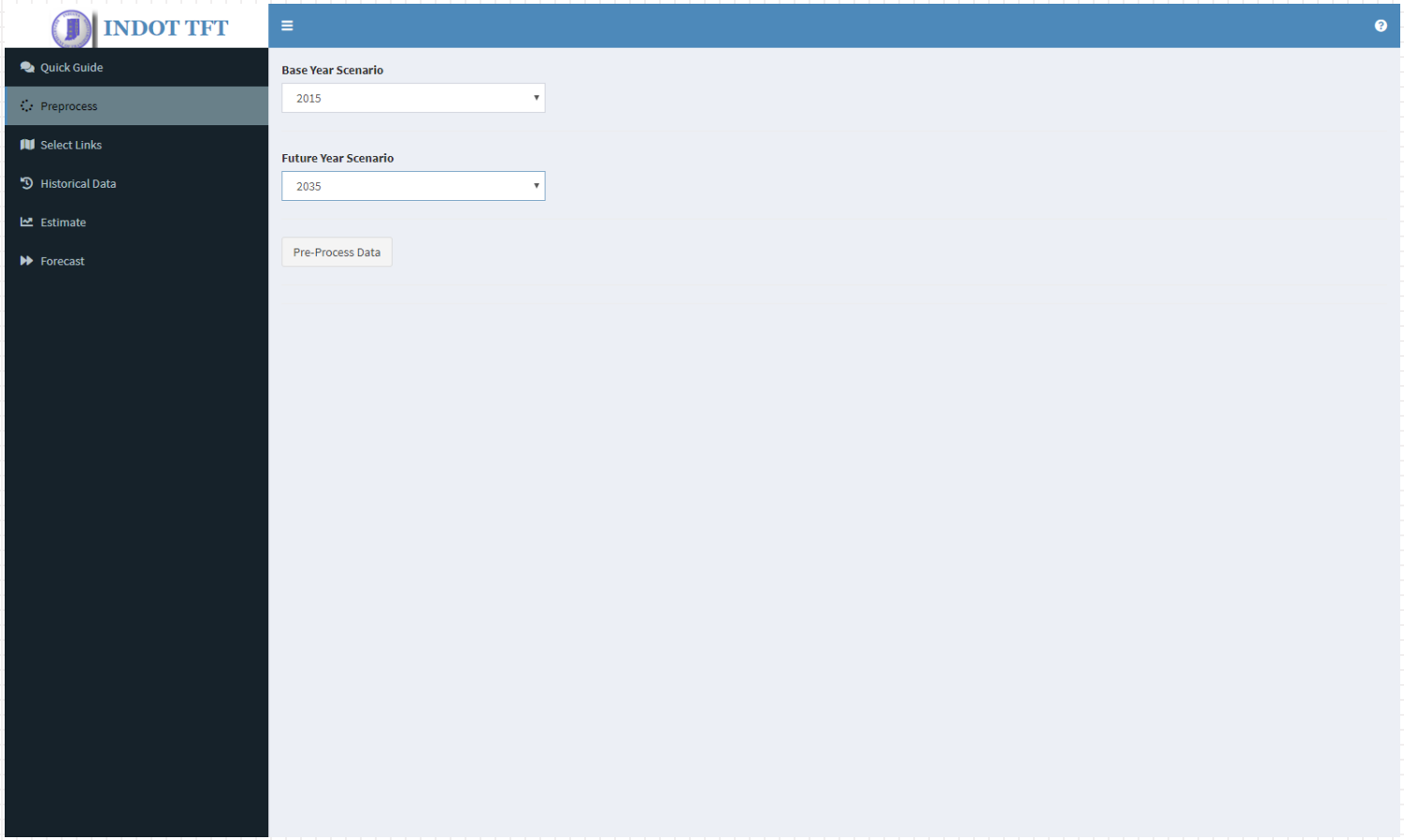
- **Brief step-by-step instructions on how to use the online tool (There will be detailed documentation on all the steps and analysis of the outputs)**



