Hydrology Calibration with PRISM

Mindy Ramsey
TMDL Program Manager, WVDEP- DWWM
Watershed Assessment Branch, 601 57th Street SE,
Charleston, WV 25304
Mindy.S.Ramsey@wv.gov, 304.926.0499 x1063

ACKNOWLEDGMENT

TETRA TECH, INC.

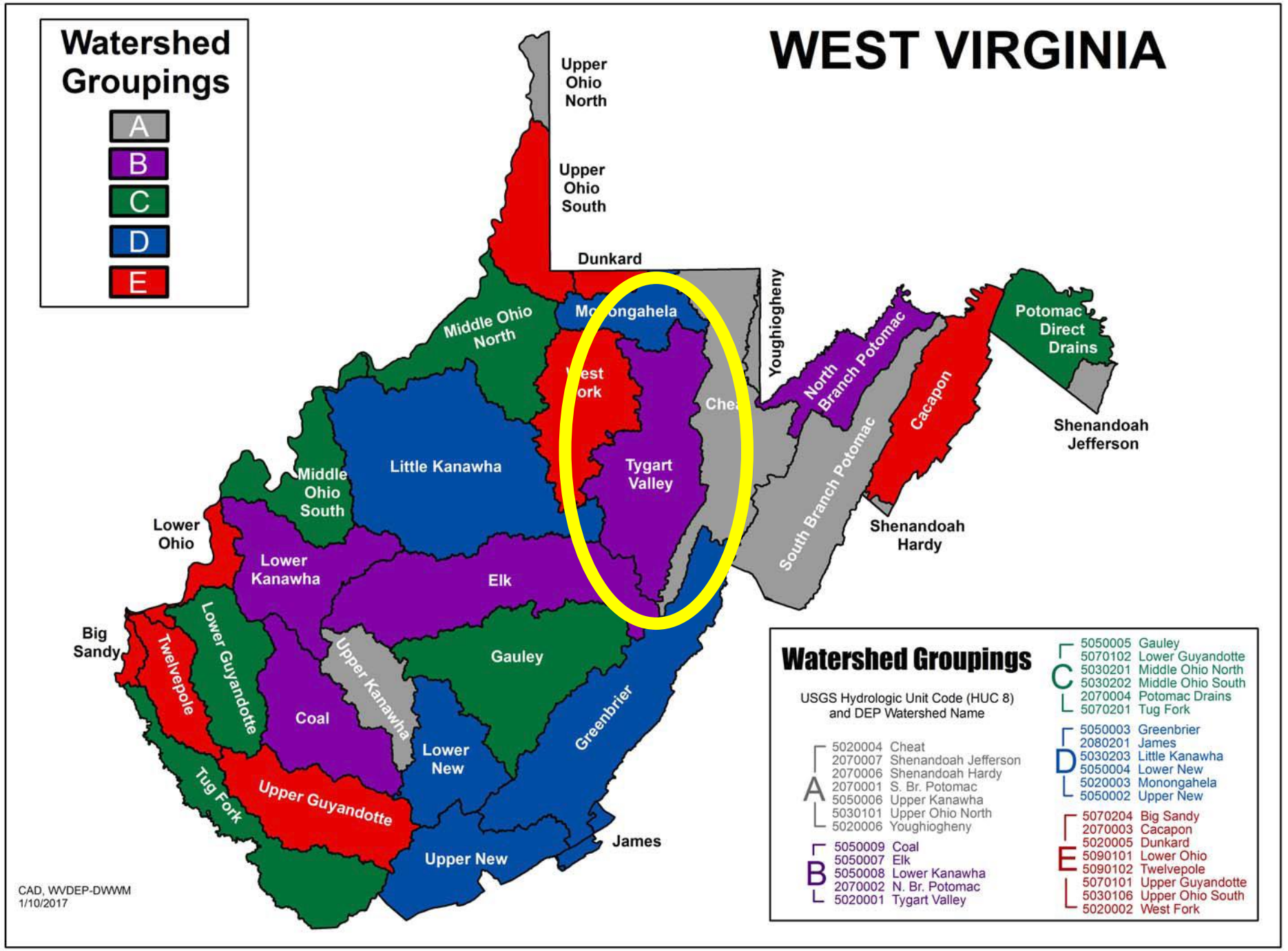
- Mustafa Faizullabhoy, PE
- John Beckman

WVDEP TMDL Program

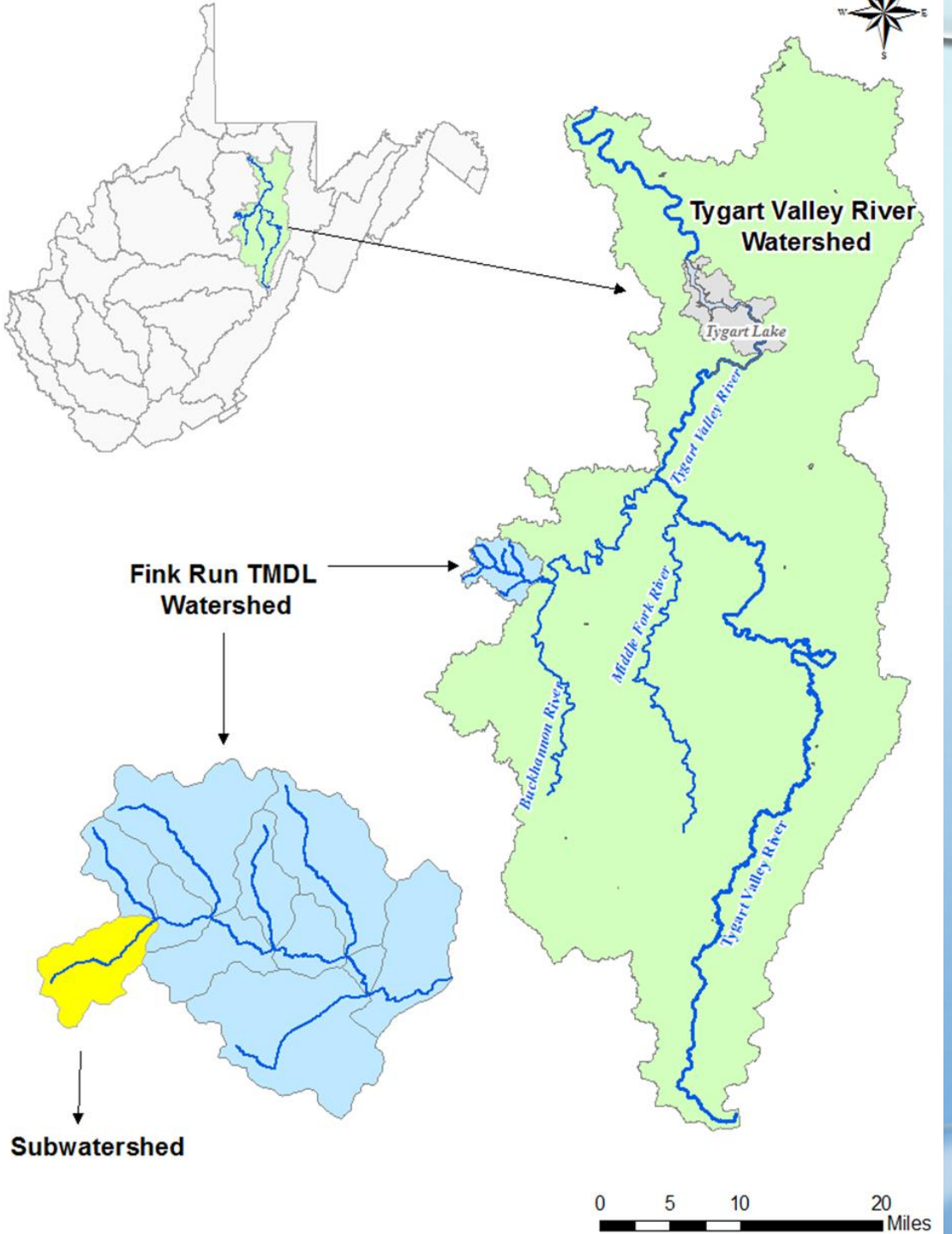
- Consent Decree late1990's ⇨ WV TMDL Program ⇨ 5,000+ EPA Approved TMDLs
  - Fecal coliform
  - Total iron and sediment
  - pH/dissolved aluminum
  - selenium, chloride, manganese
- Watershed Framework – Assessment/TMDL development on 8-digit HUC
  - Average 300 Pre-TMDL Monitoring Stations/Year
- Subwatershed delineation

