

IN THE SUPREME COURT OF PENNSYLVANIA

No. 159 MM 2017

LEAGUE OF WOMEN VOTERS OF PENNSYLVANIA, *et al.*,

Petitioners,

v.

THE COMMONWEALTH OF PENNSYLVANIA, *et al.*,

Respondents.

PETITIONERS' BRIEF IN SUPPORT OF PROPOSED REMEDIAL PLANS

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INTRODUCTION

Pursuant to this Court's January 22 and 26 Orders, Petitioners respectfully submit the two enclosed remedial districting plans. Both plans were generated by Petitioners' expert Dr. Chen using a computer algorithm and relying solely upon the traditional districting criteria of equal population, contiguity, compactness, and avoiding the division of political subdivisions. Dr. Kennedy, Petitioners' expert on Pennsylvania's political geography, has concluded that each of Petitioners' proposed plans preserves Pennsylvania's communities, and in fact stand out among Dr. Chen's simulated plans on this score. And Petitioners' experts Dr. Chen, Dr. Pegden, and Dr. Warshaw have concluded that neither of Petitioners' proposed plans exhibits partisan bias. Although Dr. Chen did not consider any partisan inputs in generating these plans, he has concluded that each plan produces an even 9-9 split in expected Republican and Democratic seats.

All of the information the Court requested about Petitioners' proposed remedial plans is set forth in Dr. Chen's supplemental report. As this information shows, both of Petitioners' proposed plans fully comply with this Court's directives for a valid districting plan, and either proposed plan would allow Pennsylvanians to cast ballots in congressional elections that are truly free and equal in accordance with the Pennsylvania Constitution.

By contrast, the Court should reject the plan proposed by the Legislative Respondents on February 9 (“Legislative Respondents’ February 9 Plan”). That plan was not considered, much less passed, by either chamber of the General Assembly. Nor was it signed by the Governor, who has rejected it. For good reason: Legislative Respondents’ February 9 Plan is a naked partisan gerrymander. According to Dr. Chen’s analysis, the number of seats Republicans would be expected to win under the plan is an extreme outlier compared to non-partisan plans. And Dr. Pegden has concluded with mathematical certainty that Legislative Respondents’ February 9 Plan reflects an intentional partisan gerrymander to favor Republicans.

Dr. Kennedy has concluded that Legislative Respondents’ February 9 Plan achieves its extreme pro-Republican advantage by subordinating traditional criteria. It splits Montgomery County four times and Berks County three times for no apparent non-partisan reason. And contrary to Legislative Respondents’ false claim, their plan is less compact than all 500 plans in Dr. Chen’s Simulation Set 1 from trial based on the Popper-Polsby measure, and less compact than 498 out of those 500 simulated plans based on the Reock measure. Legislative Respondents simply made cosmetic changes to the unconstitutional 2011 plan in a thinly veiled effort to conceal their partisan intent.

ARGUMENT

I. **Petitioners’ Proposed Remedial Plans Fully Comply With this Court’s Directives and Would Ensure Fair Elections for Pennsylvania Voters**

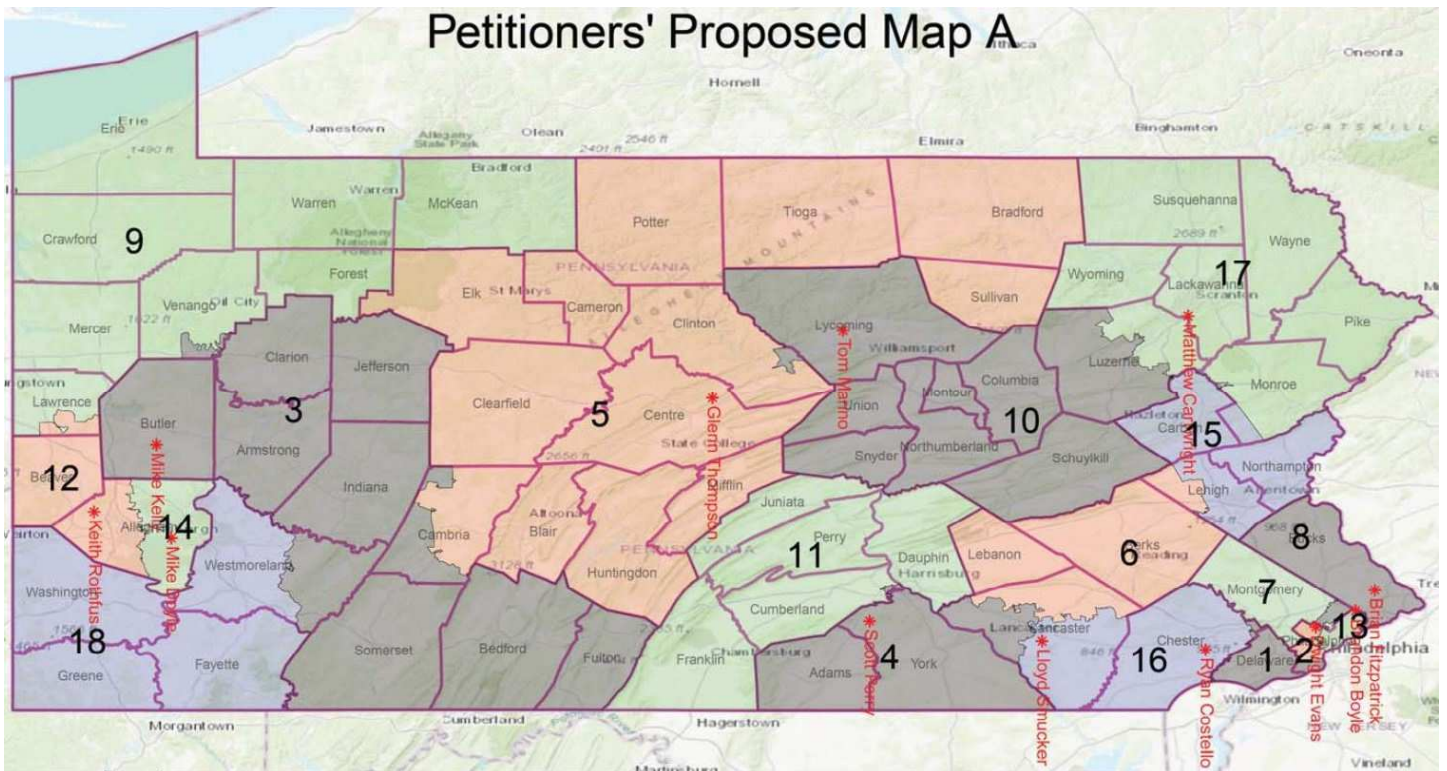
Both of Petitioners’ proposed remedial plans were generated by Dr. Chen using computer algorithms. While the algorithms used to create each plan differed slightly (as explained further below), both algorithms used *only* the traditional districting criteria of equal population, contiguity, compactness, and avoiding splitting political subdivisions. Dr. Chen did not incorporate *any* partisan data or considerations—none at all—in creating these plans. Nor have any manual adjustments been made. Far from being subordinated, the traditional districting criteria are the *exclusive* criteria underlying these plans. Indeed, this Court has recognized that Dr. Chen’s computer simulations “satisfy[] the[] traditional criteria” and can serve as a “powerful[] . . . tool” for generating new districting plans that “comport[] with traditional districting factors and [Pennsylvanians’] constitutional rights.” 2/7/18 Op. at 126-27 & n.75.

A. **Map A**

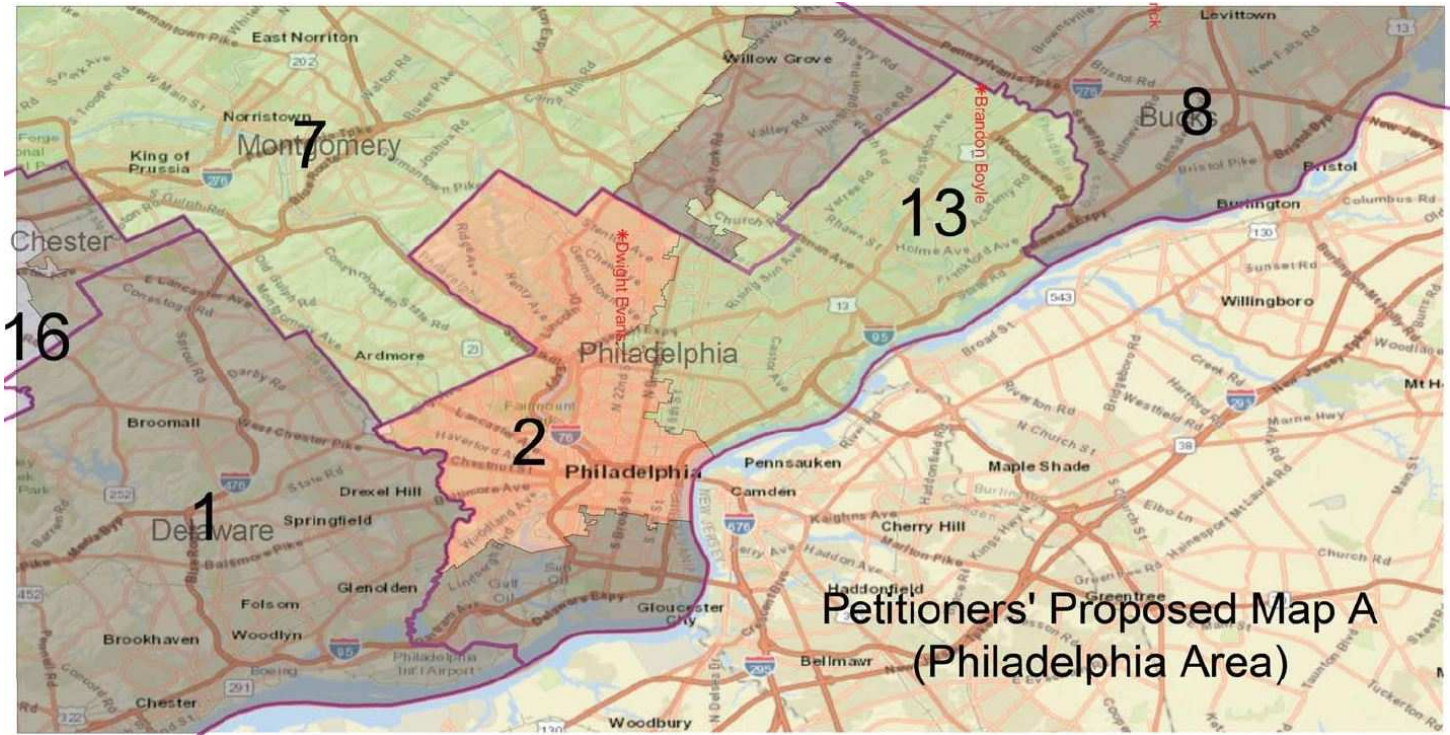
Petitioners’ first proposed plan (“Map A”) is one of the 500 plans from Dr. Chen’s Simulation Set 1 at trial. *See* Chen Suppl. Report at 2 (attached as Exhibit A). As Dr. Chen explained at trial, the algorithm underlying Simulation Set 1 prioritized, in the following order: equal population, contiguity, avoiding county splits, avoiding municipality splits, and compactness (weighted equally with

avoiding municipality splits). The algorithm randomly generated 500 plans using solely these criteria.

Below is an image of Map A, which was plan number 15 from Simulation Set 1. The red stars indicate the home addresses of the 12 incumbents who are currently running for re-election:



Below is a closer view of the Philadelphia area in Map A:



As Dr. Kennedy details in his supplemental report, Map A preserves Pennsylvania’s communities. By way of example, it restores a “Delco” seat in the 1st District, a Lehigh Valley seat in the 15th District, and an Erie seat in the 9th District. Kennedy Suppl. Report at 2, 11, 19 (attached as Exhibit B). It keeps all of Berks and Dauphin Counties entirely intact in the 6th and 11th Districts, respectively, no longer cracking the county seats of Reading and Harrisburg from their communities as under the 2011 map. *Id.* at 7, 13. Map A also keeps Montgomery County largely intact in the 7th District, grouping most of the remaining portion of Montgomery County with portions of Bucks County that share political and cultural interests. *Id.* at 9-10.

In total, Map A splits 14 counties, and it splits those counties into only 31 county fragments.¹ Chen Suppl. Report at 5. Map A thus splits fewer counties than Legislative Respondents' February 9 Plan. What's more, many of Map A's county splits are extremely minor. For instance, while Montgomery County spans three districts, only a tiny sliver of it is in the 13th District; the vast majority of Montgomery County remains intact in the 7th District. The same is true for very small portions of Chester County in the 1st District, of Clinton County in the 5th District, of Venango County in the 9th District, and of Cumberland County in the 11th District.² As a whole, Map A ensures that Pennsylvania's counties continue to serve their "central and historical role . . . as building blocks" of political life in the Commonwealth. *Holt v. 2011 Legislative Reapportionment Comm'n*, 614 38 A.3d 711, 745 (Pa. 2012).

Map A also substantially preserves Pennsylvania's municipalities and precincts. It splits a total of 50 municipalities and 20 precincts. Chen Suppl. Report at 5.

¹ For example, if a given county is split across three districts, that would count as one county that is split for purposes of the first calculation and three county fragment splits for purposes of the second calculation.

² It would be a simple task to eliminate these tiny splits by making manual adjustments to the district boundaries, but Petitioners have instead submitted plans without any manual changes.

Map A is extremely compact—much more compact than Legislative Respondents’ February 9 Plan. Map A’s mean Reock score is 0.42 and its mean Popper-Polsby score is 0.31, using a traditional latitude-longitude coordinate system. Chen Suppl. Report at 7. Both scores are higher (meaning more compact) than the Reock and Popper-Polsby scores for Legislative Respondents’ February 9 Plan, which are 0.37 and 0.28 using the same methodology. *Id.* at 20. (As explained in Part II below, Legislative Respondents used a *different* methodology to calculate Reock and Popper-Polsby scores, falsely asserting that their February 9 Plan is within the range of compactness scores for Dr. Chen’s Simulation Set 1 plans.)³

Using the same predictive methodology Dr. Chen employed at trial, Map A produces an even 9-9 split in expected Democratic and Republican seats. Chen Suppl. Report at 4. That split holds using either 2008-2010 statewide elections or 2012-2016 statewide elections to predict precinct-level partisanship. *Id.* A 9-9 split was the most common under Simulation Set 1, and thus Map A falls squarely within the heartland of expected partisan performance under a non-partisan plan. *Id.* at 16. In fact, Map A has a small mean-median gap in Republicans’ favor—1.7 using 2008-2010 statewide elections and 1.9 using 2012-2016 statewide elections. *Id.* at 5. Dr. Warshaw similarly found that Map A has a small, pro-Republican

³ All of the compactness scores required by the Court’s January 26 Order are set out in Dr. Chen’s supplemental report. Chen Suppl. Report at 5-7, 11-13.

Efficiency Gap of 4.8%. Warsaw Suppl. Report at 2 (attached as Exhibit C).

These small gaps likely reflect the small natural advantage that Republicans hold due to the clustering of Democratic voters.

Using the same Markov Chain methodology he employed at trial, Dr. Pegden found that Map A exhibits no partisan bias in favor of either party. Pegden Suppl. Report at 2 (attached as Exhibit D). Dr. Pegden found that Map A's mean-median gap does not meaningfully change upon making small random changes to its boundaries, confirming that Map A's boundaries and expected seat distribution do not artificially favor either party. *Id.*

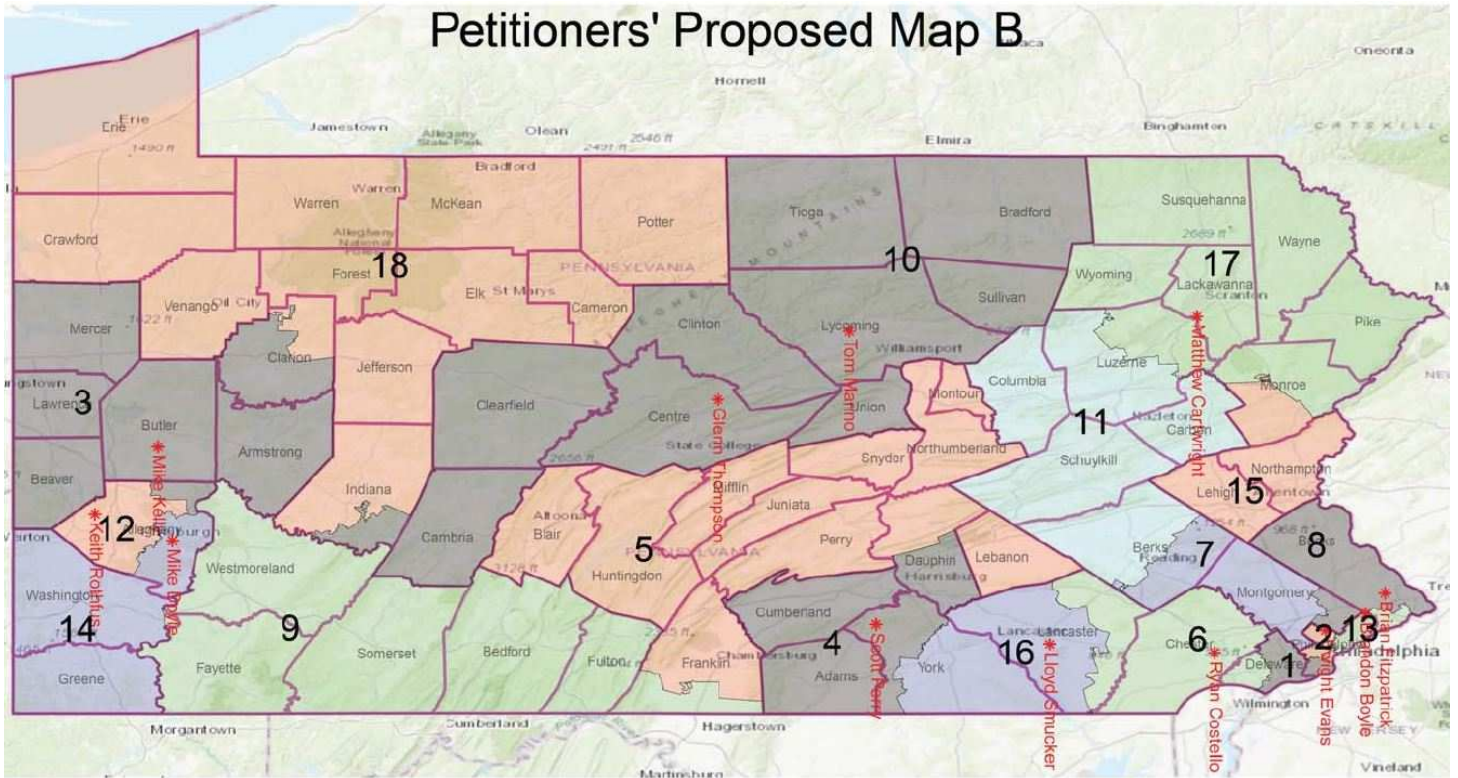
Finally, even though Dr. Chen's algorithm did not incorporate racial data or considerations, Map A contains a majority-minority district in the 2nd District, where African Americans constitute 57.3% of the voting age population. Chen Suppl. Report at 8. In another district, the 13th District, minority populations in aggregate comprise a majority of the voting age population. *Id.*

B. Map B

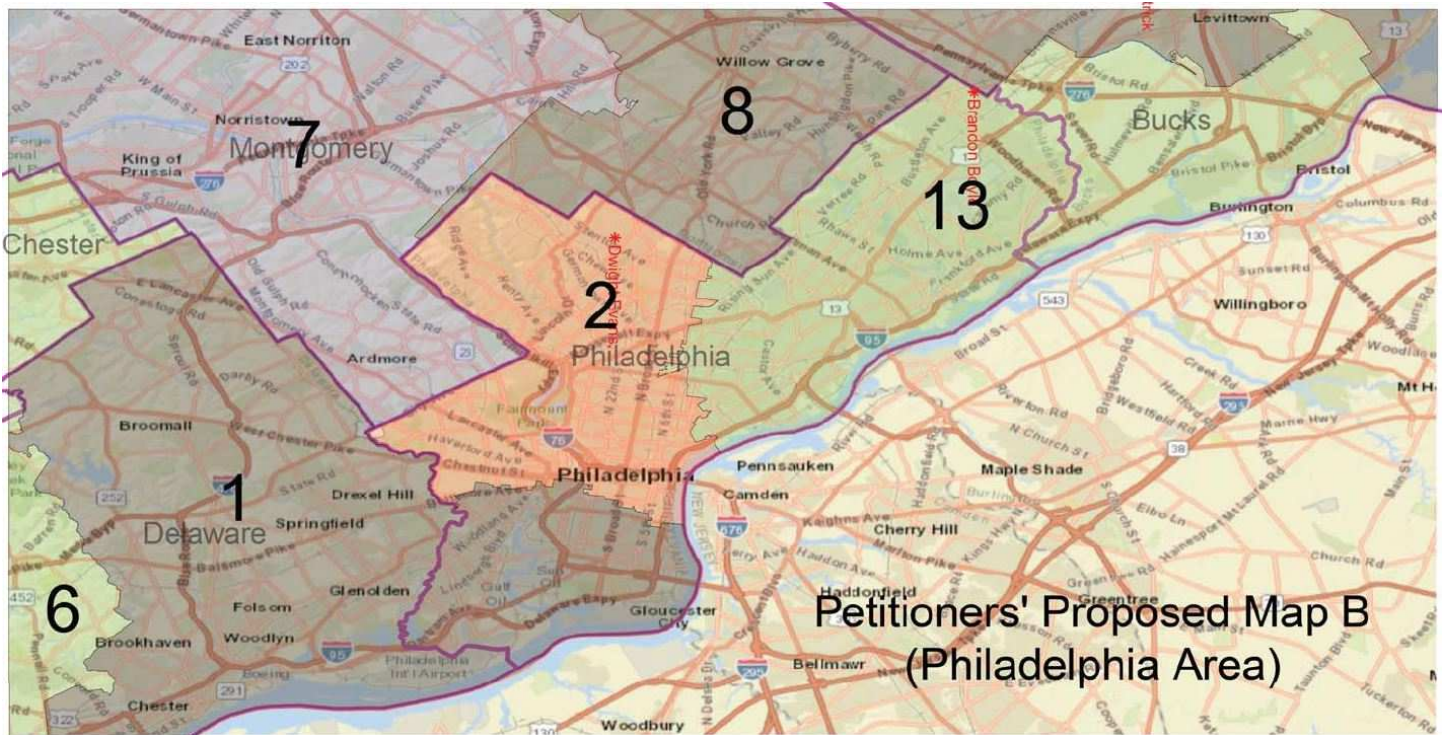
Petitioners' second proposed map ("Map B") was generated by Dr. Chen following this Court's January 22 Order, using a slightly revised algorithm. This algorithm equally weighted avoiding county, municipality, and precinct splits. Chen Suppl. Report at 11. It also added the criterion of avoiding ward splits. *Id.*

The algorithm continued to prioritize equal population and contiguity, and also sought to promote compactness. *Id.*

Below is an image of Map B, with the red stars indicating the home addresses of the 12 incumbents who are currently running for re-election:



Below is a closer view of the Philadelphia area in Map B:



As Dr. Kennedy’s supplemental report explains, Map B preserves Pennsylvania’s communities. Like Map A, Map B restores Delco, Lehigh Valley, and Erie seats in the 1st, 15th, and 18th Districts, respectively. Kennedy Suppl. Report at 24, 40, 45. The 17th District keeps together Scranton and Wilkes-Barre, the two major community centers in that region. *Id.* at 44. And Map B keeps Montgomery County almost entirely intact in the 7th District, splitting it only once. *Id.* at 31. The small portion of Montgomery County that is split is grouped with portions of Bucks County that form a shared community. *Id.* at 32.

Map B splits 15 counties, but it splits those counties into only 32 county fragments. Chen Suppl. Report at 11. Philadelphia and Allegheny Counties are

the only counties split more than once. *Id.* at 28. Map B splits just 32 municipalities and 17 precincts. *Id.* at 1. And Map B is very compact—much more compact than Legislative Respondents’ February 9 Plan. Map B has a mean Reock score of 0.42 and a mean Popper-Polsby score of 0.30, using a traditional latitude-longitude coordinate system. *Id.* at 11-12.

Using Dr. Chen’s same predictive methodology, Map B produces an even 9-9 split in expected Republican and Democratic seats. Chen Suppl. Report at 11. That split again holds using either 2008-2010 or 2012-2016 statewide elections to predict precinct-level partisanship. *Id.* And Map B, like Map A, produces small mean-median and Efficiency Gaps in Republicans’ favor. The pro-Republican mean-median gap is 2.0 using 2008-2010 elections and 2.7 using 2012-2016 elections, *id.*, and the pro-Republican Efficiency Gap is 4.8%, Warshaw Suppl. Report at 2. Dr. Pegden similarly found that Map B exhibits no partisan bias in favor of either party. Pegden Suppl. Report at 2.

As with Map A, the 2nd District in Map B contains a 57.3% African-American voting age population. Chen Suppl. Report at 15. Map B contains two additional districts, the 1st and 13th Districts, in which minority populations in aggregate comprise roughly 40% of the voting age population. *Id.*

II. Legislative Respondents' February 9 Plan Is an Extreme Partisan Gerrymander

In stark contrast to Petitioners' proposed plans, Legislative Respondents' February 9 Plan is a naked partisan gerrymander. The supplemental reports of Drs. Chen, Pegden, and Warshaw prove this to a mathematical certainty.

Based on the 2008-2010 statewide elections, Republicans would be expected to win 12 districts under Legislative Respondents' February 9 Plan—an outcome that never occurs under any of Dr. Chen's 500 simulations in Simulation Set 1. Chen Suppl. Report at 16-17. And there are 11 Republican-leaning districts using the 2012-2016 statewide elections data, a result that occurs only a tiny fraction of the time (0.6%) in Simulation Set 1. *Id.* Dr. Chen thus concludes that it is extremely statistically improbable that Legislative Respondents' February 9 Plan could have emerged from a non-partisan process. *Id.* at 17.

Dr. Pegden concludes that Legislative Respondents' February 9 Plan is an extreme outlier in its partisan bias in way that is mathematically impossible to be caused by political geography or the traditional districting criteria he considered. Pegden Suppl. Report at 2. He finds that, as with the 2011 map, Legislative Respondents' February 9 Plan has an extreme Republican bias that dissipates rapidly upon making tiny changes to district boundaries. *Id.* at 2-3. Indeed, Legislative Respondents' February 9 Plan exhibits more partisan bias toward Republicans than 99.99998% of the simulated maps he generated in the 68 billion

steps in his run. *Id.* at 1-3 & n.2. Dr. Warshaw similarly finds that Legislative Respondents' February 9 Plan has an extreme, pro-Republican Efficiency Gap that is comparable to the unconstitutional 2011 map. Warshaw Suppl. Report at 1-2.

Thus, Legislative Respondents' February 9 Plan "diminishe[s] [the] electoral power" of Democratic voters by "discriminatorily dilute[ing] the power of" their votes. 2/7/18 Op. at 121-22. And Legislative Respondents' plan achieves its "unfair partisan political advantage" by subordinating "the[] neutral criteria . . . , in whole or in part"—in contravention of this Court's directives and the Pennsylvania Constitution's Free and Equal Elections Clause. *Id.* at 123.

While Legislative Respondents' February 9 Plan splits 15 counties, it splits those counties into a total of 35 county fragments. In particular, the plan carves up Montgomery County into four different districts and Berks County into three different districts. Dr. Kennedy concludes that the only explanation for these divisions is an effort to gain partisan advantage. Kennedy Suppl. Report at 46-53.

Although Legislative Respondents' February 9 Plan splits relatively few municipalities, that is because the plan significantly subordinates compactness. Legislative Respondents apparently determined that the best way to maximize their partisan advantage while giving the veneer of compliance with the traditional criteria was to avoid municipality splits while subordinating compactness as well as county splits. Their plan is less compact than *all 500* of Dr. Chen's Simulation

Set 1 plans as measured by Popper-Polsby, Population Polygon, Minimum Convex Polygon, Schwartzberg, and Inverse Schwartzberg. Chen Suppl. Report at 18-21. The Reock measure is the one exception—and barely an exception at all, since Legislative Respondents’ February 9 Plan is less compact than 498 out of the 500 Simulation Set 1 plans. *Id.* Both of Petitioners’ proposed remedial plans are significantly more compact than Legislative Respondents’ February 9 Plan along every compactness measure. *Id.* at 18-25.

Legislative Respondents assert that the Reock and Popper-Polsby scores for their proposal “fall well within the ranges of Dr. Chen’s ‘Set One’ simulations,” Leg. Resps. 2/9/18 Br. at 10. This is false. As Dr. Chen explains in his supplemental report, Legislative Respondents used a *different* methodology to calculate Reock and Popper-Polsby than the methodology Dr. Chen used for his Simulation Set 1 plans at trial. It is only by employing that different methodology that Legislative Respondents misleadingly portray their plan as falling within the range of compactness scores of Dr. Chen’s Set 1 plans. In an apples-to-apples comparison using the same methodology, Legislative Respondents’ February 9 Plan is a clear outlier for its lack of compactness. Chen Suppl. Report at 20-23.

This Court made clear that proposed maps must prioritize all of the traditional districting criteria, not just some of them, and Legislative Respondents’ February 9 Plan fails that standard miserably. The relatively low number of

municipality splits does not alter the fact that Legislative Respondents' February 9 Plan carves up certain counties and other communities for no reason other than partisan political gain. Kennedy Suppl. Report at 46-53.

This Court held that “an election corrupted by extensive, sophisticated gerrymandering and partisan dilution of votes is not ‘free and equal’” under Article I, § 5 of the Pennsylvania Constitution. 2/7/18 Op. 131. Legislative Respondents apparently did not get the message. Their proposed plan would only perpetuate the corruption of Pennsylvania’s electoral process that has gone on for far too long.⁴

⁴ In their February 9 brief, Legislative Respondents repeat the same procedural objections this Court and the U.S. Supreme Court already rejected. Legislative Respondents assert, citing the date of the release of this Court’s opinion, that the “effective time ... to pass a remedial plan was cut to two days.” Br. 6. But the Court’s opinion was wholly consistent with the January 22 Order, and Legislative Respondents do not identify a single aspect of the opinion that altered in any way the guidance provided in the January 22 Order with respect to drawing a remedial map. Legislative Respondents made all these same complaints about timing in their stay application to the U.S. Supreme Court, which was denied. Legislative Respondents do not even acknowledge that they informed this Court at oral argument that they “would like at least three weeks” to draw a new map, which is what they got. Oral Argument Video at 1:46:05-1:46:13. During that period Legislative Respondents did not even ask the General Assembly to consider or pass the plan they submitted to this Court on February 9.