“Preprocess” Tab

Select desired base and future year scenarios

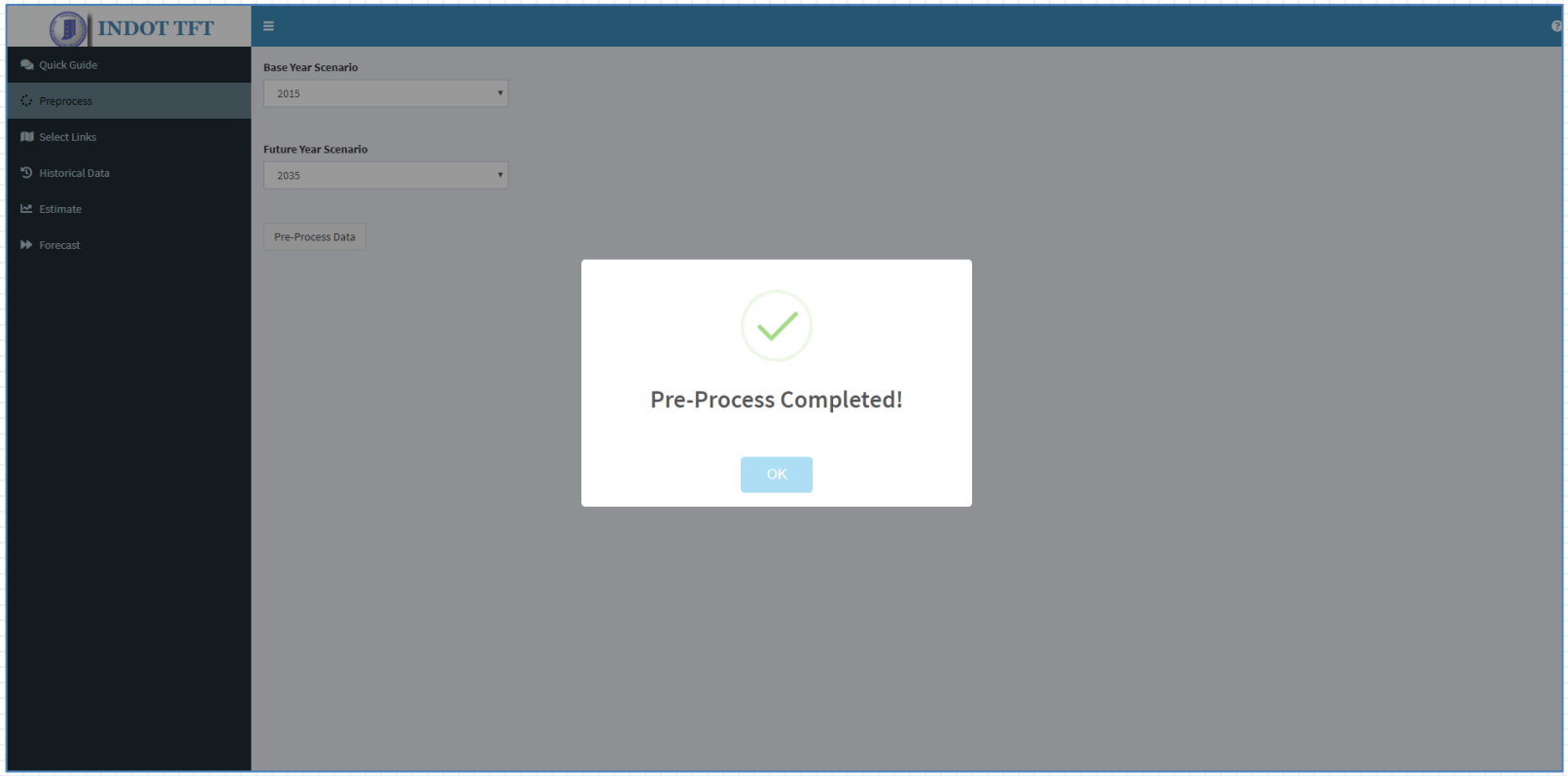
- **Note that additional scenarios can only be added by the admin**



“Preprocess” Tab (cont.)

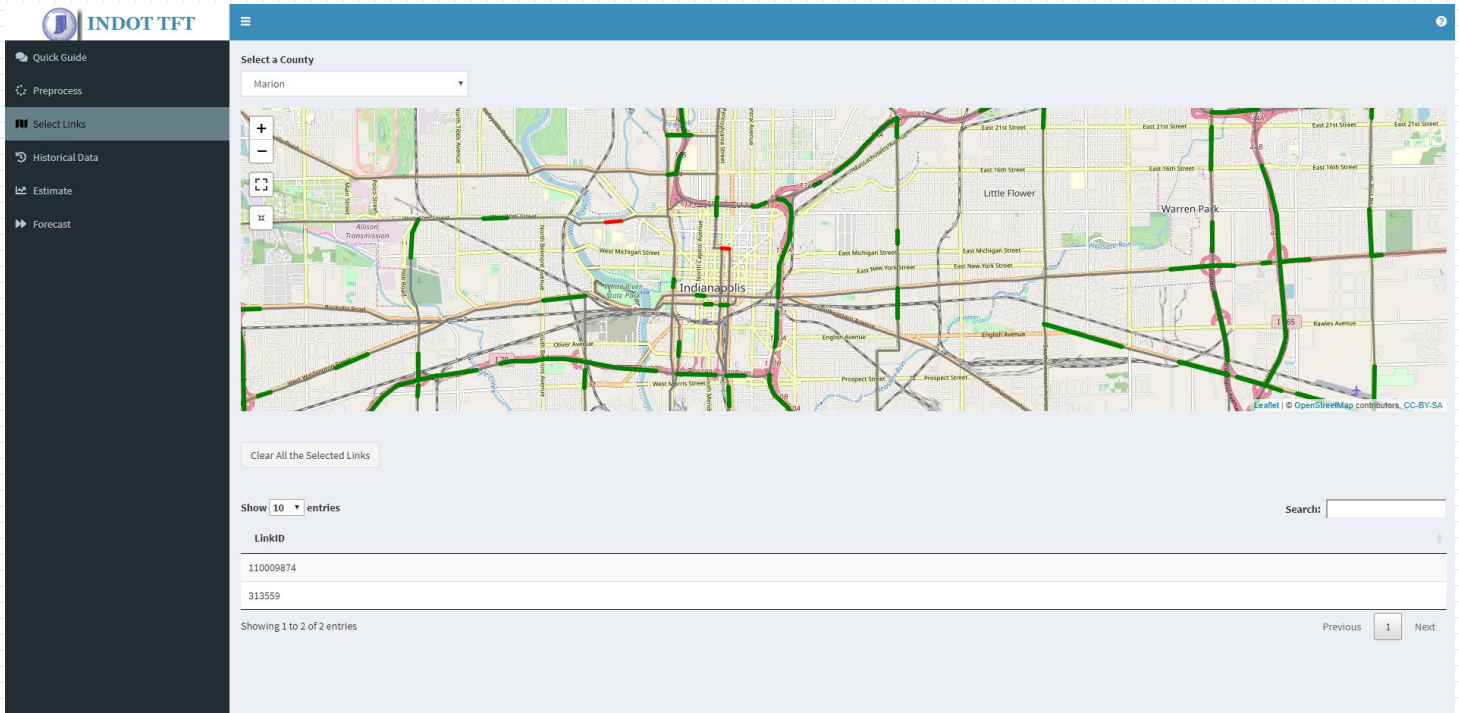
Click “Pre-process Data” button to process data for each link:

- Estimate capacities by LOS
- Join Base Year model network with historical traffic counts and the future link volume data
- A message will pop up to confirm the completion of pre-processing data.