WATERSHED GROUPINGS

- Tygart Valley River Watershed

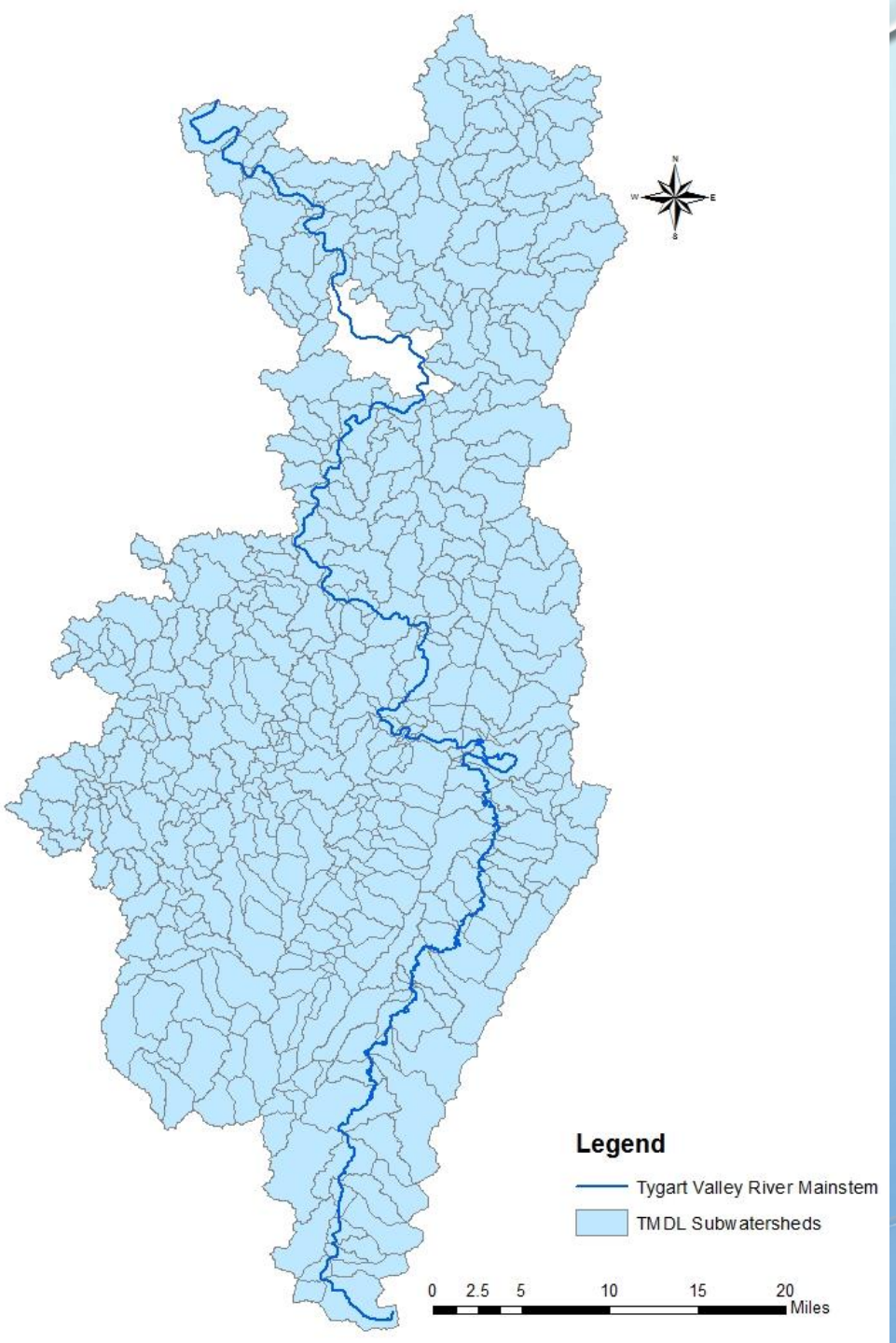


SUBWATERSHEDS



SUBWATERSHEDS

- 520 in Tygart Valley River
- Flow South to North
- 1,375 square miles
- Elevation 4,746 feet – 863 feet