Dated: February 15, 2018

Respectfully submitted,

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CERTIFICATION OF COMPLIANCE WITH PUBLIC ACCESS POLICY

I hereby certify that this filing complies with the provisions of the Public Access Policy of the Unified Judicial System of Pennsylvania: Case Record of the Appellate and Trial Courts that require filing confidential information and documents differently than non-confidential information and documents.

I certify that the preceding Brief does not contain confidential information.

/s/ Mary M. McKenzie
Mary M. McKenzie

Dated: February 15, 2018

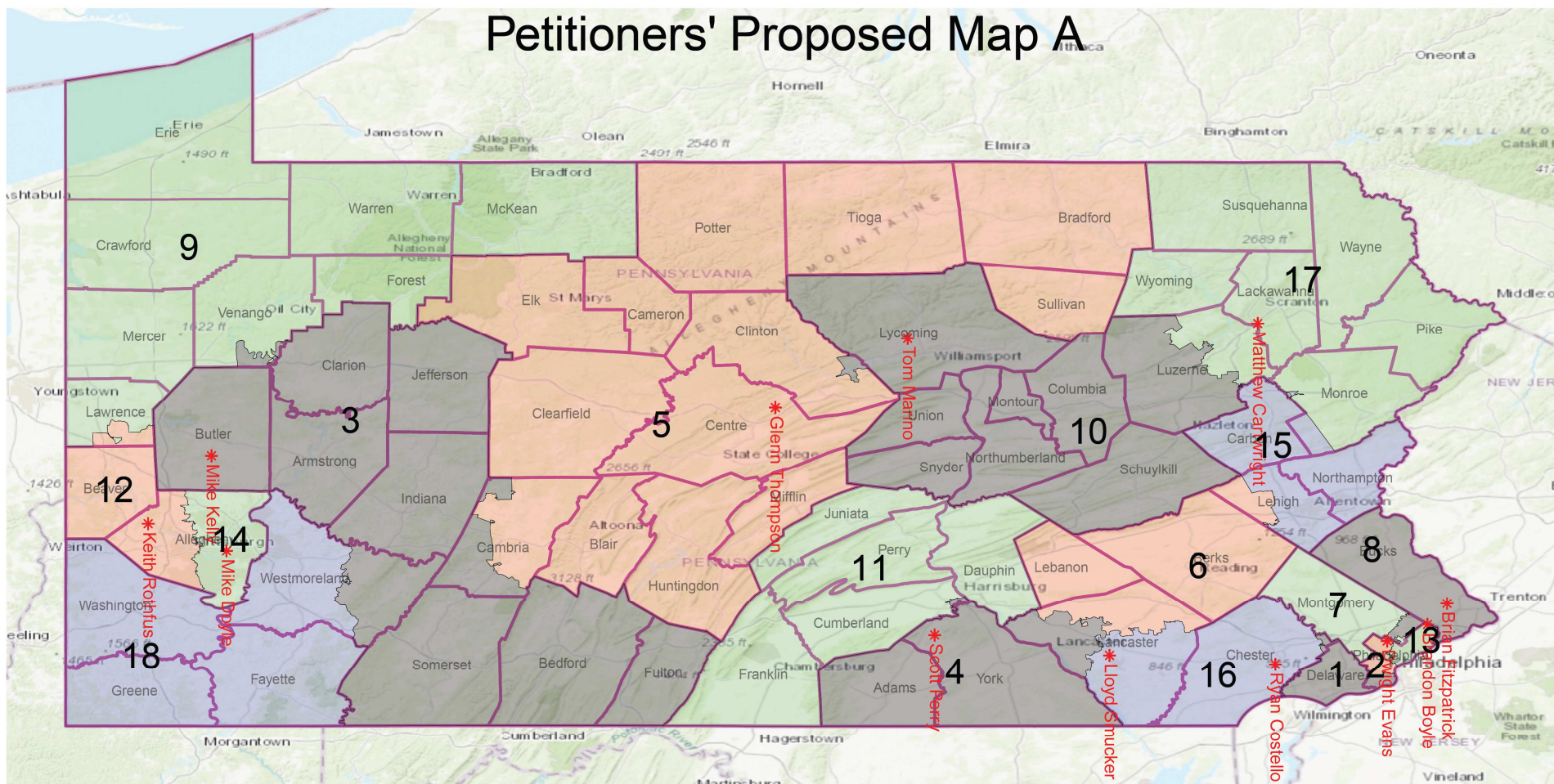
EXHIBIT A

SUPPLEMENTAL EXPERT REPORT JOWEI CHEN, Ph.D.

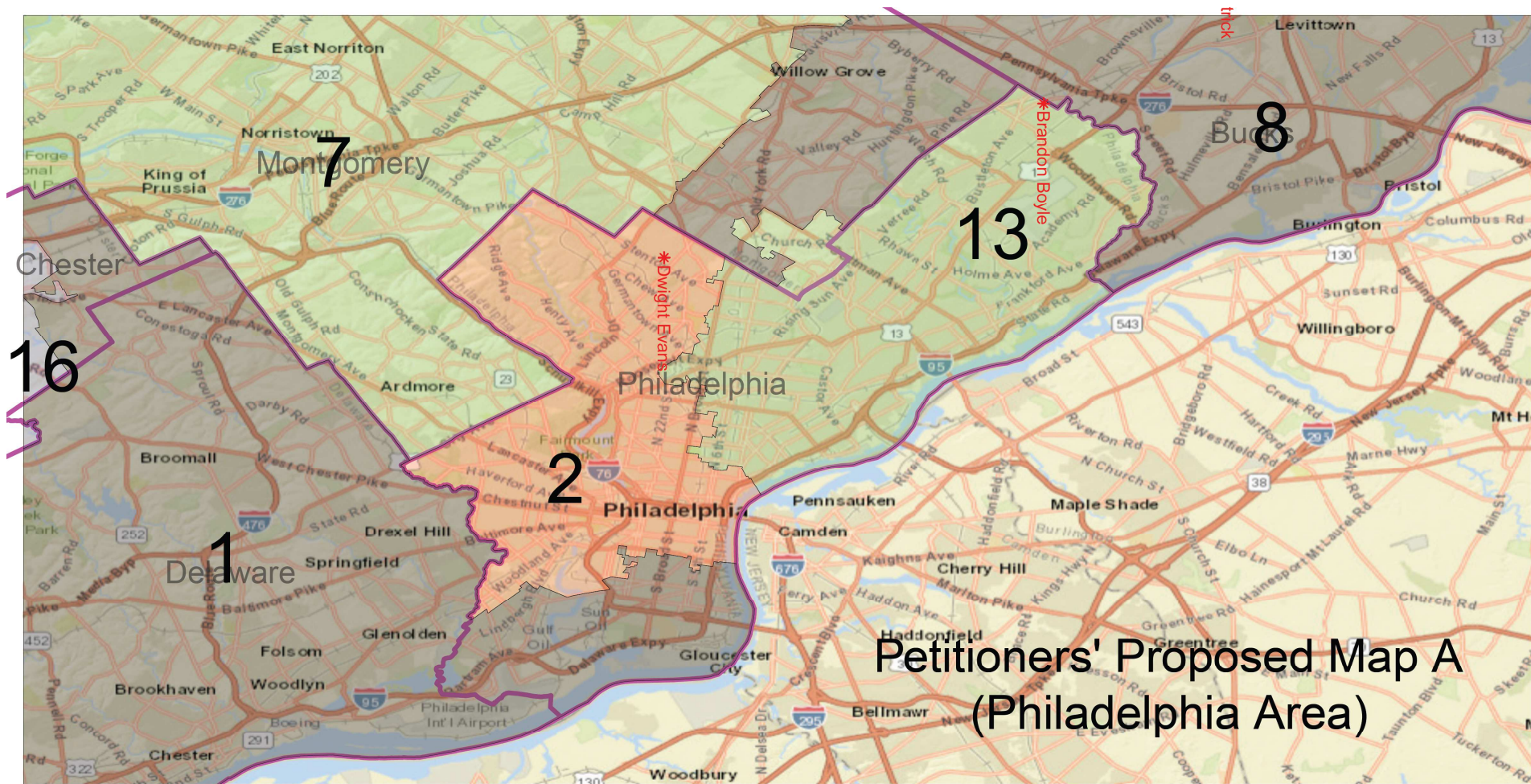
In this supplemental report, I describe the features of two plans, Proposed Map A and Proposed Map B, that Petitioners are submitting for consideration pursuant to the Court's January 22 and 26, 2018 Orders. Both of these Proposed Maps were produced by my computer simulation algorithms following traditional districting principles. Proposed Map A was one of the 500 Simulation Set 1 plans analyzed and turned over in connection with my November 27, 2017 expert report in this case. Proposed Map B was produced by a slightly modified version of this computer simulation algorithm that I designed following the Court's January 22, 2018 Order, as explained in further detail later in this report.

In this supplemental report, I also explain how Legislative Respondents' February 9, 2018 proposed plan continues to subordinate traditional districting principles, particularly geographic compactness and minimizing the division of counties, in pursuit of partisan advantage. Legislative Respondents' February 9 plan creates 35 county fragments across split counties, several more than both of Petitioners' proposed plans. In addition, while Legislative Respondents assert in their February 9 brief that their proposed plan is as compact as many of the Simulation Set 1 plans using Reock and Polsby-Popper measures, this is not true. As I explain below, Legislative Respondents present this incorrect portrayal by using an entirely different geographic coordinate system to calculate Reock and Polsby-Popper than the system I used for the Simulation Set 1 plans at trial; using a different coordinate system results in different compactness scores that cannot be directly compared. When all plans are evaluated using the same coordinate system, Legislative Respondents' February 9 plan is less geographically compact than all 500 Simulation Set 1 plans according to the Schwartzberg, Polsby-Popper, Population Polygon, and Minimum Convex Polygon measures. It is also less compact than 498 of the 500 Simulation Set 1 plans as measured by Reock score. As I detail later in this report, the choice of a particular coordinate system does not alter this conclusion: So long as the same coordinate system is used to evaluate all plans, all five compactness measurements point to the same conclusion regarding the non-compactness of the Legislative Respondents' plan.

Figure 1A:
Petitioners' Proposed Map A



**Figure 1B:
Petitioners' Proposed Map A (Philadelphia Area)**



Petitioners' Proposed Map A

In my November 27, 2017 expert report in this case, I produced and turned over 500 computer-simulated maps described as Simulation Set 1. To produce this set of simulations, the computer was programmed to follow the traditional districting principles of population equality, geographic compactness and contiguity, and avoiding the splitting of counties and municipalities. The algorithm prioritized population equality and contiguity, then avoiding county splits, and then avoiding municipality splits and promoting compactness (these latter two weighted equally). The algorithm also intentionally ignored all partisan and racial considerations, including the protection of incumbents.

Petitioners' Proposed Map A is one of these 500 maps. This proposed map was originally labeled as Plan 15 in the computer shapefiles and data I turned over in connection with my original expert report. Figure 1A is an illustration of Petitioners' Proposed Map A's boundaries statewide across Pennsylvania, while Figure 1B depicts the Proposed Map's boundaries in the Philadelphia area. The following sections describe the various features of Petitioners' Proposed Map A:

Expected Partisan Performance: My November 27, 2017 expert report used two sets of elections to measure the partisanship of congressional districts. First, I used the combined results of all six of the statewide elections held in Pennsylvania during 2008-2010, counting whether each district contained more total Republican or Democratic votes cast across these six elections. As a second measure, I used the combined results of all eleven statewide elections held in Pennsylvania during 2012-2016, once again counting whether each district contained more total Republican or Democratic votes across these elections. My original report had found that using either measure, Pennsylvania's 2011 Act 131 enacted congressional plan contained 13 Republican districts and 5 Democratic districts.

I found that Petitioners' Proposed Map A contains 9 Republican districts and 9 Democratic districts, as measured by the results of the 2012-2016 statewide elections. Using the results of the 2008-2010 statewide elections, Petitioners' Proposed Map A is also measured as having 9 Republican and 9 Democratic districts. Therefore, Petitioners' Proposed Map A achieves the most common partisan outcome, as well as the median outcome, among the 500 plans in Simulation Set 1.

I also calculated the median-mean gap, using both sets of elections, by subtracting the mean district-level Republican vote share from the median district's Republican vote share. I found that Petitioners' Proposed Map A has a median-mean gap of 1.70% using the 2008-2010 statewide elections and 1.87% using the 2012-2016 statewide elections. This small median-mean gap indicates that the median district is only slightly more Republican than the average district in Proposed Map A. This median-mean gap is near the middle of the distribution of 500 plans in Simulation Set 1, as illustrated in Figure 5 of my November 27, 2017 expert report.

County, Municipal, and Precinct Splits: Appendix A describes the counties, municipalities, and precincts split by each district in Petitioners' Proposed Map A. The map produces a total of 14 counties that are split across at least two districts. These 14 split counties produce a total of 31 county fragments that are split by district lines. In other words, if a county is split across three different districts, I count that as three county fragments, and if it is split across two districts, that is two county fragments. Map A also splits a total of 50 municipalities and 20 precincts, as listed in Appendix A.

Geographic Compactness: Table 1 below describes the compactness of each of the 18 districts in Petitioners' Proposed Map A, as measured by the five measures of compactness listed in the Court's January 26, 2018 Order: Reock, Schwartzberg, Polsby-Popper, Population Polygon, and Minimum Convex Polygon.

The use of different geographic projection and coordinate systems can result in somewhat different compactness scores. In my original expert report and at trial, I calculated compactness scores using a standard World Geodetic System 1984 (WGS84) latitude-longitude coordinate system. This latitude-longitude coordinate system is generally used in Census Bureau geographic data and maps; thus, it is most commonly used by redistricting practitioners.

However, in their February 9, 2018 brief, Legislative Respondents did not use the standard latitude-longitude coordinate system for the purposes of producing the compactness calculations presented on page 11 and on Attachment C of their brief. Instead, Legislative Respondents' compactness scores were clearly based on a Spherical Mercator projection system.

Table 1: Geographic Compactness of Petitioners' Proposed Map A:

Compactness Scores Calculated Using Standard Latitude-Longitude Coordinate System:

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.737	0.34	1.946	0.514	0.264	0.644
2	0.713	0.519	2.083	0.48	0.23	0.742
3	0.69	0.384	2.03	0.493	0.243	0.373
4	0.862	0.365	1.805	0.554	0.307	0.783
5	0.733	0.38	1.962	0.51	0.26	0.693
6	0.844	0.428	1.743	0.574	0.329	0.882
7	0.877	0.407	1.593	0.628	0.394	0.778
8	0.759	0.349	1.734	0.577	0.333	0.61
9	0.716	0.343	1.824	0.548	0.301	0.919
10	0.793	0.387	1.834	0.545	0.297	0.856
11	0.785	0.314	1.644	0.608	0.37	0.831
12	0.841	0.451	1.763	0.567	0.322	0.833
13	0.836	0.421	1.782	0.561	0.315	0.901
14	0.838	0.505	1.874	0.534	0.285	0.812
15	0.742	0.421	1.81	0.552	0.305	0.892
16	0.888	0.442	1.692	0.591	0.349	0.898
17	0.869	0.52	1.703	0.587	0.345	0.895
18	0.781	0.542	1.738	0.576	0.331	0.371
Minimum:	0.69	0.314	1.593	0.48	0.23	0.371
Maximum:	0.888	0.542	2.083	0.628	0.394	0.919
Mean:	0.795	0.418	1.809	0.556	0.31	0.762

Compactness Scores Calculated Using Spherical Mercator Projection System:

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.737	0.419	1.886	0.53	0.281	0.644
2	0.713	0.432	2.054	0.487	0.237	0.742
3	0.69	0.43	2	0.5	0.25	0.374
4	0.862	0.443	1.728	0.579	0.335	0.782
5	0.734	0.418	1.915	0.522	0.273	0.695
6	0.843	0.55	1.71	0.585	0.342	0.881
7	0.876	0.469	1.576	0.634	0.402	0.778
8	0.759	0.422	1.699	0.589	0.346	0.61
9	0.718	0.39	1.822	0.549	0.301	0.923
10	0.793	0.457	1.763	0.567	0.322	0.856
11	0.785	0.354	1.609	0.621	0.386	0.832
12	0.842	0.401	1.775	0.563	0.317	0.833
13	0.836	0.444	1.762	0.567	0.322	0.901
14	0.838	0.427	1.838	0.544	0.296	0.812
15	0.742	0.515	1.777	0.563	0.317	0.893
16	0.887	0.567	1.647	0.607	0.369	0.898
17	0.869	0.573	1.669	0.599	0.359	0.896
18	0.781	0.549	1.714	0.583	0.34	0.371
Minimum:	0.69	0.354	1.576	0.487	0.237	0.371
Maximum:	0.887	0.573	2.054	0.634	0.402	0.923
Mean:	0.795	0.459	1.775	0.566	0.322	0.762

In order to facilitate direct comparison of Petitioners' Proposed Map A to Legislative Respondents February 9, 2018 proposed plan, I use both systems - a standard WGS84 latitude-longitude coordinate system as well as a Spherical Mercator projection system - in describing the compactness of all proposed plans evaluated in this report. The upper half of Table 1 measures the compactness of all districts using a latitude-longitude coordinate system, while the lower half uses a Spherical Mercator projection system.

Using the standard latitude-longitude coordinate system, Petitioners' Proposed Map A has a mean Reock score of 0.418 and a mean Polsby-Popper score of 0.310. Using a Spherical Mercator projection system, Petitioners' Proposed Map A has a mean Reock score of 0.459 and a mean Polsby-Popper score of 0.322. Under either methodology, Map A's compactness scores fall well within the range of scores for the 500 plans in Simulation Set 1.

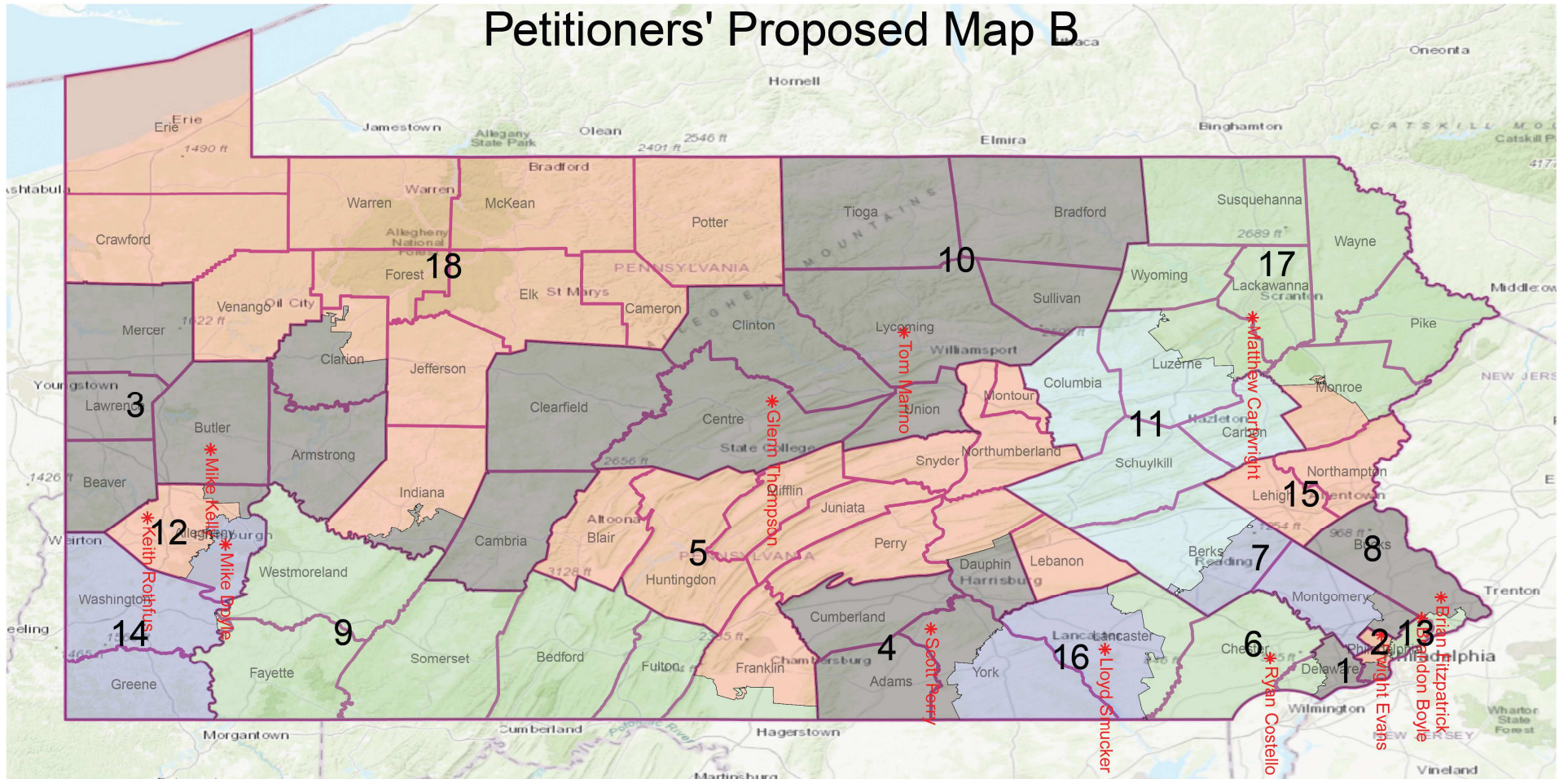
Racial Composition: Table 2 below presents calculations regarding the racial and ethnic composition of each of the 18 districts in Petitioners' Proposed Map A. Although I did not consider or incorporate racial data in generating Map A, it produces a majority African-American district in the 2nd District, as well as an additional district for which minority populations in aggregate constitute a majority of the voting age population (the 13th District).

Table 2:

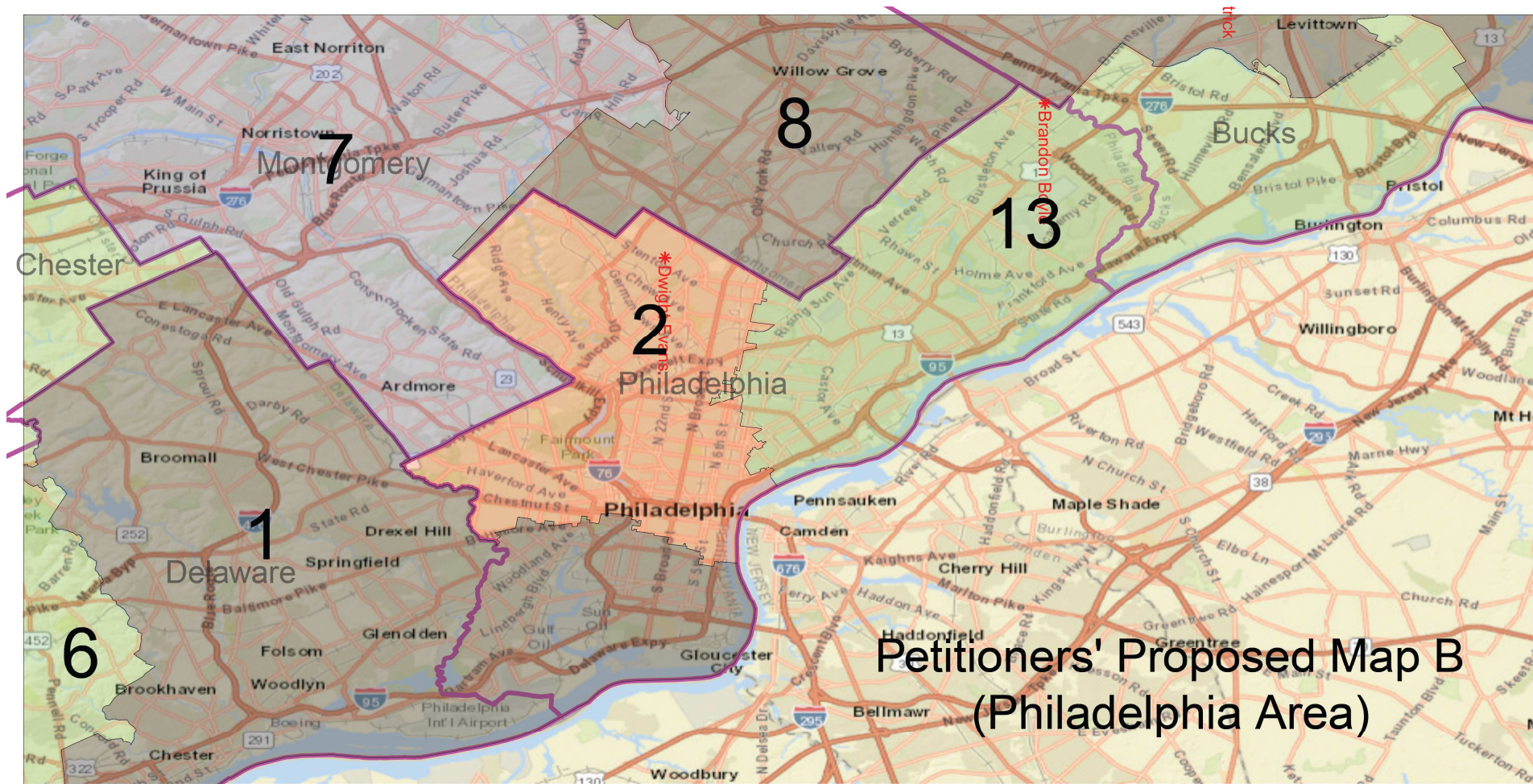
This following table presents calculations regarding the racial and ethnic composition of each of the 18 congressional districts in Petitioners' Proposed Map A. I obtained these population counts from the 2010 US Census Redistricting Data Summary File 1.

District	Total Voting Age Population	Hispanic Proportion of VAP	Any Part African-American Proportion of VAP	Non-Hispanic White Proportion of VAP
1	543,491	3.3%	19.1%	70.3%
2	567,370	3.5%	57.3%	32.7%
3	559,826	0.8%	1.7%	96.3%
4	544,639	4.5%	4.0%	89.6%
5	565,513	1.5%	2.2%	94.0%
6	536,095	9.5%	3.2%	85.8%
7	542,508	3.9%	7.5%	81.5%
8	544,886	3.5%	4.5%	87.1%
9	550,709	1.6%	4.4%	92.5%
10	561,642	3.3%	3.2%	92.3%
11	545,268	3.5%	7.6%	85.7%
12	560,817	1.2%	7.5%	88.5%
13	524,284	18.6%	25.5%	48.8%
14	570,417	1.3%	14.4%	80.1%
15	545,775	11.3%	4.7%	81.3%
16	527,619	7.7%	6.2%	82.6%
17	556,078	5.1%	4.7%	88.2%
18	563,287	0.8%	3.1%	94.8%
19	543,491	3.3%	19.1%	70.3%

**Figure 2A:
Petitioners' Proposed Map B**



**Figure 2B:
Petitioners' Proposed Map B (Philadelphia Area)**



**Petitioners' Proposed Map B
(Philadelphia Area)**

Petitioners' Proposed Map B

I produced Map B using an algorithm that is slightly modified from the algorithm used to generate the plans in Simulation Set 1. First, whereas Simulation Set 1 prioritized avoiding county splits above municipality splits, this modified algorithm equally weights county and municipality splits. Second, this algorithm expressly incorporated the criterion of avoiding precincts splits, which is also equally weighted with county and municipality splits. Third, the algorithm also adds the criterion of avoiding wards splits (but weighted below county, municipality, and precinct splits). This algorithm also continues to incorporate the criterion of promoting compactness.

Figure 2A is an illustration of Petitioners' Proposed Map B's boundaries statewide across Pennsylvania, while Figure 2B depicts Map B's boundaries in the Philadelphia area.

Expected Partisan Performance: Like Map A, I found that Petitioners' Proposed Map B contains 9 Republican districts and 9 Democratic districts, as measured by the results of the 2008-2010 or 2012-2016 statewide elections.

I also calculated the median-mean gap, using both sets of elections, by subtracting the mean district-level Republican vote share from the median district's Republican vote share. I found that Petitioners' Proposed Map B has a median-mean gap of 1.98% using the 2008-2010 statewide elections and 2.79% using the 2012-2016 statewide elections. This small median-mean gap indicates that the median district is only slightly more Republican than the average district in Proposed Map B. This median-mean gap is within the normal range of the distribution of 500 plans in Simulation Set 1, as illustrated in Figure 5 of my November 27, 2017 expert report.

County, Municipal, and Precinct Splits: Appendix B describes the counties, municipalities, and precincts split by each district in Petitioners' Proposed Map B. As explained above, the revised algorithm used to generate Map B weighted county, municipality, and precinct splits equally, whereas as Simulation Set 1 had prioritized avoiding county splits above municipality splits.

Map B splits a total of 15 counties, and produces a total of 32 county fragments split by district lines. The map splits just 32 municipalities and 17 precincts.

Geographic Compactness: Table 3 describes the compactness of each of the 18 districts in Petitioners' Proposed Map B, as measured by the five measures of compactness listed in the Court's January 26, 2018 Order: Reock, Schwartzberg, Polsby-Popper, Population Polygon, and

Minimum Convex Polygon. The upper half of Table 3 calculates these scores using the latitude-longitude coordinate system that I used at trial, while the lower half uses a Spherical Mercator projection system.

Using the standard latitude-longitude coordinate system, Petitioners' Proposed Map B has a mean Reock score of 0.415 and a mean Polsby-Popper score of 0.302. Using a Spherical Mercator projection system, Petitioners' Proposed Map B has a mean Reock score of 0.457 and a mean Polsby-Popper score of 0.315. As before, under either methodology, Map B produces compactness scores well within the range of the plans I produced in Simulation Set 1 at trial.