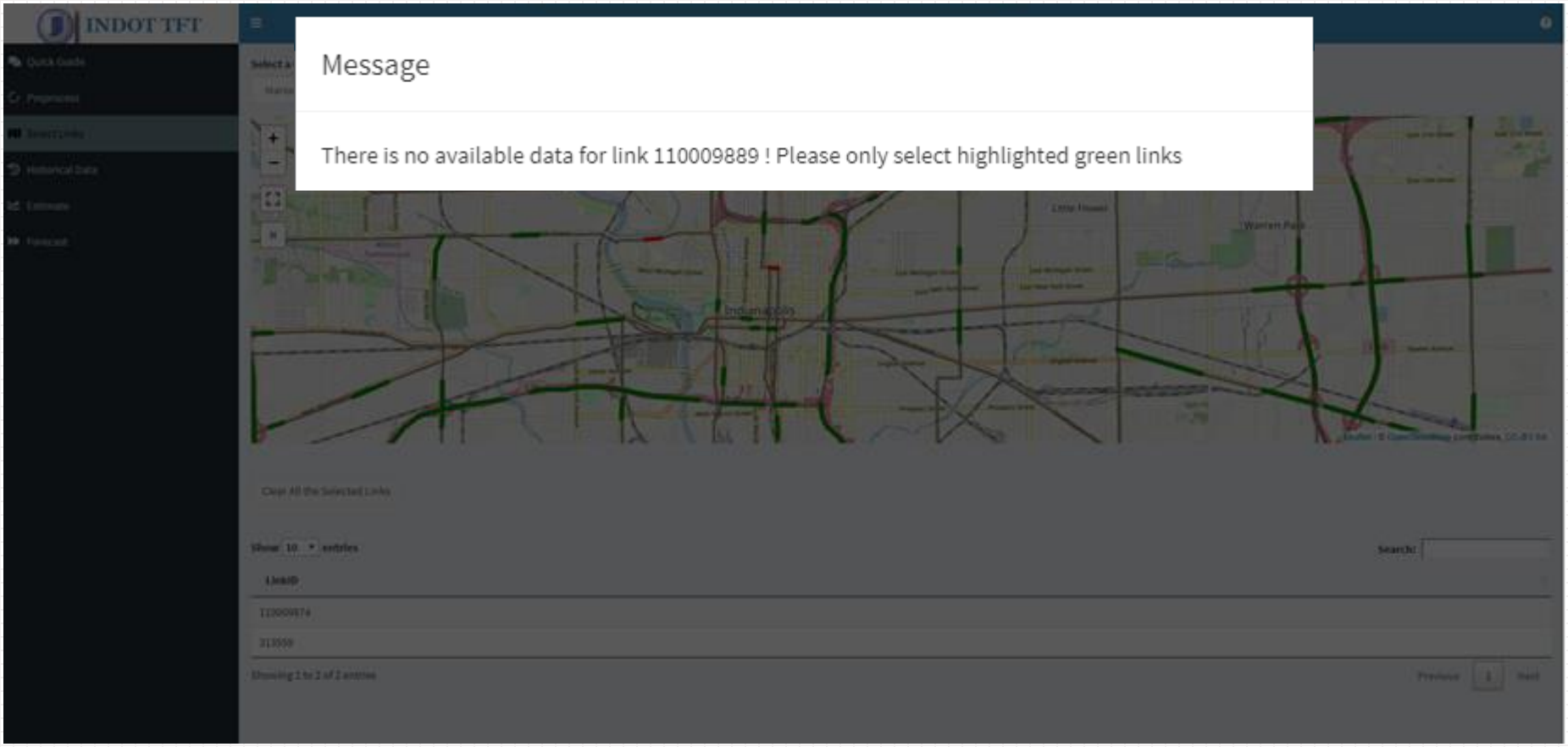
“Select Links” Tab (cont.)

- *It may take up to a minute or two for the map to load! Do not switch among tabs before the map is loaded*
- A dropdown menu is provided for easier navigation through the network by choosing the County where desired roadway exists
- The highlighted green links are the ones with available historical count data (the final version will cover all state-owned roads)
- Once clicked, the link will be highlighted red and link ID of the selected link will be displayed at the bottom of the page