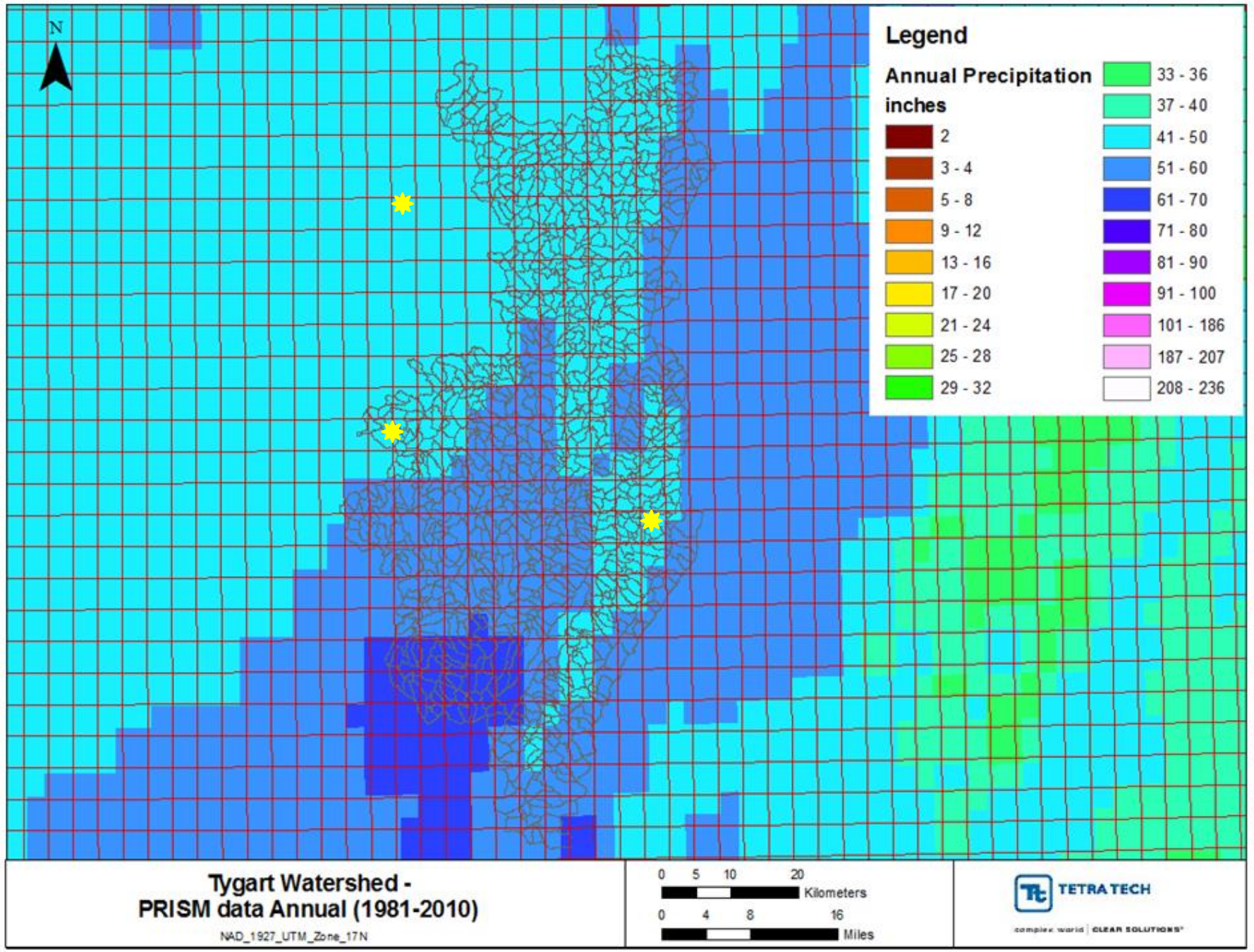
WATERSHED MODEL

- Load Simulation Program C++ (LSPC) – dynamic watershed model
  - Simulate watershed hydrology and pollutant transport
  - Flow / water budget (infiltration, runoff, evapotranspiration, snow)
  - Pervious / Impervious land uses
  - Instream water quality
  - Pollutant behavior (e.g., pH <> Metals, decay rates, build up/wash off)
  - DRIVEN BY WEATHER FILES

WEATHER FILES

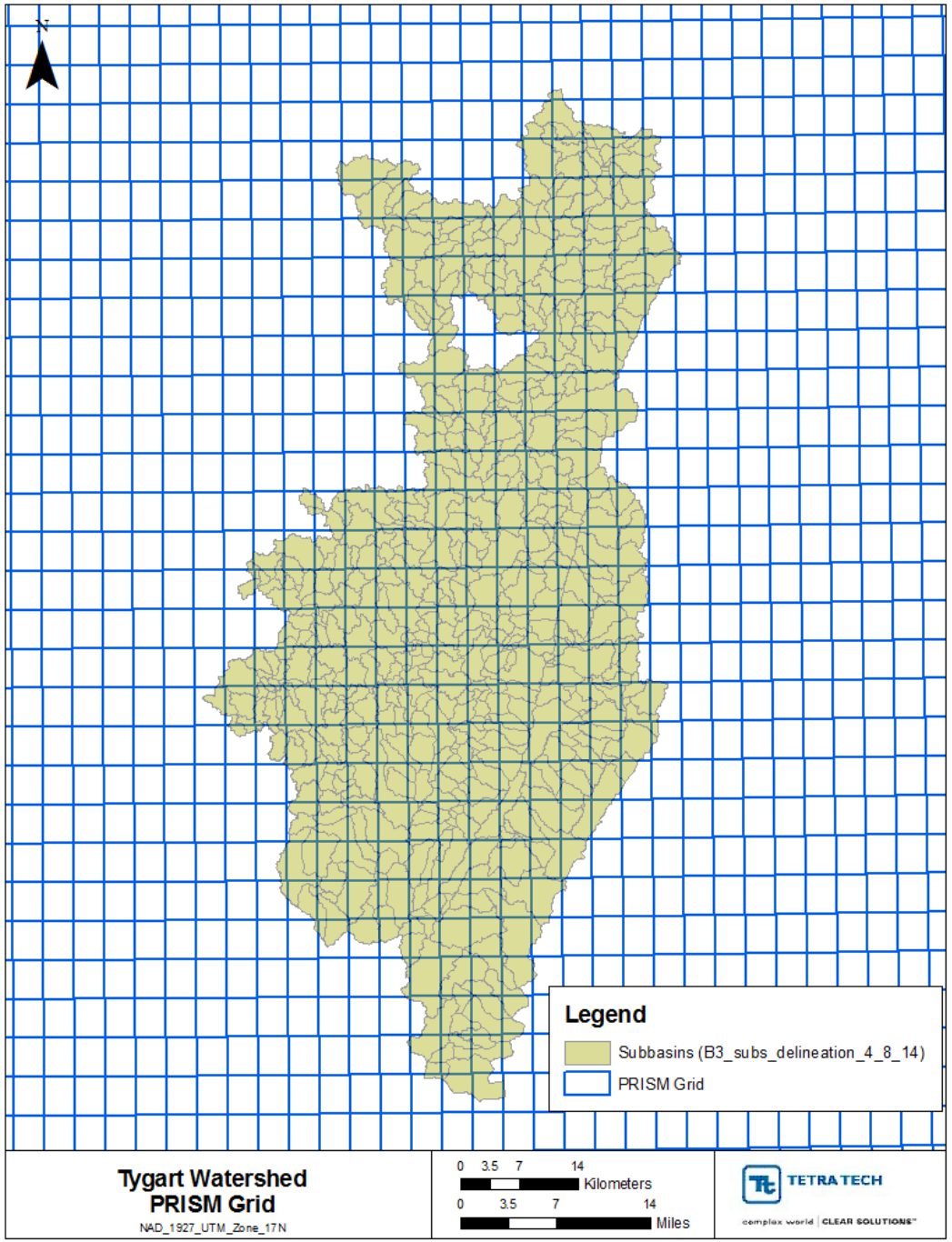
- Traditionally used NOAA National Climatic Data Center weather stations – limitations:
  - Available long term data in watershed
  - Variation in weather for large watersheds
  - Artificially loading pollutants simultaneously
- PRISM- Oregon State University's PRISM Climate Group