Table 3: Geographic Compactness of Petitioners' Proposed Map B:

Compactness Scores Calculated Using Standard Latitude-Longitude Coordinate System:

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.733	0.416	1.816	0.551	0.303	0.713
2	0.739	0.567	1.942	0.515	0.265	0.792
3	0.798	0.522	1.702	0.587	0.345	0.662
4	0.806	0.484	1.691	0.591	0.35	0.817
5	0.624	0.283	2.23	0.448	0.201	0.463
6	0.764	0.423	1.813	0.552	0.304	0.81
7	0.705	0.307	1.959	0.51	0.26	0.644
8	0.721	0.351	1.744	0.573	0.329	0.554
9	0.806	0.244	2.054	0.487	0.237	0.653
10	0.718	0.237	1.909	0.524	0.274	0.706
11	0.811	0.63	1.783	0.561	0.315	0.753
12	0.838	0.454	1.749	0.572	0.327	0.822
13	0.796	0.268	1.915	0.522	0.273	0.891
14	0.796	0.448	1.777	0.563	0.317	0.522
15	0.753	0.451	1.738	0.575	0.331	0.898
16	0.909	0.526	1.622	0.616	0.38	0.916
17	0.875	0.504	1.648	0.607	0.368	0.94
18	0.645	0.363	1.987	0.503	0.253	0.735
Minimum:	0.624	0.237	1.622	0.448	0.201	0.463
Maximum:	0.909	0.63	2.23	0.616	0.38	0.94
Mean:	0.769	0.415	1.838	0.548	0.302	0.738

Compactness Scores Calculated Using Spherical Mercator Projection System:

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.733	0.455	1.766	0.566	0.321	0.712
2	0.739	0.494	1.899	0.527	0.277	0.792
3	0.798	0.569	1.727	0.579	0.335	0.663
4	0.806	0.473	1.65	0.606	0.367	0.818
5	0.624	0.368	2.155	0.464	0.215	0.463
6	0.764	0.491	1.765	0.567	0.321	0.809
7	0.705	0.386	1.921	0.52	0.271	0.644
8	0.72	0.425	1.718	0.582	0.339	0.555
9	0.806	0.306	1.961	0.51	0.26	0.651
10	0.718	0.274	1.861	0.537	0.289	0.709
11	0.812	0.545	1.725	0.58	0.336	0.753
12	0.838	0.564	1.71	0.585	0.342	0.822
13	0.796	0.288	1.865	0.536	0.287	0.891
14	0.796	0.431	1.781	0.561	0.315	0.522
15	0.753	0.519	1.686	0.593	0.352	0.898
16	0.909	0.62	1.567	0.638	0.407	0.916
17	0.875	0.585	1.611	0.621	0.385	0.94
18	0.645	0.428	1.966	0.509	0.259	0.737
Minimum:	0.624	0.274	1.567	0.464	0.215	0.463
Maximum:	0.909	0.62	2.155	0.638	0.407	0.94
Mean:	0.769	0.457	1.796	0.56	0.315	0.739

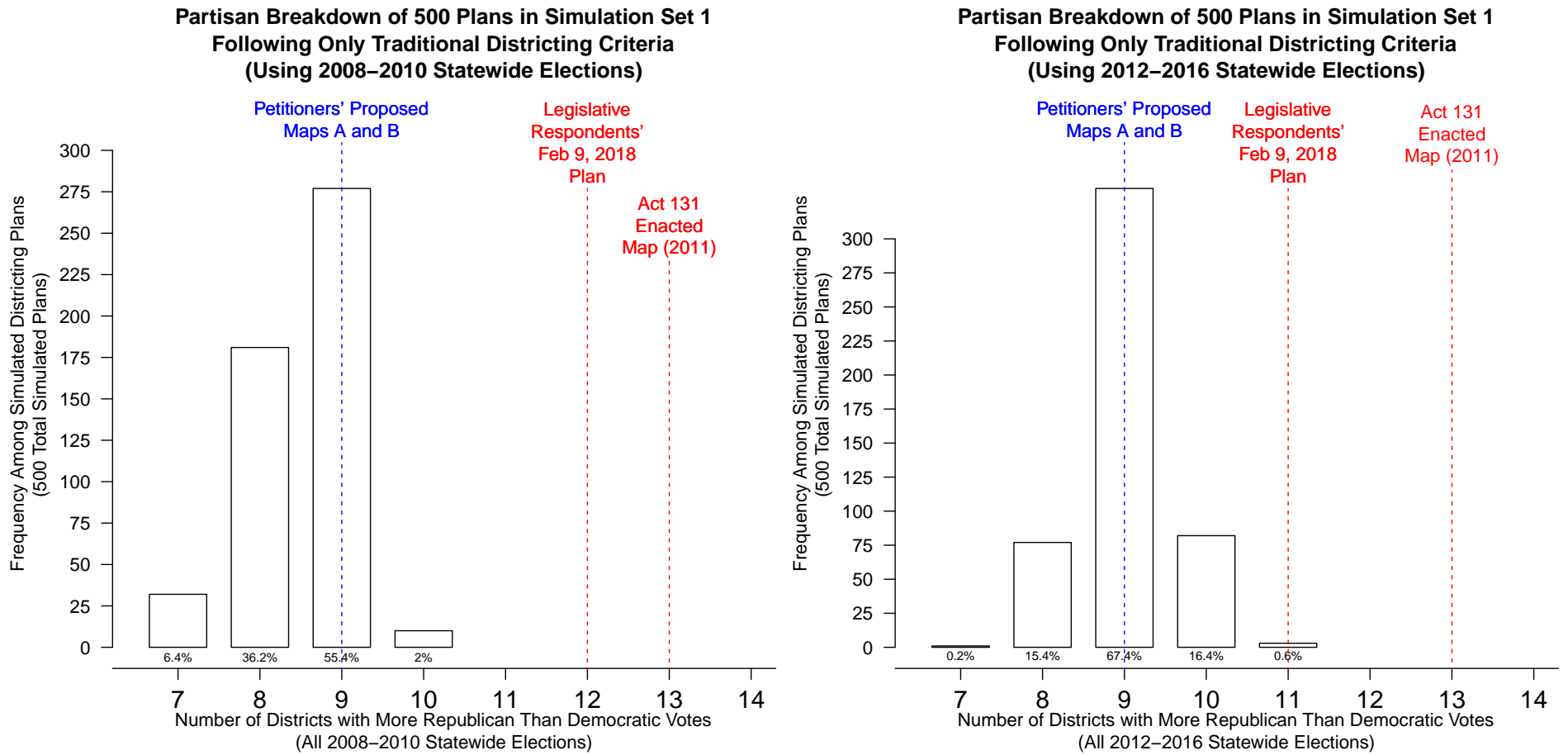
Racial Composition: Table 4 presents calculations regarding the racial and ethnic composition of each of the 18 districts in Petitioners' Proposed Map B. Again, although I did not incorporate racial data in generating Map B, it produces a majority African-American district in the 2nd District. Map B also produces two additional districts in which minority groups comprise roughly 40% of the voting age population (the 1st and 13th Districts).

Table 4:

This following table presents calculations regarding the racial and ethnic composition of each of the 18 congressional districts in Petitioners' Proposed Map B. I obtained these population counts from the 2010 US Census Redistricting Data Summary File 1.

District	Total Voting Age Population	Hispanic Proportion of VAP	Any Part African-American Proportion of VAP	Non-Hispanic White Proportion of VAP
1	542,434	3.7%	27.5%	60.9%
2	563,486	6.8%	57.3%	30.2%
3	555,012	0.8%	3.1%	94.9%
4	548,843	3.9%	7.7%	85.2%
5	549,052	2.7%	1.9%	94.1%
6	528,882	4.5%	5.3%	86.3%
7	542,048	3.8%	6.3%	83.4%
8	543,206	2.7%	4.9%	87.8%
9	561,455	0.8%	2.5%	95.5%
10	569,120	1.8%	3.2%	92.6%
11	551,095	9.4%	3.7%	85.7%
12	568,880	1.5%	9.0%	84.9%
13	530,503	15.5%	17.4%	59.5%
14	562,553	1.1%	12.6%	83.9%
15	543,720	11.7%	5.2%	80.3%
16	538,013	7.1%	5.1%	85.6%
17	558,077	4.8%	4.5%	88.7%
18	553,845	1.5%	3.6%	93.3%
19	542,434	3.7%	27.5%	60.9%

Figure 3:



Legislative Respondents' February 9 Plan

I reviewed and evaluated the files submitted by Legislative Respondents depicting their February 9, 2018 proposed plan.¹

Expected Partisan Performance: I found that the Legislative Respondents' February 9 Plan contains 12 Republican districts and 6 Democratic districts, as measured by the results of the 2008-2010 statewide elections. I also found that the Legislative Respondents' Plan contains 11 Republican districts and 7 Democratic districts, as measured by the results of the 2012-2016 statewide elections.

Both of these results represent extreme outliers when compared to the 500 Simulation Set 1 plans from my November 27, 2017 expert report that were produced by a non-partisan computer simulation algorithm following traditional districting principles. As illustrated in Figure 3, the majority of the 500 Simulation Set 1 plans created 9 Republican seats, measured using the 2008-2010, and none of the 500 plans produced 12 Republican seats, as Legislative Respondents' February 9 Plan does. Similarly, over two-thirds of the 500 Simulation Set 1 plans created 9 Republican seats as measured using the 2012-2016 statewide elections, while only 3 of 500 plans created 11 Republican seats. Thus, the Legislative Respondents' Plan's creation of 12 11 Republican districts represents an extreme outcome compared to the 500 Simulation Set 1 plans. I am able to conclude that it is highly statistically improbable for the Legislative Respondents' February 9 Plan to have emerged from a partisan-neutral districting process.

Indeed, the median-mean gap for Legislative Respondents' February 9 Plan is 4.53 in Republicans' favor using 2008-2010 statewide elections and 4.75 using 2012-2016 statewide elections. These figures are far higher than the corresponding median-mean gaps for Petitioners' proposed plans, and confirm the extreme partisan bias of Legislative Respondents' plan.

County Splits: It is apparent that Legislative Respondents' February 9 Plan failed to adhere to the Court's January 22, 2018 Order to produce a plan that does not divide counties

¹ Legislative Respondents submitted a shapefile ("JointSubmissionShape.shp") depicting 18 districts and a partial block assignment file ("BlockFileJointSubmissionPlan.txt"). Legislative Respondents' block assignment file is not a complete assignment file assigning all 2010 Census blocks to districts. As of the 2010 Census, the Census Bureau created geographic boundaries for 421,545 census blocks in Pennsylvania.¹ See https://www2.census.gov/census_2010/01-Redistricting_File--PL_94-171/Pennsylvania/. Legislative Respondents' block assignment file assigns districts for most, but not all, of these blocks. According to the Census Bureau's 2010 listing of census blocks, there are 183 census blocks in Pennsylvania that are not assigned to congressional districts in Legislative Respondents' February 9 plan. I evaluated Legislative Respondents' February 9 Plan using the "JointSubmissionShape.shp" shapefile.

"except where necessary to ensure equality of population." This failure to follow the Court's Order is best illustrated by the excessive number of times various individual counties were split in Legislative Respondents' February 9 Plan. In particular, Legislative Respondents' February 9 Plan splits Montgomery County across four different districts. Given that Montgomery County's population (799,874) is barely above the required population of a district to ensure population equality (705,687), splitting Montgomery County four times cannot possibly be "necessary to ensure equality of population."

Thus, a more detailed statistic that measures compliance with the Court's Order regarding the dividing of counties is the total number of county fragments within the split counties in each plan. The Legislative Respondents' February 9 Plan splits 15 counties, but it splits those counties into a total of 35 county fragments. By contrast, Petitioners' Map A splits 14 counties into 31 county fragments, and Petitioners' Map B splits 15 counties into 31 county fragments.

Geographic Compactness: Table 5 below describes the compactness of each of the 18 districts in Legislative Respondents' Proposed Plan, as measured by the five measures of compactness listed in the Court's January 26, 2018 Order: Reock, Schwartzberg, Polsby-Popper, Population Polygon, and Minimum Convex Polygon.

As discussed earlier, in their February 9, 2018 brief, Legislative Respondents did not use a standard latitude-longitude coordinate system for the purposes of producing the compactness calculations presented on page 11 and on Attachment C of their brief. Instead, Legislative Respondents' calculations were clearly based on a Spherical Mercator projection system. Yet Legislative Respondents made an apples-to-oranges comparison on page 11 of their brief by plotting the compactness of their plan using a Spherical Mercator projection system against the compactness of my Simulation Set 1 plans using a latitude-longitude coordinate system.

**Table 5: Geographic Compactness of Legislative Respondents' February 9, 2018 Plan:
Compactness Scores Calculated Using Standard Latitude-Longitude Coordinate System:**

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.686	0.254	2.439	0.41	0.168	0.713
2	0.743	0.44	1.635	0.612	0.374	0.78
3	0.623	0.344	2.072	0.483	0.233	0.707
4	0.823	0.23	1.745	0.573	0.328	0.829
5	0.832	0.277	1.783	0.561	0.314	0.76
6	0.629	0.433	2.05	0.488	0.238	0.584
7	0.675	0.361	2.353	0.425	0.181	0.515
8	0.776	0.367	1.618	0.618	0.382	0.687
9	0.784	0.306	1.823	0.548	0.301	0.67
10	0.798	0.457	1.643	0.609	0.371	0.739
11	0.651	0.306	2.144	0.466	0.217	0.702
12	0.705	0.432	2.009	0.498	0.248	0.462
13	0.696	0.31	2.006	0.498	0.248	0.55
14	0.715	0.33	2.138	0.468	0.219	0.836
15	0.731	0.497	1.805	0.554	0.307	0.897
16	0.821	0.493	1.679	0.595	0.355	0.925
17	0.839	0.515	1.616	0.619	0.383	0.876
18	0.693	0.302	2.159	0.463	0.214	0.403
Minimum:	0.623	0.23	1.616	0.41	0.168	0.403
Maximum:	0.839	0.515	2.439	0.619	0.383	0.925
Mean:	0.734	0.37	1.929	0.527	0.282	0.702

Compactness Scores Calculated Using Spherical Mercator Projection System:

District	Min. Convex Polygon	Reock	Schwartzberg	Inverse Schwartzberg	Polsby-Popper	Population Polygon
1	0.686	0.299	2.393	0.418	0.175	0.713
2	0.743	0.553	1.609	0.621	0.386	0.78
3	0.622	0.282	2.097	0.477	0.227	0.708
4	0.823	0.298	1.666	0.6	0.36	0.829
5	0.829	0.37	1.671	0.598	0.358	0.761
6	0.629	0.419	2.002	0.499	0.249	0.585
7	0.675	0.39	2.316	0.432	0.186	0.516
8	0.776	0.443	1.59	0.629	0.396	0.688
9	0.784	0.371	1.752	0.571	0.326	0.668
10	0.797	0.428	1.61	0.621	0.386	0.74
11	0.65	0.27	2.068	0.484	0.234	0.701
12	0.705	0.425	2.035	0.491	0.242	0.462
13	0.696	0.404	1.971	0.507	0.257	0.551
14	0.715	0.41	2.099	0.476	0.227	0.836
15	0.731	0.517	1.755	0.57	0.325	0.897
16	0.821	0.525	1.649	0.606	0.368	0.925
17	0.84	0.564	1.58	0.633	0.4	0.877
18	0.693	0.353	2.157	0.464	0.215	0.402
Minimum:	0.622	0.27	1.58	0.418	0.175	0.402
Maximum:	0.84	0.564	2.393	0.633	0.4	0.925
Mean:	0.734	0.407	1.89	0.539	0.295	0.702

I determined that Legislative Respondents used this different projection system when I attempted to replicate the compactness scores reported in Attachment C of their brief. I discovered that Legislative Respondents' calculations of their proposed plan's Reock and Polsby-Popper scores could be reproduced only by taking the shapefile of Legislative Respondents' Proposed Plan and transforming the coordinates into a Spherical Mercator projection system. A Spherical Mercator projection system is entirely different from the standard WGS84 latitude-longitude coordinate system that I had used to calculate compactness scores in my November 2017 expert report. These two different coordinate systems results in different compactness scores, even when evaluating the same districting plan.

In order to facilitate a direct, apples-to-apples comparison of Legislative Respondents February 9, 2018 proposed plan to Petitioners' Proposed Maps and to the 500 Simulation Set 1 plans, I use both coordinate systems - a standard WGS84 latitude-longitude coordinate system as well as a Spherical Mercator projection system - in describing the compactness of all proposed plans evaluated in this report.

Using the standard latitude-longitude coordinate system, Legislative Respondents' Proposed Plan has a mean Reock score of 0.370 and a mean Polsby-Popper score of 0.282. Using a Spherical Mercator projection system, Legislative Respondents' Proposed Plan has a mean Reock score of 0.407 and a mean Polsby-Popper score of 0.295.

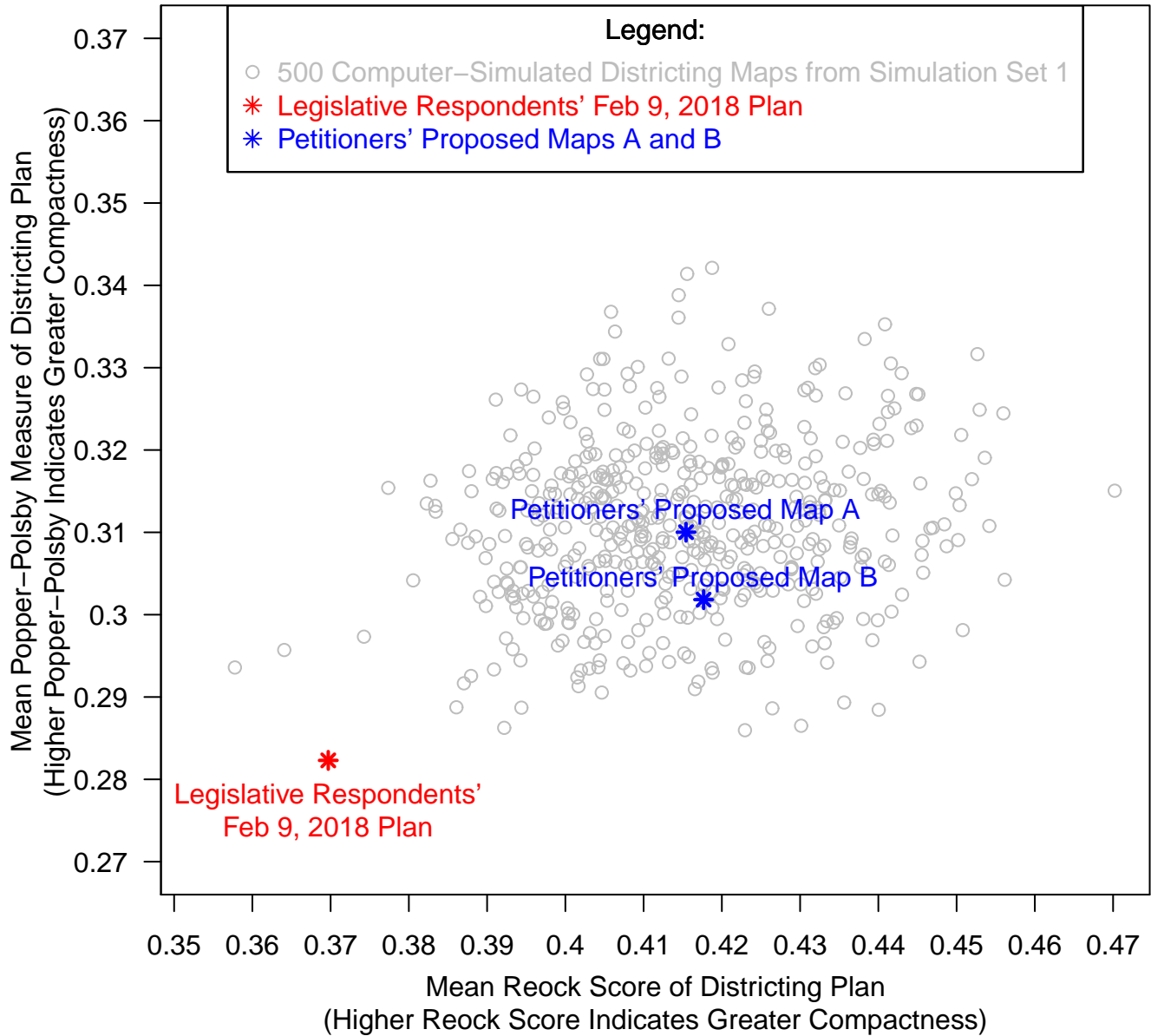
Having calculated the compactness scores for Legislative Respondents' Proposed Plan using the two different coordinate systems, we can thus observe a direct apples-to-apples comparison of Legislative Respondents' Plan to the 500 Simulation Set 1 plans in terms of geographic compactness in Figure 4. This Figure presents Reock and Polsby-Popper score calculations of all plans using the standard WGS84 latitude-longitude coordinate system. The 500 Simulation Set 1 plans are depicted by 500 gray circles, the Petitioners' Proposed Maps are depicted by blue stars, and the Legislative Respondents' February 9 Plan appears in a red star in the lower left corner of the Figure.

This Figure clearly reveals that the Legislative Respondents' Plan is less geographically compact than all 500 plans in Simulation Set 1, as measured by mean Popper-Polsby score. Legislative Respondents' Plan is also less compact than 498 of the 500 Simulation Set 1 plans, as measured by mean Reock score. Petitioners' Proposed Maps A and B, on the other hand, are in

the middle of the distribution of compactness scores, using either the Reock or Polsby-Popper measures of compactness.

Figure 4:

Compactness of Legislative Respondents' and Petitioners' Proposed Maps and 500 Simulation Set 1 Maps from Expert Report of November 27, 2017 (Calculated Using Standard Latitude-Longitude Coordinate System)



A similar pattern appears when using any of the other measures of compactness requested by the Court's January 26, 2018 Order. Figure 5 compares all of the proposed plans to Simulation Set 1 using the Minimum Convex Polygon measure (horizontal axis) and the Population Polygon measure (vertical axis). The Minimum Convex Polygon of a district measures the ratio of the district's areas to the area of the smallest convex polygon containing the district, while the Population Polygon of a district measures the ratio of the district's population to the population of the smallest convex polygon containing the district. This Figure shows the mean score for all plans using both of these measures.

Once again, it is apparent from this Figure that the Legislative Respondents' Plan is less geographically compact than all 500 of the Simulation Set 1 plans, as measured by either the Minimum Convex Polygon or the Population Polygon measures. The Legislative Respondents' Plan is far outside of the entire distribution of the 500 simulated plans, confirming once again that the Legislative Respondents' Plan significantly subordinates the traditional districting principle of geographic compactness. Petitioners' Proposed Maps A and B, on the other hand, are inside the normal range of the distribution of compactness scores using these two measures.

The same finding is confirmed once again when using the Schwartzberg measure of district compactness. The Schwartzberg score of a district is calculated by dividing the length of a district's perimeter by the circumference of a hypothetical circle whose area is equal to the district's area. Thus, unlike the previous four measures of compactness, a lower Schwartzberg score - that is, a district whose perimeter is shorter relative to the circumference of a circle with equal area - indicates a more compact district. As a result, redistricting scholars often simply measure the inverse of the Schwartzberg score, in order to create a scale on which higher scores indicate more compact districts.

In Figure 6, I present both methods of calculating the Schwartzberg score for all 500 simulated plans, as well as the Legislative Respondents' Plan and Petitioners' Proposed Maps A and B. The vertical axis measures the mean Schwartzberg score for each plan, while the horizontal axis measures the mean Inverse Schwartzberg score for each plan.

Once again, it is apparent from this Figure that the Legislative Respondents' Plan is less geographically compact than all 500 of the Simulation Set 1 plans, as measured by either the Schwartzberg or the Inverse Schwartzberg measures. The Legislative Respondents' Plan has a lower mean Inverse Schwartzberg score, indicating less compact districts, than all 500

Simulation Set 1 plans. Similarly, the Legislative Respondents' Plan has a higher mean Schwartzberg score than all 500 Simulation Set 1 plans, once again indicating a less compact districting plan. Petitioners' Proposed Maps A and B, on the other hand, are near the middle of the normal range of Simulation Set 1's distribution of compactness scores using the Schwartzberg and the inverse Schwartzberg measures.

In summary, the Court's January 26, 2018 Order specified five measures of district compactness. Legislative Respondents asserted in their February 9 brief that their proposed plan is as compact as many of the Simulation Set 1 plans using the Reock and Polsby-Popper measures. This assertion is not true because Legislative Respondents produced their proposed plan's compactness calculations by using an entirely different geographic coordinate system than the one I used for the 500 Simulation Set 1 plans at trial. When all plans are evaluated using the same coordinate system, Legislative Respondents' February 9 plan is less geographically compact than all 500 Simulation Set 1 plans according to the Schwartzberg, Polsby-Popper, Population Polygon, and Minimum Convex Polygon. It is also less compact than 498 of the 500 Simulation Set 1 plans, as measured by Reock score. I am thus able to conclude, with extremely strong statistical certainty, that Legislative Respondents' February 9 proposed plan significantly subordinates geographic compactness and could not have arisen from a partisan-neutral district process adhering to the Court's January 22, 2018 Order requiring compact districts.

Figure 5:

Compactness of Legislative Respondents' and Petitioners' Proposed Maps and 500 Simulation Set 1 Maps from Expert Report of November 27, 2017 (Calculated Using Standard Latitude-Longitude Coordinate System)

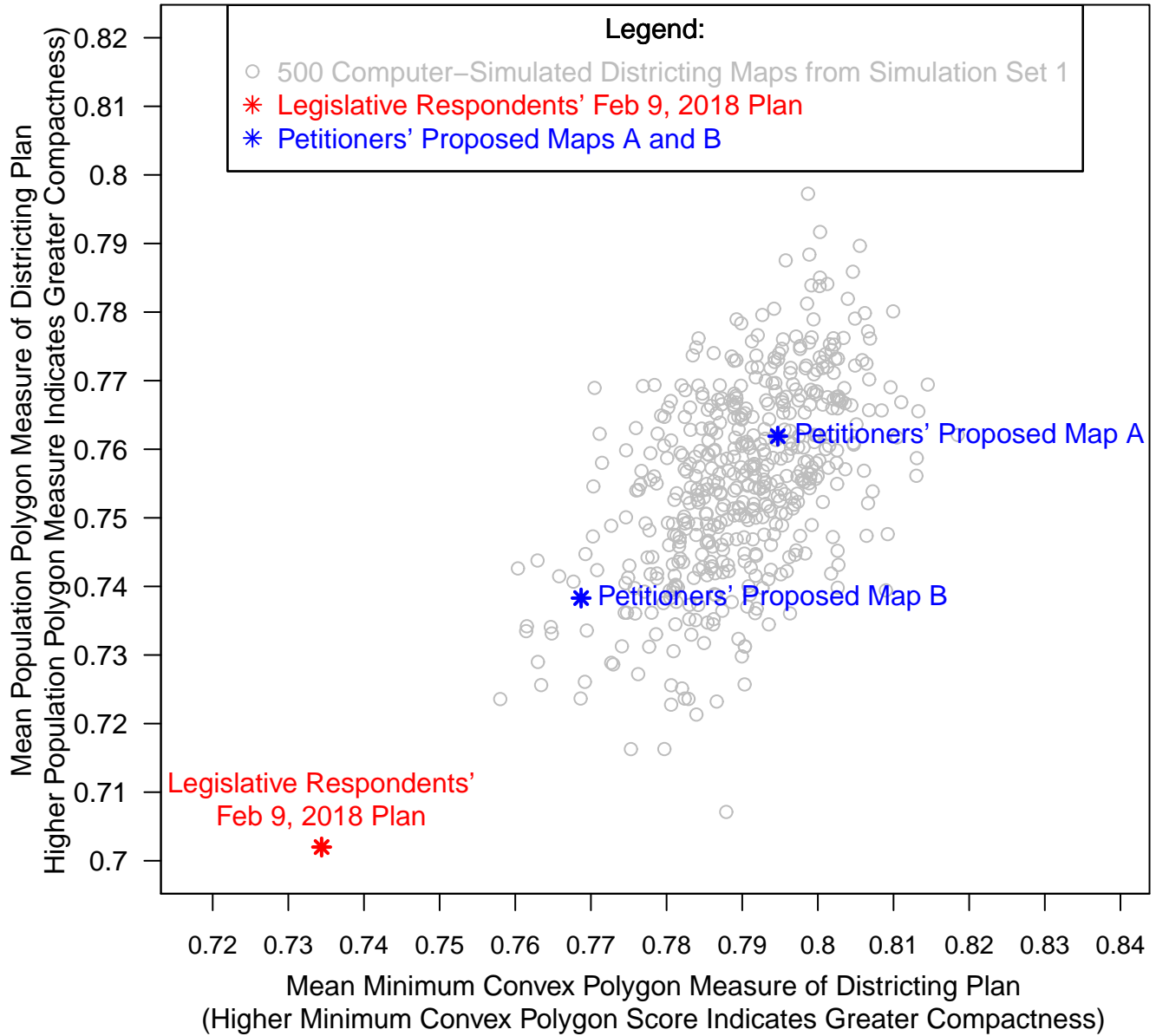
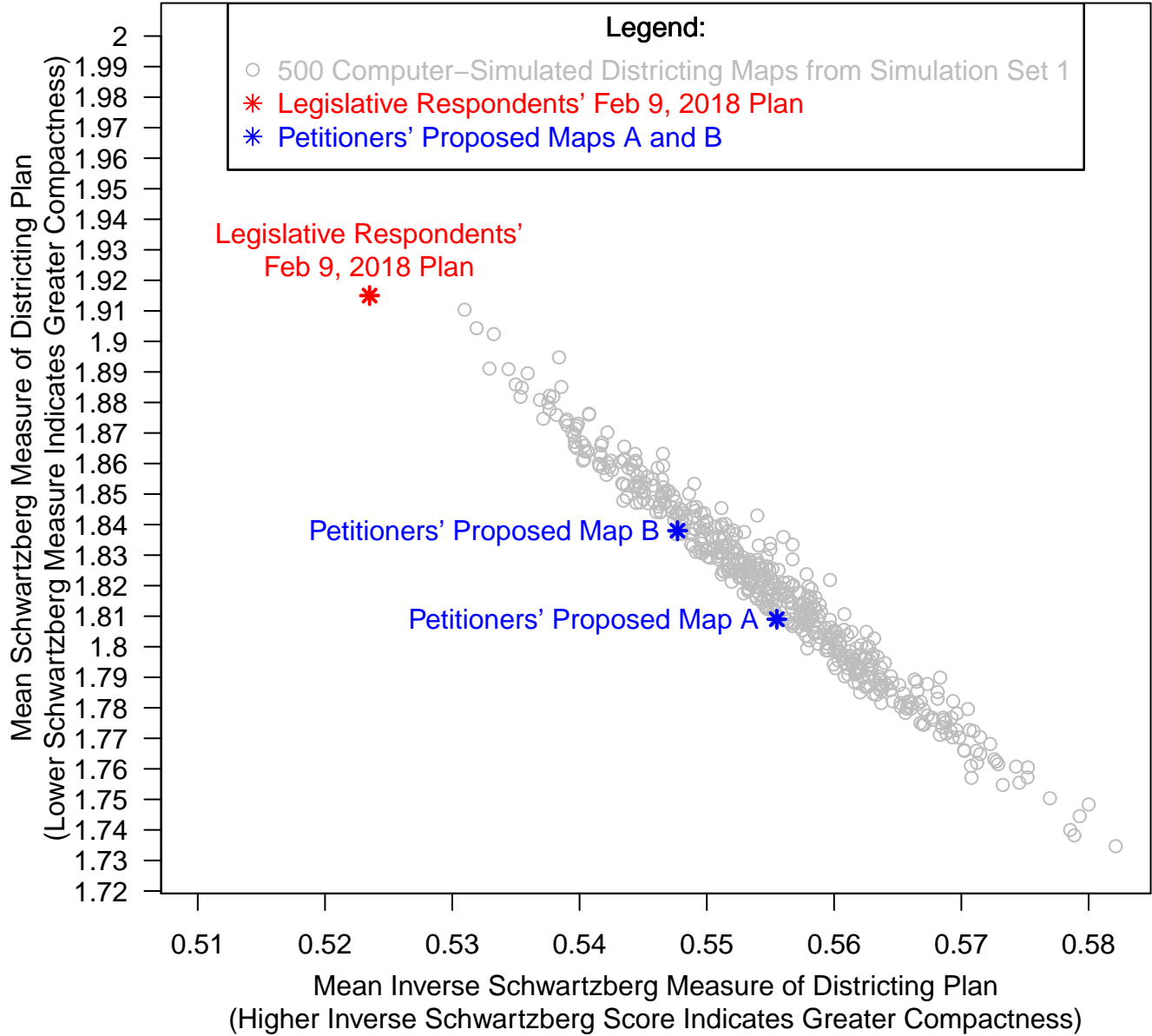