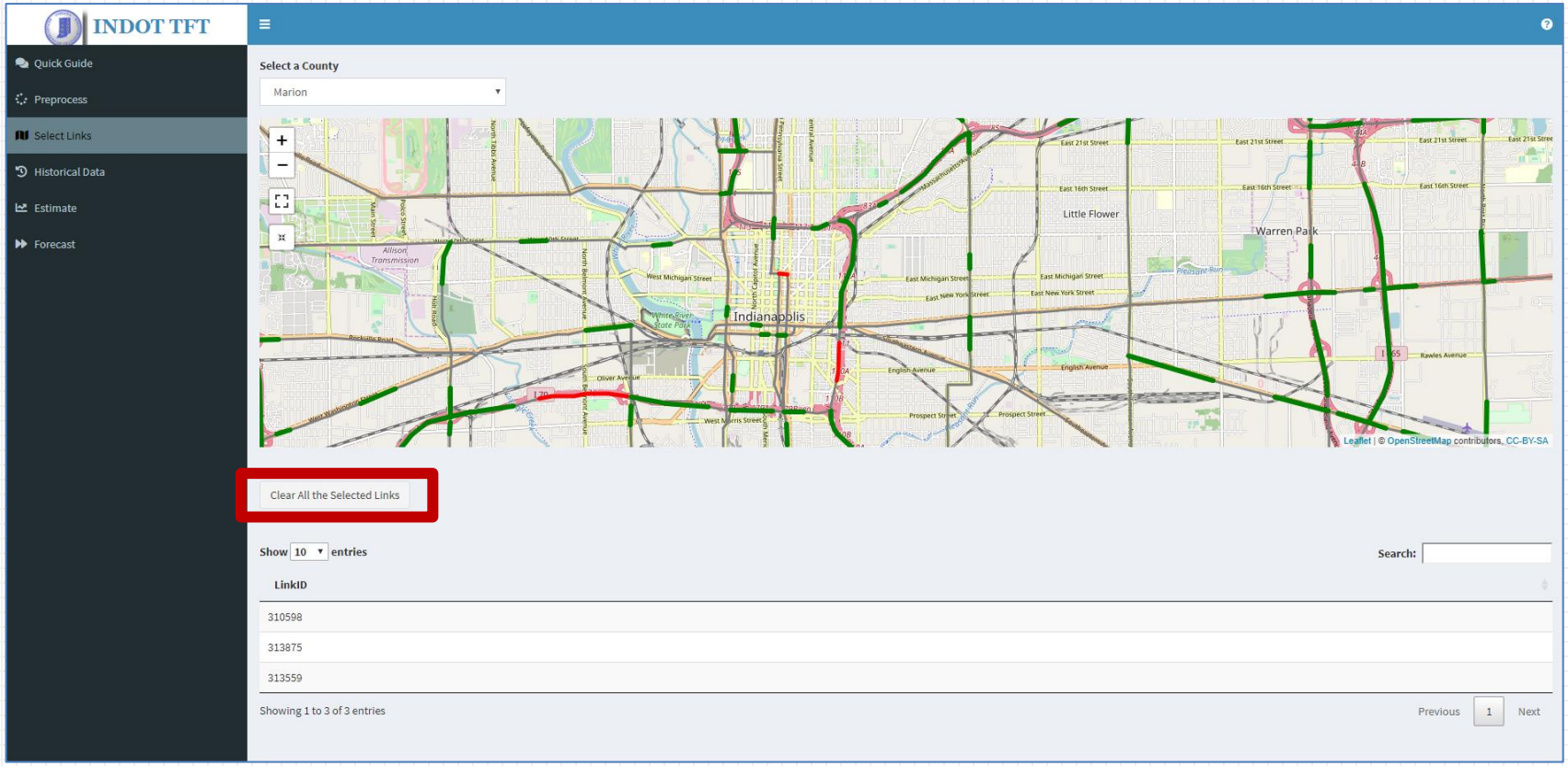
“Select Links” Tab (cont.)

- Clicking the non-highlighted links will trigger a warning message



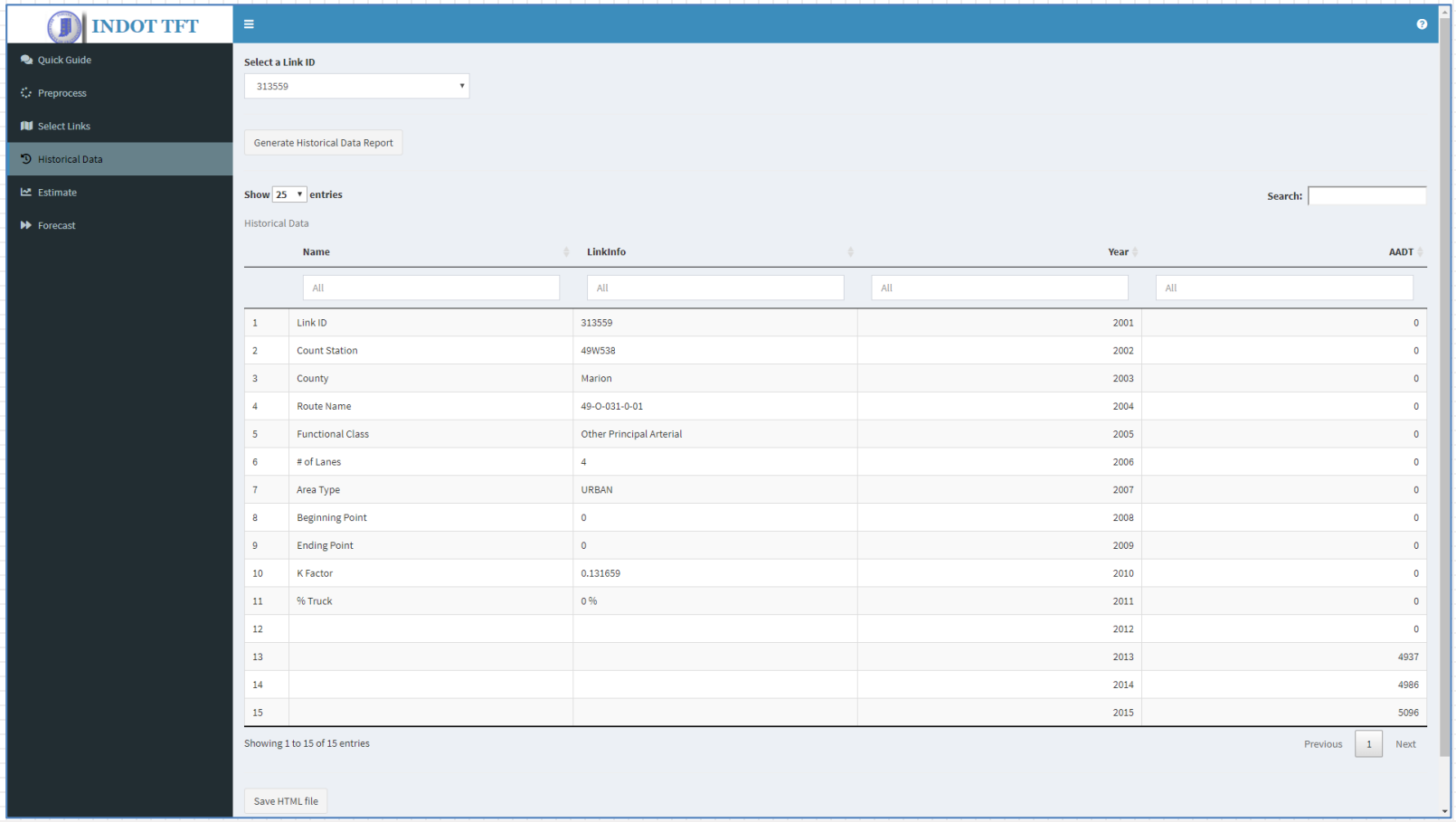
“Select Links” Tab (cont.)