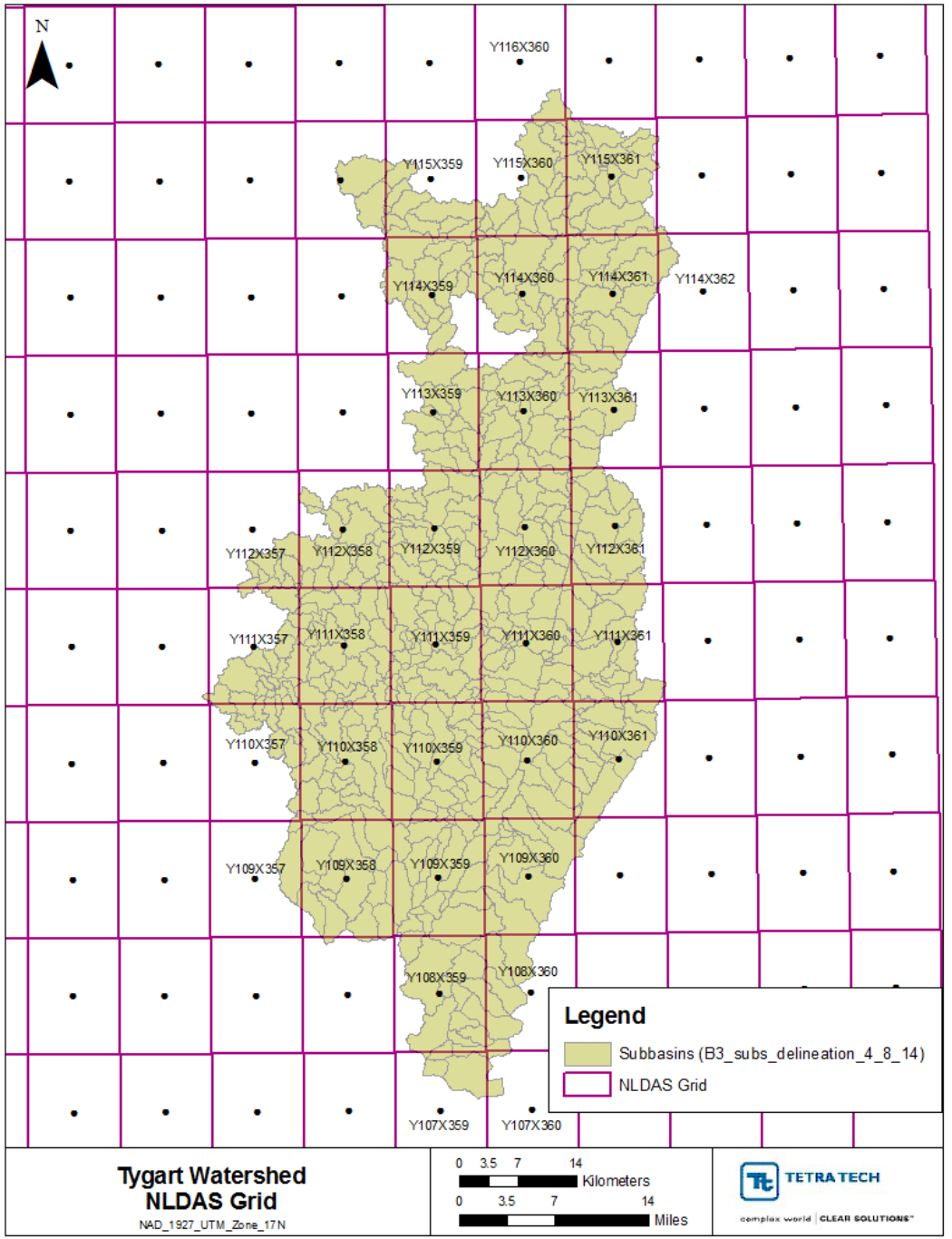
WEATHER STATIONS



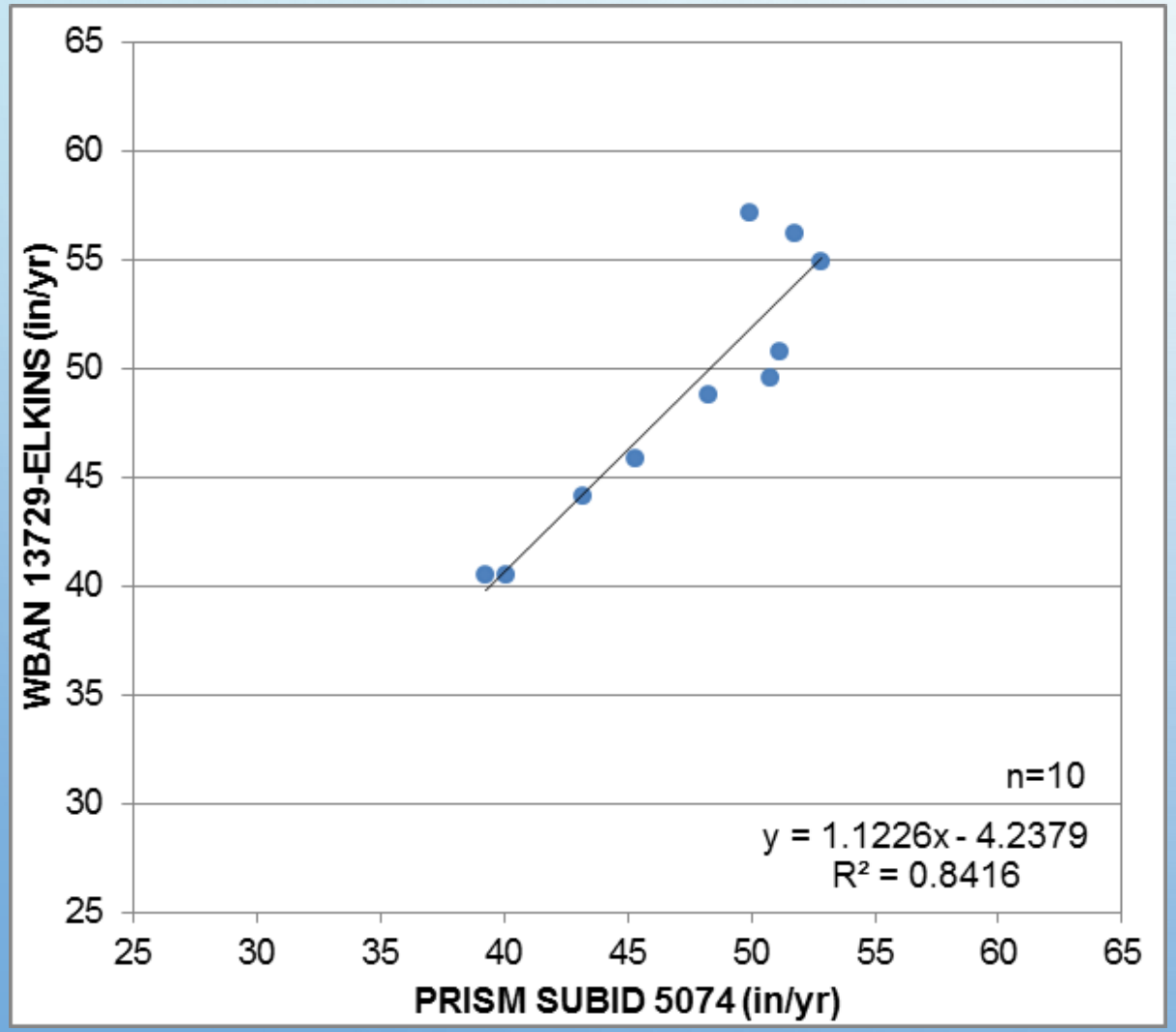
NATIONAL DATA SETS

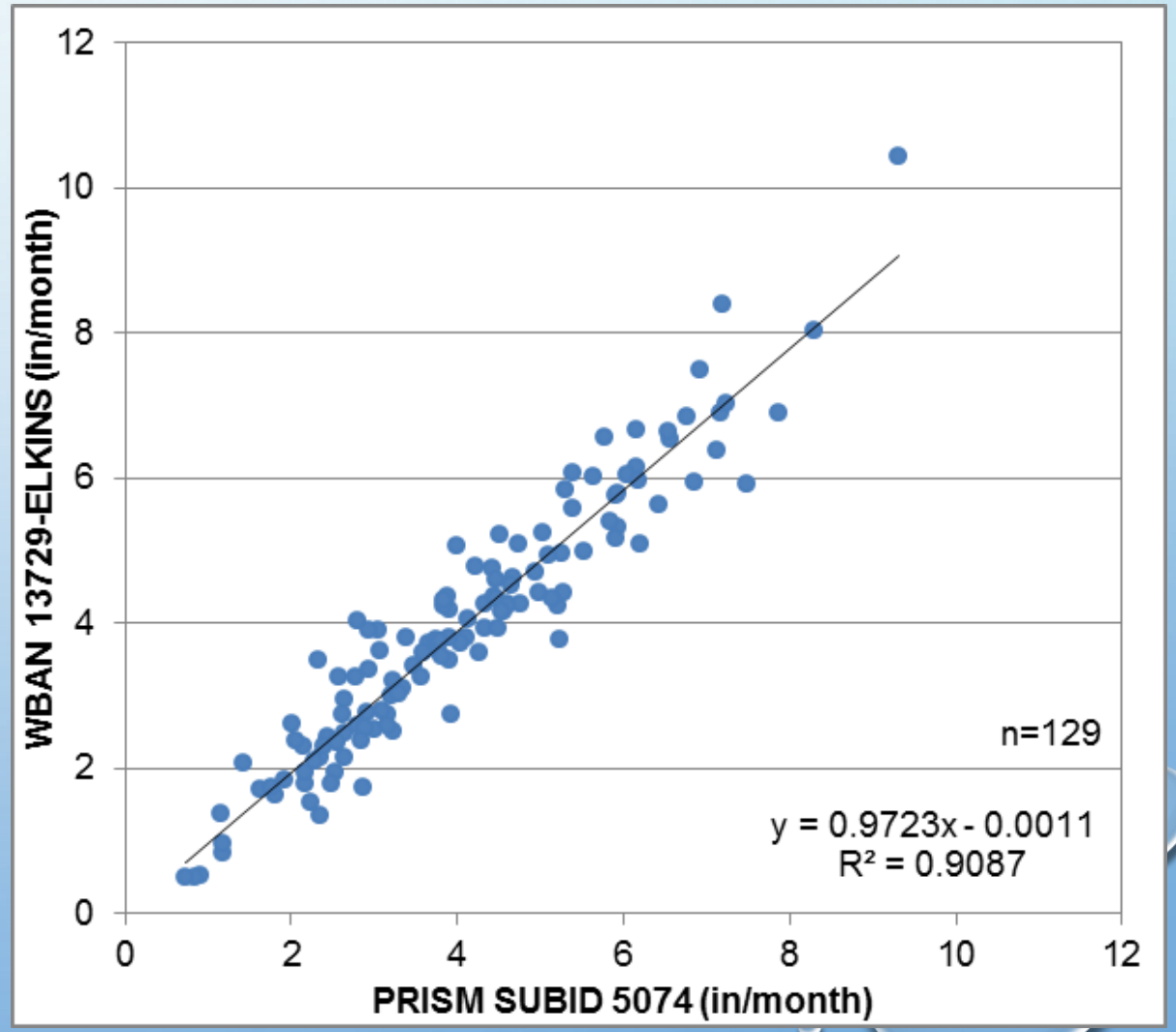
- PRISM Spatial Resolution: 4 km grid scale
- PRISM Temporal Resolution: Daily, weekly, monthly
- Data from North American Land Data Assimilation System (NLDAS-2) / NOAA Weather Stations
  - Rain gauge data + radar observations = precipitation, solar radiation, wind, humidity.
  - Hourly weather on a 12 km grid scale
- Disaggregate 4 km daily to hourly informed by NLDAS-2
- Area weighted 4 km hourly to create weather file for each subwatersheds