Figure 6:

Compactness of Legislative Respondents' and Petitioners' Proposed Maps and 500 Simulation Set 1 Maps from Expert Report of November 27, 2017 (Calculated Using Standard Latitude–Longitude Coordinate System)



Appendix A:
County, Municipality, and Precinct Splits in Petitioners' Proposed Map A

Plan Totals:

14 Split Counties, divided into 31 County Fragments
50 Split Municipalities, 20 Split Precincts

District	Split Counties	Split Municipalities	Split Precincts
1	Chester; Philadelphia	Easttown township; Philadelphia city; Tredyffrin township	EASTTOWN TWP VTD 07; PHILADELPHIA WD 01 PCT 13
2	Philadelphia	Philadelphia city	PHILADELPHIA WD 01 PCT 13; PHILADELPHIA WD 43 PCT 14
3	Cambria; Venango; Westmoreland	Barr township; Cambria township; Derry township; Donegal township; Falls Creek borough; Latrobe city; Northern Cambria borough; Richland township; Seven Springs borough; Unity township	CAMBRIA TWP VTD COLVER; RICHLAND TWP Voting District; DERRY TWP VTD COOPERSTOWN; UNITY TWP VTD WHITNEY
4	Cumberland; Lancaster	Lancaster city; Lancaster township; Lower Allen township; Manheim township; Manor township; Mount Joy township; Penn township; Rapho township; Warwick township	LOWER ALLEN TWP PCT 01; PENN TWP DIST JUNCTION
5	Cambria; Clinton	Barr township; Cambria township; Falls Creek borough; Northern Cambria borough; Wayne township	CAMBRIA TWP VTD COLVER; WAYNE TWP Voting District
6	Lancaster; Lehigh	Earl township; East Earl township; Manheim township; Mount Joy township; New Holland borough; Penn township; Rapho township; Upper Leacock township; Upper Macungie township; Warwick township; West Earl township	PENN TWP DIST JUNCTION; WEST EARL TWP VTD EARLVILLE; UPPER MACUNGIE TWP DIST 04
7	Montgomery	Abington township; Cheltenham township; Telford borough; Upper Moreland township	CHELTENHAM TWP VTD 02 ED 04; UPPER MORELAND TWP VTD 07 ED 02
8	Montgomery	Abington township; Cheltenham township; Telford borough; Upper Moreland township	CHELTENHAM TWP VTD 02 ED 04; CHELTENHAM TWP VTD 05 ED 02; UPPER MORELAND TWP VTD 07 ED 02
9	Lawrence; Venango	Richland township; Shenango township; Wayne township	WAYNE TWP VTD 01; RICHLAND TWP Voting District
10	Clinton; Luzerne	Bear Creek township; Edwardsville borough; Hanover township; Kingston borough; Lehman township; Wayne township; Wilkes-Barre city	WAYNE TWP Voting District; BEAR CREEK TWP DIST 03
11	Cumberland	Lower Allen township	LOWER ALLEN TWP PCT 01
12	Allegheny; Lawrence	Baldwin borough; McCandless township; McDonald borough; Pine township; Pittsburgh city; Ross township; Shenango township; Wayne township; Whitehall borough	PITTSBURGH WD 06 DIST 05; ROSS TWP WD 02 DIST 03; WAYNE TWP VTD 01
13	Montgomery; Philadelphia	Abington township; Cheltenham township; Philadelphia city	CHELTENHAM TWP VTD 05 ED 02; PHILADELPHIA WD 43 PCT 14
14	Allegheny	Baldwin borough; McCandless township; Pine township; Pittsburgh city; Ross township; Trafford borough; Whitehall borough	PITTSBURGH WD 06 DIST 05; ROSS TWP WD 02 DIST 03
15	Lehigh;	Tunkhannock township; Upper Macungie township	UPPER MACUNGIE TWP DIST 04;

	Monroe		TUNKHANNOCK TWP Voting District
16	Chester; Lancaster	Earl township; East Earl township; Easttown township; Lancaster city; Lancaster township; Manheim township; Manor township; New Holland borough; Tredyffrin township; Upper Leacock township; West Earl township	EASTTOWN TWP VTD 07; WEST EARL TWP VTD EARLVILLE
17	Luzerne; Monroe	Bear Creek township; Edwardsville borough; Hanover township; Kingston borough; Lehman township; Tunkhannock township; Wilkes-Barre city	BEAR CREEK TWP DIST 03; TUNKHANNOCK TWP Voting District
18	Westmoreland	Derry township; Donegal township; Latrobe city; McDonald borough; Seven Springs borough; Trafford borough; Unity township	DERRY TWP VTD COOPERSTOWN; UNITY TWP VTD WHITNEY

**Appendix B:
County, Municipality, and Precinct Splits in Petitioners' Proposed Map B**

Plan Totals:

15 Split Counties, divided into 32 County Fragments
32 Split Municipalities, 17 Split Precincts

District	Split Counties	Split Municipalities	Split Precincts
1	Delaware; Philadelphia	Edgmont township; Philadelphia city; Upper Chichester township	EDGMONT 01; PHILADELPHIA WD 08 PCT 28
2	Philadelphia	Philadelphia city	PHILADELPHIA WD 08 PCT 28; PHILADELPHIA WD 43 PCT 13
3	Allegheny; Clarion	Emlenton borough; Richland township; Washington township; West Deer township	WEST DEER TWP DIST 07; WASHINGTON TWP Voting District
4	Dauphin; York	Dauphin borough; Dover township; Middle Paxton township; Shippensburg borough	DAUPHIN Voting District; DOVER TWP DIST 04
5	Dauphin; Franklin	Antrim township; Dauphin borough; Middle Paxton township; Peters township; Shippensburg borough; Tunnelhill borough	DAUPHIN Voting District; ANTRIM TWP VTD 01
6	Delaware; Lancaster	Adamstown borough; Edgmont township; Paradise township; Upper Chichester township	EDGMONT 01; PARADISE TWP Voting District
7	Berks; Montgomery	Brecknock township; Lower Alsace township; Telford borough; Upper Dublin township	BRECKNOCK TWP DIST 02; UPPER DUBLIN TWP VTD 05 ED 02
8	Bucks; Montgomery	Bristol township; Hulmeville borough; Telford borough; Upper Dublin township	HULMEVILLE Voting District; UPPER DUBLIN TWP VTD 05 ED 02
9	Franklin; Washington	Antrim township; North Charleroi borough; Peters township; Trafford borough	ANTRIM TWP VTD 01; NORTH CHARLEROI VTD 02
10	Indiana	Brush Valley township; Falls Creek borough; Tunnelhill borough	BRUSH VALLEY TWP Voting District
11	Berks; Luzerne	Adamstown borough; Brecknock township; Lake township; Lower Alsace township	BRECKNOCK TWP DIST 02; LAKE TWP Voting District
12	Allegheny	Bethel Park Borough; Harmar township; McDonald borough; Pittsburgh city; Richland township; West Deer township	HARMAR TWP DIST 02; WEST DEER TWP DIST 07
13	Bucks; Philadelphia	Bristol township; Hulmeville borough; Philadelphia city	HULMEVILLE Voting District; PHILADELPHIA WD 43 PCT 13
14	Allegheny; Washington	Bethel Park Borough; Harmar township; McDonald borough; North Charleroi borough; Pittsburgh city; Trafford borough	HARMAR TWP DIST 02; NORTH CHARLEROI VTD 02
15	Monroe	Tobyhanna township	TOBYHANNA TWP VTD EAST
16	Lancaster; York	Dover township; Paradise township	PARADISE TWP Voting District; DOVER TWP DIST 04
17	Luzerne; Monroe	Lake township; Tobyhanna township	LAKE TWP Voting District; TOBYHANNA TWP VTD EAST
18	Clarion; Indiana	Brush Valley township; Emlenton borough; Falls Creek borough; Washington township	WASHINGTON TWP Voting District; BRUSH VALLEY TWP Voting District

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification to authorities.

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke at the bottom.

EXHIBIT B

SUPPLEMENTAL REPORT
ON
PENNSYLVANIA'S CONGRESSIONAL DISTRICTS
BY
JOHN J. KENNEDY, PhD
FEBRUARY 15, 2018

This report is a supplement to my November 27, 2017 Report on Pennsylvania’s Congressional Districts submitted to Pennsylvania’s Commonwealth Court. Its purpose is to assess certain maps the parties have provided to the Pennsylvania Supreme Court to replace the 2011 map that the court ruled violated the Pennsylvania State Constitution.

Petitioners’ Maps

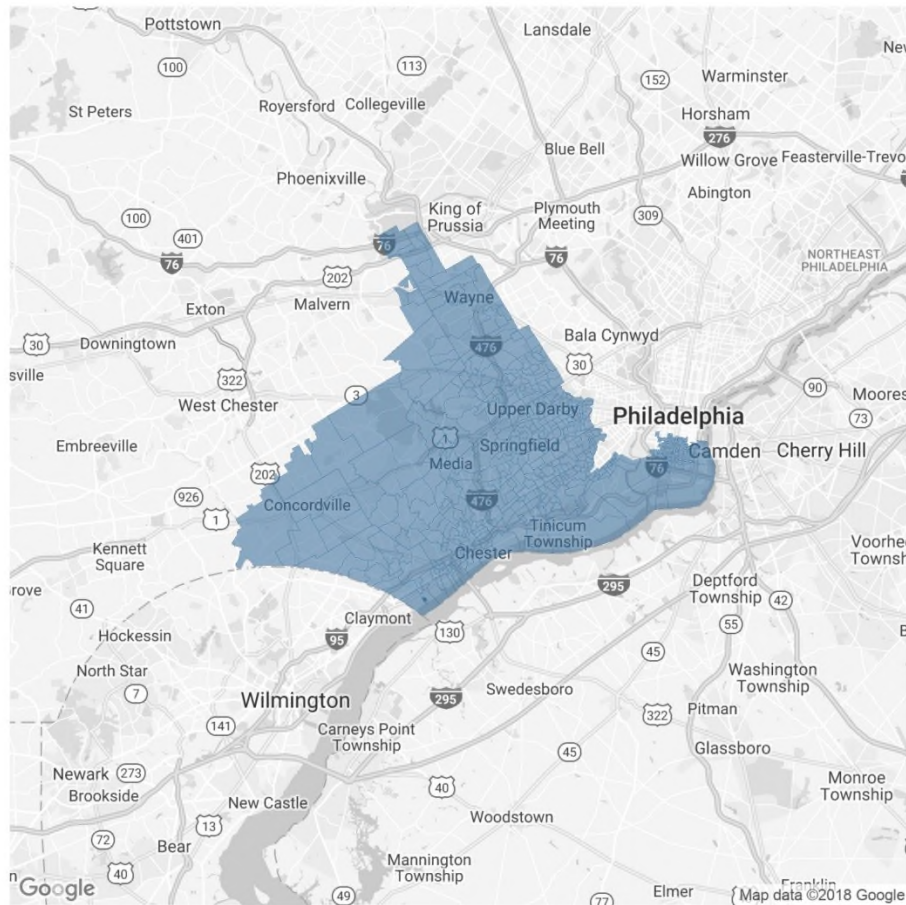
In conjunction with preparing this report, I analyzed proposed maps for Pennsylvania’s congressional districts generated by Dr. Jowei Chen. I concluded that two of them—designated as Petitioners’ Map A and Map B—stand out among the simulated plans in achieving the standards set forth by the Pennsylvania Supreme Court in the January 22, 2018 decision.

Given Pennsylvania’s population of almost 13 million inhabitants unevenly distributed across roughly 46,000 square miles in a state containing highly populated urban areas, vast sparsely populated ones, and medium sized cities in between, no map will be perfect. However, in my opinion, the two maps proposed by Petitioners provide the citizens of the Commonwealth the best opportunity to register their voting preference while preserving communities of interest.

My objective, as someone who has written extensively about Pennsylvania’s Political History and Geography, is to determine which maps best protect the integrity of the state’s communities of interest. Below I outline the strengths of Petitioners’ proposed maps from this standpoint. I then evaluate the map proposed by Legislative Respondents on February 9, 2018 (“Legislative Respondents’ February 9 Plan”), and explain how that plan divides communities of interest for obviously partisan political motivations.

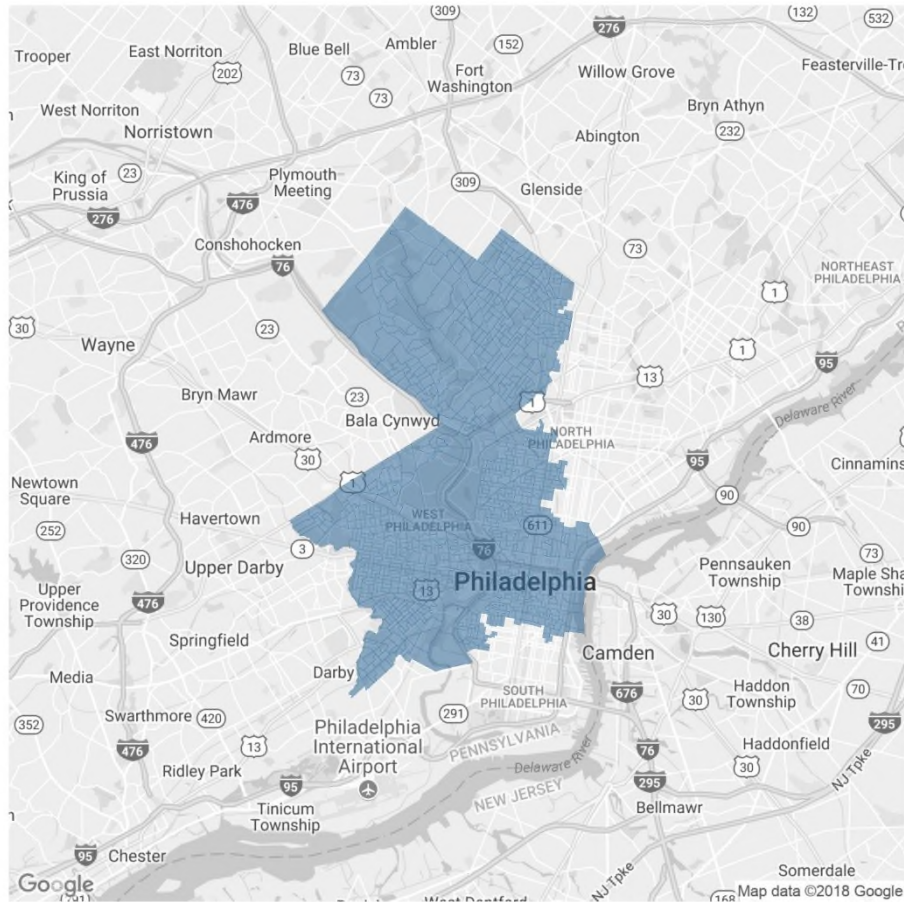
I. Petitioners' Map A

1st Congressional District



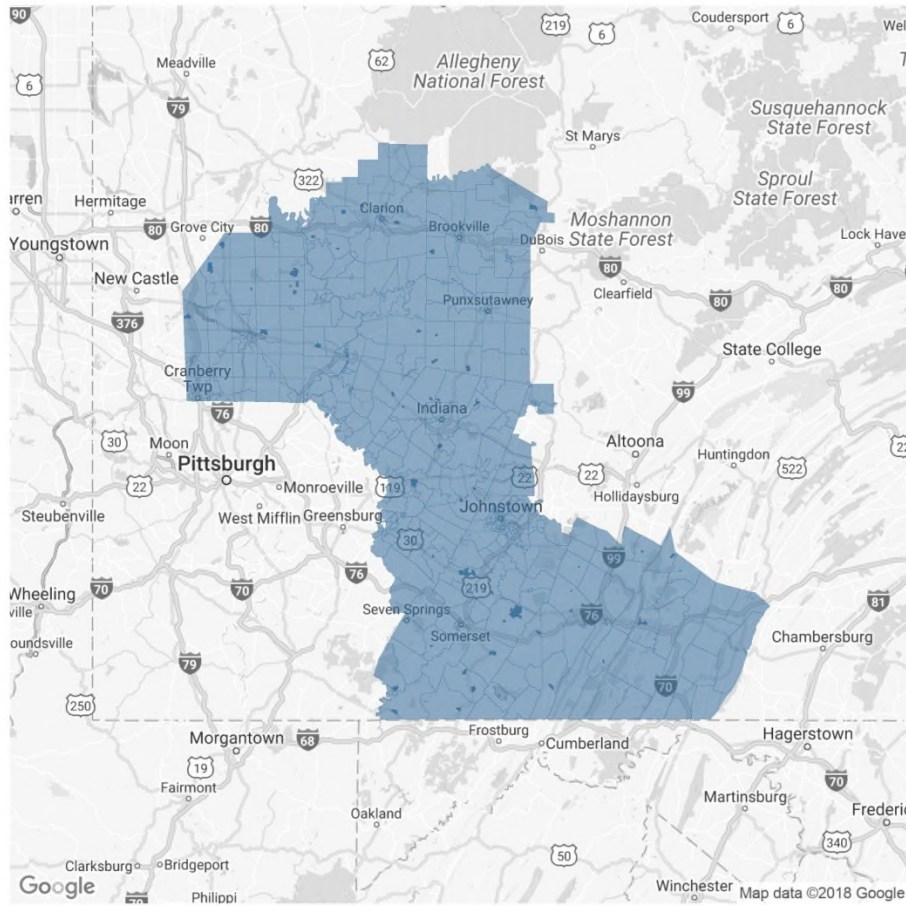
The 1st Congressional District under Map A marks a return to what can again be described as the “Delco” seat. It contains the entirety of Delaware County, a sharp departure from the 2011 map, where some Democratic-heavy municipalities from Delaware County were packed into the neighboring Philadelphia-based district in an odd appendage. Because Delaware County’s population is not sufficiently large to warrant its own individual congressional district, a narrow section of south Philadelphia and a sliver of Chester counties are included within this district. This makes sense from a geographic compactness and community interest standpoint, a far cry from the previous map that grouped parts of Delaware County together with Berks and Lancaster Counties in the infamous “Goofy Kicking Donald Duck” district.

2nd Congressional District



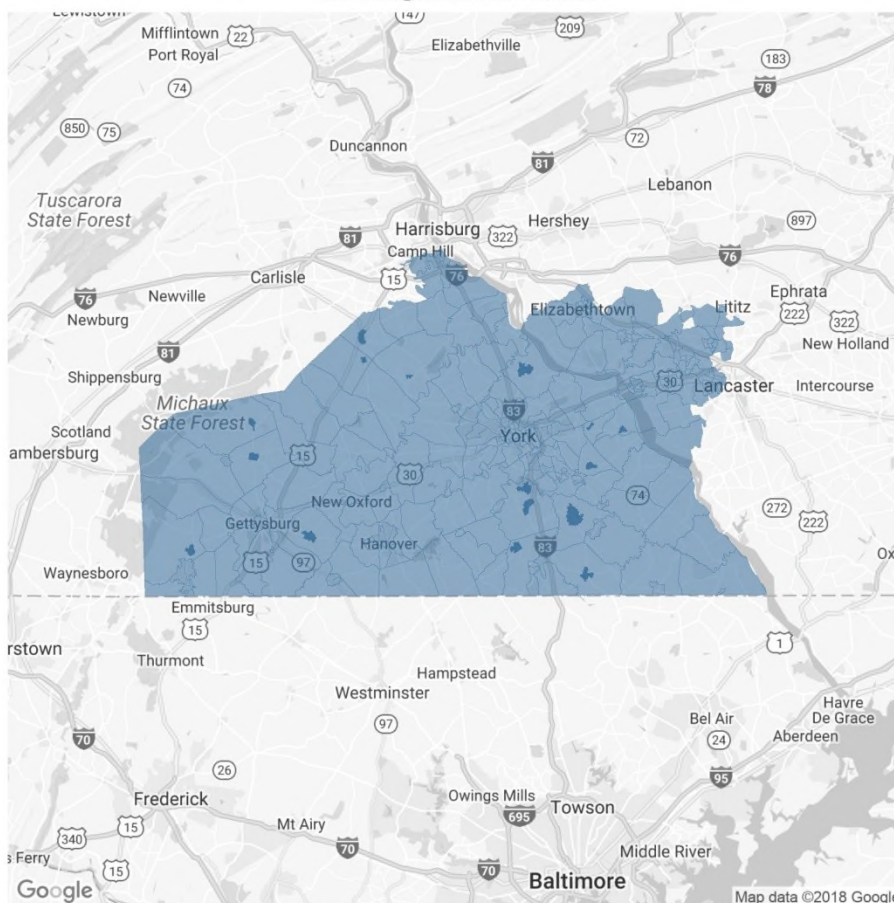
The 2nd Congressional District is a minority-majority district that is fully contained within the city borders. It includes West Philadelphia, parts of South Philadelphia, and Center City Philadelphia.

3rd Congressional District



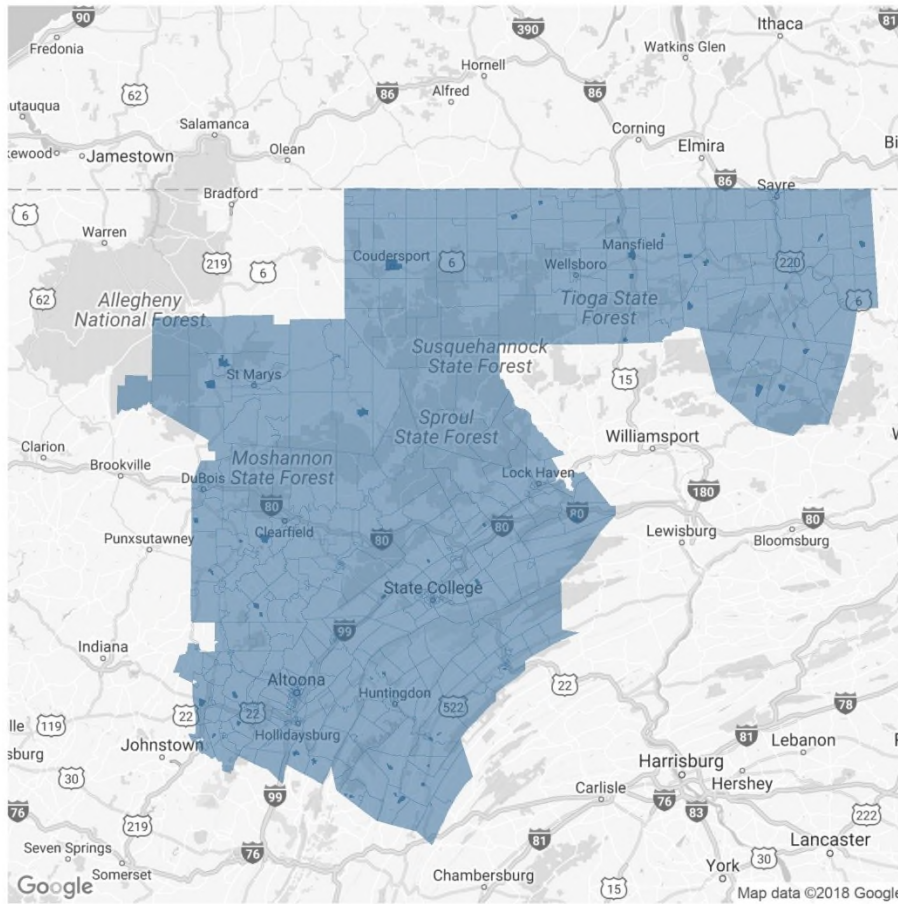
Located in west-central Pennsylvania, the 3rd Congressional District contains 11 counties due to the slight populations of these counties. The district splits only three of these counties, Cambria, Westmoreland, and Venango—the latter of which is just barely split. Though its land area is large due to the scattered populations in this area, the district itself is relatively compact.

4th Congressional District



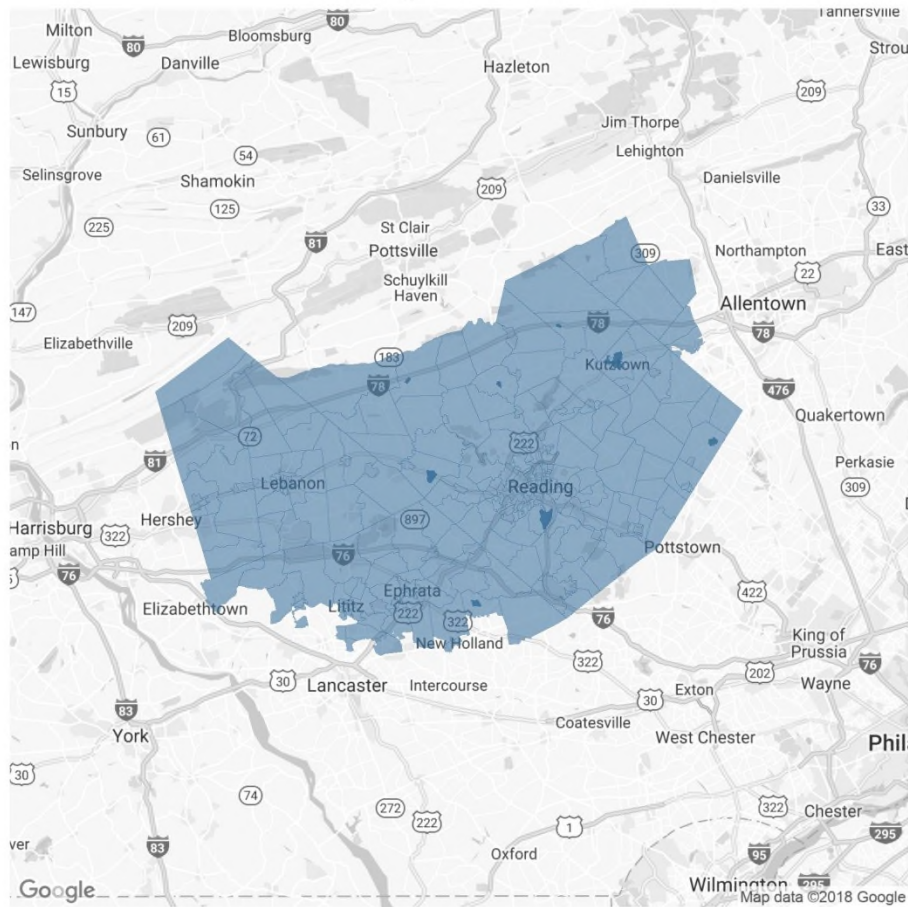
The 4th Congressional District is located along the Commonwealth’s southern border and includes the entirety of Adams and York as well as a part of western Lancaster County, a geographic combination of several common communities of interest. Unlike the 2011 map, the 4th District in Map A no longer includes Harrisburg, which the 2011 map had cracked in order to dilute the strength of its Democratic voters.

5th Congressional District



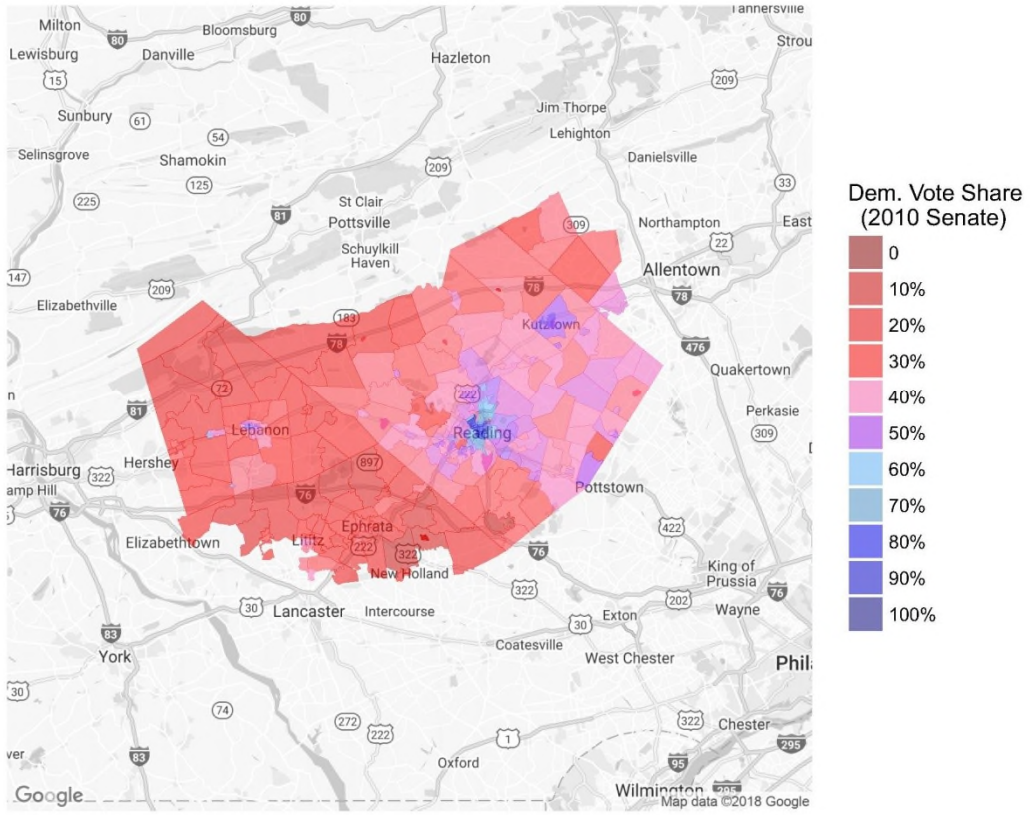
Necessitated by the sparsely populated terrain of parts of mid-state Pennsylvania as well as its northern tier, the 5th Congressional District is the most expansive congressional district included within this map. Nevertheless, it does well to maintain a geographic balance while preserving the integrity of the 13 counties contained within it, only two of which, Cambria and Clinton, are split.