- Selected links can be individually unselected by re-clicking them or can be unselected all at once by clicking the “Clear All Selected Links” button



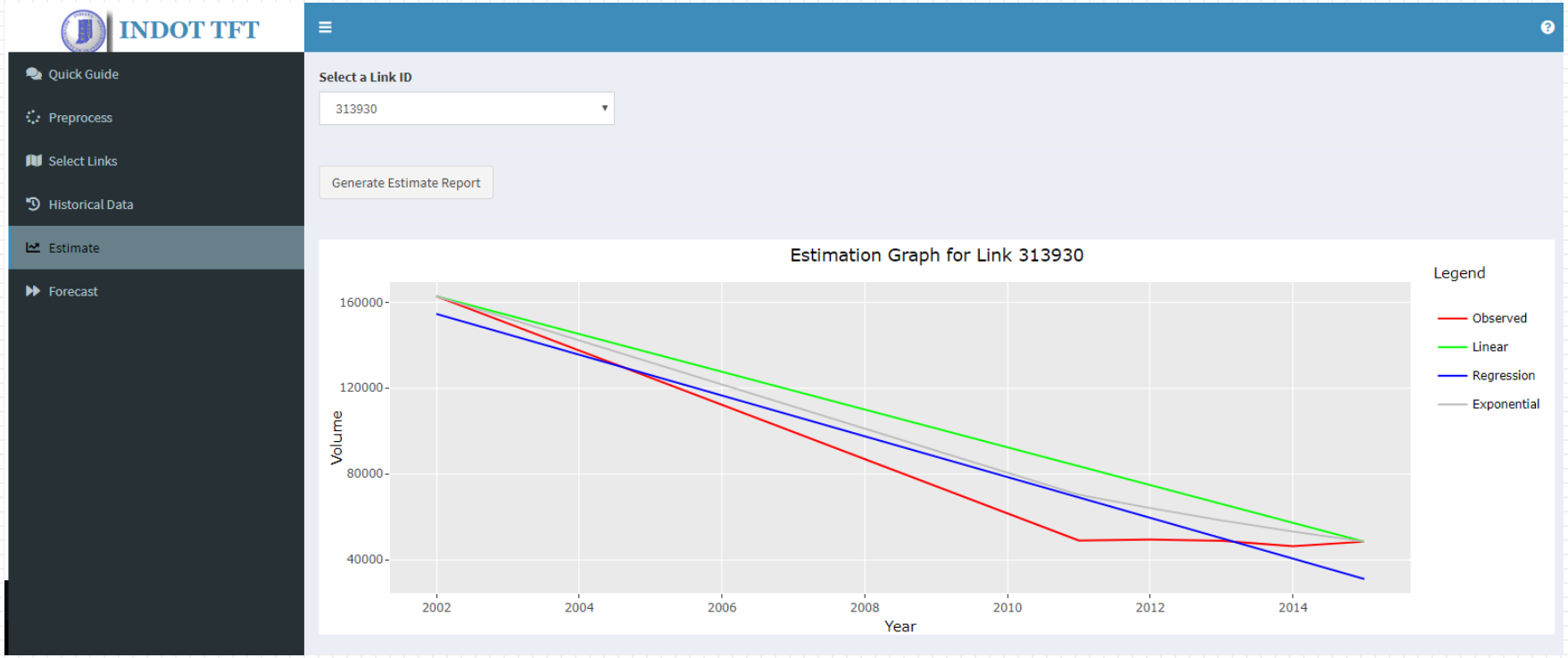
“Historical Data” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Historical Data Report” to generate the table with historical information



“Estimation” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Estimate Report” to generate the estimate graph and table



“Estimation” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Estimate Report” to generate the estimate graph and table

Show 25 entries

Search:

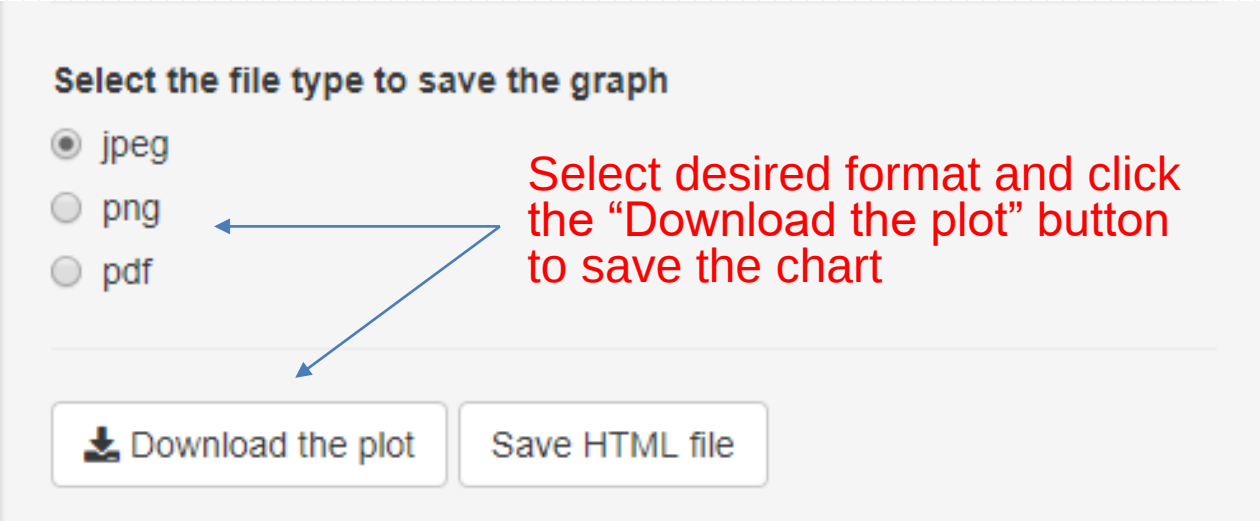
Estimation Data

	Name	LinkInfo	Estimation	History	ISTDM
	All	All	All	All	All
1	Link ID	313930	--Linear--	--Linear--	--Linear--
2	Count Station	971332	Estimated Line	Y = 162850 -8803.00 (X - 2002)	Y = 116486.99 + 17.21 (X - 2015)
3	County	Marion	R-Square	90.48 %	N/A
4	Route Name	49-I-065-0-01			
5	Functional Class	Interstate	--Regression--	--Regression--	--Regression--
6	# of Lanes	8	Estimated Line	Y = 19183365.1 -9504.88 X	Y = 81814.65 + 17.21 X
7	Area Type	URBAN	R-Square	91.66 %	N/A
8	Beginning Point	10.45			
9	Ending Point	10.95	--Exponential--	--Exponential--	--Exponential--
10	K Factor	0.111967	Estimated Line	Y = 162850 (1 -8.909%)^n	Y = 116486.99 (1 + 0.015%)^n
11	% Truck	15.209 %	R-Square	89.43 %	N/A
12	ISTDM Base Volume	116487	Annual Growth Rate	-8.909%	0.015%
13	ISTDM Future Volume	116831	Annual Growth Rate - adj.	1.038%	1.038%

“Estimation” Tab (cont.)

“Report and Graph” HTML Report

- Download Estimation Graphs (By default will be saved under the browser’s main download folder)
  - Static jpg, png, or pdf file



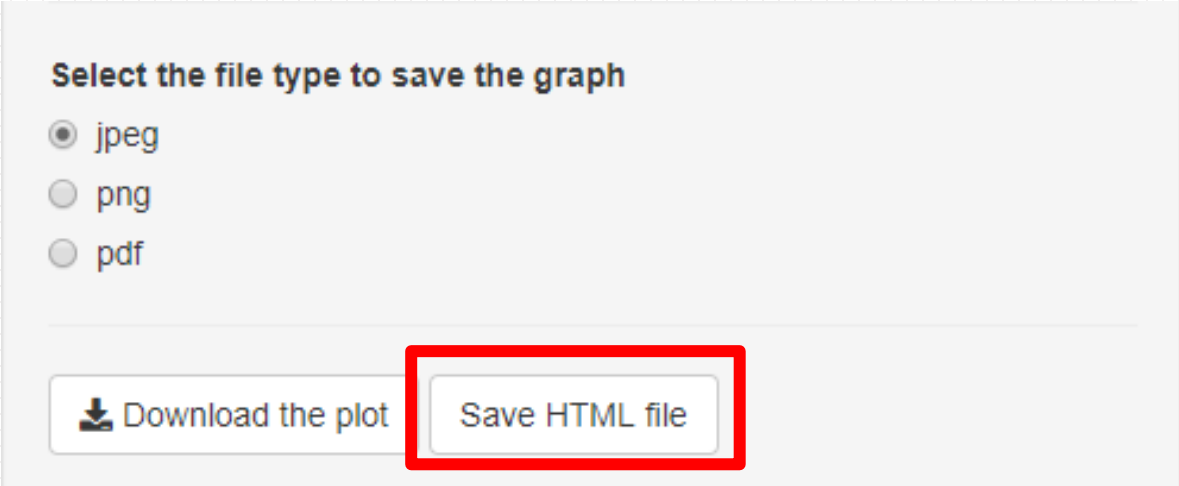
Select desired format and click the “Download the plot” button to save the chart

“Estimate Graphs – Link XXX.jpg” →XXX is the link ID

“Estimation” Tab (cont.)

“Report and Graph” HTML Report

- Save the entire HTML file to Dropbox
  - The saved HTML file has live charts and can be shared with others (they only need a web browser to open the file)