N
Legend
Subbasins (B3_subs_delineation_4_8_14)
PRISM Grid
Tygart Watershed
PRISM Grid
NAD_1927_UTM_Zone_17N
0 3.5 7 14
Kilometers
0 3.5 7 14
Miles
TETRA TECH
complex world | CLEAR SOLUTIONS™


N
Y116X360
Y115X359
Y115X360
Y115X361
Y114X359
Y114X360
Y114X361
Y114X362
Y113X359
Y113X360
Y113X361
Y112X357
Y112X358
Y112X359
Y112X360
Y112X361
Y111X357
Y111X358
Y111X359
Y111X360
Y111X361
Y110X357
Y110X358
Y110X359
Y110X360
Y110X361
Y109X357
Y109X358
Y109X359
Y109X360
Y108X359
Y108X360
Y107X359
Y107X360
Legend
Subbasins (B3_subs_delineation_4_8_14)
NLDAS Grid
Tygart Watershed
NLDAS Grid
NAD_1927_UTM_Zone_17N
0 3.5 7 14
Kilometers
0 3.5 7 14
Miles
TETRA TECH
complex world | CLEAR SOLUTIONS™

VALIDATION

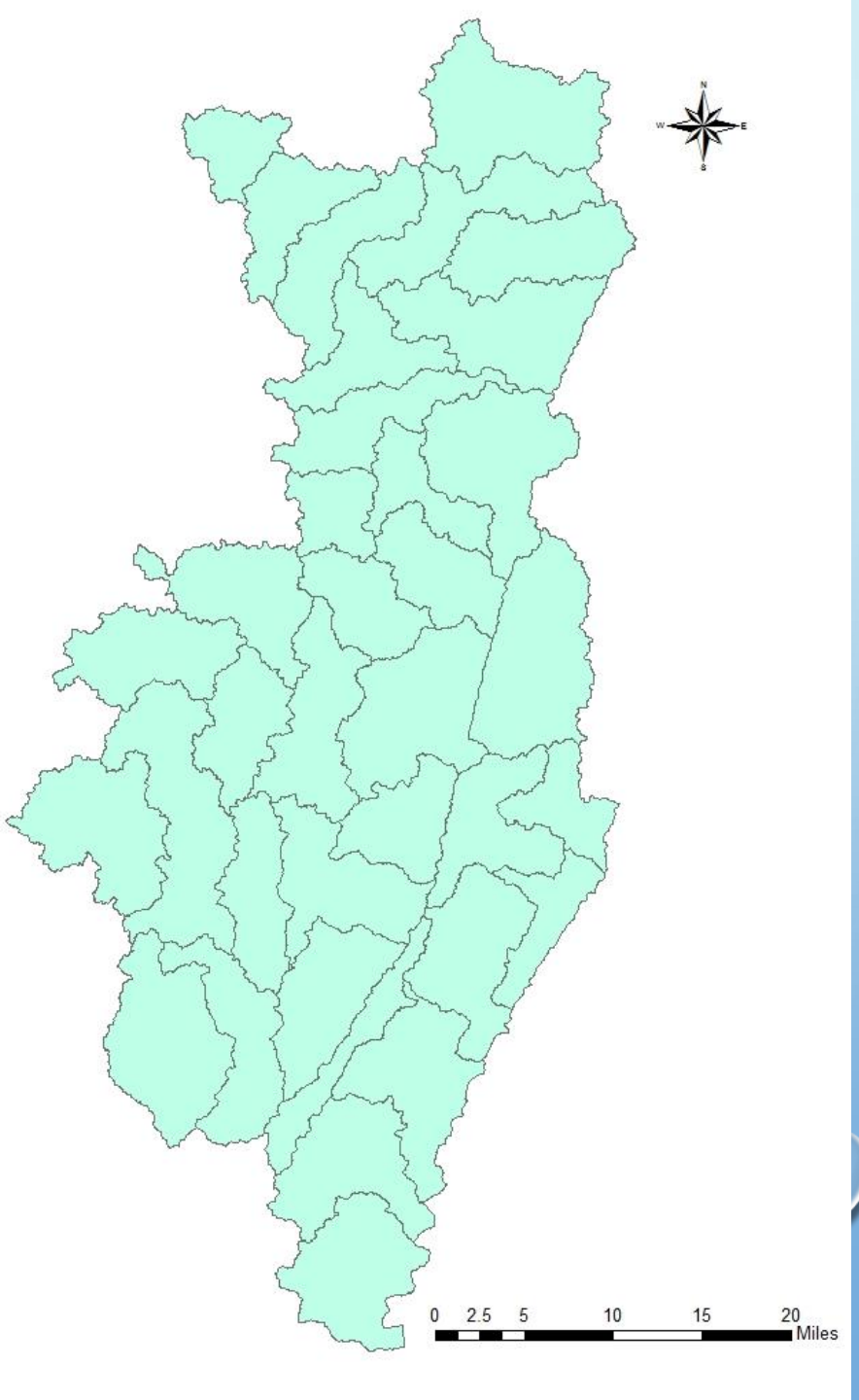

WBAN 13729-ELKINS (in/yr)
PRISM SUBID 5074 (in/yr)
n=10
y = 1.1226x - 4.2379
R² = 0.8416


WBAN 13729-ELKINS (in/month)
PRISM SUBID 5074 (in/month)
n=129
y = 0.9723x - 0.0011
R² = 0.9087