6th Congressional District

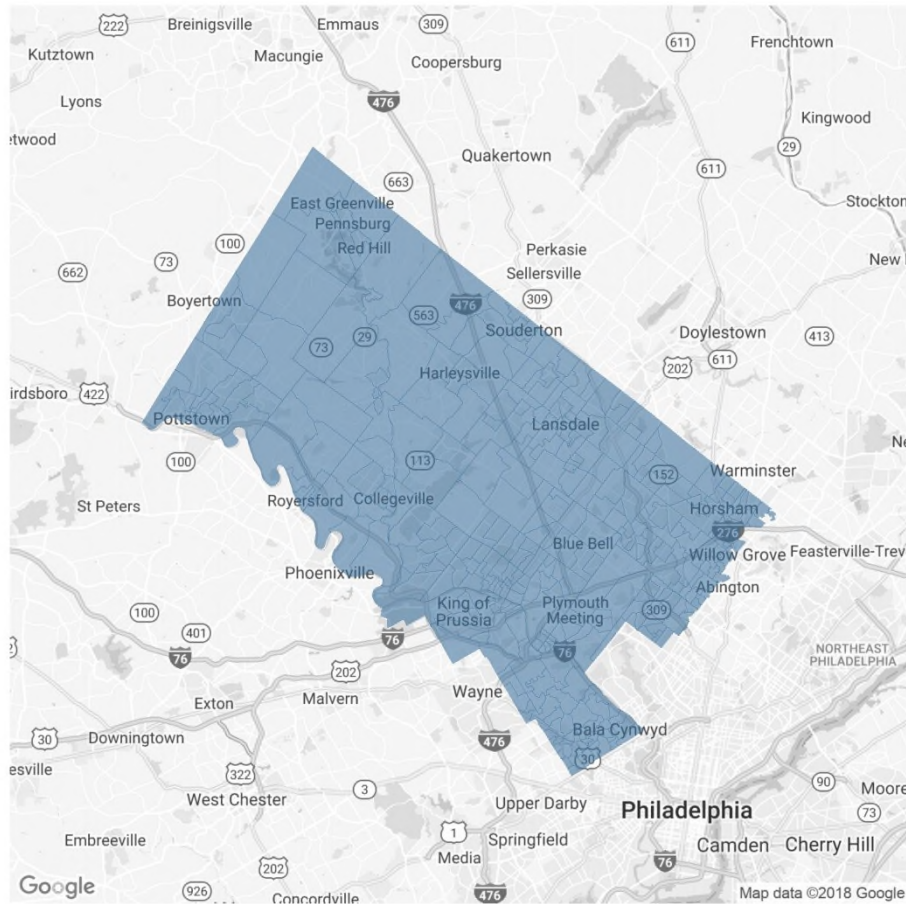


The 6th Congressional District includes the entirety of Berks County, as well as small portions of western Lehigh, northern Lancaster, and eastern Lebanon counties. The preservation of Berks County is notable, since the 2011 map split Berks County into four different congressional districts, taking pains to crack its Democratic voters. Berks County is unique in that it is a “Metropolitan Statistical Area” itself, while still a part of the “Combined Statistical Area” of Philadelphia-NJ-DE-MD. The City of Reading, which is the county seat, is no longer split from the rest of Berks County as under the 2011 map. Rather, as illustrated on the red-blue map, Reading and its suburbs are intact within this district, preserving the vital role that Reading plays in the broader community within Berks County.

6th Congressional District

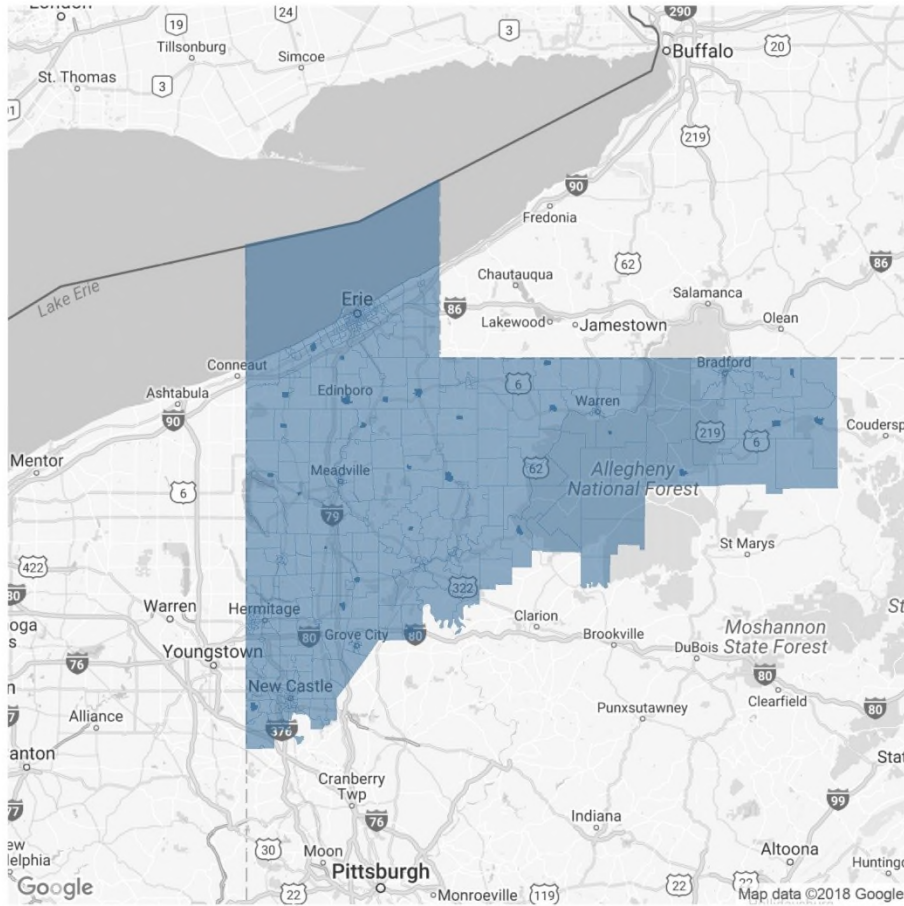


7th Congressional District



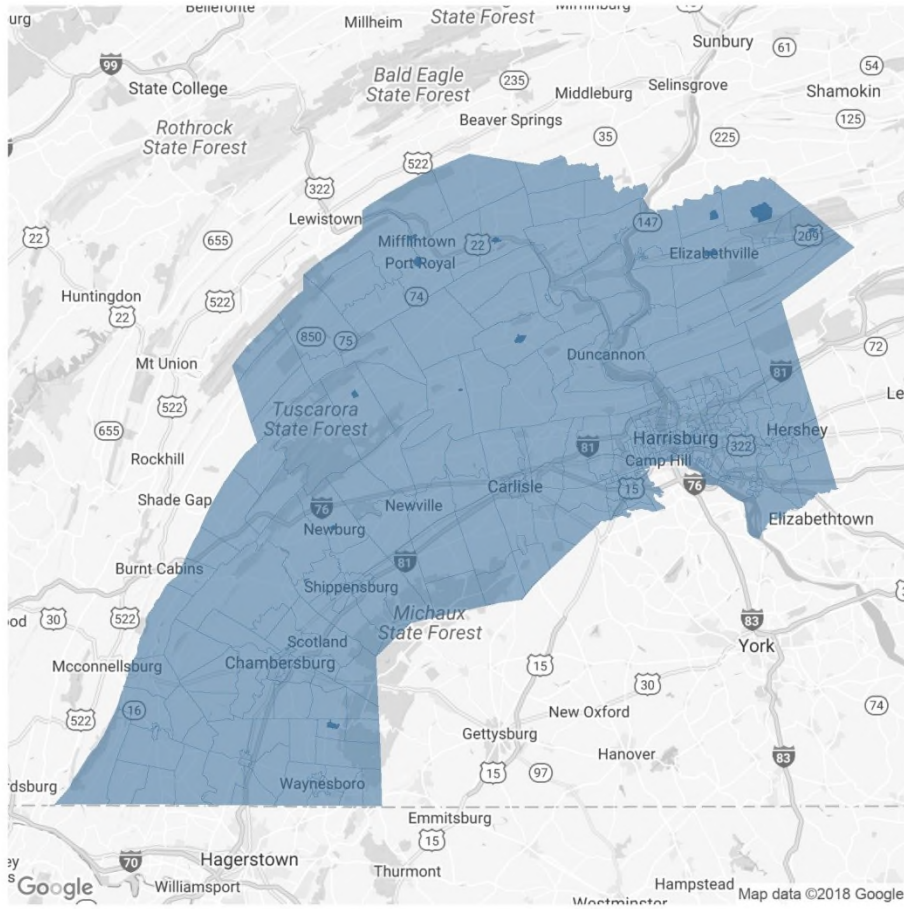
The 7th Congressional District in this map includes almost the entirety of Montgomery County, in stark contrast to the 2011 map, which carved up the state's third largest county into five different congressional districts. Because its population is slightly larger than the size of a congressional district in Pennsylvania, it is not possible for Montgomery County to avoid being split. However, this map minimizes the impact considerably shaving off a piece on its eastern side that bears many similarities with the Bucks County-based 8th Congressional District to which that piece is joined. These adjacent communities in the two areas that straddle the Montgomery County split share many commonalities. For instance, both currently share two seats in the Pennsylvania State Senate (12th and 24th). In fact, a tiny sliver of the southeastern portion of Montgomery County was also placed within the 13th District in the previous map.

9th Congressional District



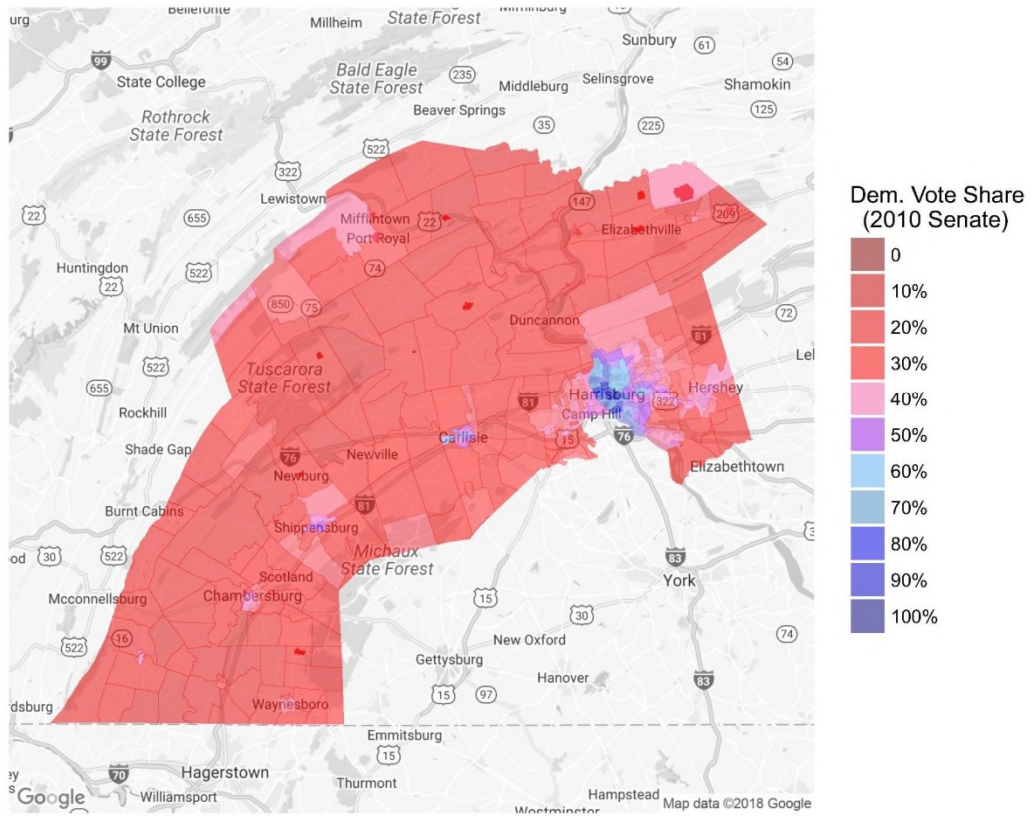
The 9th Congressional District is in the northwest corner of the state. This is an Erie-centered seat, keeping the largest municipality in the area together with its greater metropolitan area; this is consistent with the historic treatment of Erie and a change from the 2011 map, which had split Erie from its suburbs. This district includes eight counties, but only two are split, Lawrence and Venango. And each of those counties is split by only a slight amount to achieve population equality.

11th Congressional District

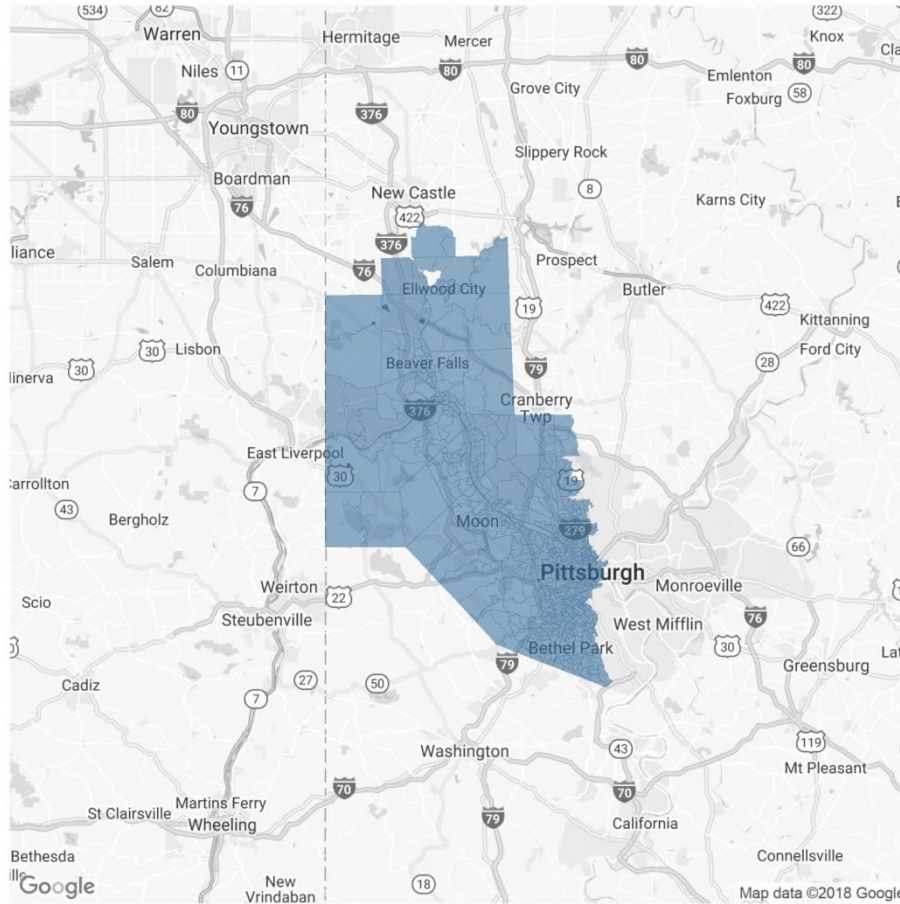


The 11th Congressional District is located along the southern end of the state's portion of the Susquehanna River, taking in five whole counties. It should be noted that (as illustrated on the red-blue map) Dauphin County and Harrisburg (along with its suburbs) are preserved, unlike in the 2011 map.

11th Congressional District



12th Congressional District



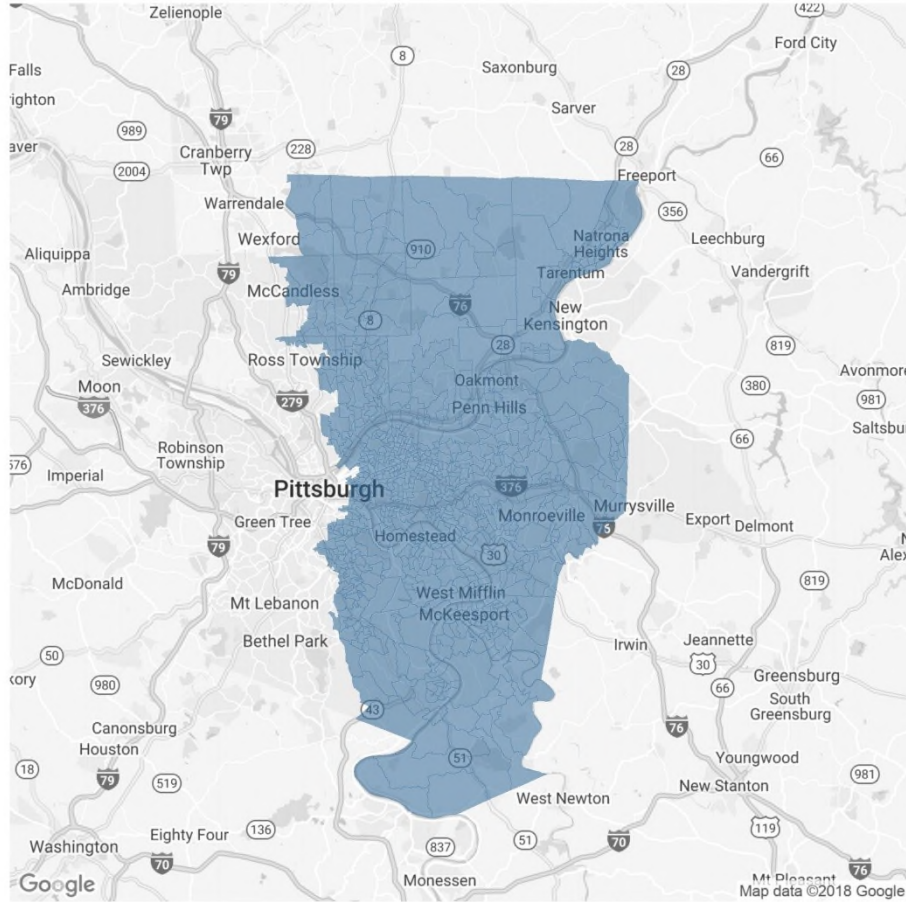
The 12th Congressional District is comprised primarily of the western Pittsburgh metropolitan area (including part of Allegheny County as well as adjacent Beaver County and a small portion of southern Lawrence County, to achieve population equality). This district is compact, and far more so than the equivalent district in the 2011 map, which stretched from Lawrence County to Somerset County, a distance of approximately 120 miles.

13th Congressional District



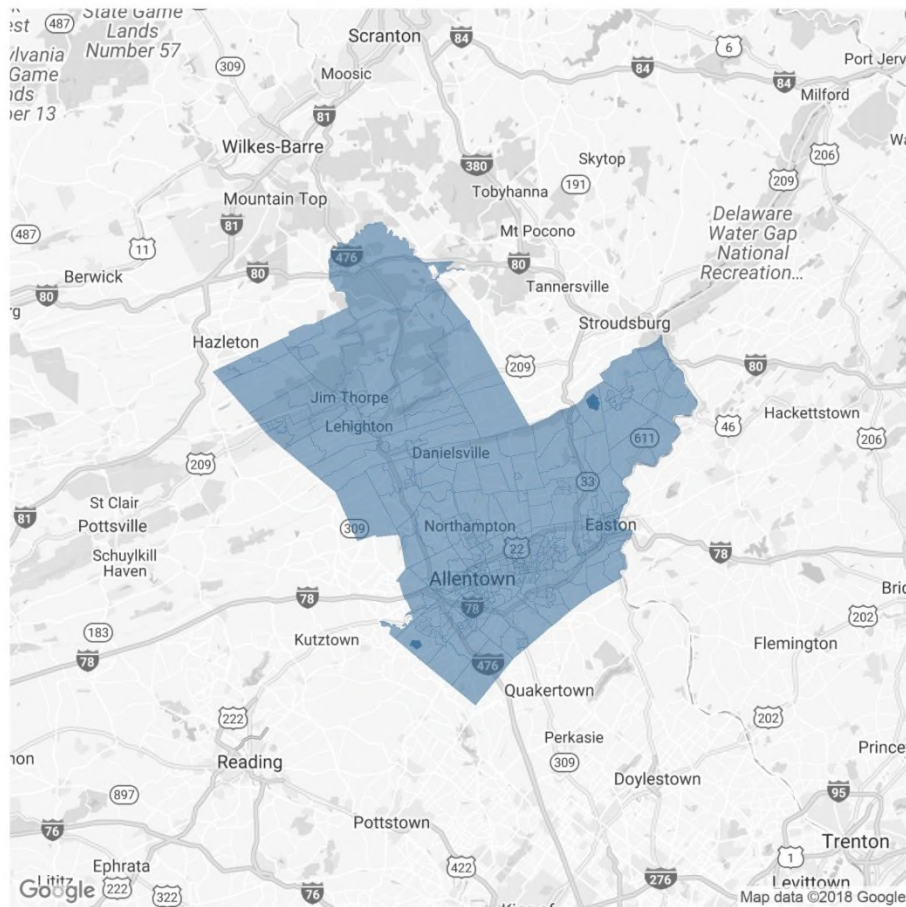
The 13th Congressional District, which is contained almost completely within Philadelphia, includes the north and northeast areas of the state's largest city. In addition to Philadelphia, the district includes the Montgomery County township of Cheltenham (just over the county line) to achieve population equality. It is extremely compact, contains no tentacles designed to crack municipalities from its neighboring counties, and makes sense geographically.

14th Congressional District



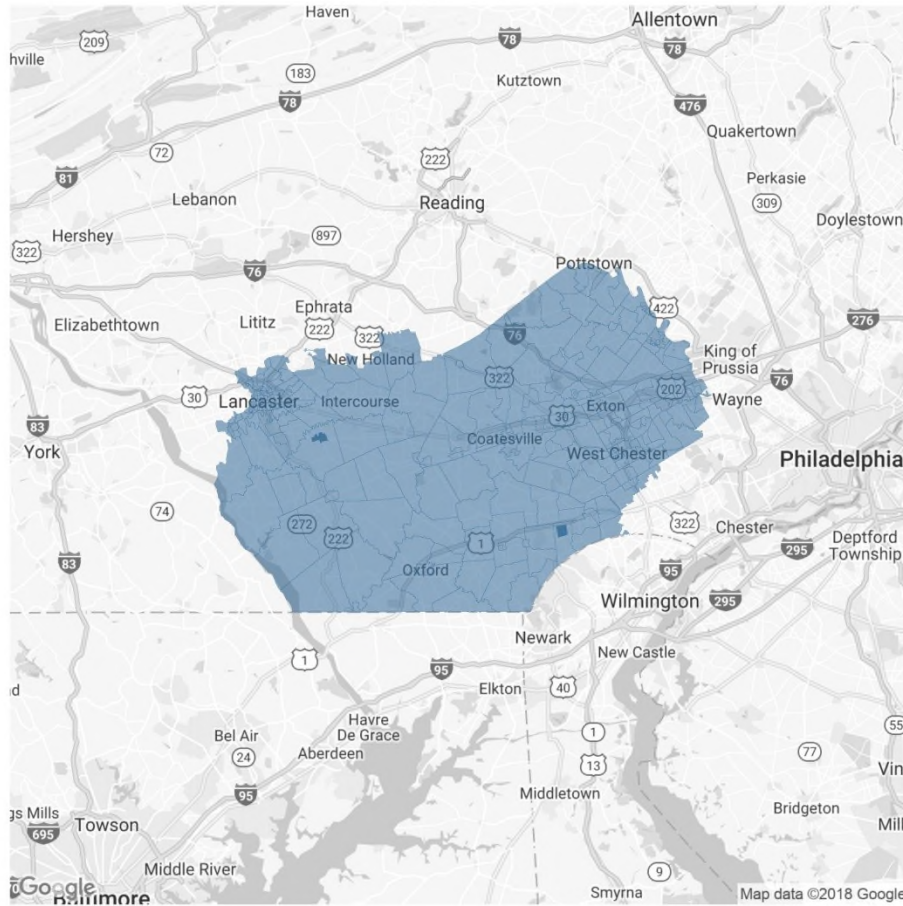
The 14th Congressional District includes the eastern parts of the Pittsburgh metropolitan area. It is confined entirely within Allegheny County and is extremely compact.

15th Congressional District



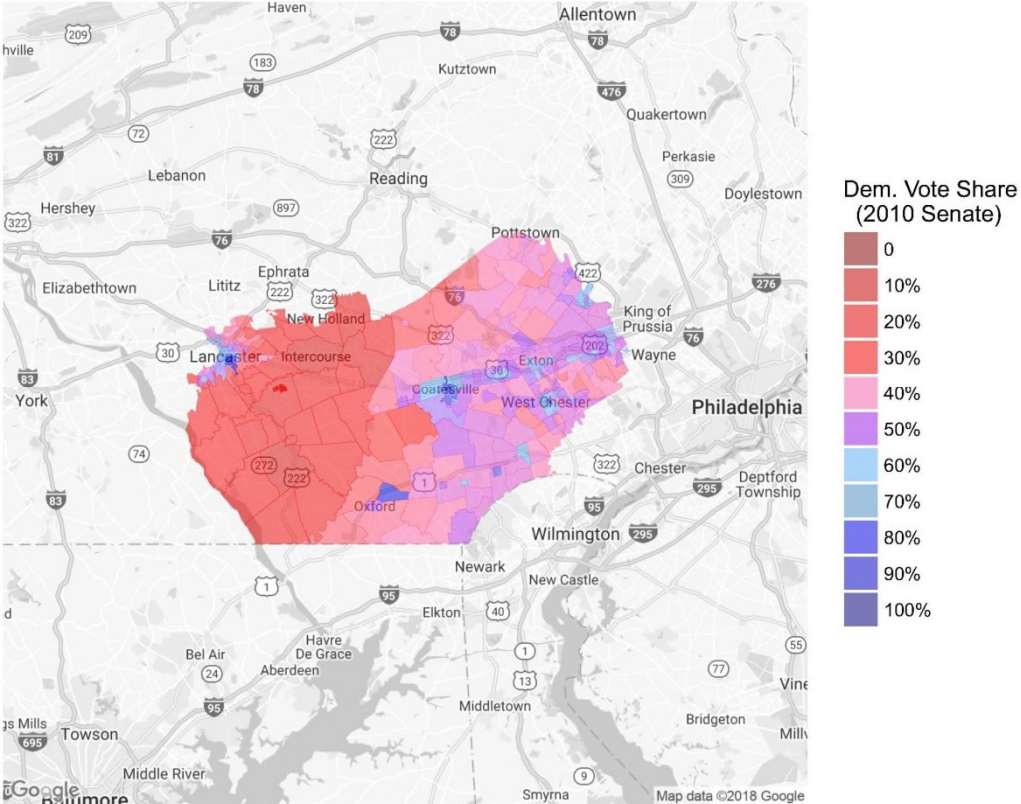
Map A also restores the Lehigh Valley seat in the 15th Congressional District. Unlike the 2011 map, the region is preserved by including all of Northampton and Carbon counties, almost all of Lehigh County, as well as a small portion of southwestern Monroe County, within the same district. Although a portion of the northwest corner of Lehigh County is included in the neighboring 6th Congressional District, this largely rural section of the county is compatible with the character of northeastern Berks County, which it abuts. Most importantly, however, the three major cities in the Lehigh Valley—Allentown, Bethlehem, and Easton, as well as their suburbs—are all wholly included within this district, as illustrated on the red-blue map.

16th Congressional District

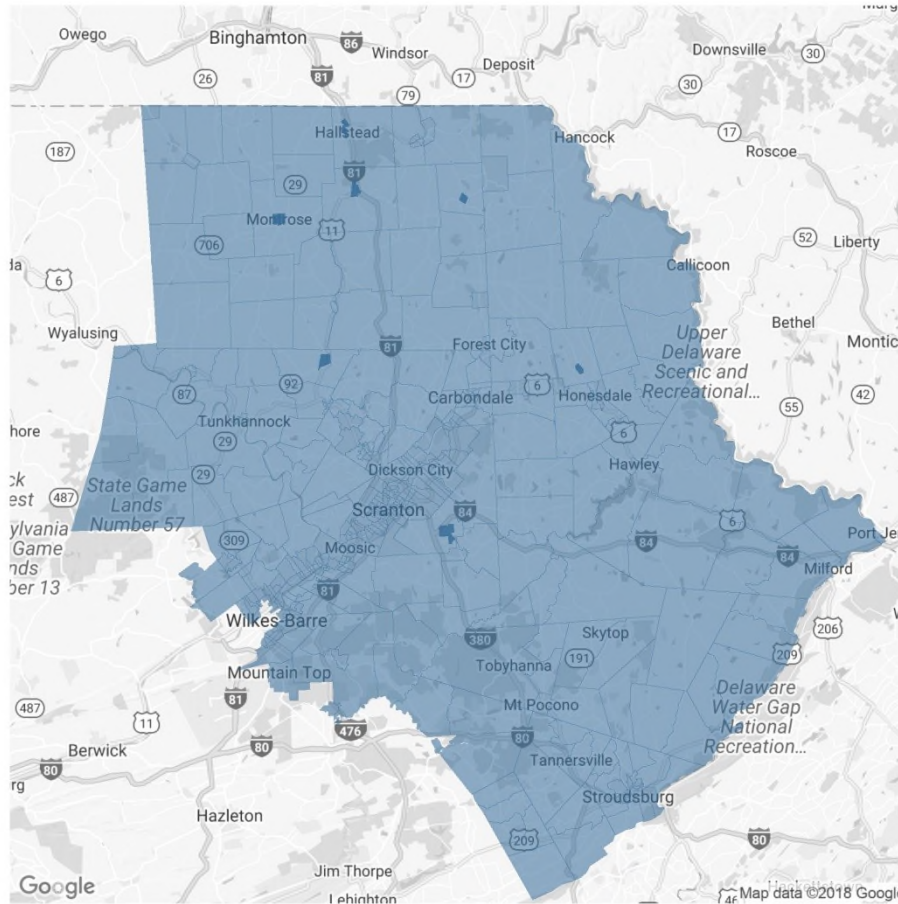


The 16th Congressional District contains Chester County in its entirety, markedly different than the degree to which it was carved up in the 2011 map. This district also contains roughly half of Lancaster County, including the City of Lancaster. Because Chester County remains intact, absent is the sort of cracking of municipalities like that of Coatesville, Kennett Square, and Oxford that occurred under the 2011 map. As illustrated in the red-blue map, this district keeps the City of Lancaster intact. This district also includes Caln Township, previously split between three congressional districts in the 2011 map.