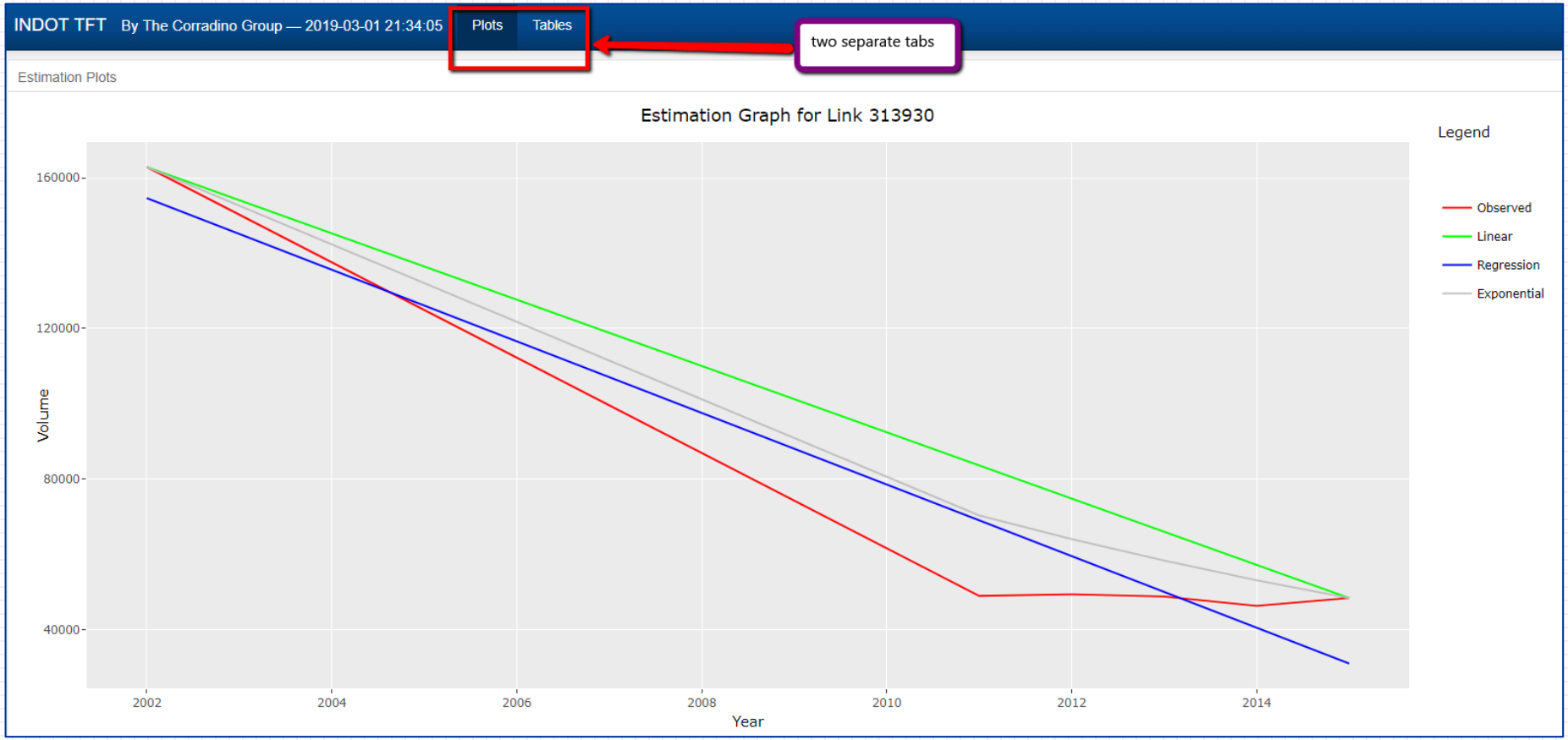


“EstimateReport_ LinkXXX.html”→XXX is the link ID

“Estimation” Tab (cont.)