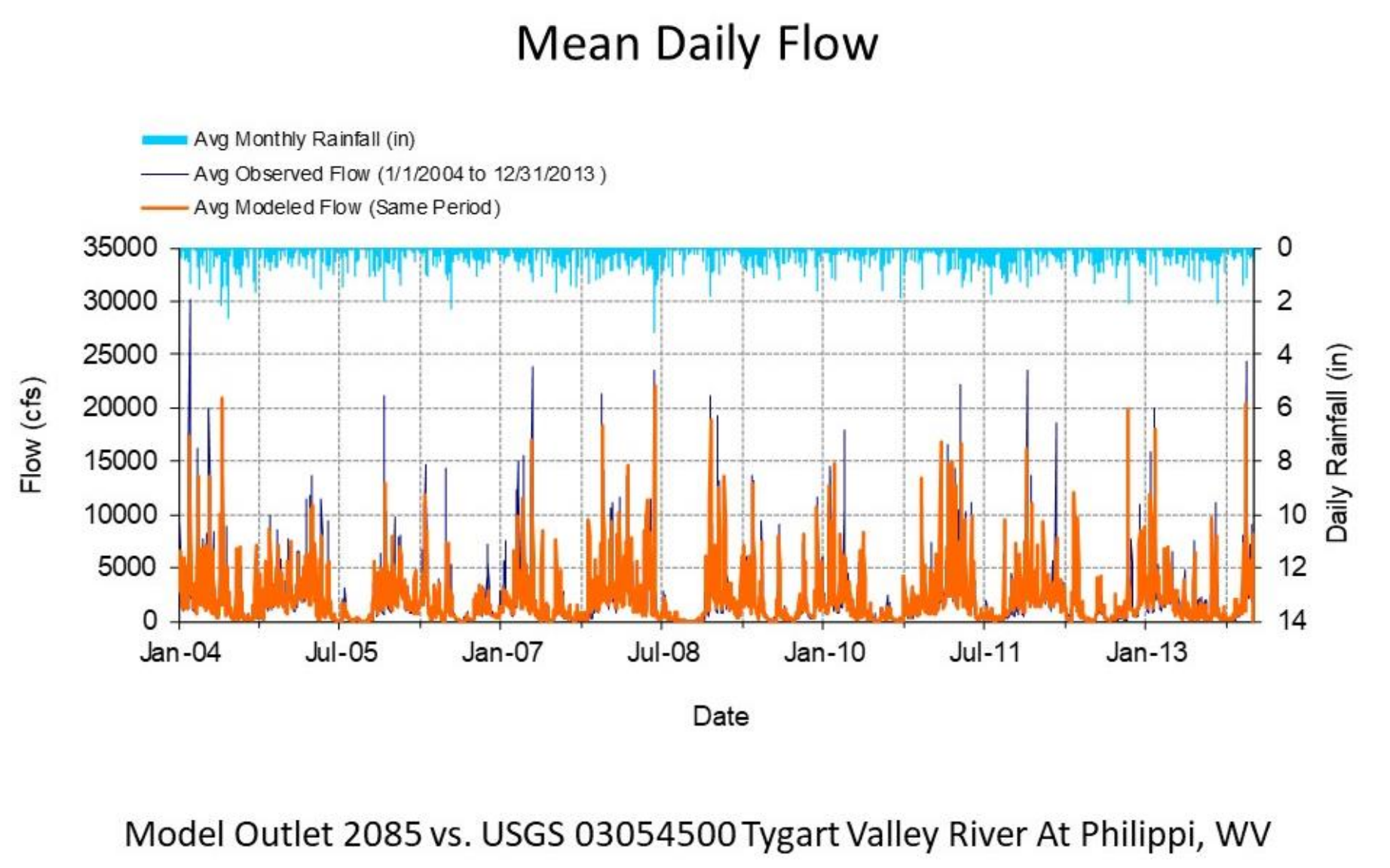
- Weather file for each 520 Subwatersheds
  - Model / hardware limit around 250 weather files