16th Congressional District

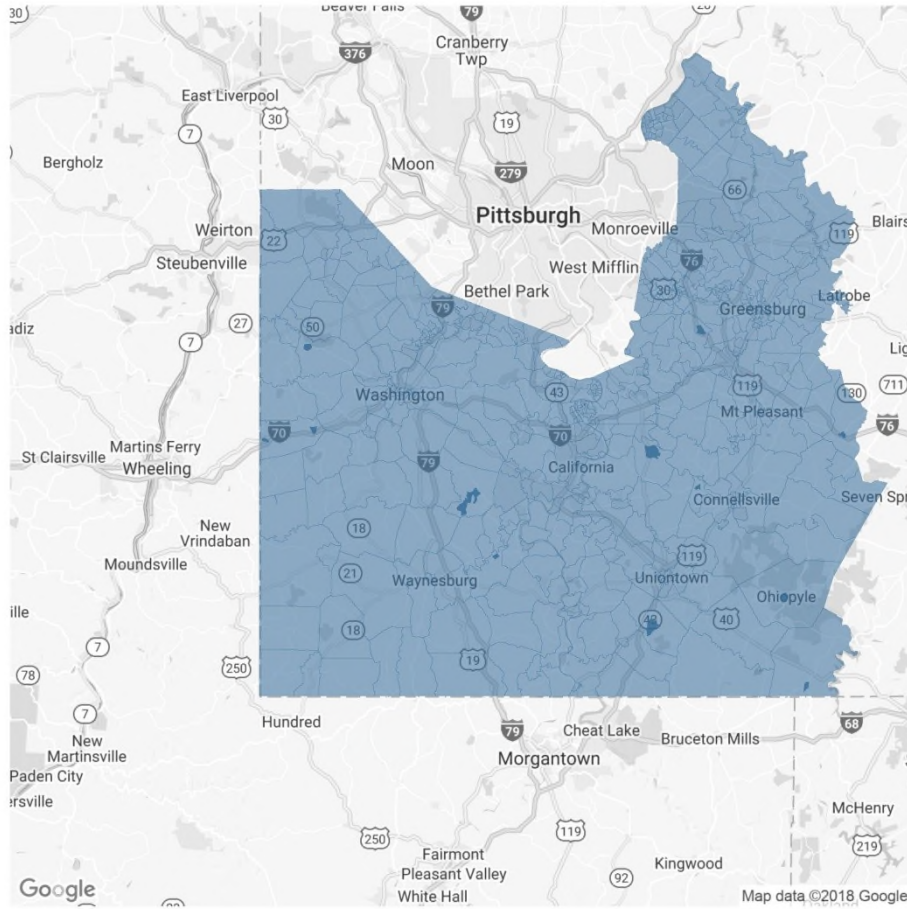


17th Congressional District



The 17th Congressional District is a compact district, located in the northeast quadrant of the state. It contains seven counties, only one of which, Luzerne, is split. It possesses none of the strange geographic features present in the 2011 map and contains communities that share similar interests, such as the cities of Scranton and Wilkes-Barre as well as portions of what is considered the Poconos. Scranton/Wilkes-Barre are part of a Metropolitan Statistical Area that shares both a single media market and several minor league sports teams.

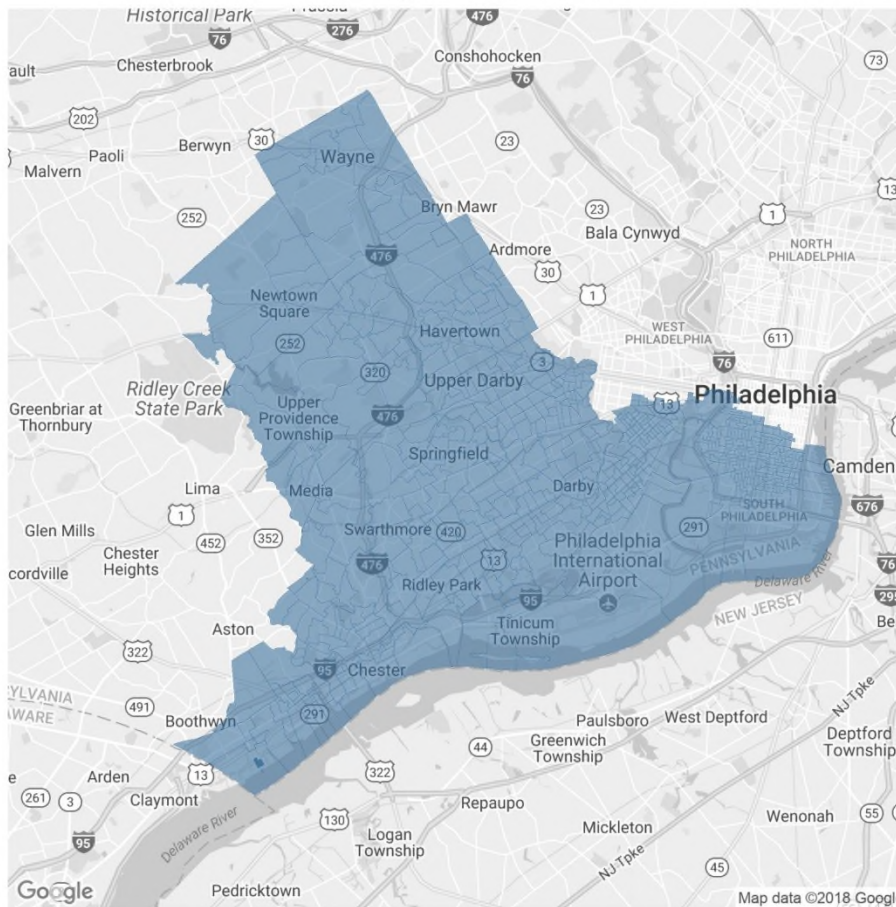
18th Congressional District



Located in the southwest quadrant of the state, the 18th District includes four counties, Washington, Greene, Fayette, and Westmoreland. Westmoreland is split between this and the adjacent 3rd District, but the 18th District contains the other three counties in their totality, which makes sense due to their location in the far southwest corner of the Commonwealth.

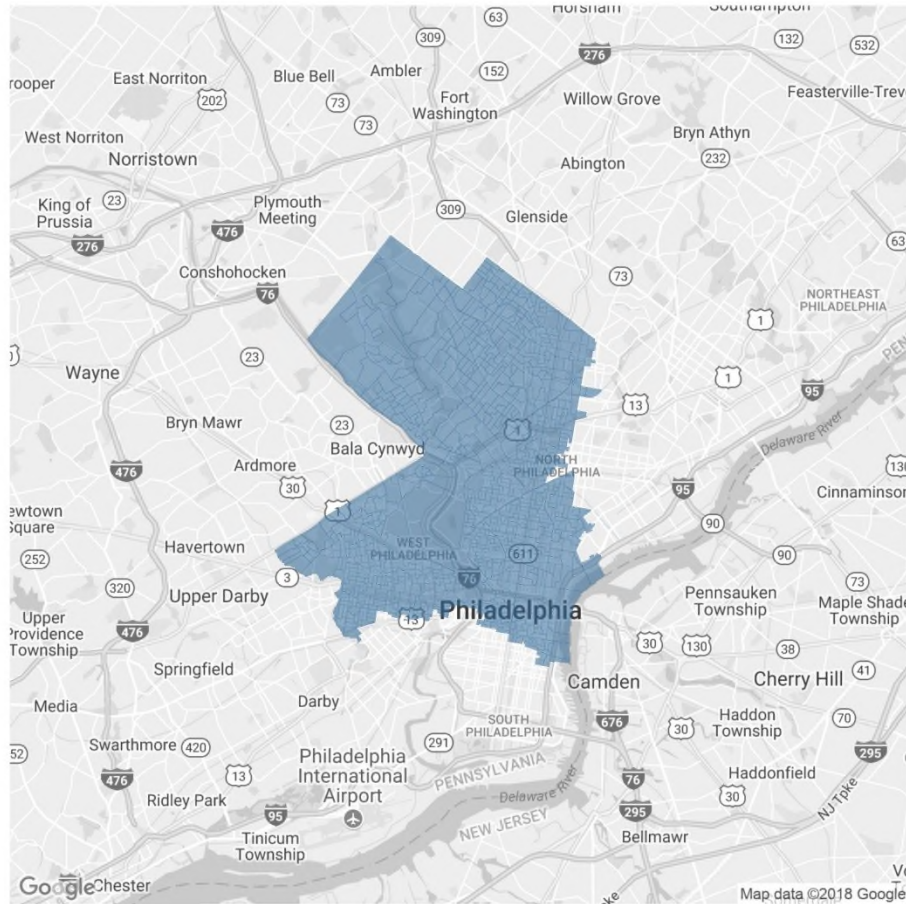
II. Petitioners' Map B

1st Congressional District



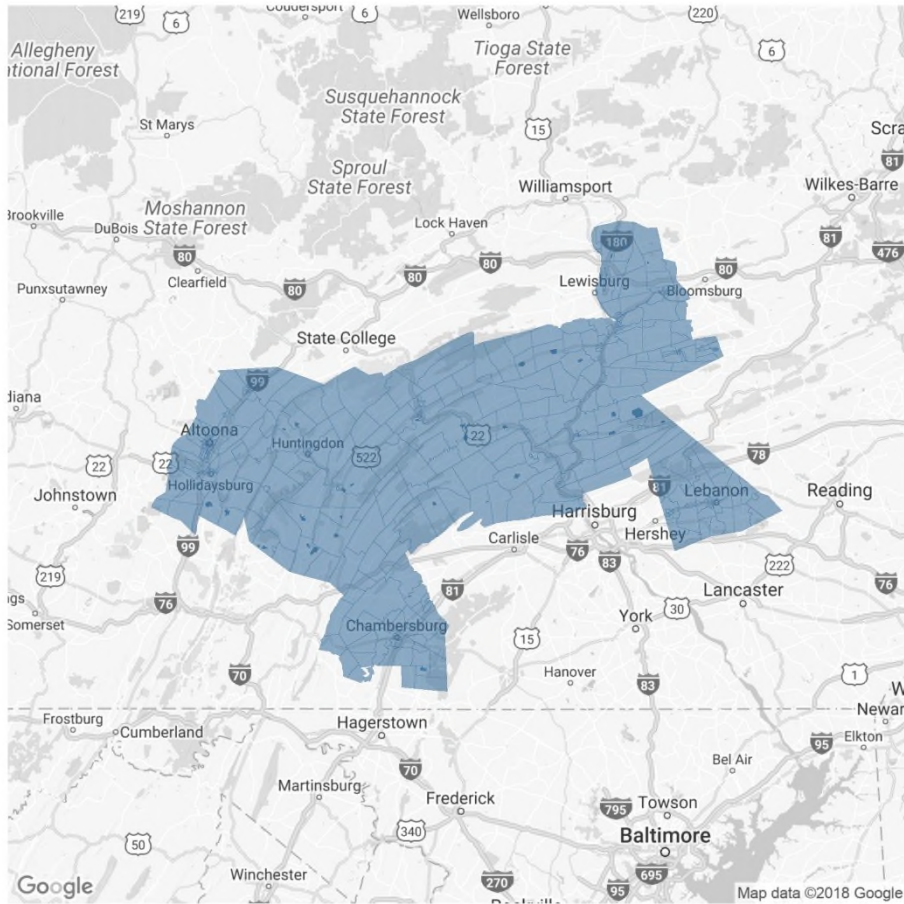
Like Map A, the 1st Congressional District under Map B restores a Delco seat. It is compact, including eastern and central Delaware County and South Philadelphia, and bears no resemblance to the infamous “Goofy Kicking Donald Duck” Delco district of the 2011 map. This district does not have any tentacles reaching out and grabbing certain municipalities, and it makes geographic sense. The City of Chester resides within this district and unlike in the 2011 map, Chester is not cracked from much of the rest of Delaware County and packed into a Philadelphia-based seat.

2nd Congressional District



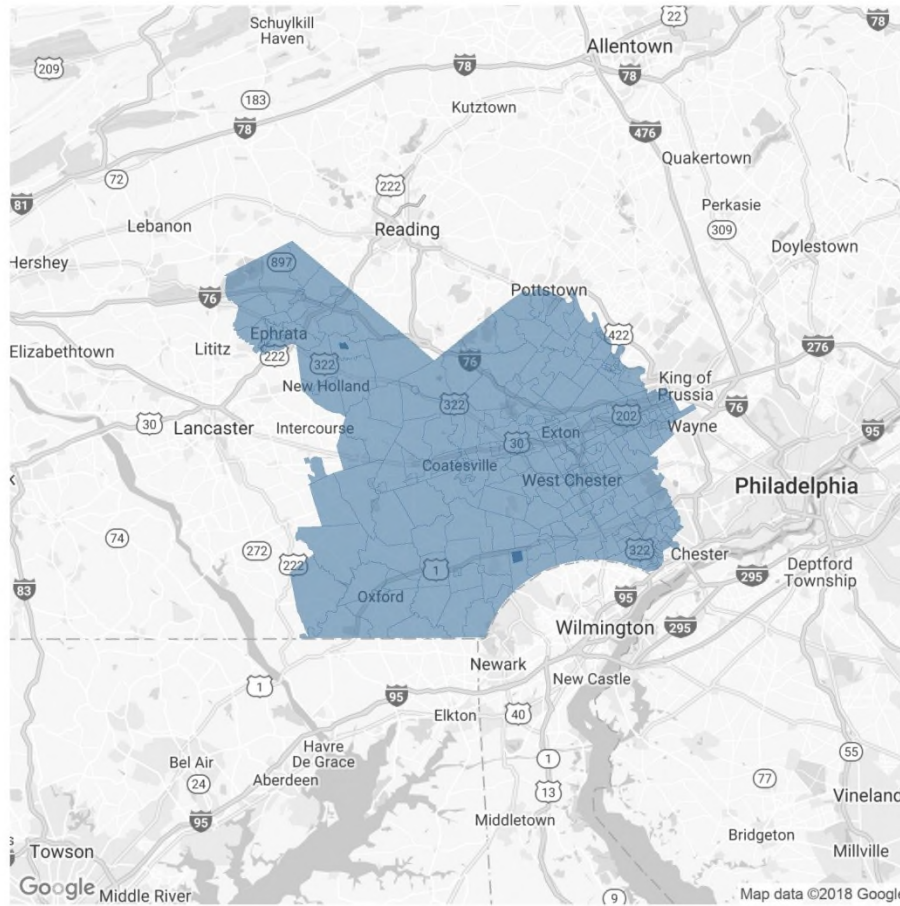
The 2nd Congressional District is a minority-majority district that is fully contained within the Philadelphia borders. Unlike the 2011 map, as well as Legislative Respondents' February 9 Plan, the 2nd Congressional District of Map B does not contain any municipalities from the adjacent areas of Montgomery County.

5th Congressional District



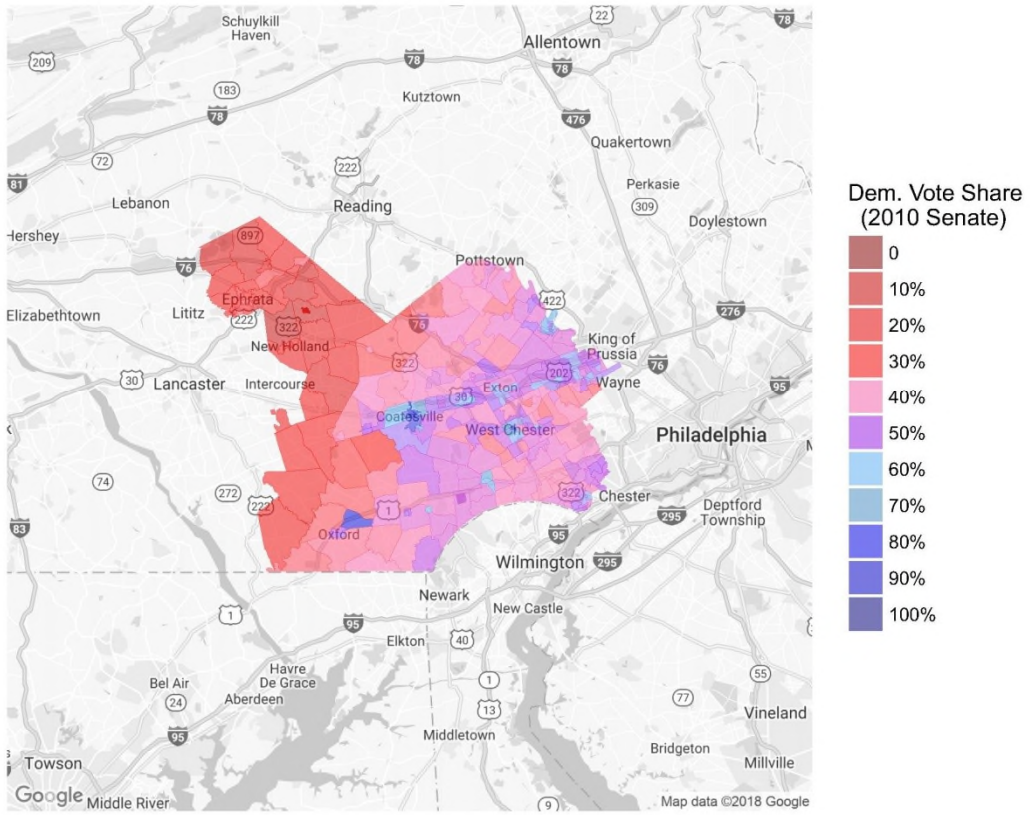
The 5th Congressional District contains nine complete counties as well as most of another (Franklin) in the central part of the state, all of which share a similar political and cultural history.

6th Congressional District

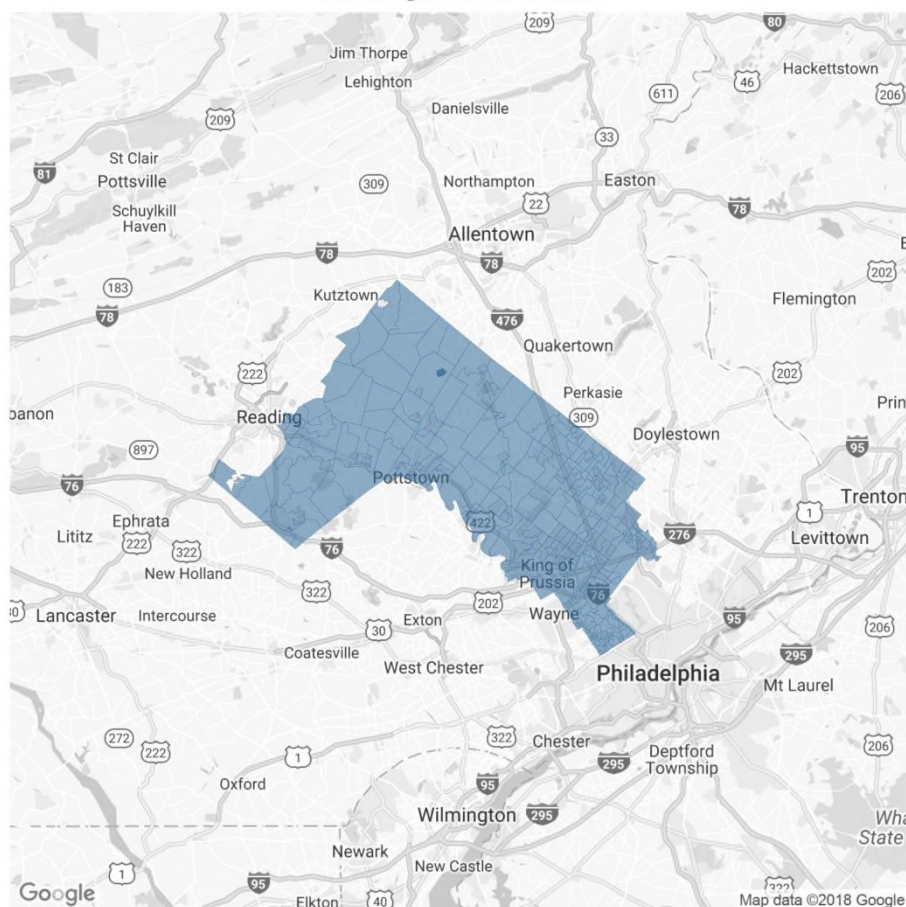


The 6th Congressional District is centered in Chester County and includes western Delaware County and a small part of eastern Lancaster County. This district is far more compact than the equivalent Chester County district in the 2011 map. As illustrated in the red-blue map, municipalities that were cracked in the previous map, such as the city of Coatesville, are returned to their Chester County community.

6th Congressional District

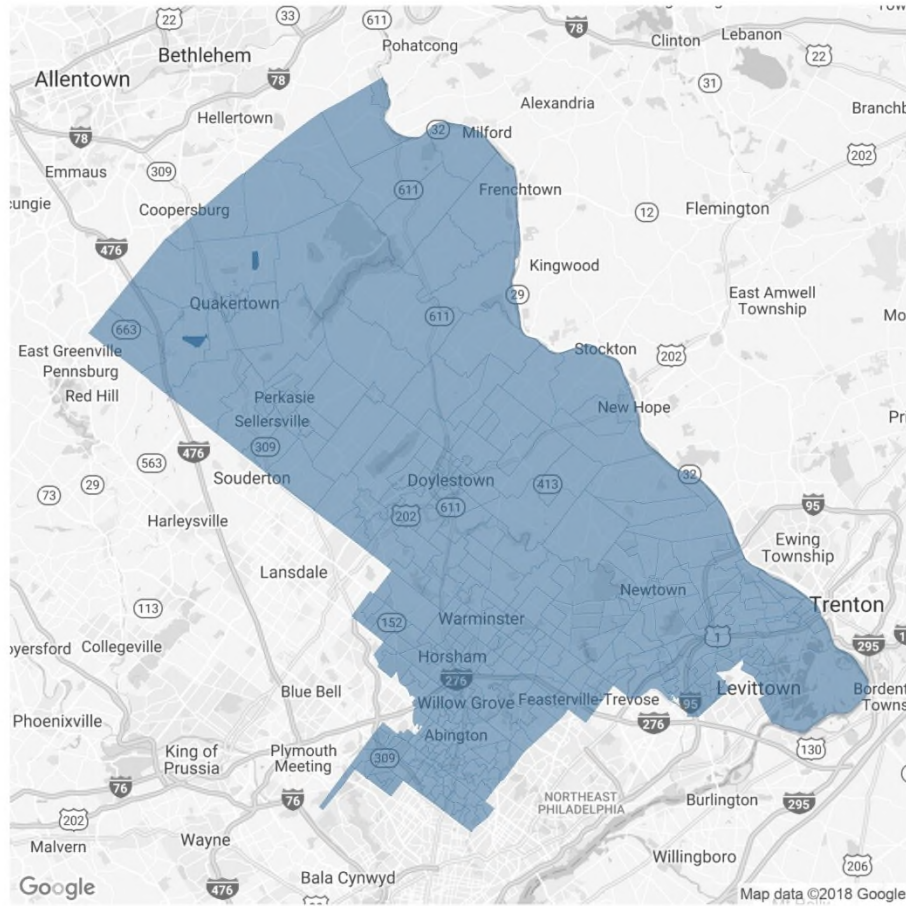


7th Congressional District



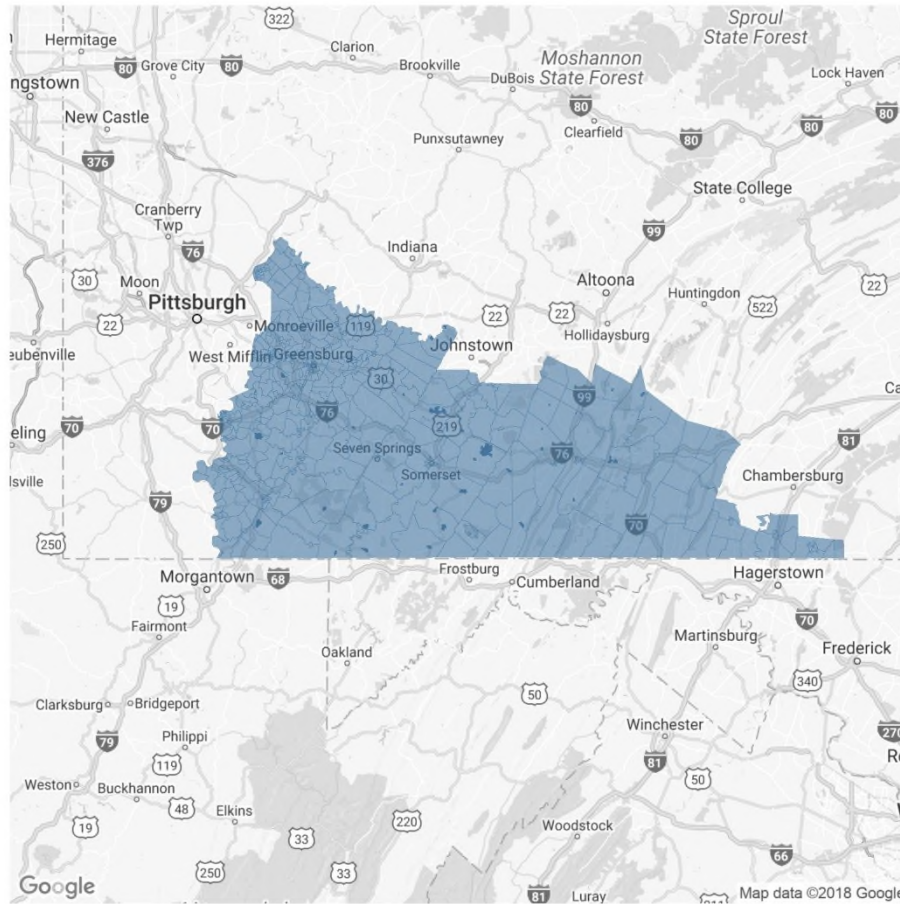
The 7th Congressional District takes in southeastern Berks County and also most of Montgomery County to the southeast. It's important to note that southern Berks County and western Montgomery County (along with northern Chester County) form a community of interest. This is recognized by the "Tri-County Chamber of Commerce," which serves these specific areas and is based in Pottstown. This portion of Berks County is also tied to MontCo through the Boyertown Area School District (BASD), which straddles the county line with various schools located in each of the two counties.

8th Congressional District



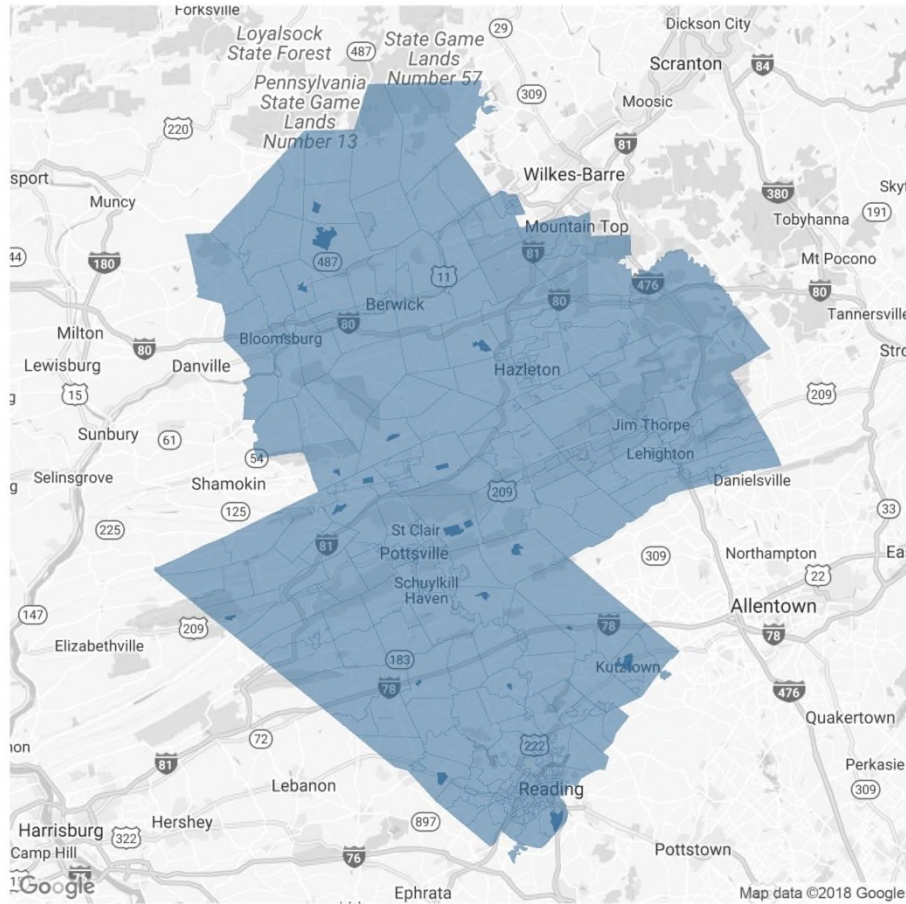
The 8th Congressional District contains most of Bucks County with the exception of a small sliver at the southwest corner, which is part of Philadelphia-based 13th District. In addition, the 8th District takes in parts of southeastern Montgomery County along the Bucks County border. Communities within this region have much in common such as transportation, as PA Route 611 connects Horsham Township (Montgomery) and Warminster Township (Bucks), and the Eastern Montgomery Chamber of Commerce, which also serves the business community in parts of eastern Bucks County.

9th Congressional District



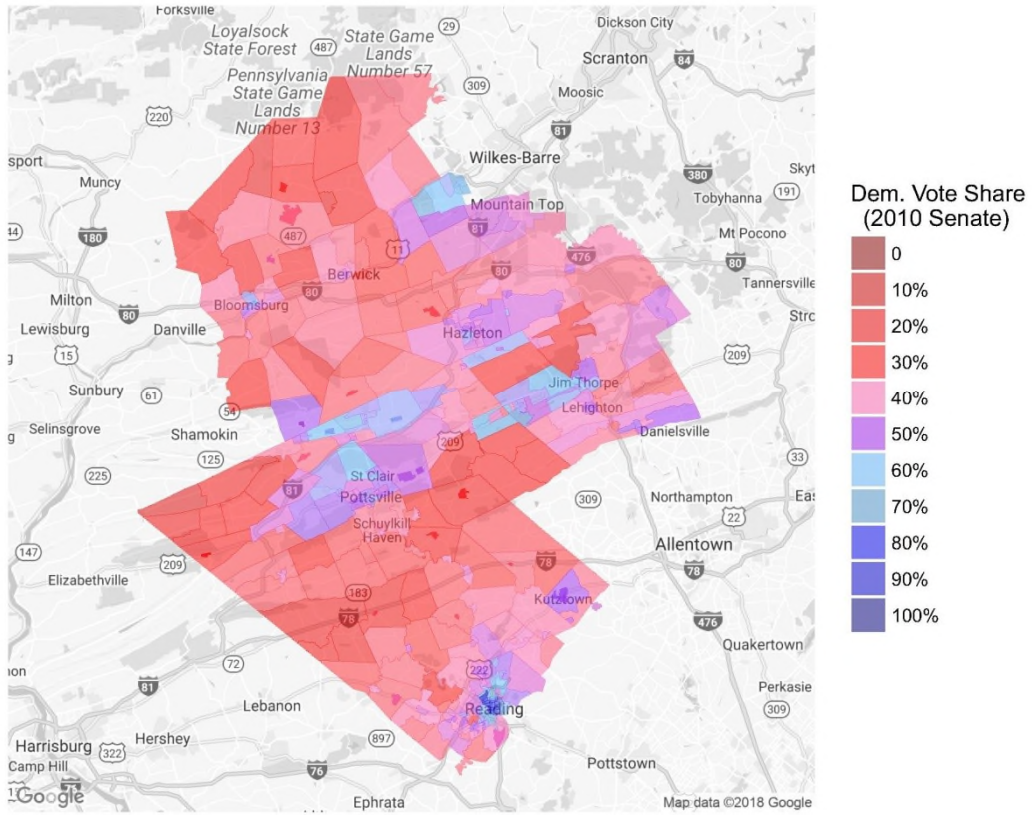
The 9th Congressional District moves from central to southcentral Pennsylvania and contains five complete counties as well as one (Franklin), of which only a small portion is split at its southernmost border.