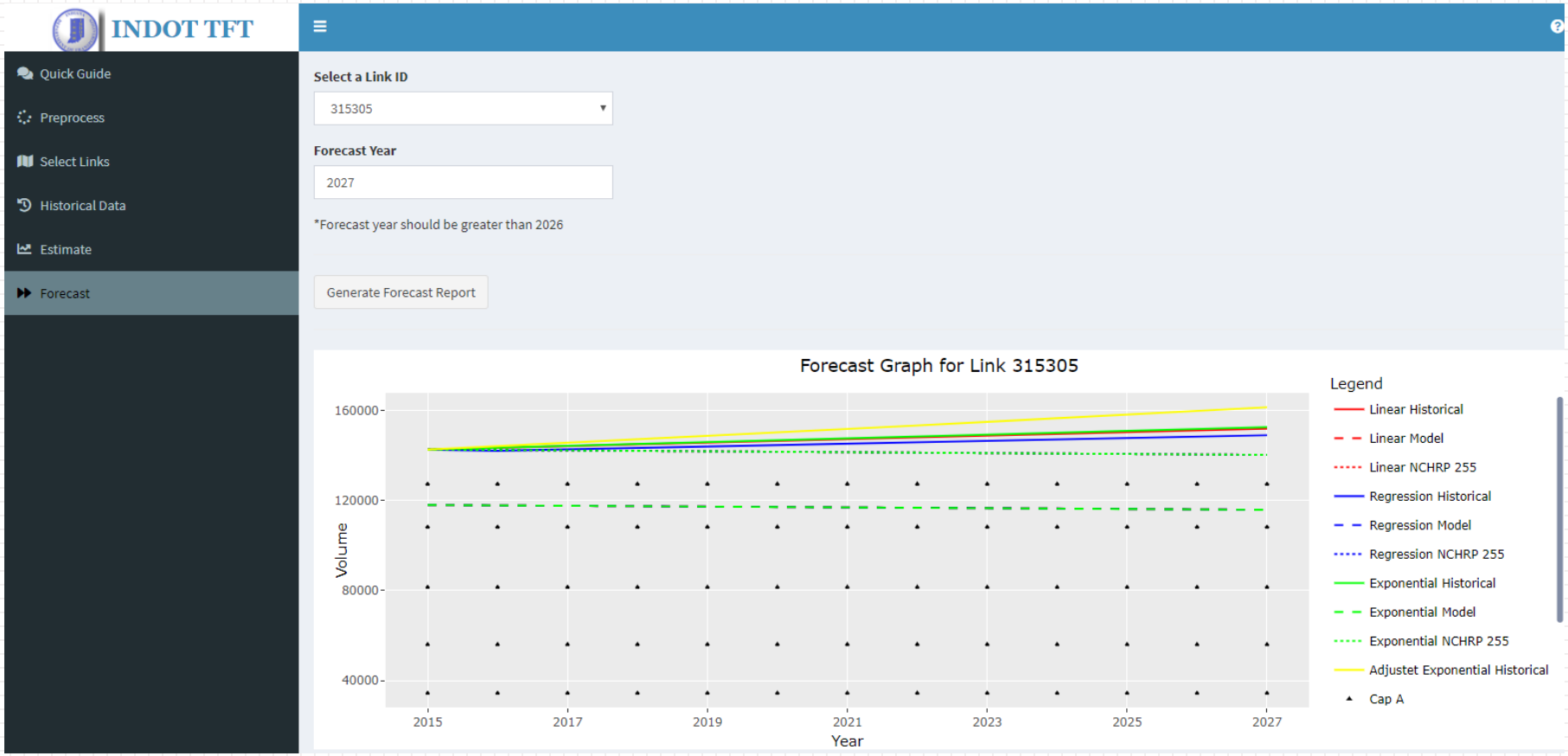
“Report and Graph” HTML Report

- Saved HTML file inside Dropbox folder (still “live” plots)



“Forecast” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Forecast Report” to generate the forecast graph and table



“Forecast” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Forecast Report” to generate the forecast graph and table

Show 25 entries

Search:

Forecast Data

	Name	LinkInfo	Year	Lin_History	Lin_ISTDM	Lin_NCHRP_255	Break1	Reg_History	Reg_ISTDM	Reg_NCHRP_255	Break2	Exp_History	Exp_ISTDM	Exp_NCHRP_255	Break3	Exp_Adj_History
	All	All	All	All	All	All	All	All	All	All	All	All	All	All	All	All
1	Link ID	315305	2015	142678	118034	142678		142678	118034	142678		142678	118034	142678		142678
2	Count Station	971340	2016	143452	117857	142482		142129	117857	142482		143483	117855	142480		144159
3	County	Marion	2017	144227	117680	142287		142760	117680	142287		144293	117675	142281		145655
4	Route Name	49-I-065-0-01	2018	145001	117503	142091		143391	117503	142091		145108	117496	142083		147167
5	Functional Class	Interstate	2019	145776	117326	141896		144022	117326	141896		145927	117317	141886		148695
6	# of Lanes	8	2020	146550	117148	141699		144653	117148	141699		146751	117138	141688		150238
7	Area Type	URBAN	2021	147325	116971	141504		145285	116971	141504		147579	116960	141492		151798
8	Beginning Point	11.57	2022	148099	116794	141308		145916	116794	141308		148412	116782	141295		153373
9	Ending Point	11.8	2023	148874	116617	141113		146547	116617	141113		149250	116604	141098		154965
10	K Factor	0.087136	2024	149648	116439	140916		147178	116439	140916		150093	116426	140902		156574
11	% Truck	10.54 %	2025	150423	116262	140721		147809	116262	140721		150940	116249	140706		158199
12	ISTDM Base Volume	118034	2026	151197	116085	140525		148440	116085	140525		151792	116072	140511		159841
13	ISTDM Future Volume	114490	2027	151972	115908	140330		149072	115908	140330		152649	115895	140315		161501

Showing 1 to 13 of 13 entries

Previous 1 Next

Select the file type to save the graph

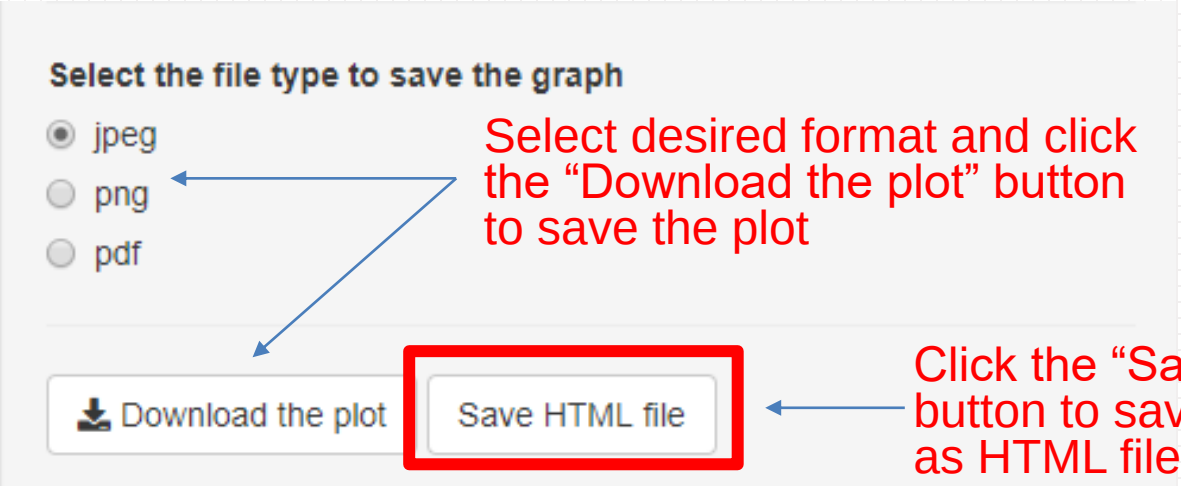
- jpeg
- png
- pdf

Download the plot | Save HTML file

“Forecast” Tab (cont.)

“Report and Graph” HTML Report

- Download forecasting plot as .JPG, PNG, or PDF
- Save the entire HTML file (inside Dropbox folder)



Select desired format and click the “Download the plot” button to save the plot

Click the “Save HTML file” button to save the entire report as HTML file

“ForecastReport_ LinkXXX_.html”→XXX is the link ID

Acknowledgements

- **Johnny Han (**jhan@corradino.com**) – Corradino Indianapolis.**
- **Roy Nunnally, Greg Katter, Korey Chu – Indiana DOT**

Questions ?