- Representative weather file on 12-digit HUC resolution

- 36 individual weather files



HYDROLOGY CALIBRATION ACCURACY

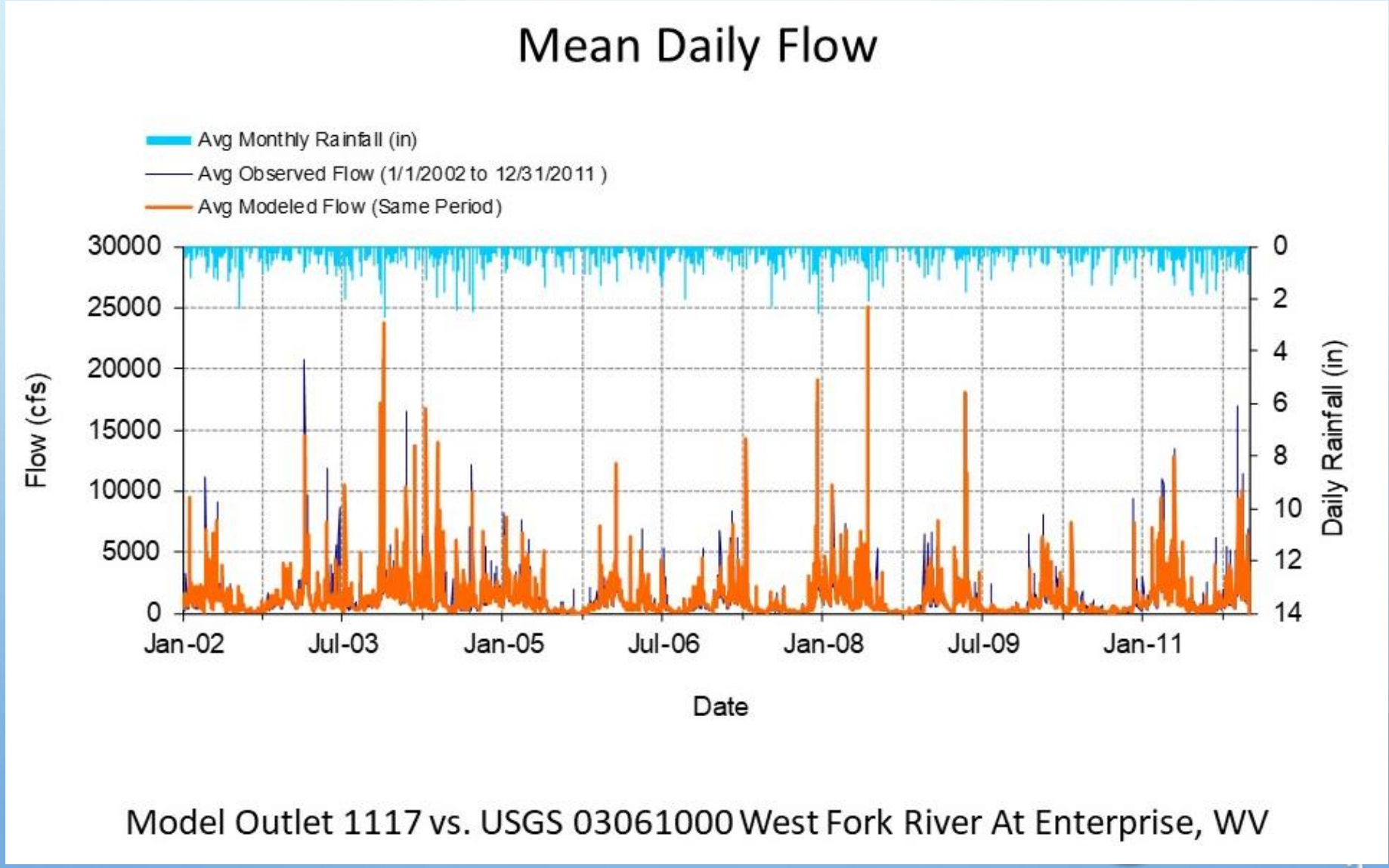


LSPC Simulated Flow		Observed Flow Gage	
REACH OUTFLOW FROM SUBBASIN 2085 10-Year Analysis Period: 1/1/2004 - 12/31/2013 Flow volumes are (inches/year) for upstream drainage area		USGS 03054500 TYGART VALLEY RIVER AT PHILIPPI, WV Hydrologic Unit Code: 5020001 Latitude: 39.15037545 Longitude: -80.038691 Drainage Area (sq-mi): 914	
Total Simulated In-stream Flow:	**29.42**	Total Observed In-stream Flow:	**29.19**
Total of simulated highest 10% flows:	**11.59**	Total of Observed highest 10% flows:	**12.50**
Total of Simulated lowest 50% flows:	**3.49**	Total of Observed Lowest 50% flows:	**3.33**
Simulated Summer Flow Volume (months 7-9):	**2.42**	Observed Summer Flow Volume (7-9):	**2.22**
Simulated Fall Flow Volume (months 10-12):	**8.02**	Observed Fall Flow Volume (10-12):	**7.12**
Simulated Winter Flow Volume (months 1-3):	**11.60**	Observed Winter Flow Volume (1-3):	**11.60**
Simulated Spring Flow Volume (months 4-6):	**7.38**	Observed Spring Flow Volume (4-6):	**8.24**
Total Simulated Storm Volume:	**15.09**	Total Observed Storm Volume:	**14.49**
Simulated Summer Storm Volume (7-9):	**1.40**	Observed Summer Storm Volume (7-9):	**1.27**

Errors (Simulated-Observed)	*Error Statistics*
Error in total volume:	0.81
Error in 50% lowest flows:	4.96
Error in 10% highest flows:	-7.33
Seasonal volume error - Summer:	8.84
Seasonal volume error - Fall:	12.61
Seasonal volume error - Winter:	-0.01
Seasonal volume error - Spring:	-10.39
Error in storm volumes:	4.11
Error in summer storm volumes:	10.03

Nash-Sutcliffe Coefficient of Efficiency, E:	0.669	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.567	as E or E' approaches 1.0	

CALIBRATION WITH ONE WEATHER FILE



LSPC Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM SUBBASIN 1117		USGS 03061000 WEST FORK RIVER AT ENTERPRISE, WV		
10-Year Analysis Period: 1/1/2002 - 12/31/2011 Flow volumes are (inches/year) for upstream drainage area		Hydrologic Unit Code: 5020002 Latitude: 39.42230818 Longitude: -80.2759187 Drainage Area (sq-mi): 759		
Total Simulated In-stream Flow:	**21.46**	Total Observed In-stream Flow:		**21.25**
Total of simulated highest 10% flows:	**8.71**	Total of Observed highest 10% flows:		**8.94**
Total of Simulated lowest 50% flows:	**2.68**	Total of Observed Lowest 50% flows:		**2.59**
Simulated Summer Flow Volume (months 7-9):	**2.09**	Observed Summer Flow Volume (7-9):		**1.91**
Simulated Fall Flow Volume (months 10-12):	**5.25**	Observed Fall Flow Volume (10-12):		**5.04**
Simulated Winter Flow Volume (months 1-3):	**8.21**	Observed Winter Flow Volume (1-3):		**8.00**
Simulated Spring Flow Volume (months 4-6):	**5.91**	Observed Spring Flow Volume (4-6):		**6.30**
Total Simulated Storm Volume:	**10.09**	Total Observed Storm Volume:		**10.07**
Simulated Summer Storm Volume (7-9):	**1.01**	Observed Summer Storm Volume (7-9):		**1.00**
Errors (Simulated-Observed)	*Error Statistics*			
Error in total volume:	0.97			
Error in 50% lowest flows:	3.32			
Error in 10% highest flows:	-2.53			
Seasonal volume error - Summer:	9.14			
Seasonal volume error - Fall:	4.07			
Seasonal volume error - Winter:	2.70			
Seasonal volume error - Spring:	-6.20			
Error in storm volumes:	0.24			
Error in summer storm volumes:	1.38			
Nash-Sutcliffe Coefficient of Efficiency, E:	0.642	Model accuracy increases	0.578	0.704
Baseline adjusted coefficient (Garrick), E':	0.554	as E or E' approaches 1.0	0.506	0.599

LESSONS LEARNED

- One weather station: centralized, 2 dams w/high resolution flow data
- PRISM data preparation:
  - Process to disaggregate introduced error
  - Continual mist – change calibration parameter to address
  - Missing peak run-off events
  - Increases difficulty of water quality calibration
- Possible Solutions: remove erroneous data from NLDAS-2 or rely solely on NOAA weather stations to disaggregate PRISM daily

REFERENCES

NCAR (National Center for Atmospheric Research). 2013. NCAR Research Staff. Last modified 20 Nov 2013. Electronic source, available at https://climatedataguide.ucar.edu/climate-data/nldas-north-american-land-data-assimilation-system-monthly-climatologies , accessed May 11, 2015.

PRISM Climate Group. 2014. Oregon State University. Electronic source, available at http://prism.oregonstate.edu , accessed April 15, 2014.

West Virginia Department of Environmental Protection. 2016. Total Maximum Daily Loads for the Tygart Valley River Watershed, West Virginia, Technical Report. Available at http://www.dep.wv.gov/WWE/watershed/TMDL/grpb/Pages/default.aspx, accessed May 18, 2017