11th Congressional District

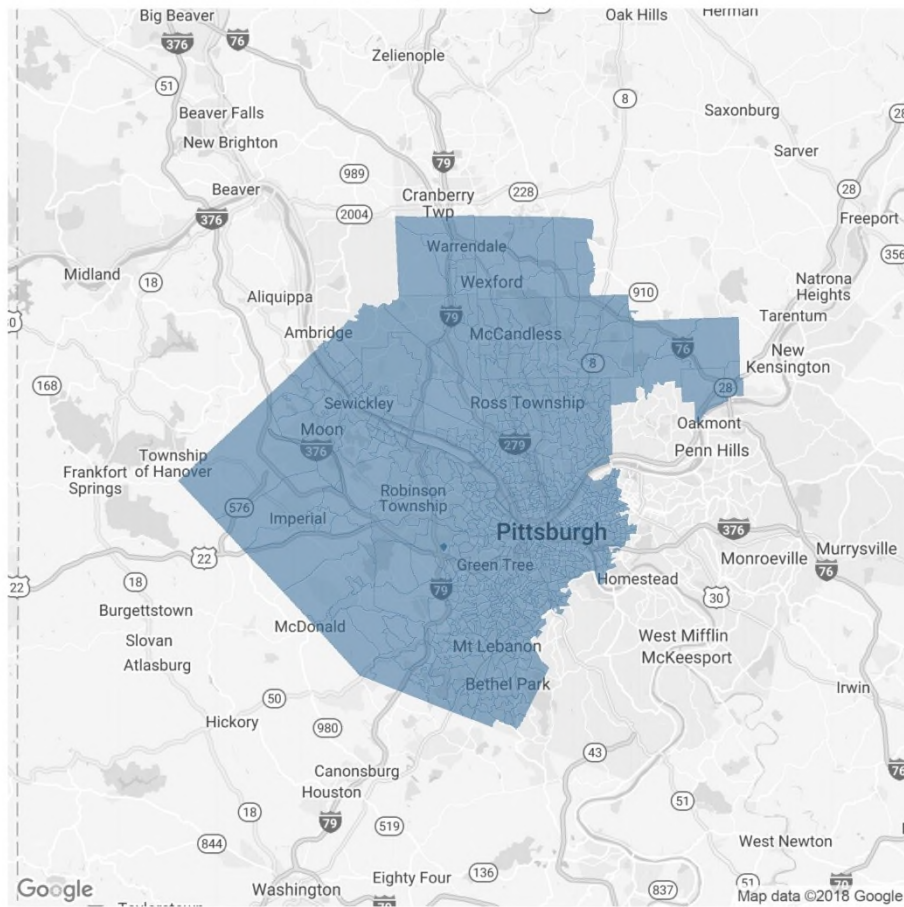


The 11th Congressional District can be described as a “coal region” district, beginning in southern Luzerne County and flowing southward to include neighboring Carbon, Columbia, Schuylkill, and northern Berks County, including the city of Reading. Unlike the 2011 map and as illustrated in the red-blue map below, Reading is kept intact with its metropolitan area. Culturally and politically, Reading has more in common with Schuylkill County than it does with the Amish Country-based district in Lancaster County, where it was placed in the 2011 map.

11th Congressional District

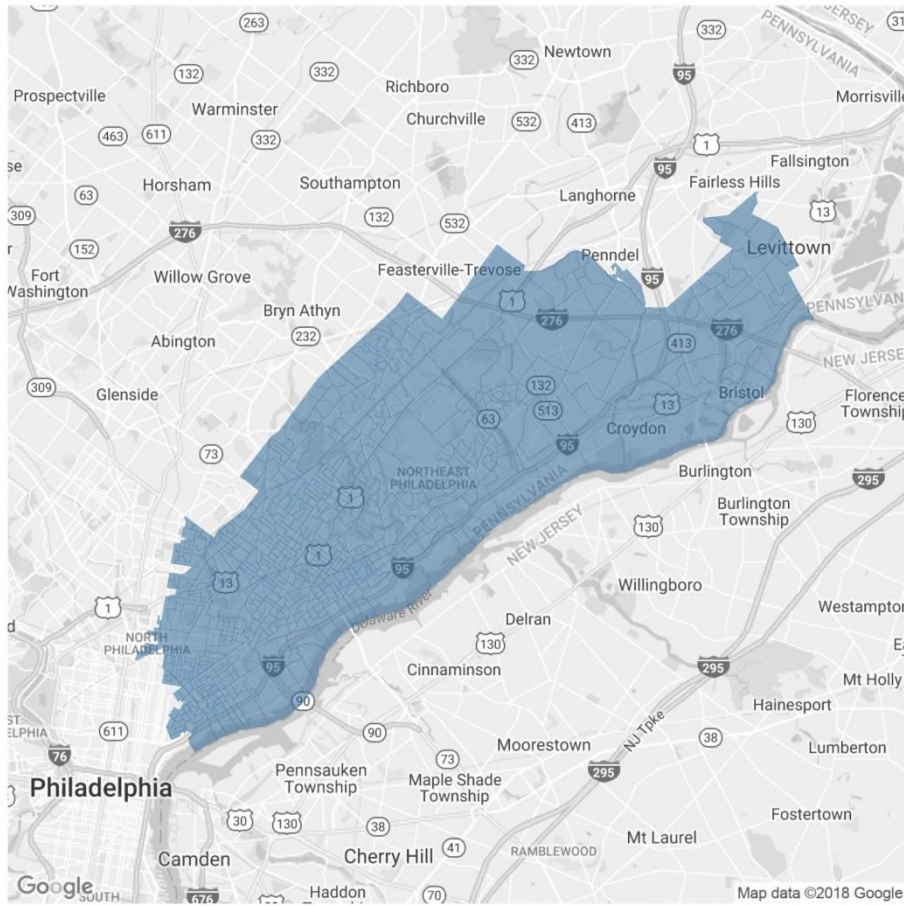


12th Congressional District



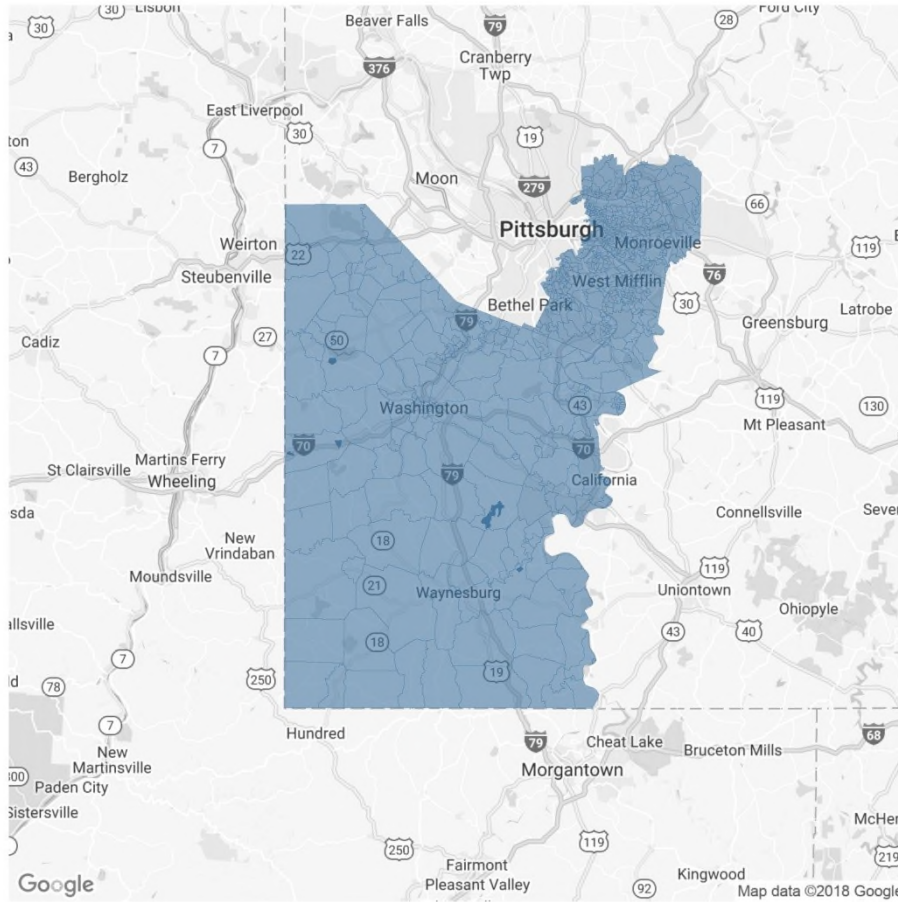
The 12th Congressional District is based in the city of Pittsburgh and its western suburbs, unlike the congressional map approved in 2011. This is a compact district which (unlike the 2011 map) does not contain a tentacle climbing up the Allegheny River clearly designed to pack in Democratic voters along the way.

13th Congressional District



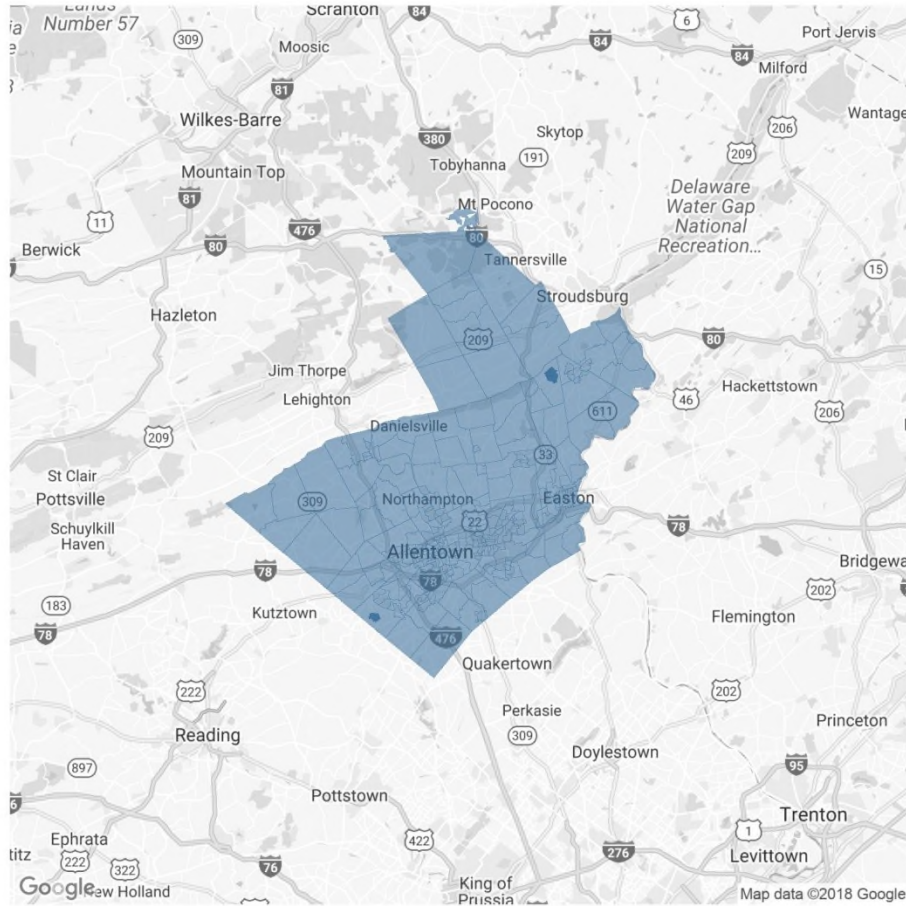
The 13th Congressional District is based primarily in Northeast Philadelphia but also includes several similar suburbs located in southwestern Bucks County, such as Bensalem Township and Bristol Borough. It is a compact district.

14th Congressional District



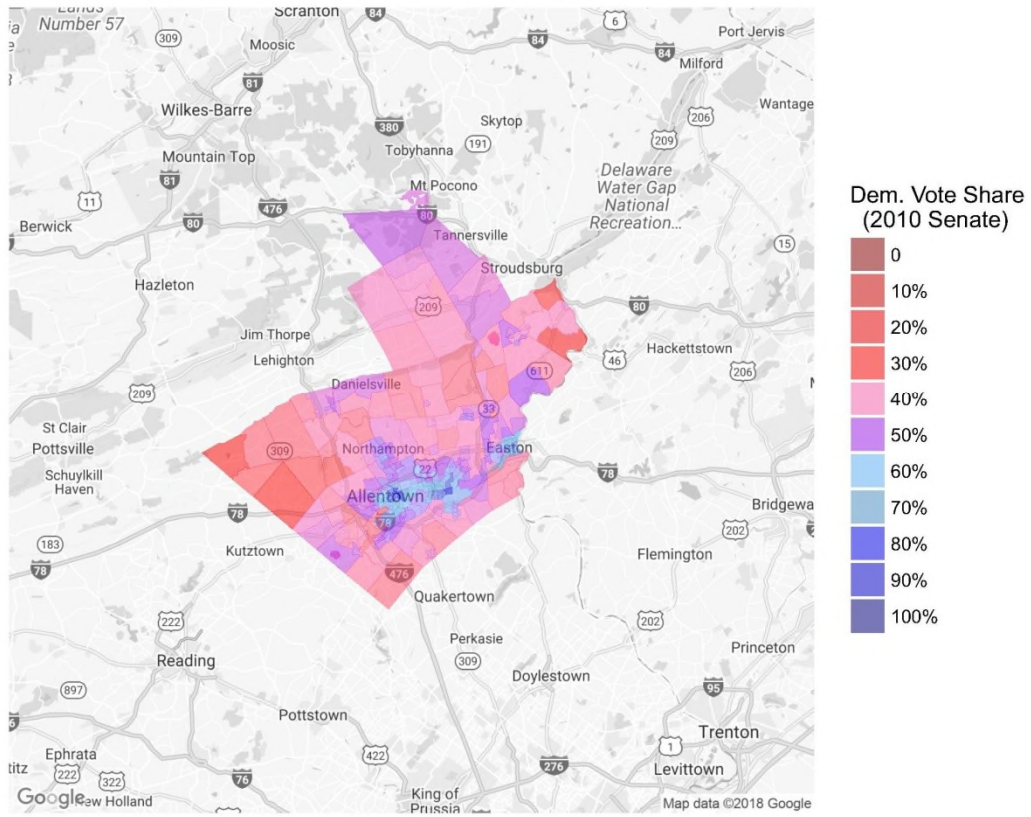
The 14th Congressional District is compactly drawn in the southwest corner of the Commonwealth and includes Greene, Washington, and parts of the eastern Pittsburgh metropolitan area.

15th Congressional District

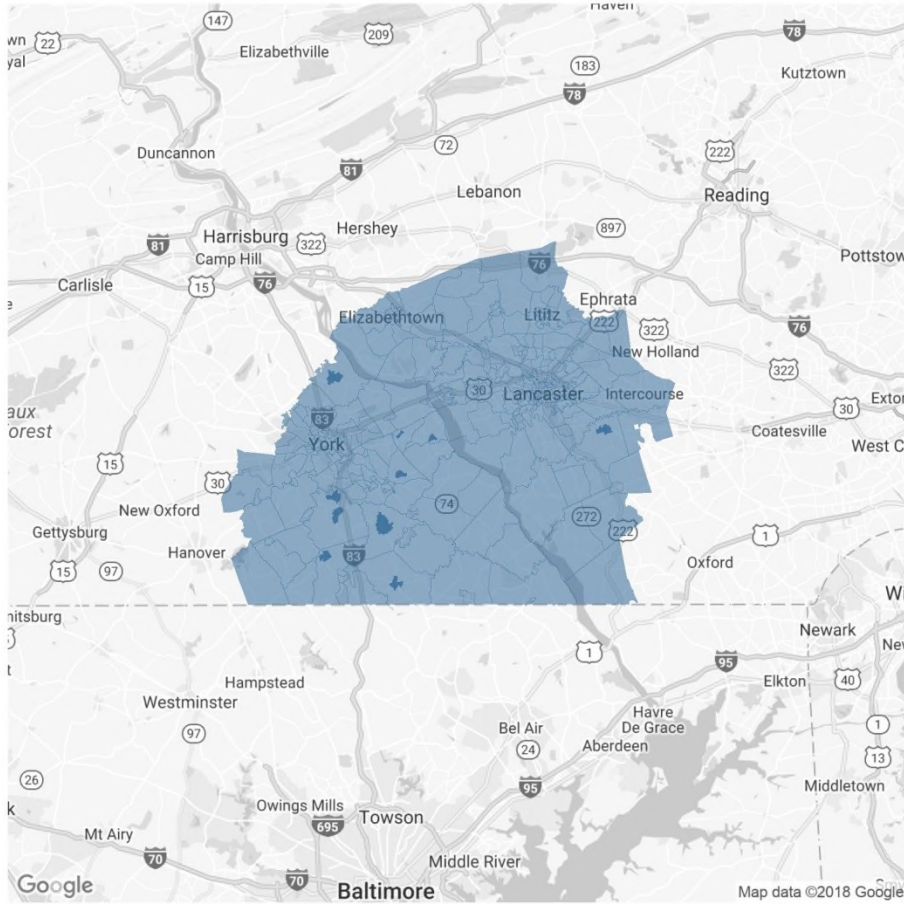


Like Map A, Map B restores the 15th Congressional District as a Lehigh Valley district. It includes Lehigh, Northampton, and parts of Monroe County. The 2011 map had split off the City of Easton and parts of the Bethlehem area, thereby cracking those Democratic voters out of what was historically a competitive district. As illustrated in the red-blue map, Map B (like Map A) reunites these municipalities in the Lehigh Valley community of interest.

15th Congressional District

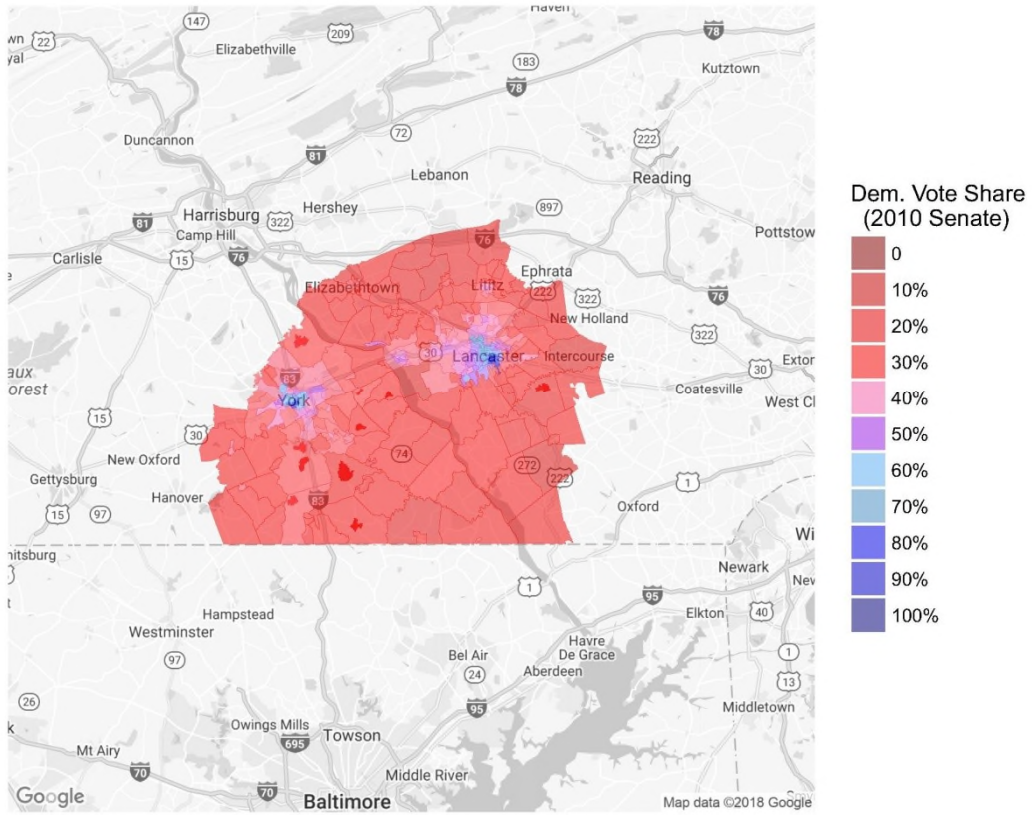


16th Congressional District

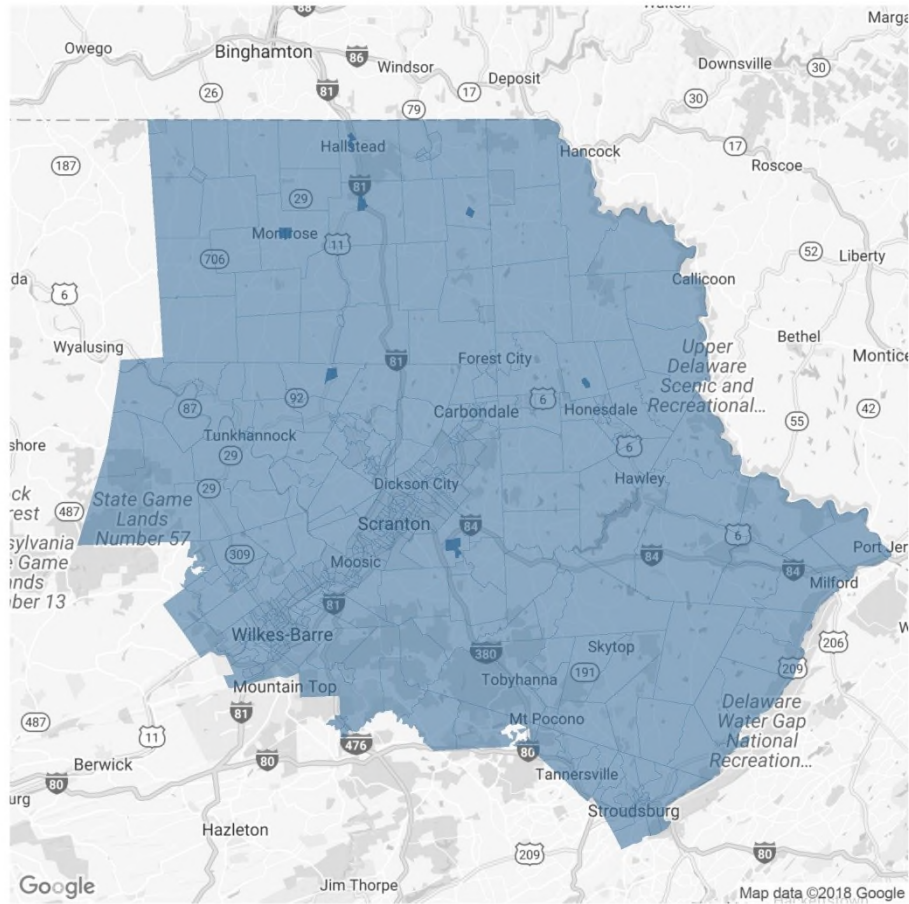


The 16th Congressional District includes the majority of Lancaster County, including the county seat, itself, and most of York County. Extremely compact, it lacks the tendrils that ensnared the capital city of Harrisburg in the 2011 map.

16th Congressional District

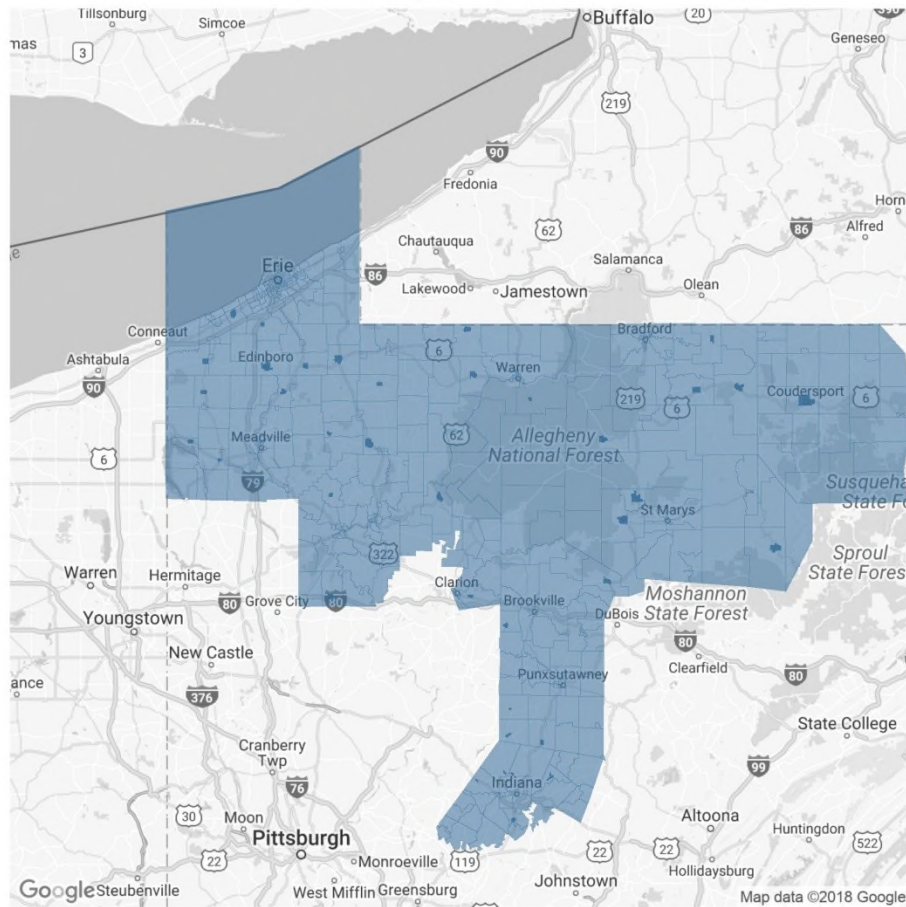


17th Congressional District



The 17th Congressional District is also a compact district located in the northeast quadrant of the state. It contains the two primary communities in the region, Lackawanna County (Scranton), and parts of Luzerne County (including the county seat Wilkes-Barre) as well as the whole of four other counties and the northern half of Monroe County.

18th Congressional District

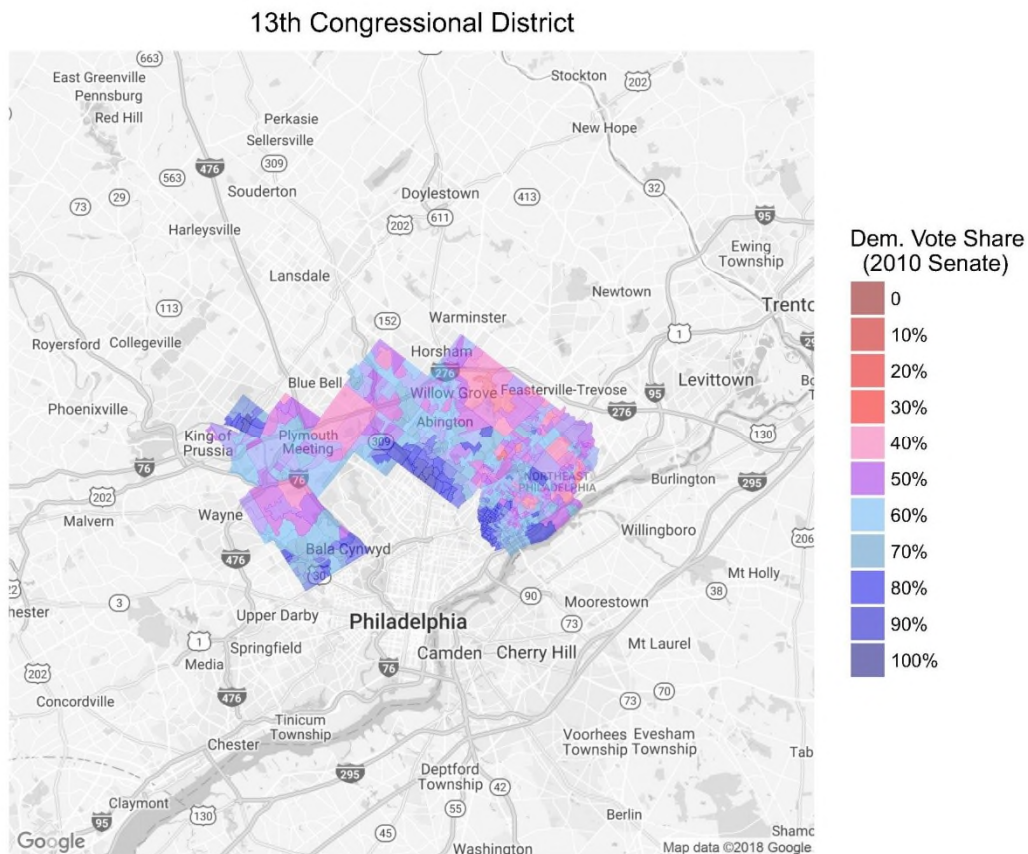


The 18th Congressional District flows across the northern tier of the state, containing 12 counties, some of which are only sparsely populated, and only two of which are split (Clarion and Indiana). Most importantly, it encompasses the totality of Erie County. The latter is notable, as the 2011 map had cracked the city from its eastern suburbs for the first time in the modern redistricting era.

III. Legislative Respondents' February 9 Plan

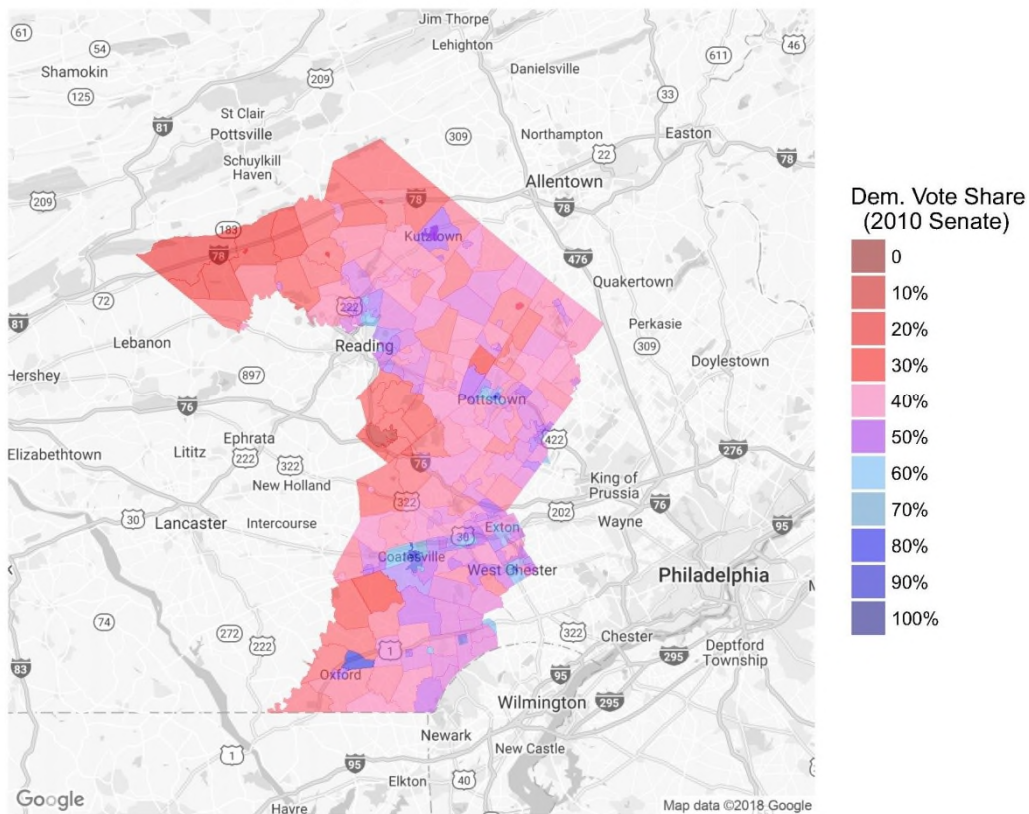
On February 9, 2018, the Republican legislative leaders of the Pennsylvania House of Representatives and the Pennsylvania Senate released a proposed map. In my opinion as an expert in Pennsylvania political geography, the proposal contains significant flaws that are inconsistent with the Pennsylvania Supreme Court's guidance that political motivations may not subordinate the preservation of political subdivisions.

Some of the most serious issues with this map occur in the southeast. For instance, Montgomery County is divided into four different congressional districts, the 6th, 7th, 8th, and 13th. I can discern no explanation for this four-way split of Montgomery County other than partisan motivations. The 13th is particularly strangely drawn, running from Northeast Philadelphia into eastern Montgomery County, and then whipping across to the southwestern section adjacent to Delaware County. The red-blue map indicates that this district packs in the most strongly Democratic regions of Montgomery County with a Philadelphia-based district.



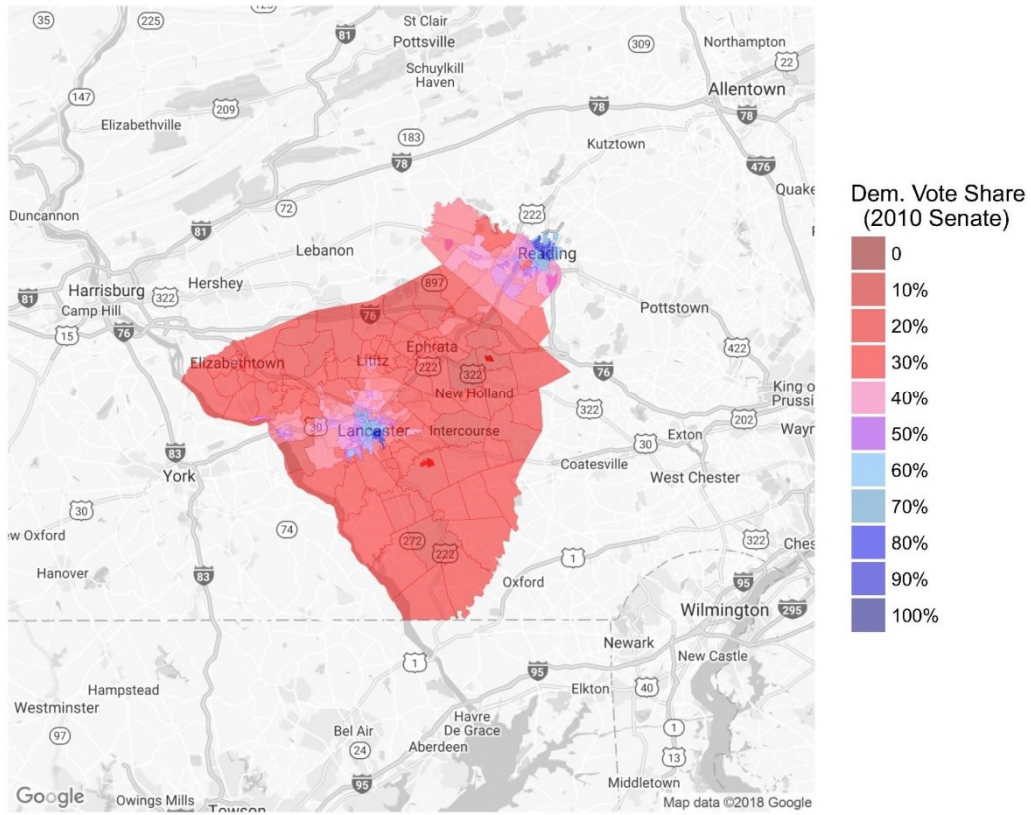
The remaining portions of Montgomery County have been split between the 6th, 7th, and 8th Districts—all of which continue to have odd appendages that graft Republican areas of Montgomery County in order to bolster Republican strength in each of these districts. The revised 6th District stretches all the way from the southern end of Chester County along the Maryland state line, grabbing the more Republican western part of Montgomery County, and then extending into Berks County (where it carefully continues to carve Reading from its suburbs). In such a high density area, it is unreasonable to group together so many disparate communities.

6th Congressional District



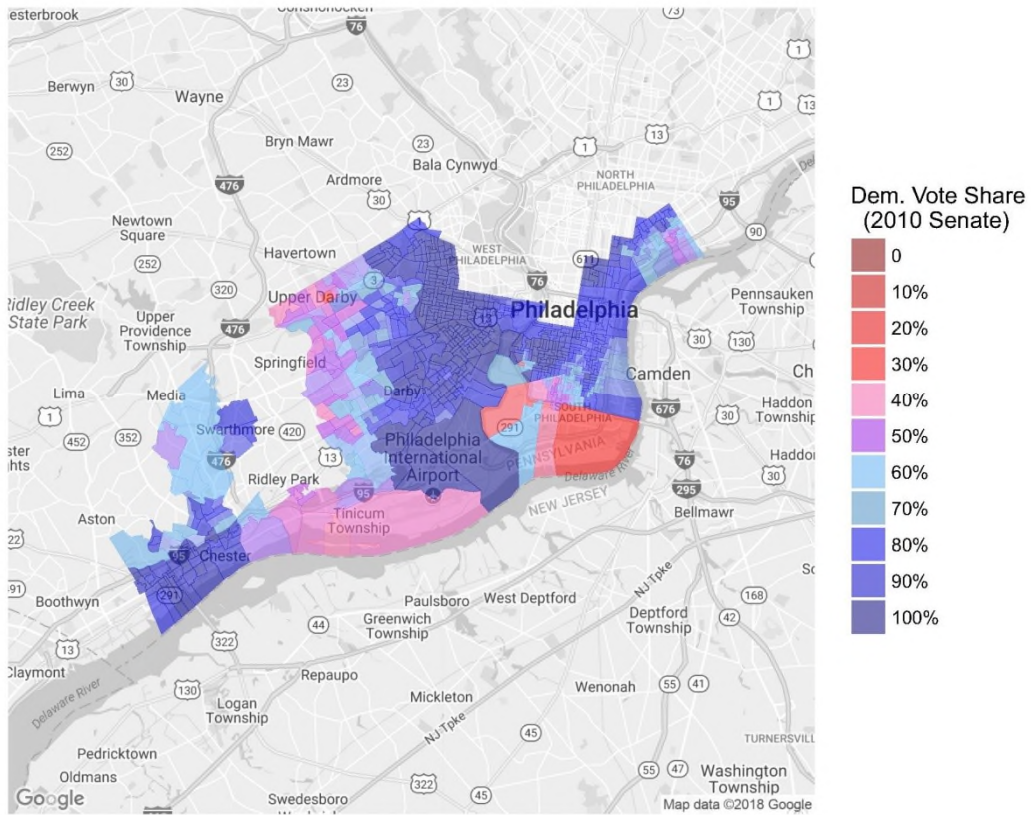
Just like the 2011 map, Legislative Respondents' proposed 16th District removes Reading from much of the rest of Berks County and corrals it into the Lancaster County-based and heavily Republican 16th congressional district. This is a textbook example of the cracking technique used to dilute the votes of voters of a particular party, in this case the Democratic voters of Reading.

16th Congressional District



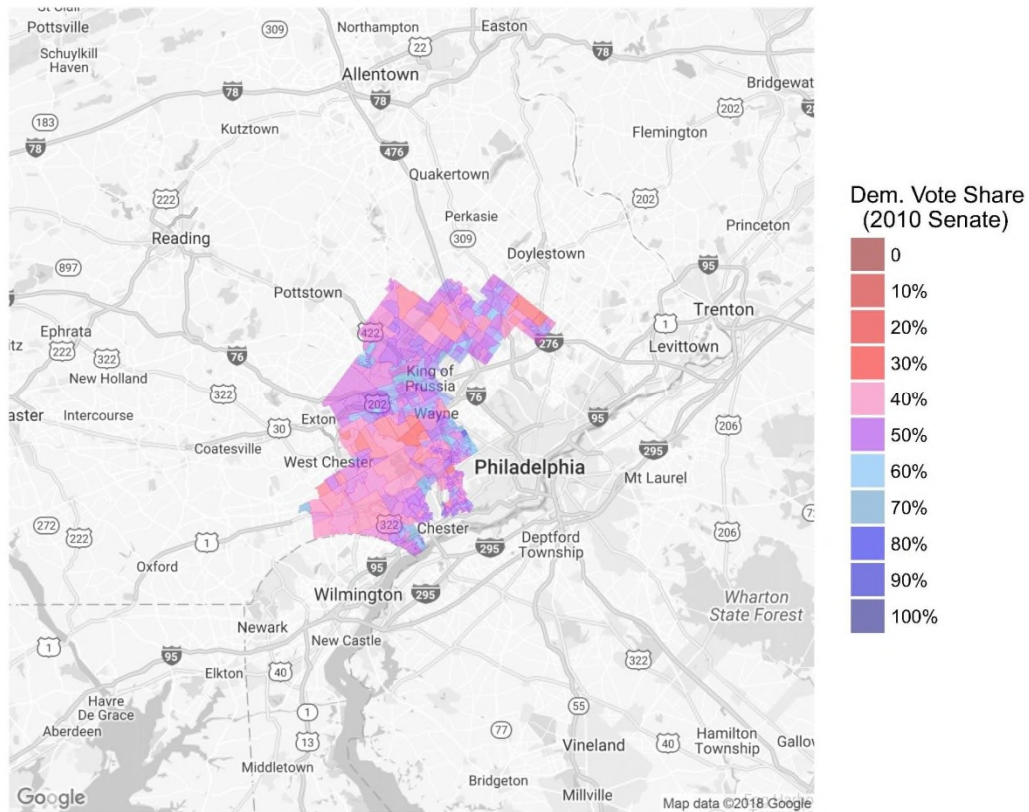
The 7th District similarly stretches all the way from the Maryland line through Delaware County. As with the 2011 map, the 7th District continues to carve out Chester and Swarthmore, which are packed into the Philadelphia-based 1st District.

1st Congressional District



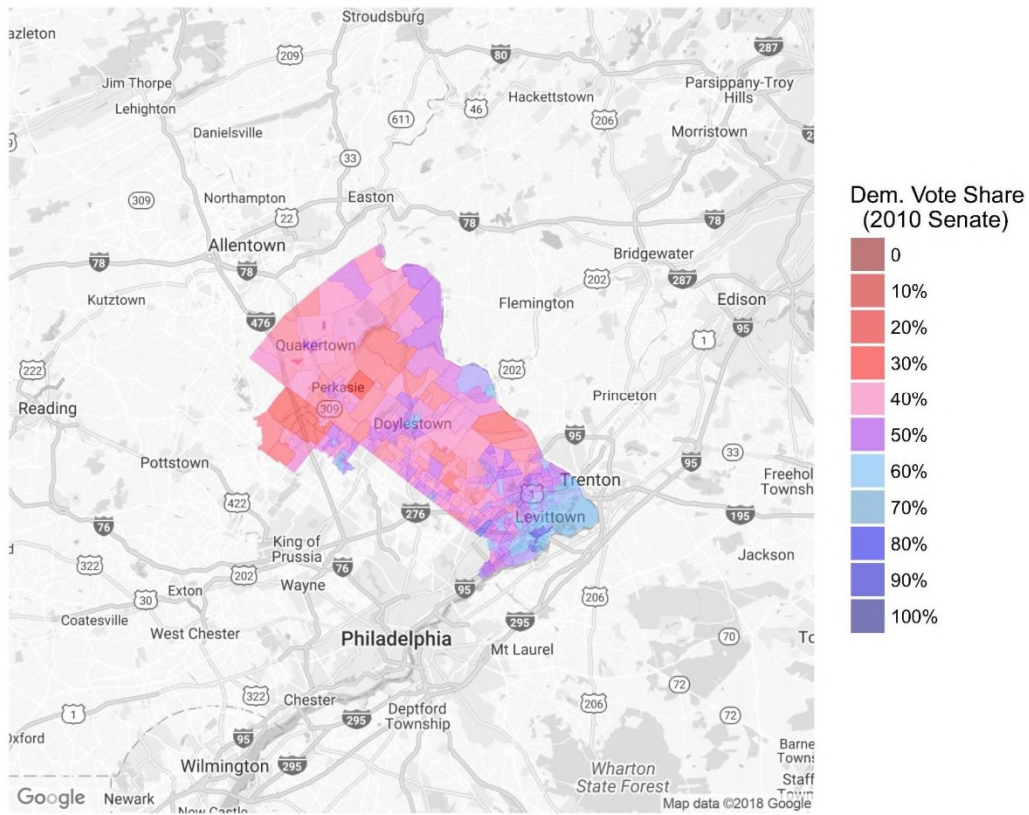
The 7th District then extends through western Montgomery County up to the Bucks County line to include the more Republican portion of northern Montgomery County. Again, in such a high density area, there is no reason other than partisan motivations to group together so many disparate communities.

7th Congressional District



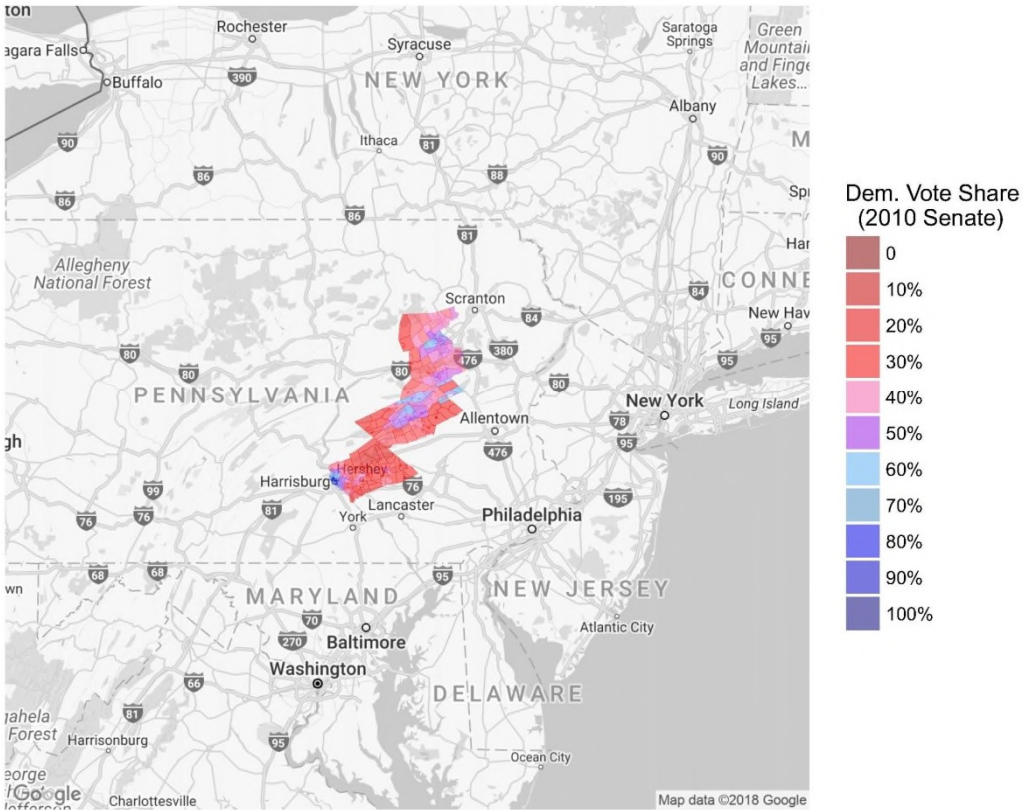
The 8th District continues to be centered in Bucks County, but it has an appendage extending southward into Montgomery County, for no ostensible reason other than to graft in the highly Republican areas of northern Montgomery County. As discussed above, while a portion of MontCo has been incorporated into the Bucks County-centered seat previously, it traditionally has been the townships located in the northeastern part of MontCo, which are very similar to the communities in Bucks County.

8th Congressional District



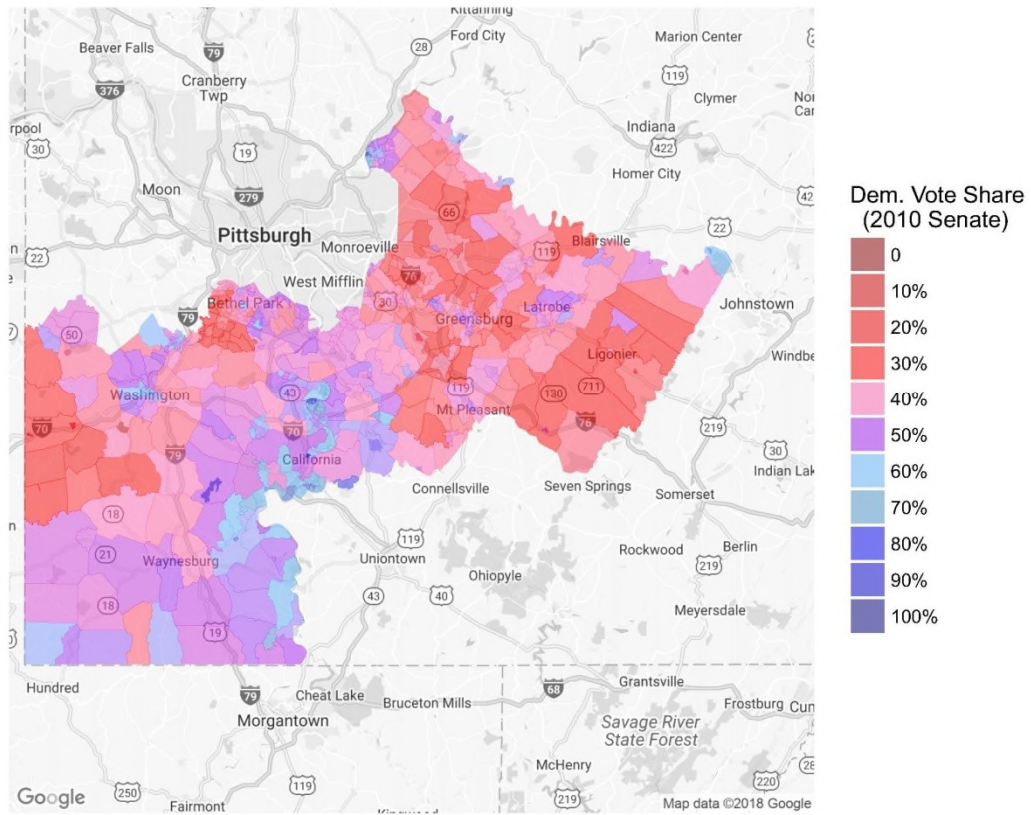
In central Pennsylvania, Harrisburg and half of Dauphin County continue to be combined with the 11th Congressional District, which extends up through Lebanon, Schuylkill, and much of Luzerne County (excising Wilkes-Barre). This district clearly combines different communities of interest, for no apparent reason other than to crack Harrisburg.

11th Congressional District



In the western part of the state, the 18th District, located in the southwest corner, includes Greene and Washington Counties but curiously bypasses strong Democrat regions of Fayette County, which abuts both, on its way to seizing Westmoreland County.

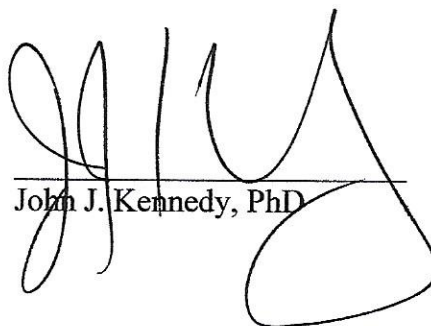
18th Congressional District



In summation, Legislative Respondents' February 9 Plan makes numerous decisions to divide Pennsylvania's communities for flagrantly partisan motivations. Both of Petitioners' proposed plans do a far better job of preserving Pennsylvania's communities of interest.

February 15, 2018

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification



John J. Kennedy, PhD

EXHIBIT C

Supplemental Report of Christopher Warshaw

February 15, 2018

My name is Christopher Warshaw. I have been an Assistant Professor of Political Science at George Washington University since August 2017. Prior to that, I was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016. My full background and qualifications are presented in the expert report I submitted to the Commonwealth Court in this case. I have been asked by counsel representing the petitioners in *League of Women Voters of Pennsylvania v. the Commonwealth of Pennsylvania* to evaluate the partisan bias in the congressional districting plan proposed by the Legislative Respondents on February 9, as well as in two congressional districting plans proposed by the petitioners. I am being compensated at a rate of \$220 per hour.

Summary

In short, I find that the plan proposed by the Legislative Respondents is an extreme partisan gerrymander. It is just as extreme as the 2011 plan struck down by this Court. In contrast, the two nonpartisan plans proposed by the petitioners exhibit no clear bias in favor of either party.

Methodology

The goal of partisan gerrymandering is to create legislative districts that are as “efficient” as possible in translating a party’s vote share into seat share (McGhee 2014, 2017; Caughey, Tausanovitch, and Warshaw 2017). In practice, this entails “wasting” more votes of the disadvantaged party than of the advantaged one by “cracking” opposing-party majorities across multiple districts and “packing” them into a few overwhelming strongholds. I measure the relative number of wasted votes for each party using the Efficiency Gap (EG), which is defined as “the difference between the parties’ respective wasted votes, divided by the total number of votes cast in the election” (Stephanopoulos and McGhee 2015, 831; see also McGhee 2014, 2017).¹ All of the losing party’s votes are wasted if they lose the election. When a party wins an election, the wasted votes are

1. In order to account for unequal turnout across districts, I calculate the Efficiency Gap using the formula: $EG = S_D^{margin} - 2 * V_D^{margin}$ where S_D^{margin} is the Democratic Party’s seat margin based on the presidential results in 2016 (the seat share minus 0.5) and V_D^{margin} is the Democratic Party’s vote margin. V_D^{margin} is calculated by aggregating the raw votes for the Democratic presidential candidate across all districts, dividing by the total two-party vote cast across all districts, and subtracting 0.5 (McGhee 2017, 11-12).

those above the 50%+1 needed to win. I use presidential voting patterns to calculate the Efficiency Gap for these new districts since no actual congressional elections have been conducted under these proposed maps, and presidential voting patterns have the “advantage of being (mostly) unaffected by district-level candidate characteristics” (Stephanopoulos and McGhee 2015, 868).

Findings

1. Legislative Respondents’ Feb. 9 Plan: First, I evaluated the Efficiency Gap for the plan proposed by Legislative Respondents on Feb. 9. Based on the 2016 presidential voting results, I find that this plan has a pro-Republican Efficiency Gap of -15.9%. This is comparable to the 2011 plan that was struck down by this Court as a violation of the Pennsylvania Constitution. Indeed, just like the 2011 plan, it is one of the most extreme partisan gerrymanders in the past four decades of congressional districting plans. As I explained in my initial report, prior to the 2011 plan, Pennsylvania had never had an efficiency gap of 15% or more in favor of either party, and only once had an efficiency gap of 10% or more.

2. Petitioners’ plans: Next, I evaluated two plans proposed by the Petitioners based on the maps generated by their expert Jowei Chen. Using the same methodology that I used to evaluate the Legislative Respondents’ Feb. 9 plan, I find that both plans have pro-Republican Efficiency Gaps of -4.8%. The Efficiency Gaps in these plans are much closer to the neutral Efficiency Gap that has been the long-term historical norm in Pennsylvania. They show no indication of partisan gerrymandering.

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa. C.S. §4904 relating to unsworn falsification to authorities.

/s/ 
Christopher Warshaw

February 15, 2018

References

- Caughey, Devin, Chris Tausanovitch, and Christopher Warshaw. 2017. “Partisan Gerrymandering and the Political Process: Effects on Roll-Call Voting and State Policies.” *Election Law Journal*.
- McGhee, Eric. 2014. “Measuring Partisan Bias in Single-Member District Electoral Systems.” *Legislative Studies Quarterly* 39 (1): 55–85.
- . 2017. “Measuring Efficiency in Redistricting.” *Election Law Journal: Rules, Politics, and Policy*.
- Stephanopoulos, Nicholas O., and Eric M. McGhee. 2015. “Partisan Gerrymandering and the Efficiency Gap.” *University of Chicago Law Review* 82 (2): 831–900.

EXHIBIT D

An analysis of proposed Pennsylvania districting maps

Wesley Pegden

February 15, 2018

I am an Associate professor in the department of Mathematical Sciences at Carnegie Mellon University, where I have been a member of the faculty since 2013. I was an expert witness for the petitioners, testifying about my analysis of the 2011 Congressional districting of Pennsylvania based on the method I developed with my co-authors M. Chikina and A. Frieze in the paper *Assessing significance in a Markov Chain without mixing*^[1], which was published in the Proceedings of the National Academy of Sciences.

I have been asked to undertake an analysis of some maps which have been offered as proposed replacements for the 2011 map. In particular, I am analyzing Maps A and B which were provided to me by the Petitioners' counsel for analysis, and the February 9th proposal of the Legislative Respondents, which I will call Map R in this analysis. The analysis I present here uses precisely the same methodology as I used for my expert report (Petitioners' Exhibit 117) and discussed in my testimony.

Results

I analyzed maps using the same methodology (and exactly the same code) as used in my expert report^[2]. In particular, my method works by **beginning with the map in question**, and then making a **sequence of small random changes to the map** (while preserving properties such as contiguity, compactness, *etc.*, as detailed in my expert report). My test thus encounters a sequence of many maps, each one small random change from the map which preceded it, and evaluates the partisanship of each encountered map using a standard metric^[3].

For the districting in question, I report an ε value; this is the fraction of maps encountered in the sequence of small changes which were at least as partisan as it; thus, a small value of ε indicates that the map is carefully crafted with respect to partisanship: small changes quickly decrease the partisanship of the map.

The statistical rigor of my approach is derived from a theorem proved in the earlier-mentioned [CFP] paper. This theorem proves that it is impossible for a typical districting of a state (with the constraints I consider) to fail my test (by exhibiting a small ε) because of the particular political geography of the state^[4]. In particular, this theorem allows me to report p -value for each run of my test, which allows me to determine that a small observed ε -value is a statistically significant observation, irrespective of the political geography of Pennsylvania^[5].

My results for the maps in question are given in the table which follows. For each map, I have done two runs, one in which District 2 is frozen in my test, and another in which it is not.

^[1]referred to hereafter as [CFP]

^[2]In my runs in this analysis, I did $2^{36} \approx 68$ billion steps for each run, while in my expert report I did 2^{40} or 2^{39} steps for each run. The certainty with which the test detects gerrymandered districtings is reported in my p -values, and these values account for the number of maps encountered by the test in any given run. In particular, statistically significant observations in shorter runs of my test are equally valid as statistically significant observations from longer runs.

^[3]I use the Median-Mean test, which has been used since the 19th century in the evaluation of political districts.

^[4]In fact, the theorem is much more general, applying not just to states with varying political geographies, but to applications of small random changes across areas of science and mathematics.

^[5]In particular, the p value for my test is an upper bound on the probability that a randomly chosen districting satisfying the imposed constraints could would perform as badly on my test as I observe for the run.

map	steps	Freeze D.2?	$\varepsilon =$	$p =$
Map A	2^{36} steps	yes	.087	.4
Map A	2^{36} steps	no	.098	.5
Map B	2^{36} steps	yes	.097	.4
Map B	2^{36} steps	no	.12	.5
Map R	2^{36} steps	yes	.0000002	.0006
Map R	2^{36} steps	no	.0000001	.0005

I should emphasize that the notion of bias employed in my evaluation is extremely conservative. Indeed, **all three plans I evaluated here exhibit structural advantages for Republicans.** (All three have pro-Republican median-mean scores in my analysis.) To call a districting gerrymandered, my methodology requires a districting not only to have a structural partisan advantage, but also for that structural partisan advantage to be demonstrably carefully crafted, in the sense that it becomes consistently less severe when small random changes are made to the districting. *Thus, although all three plans exhibit structural advantages for Republicans, only Map R is detected as gerrymandered in the sense that it is demonstrably carefully crafted with respect to partisan bias.*

Thus, to summarize:

Map A exhibits a structural advantage for Republicans. When small random changes are made to the map by my algorithm, a significant number of maps are found which are even more favorable to Republicans, and a significant number are found which are less favorable. On balance, small changes tend to increase the favorability of the map for Republicans, (the ε shift bias is in the Democrat direction) but this finding is not remotely statistically significant for my test; p -values of .4 or .5 mean that the finding could be typical of 40%–50% of the set of comparison maps. Thus **my analysis does not detect partisan gerrymandering in this map.**

Map B exhibits a structural advantage for Republicans. When small random changes are made to the map by my algorithm, a significant number of maps are found which are even more favorable to Republicans, and significant number are found which are less favorable. On balance, small changes tend to decrease the favorability of the map for Republicans, (the ε shift bias is in the Republican direction) but the finding is not remotely statistically significant for my test; p -values of .4 or .5 mean that the finding could be typical of 40%–50% of the set of comparison maps. Thus **my analysis does not detect partisan gerrymandering in this map.**

Map R exhibits a structural advantage for Republicans. When small random changes are made to the map by my algorithm, **the overwhelming majority (99.99998%) of encountered maps have less structural advantage for Republicans.** This finding is highly statistically significant and demonstrates that the map is carefully crafted with respect to partisan bias in favor of the Republican party. The p -values of .0006 and .0005 indicate that a typical districting of the state would have probabilities at most 00.06% and 00.05%, respectively, of failing my test as badly as Map R did in these runs. Thus **my analysis detects partisan gerrymandering in this map to a remarkable degree of certainty.**

Summary

My test does not detect pro-Democratic or pro-Republican gerrymandering in Maps A or B, but does detect pro-Republican gerrymandering in Map R. In particular, like the current 2011 Congressional districting of Pennsylvania, I find that Map R is a gross outlier with respect to partisan bias in a way that is mathematically impossible to be caused by political geography and the traditional districting criteria I consider. Quantitatively, more than 99.99998% of maps encountered in the runs of my the test are less partisan than Map R.

Quantitatively, the theorem I employ to rigorously justify my statistical confidence proves that more than 99.9% of *all* districtings of Pennsylvania satisfying the traditional criteria I considered would pass my

gerrymandering test, showing in a mathematically rigorous way that Map R was an extremely careful choice made to maximize partisan advantage.

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. §4904 relating to unsworn falsification to authorities.



Wesley Pegden
2/15/18