

Lindleys' Map of Warsaw (1:2,500) as a tool for understanding the urban space preservation*



<https://atlasfontium.pl/lindleys-map-of-warsaw/>

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Zarys treści: Głównym przedmiotem zainteresowania autorki artykułu jest plan Lindleyów w skali 1:2500 (1897–1901), będący jednym z rezultatów prac kartograficznych podjętych w związku z rozwojem sieci kanalizacyjnej i wodociągowej w Warszawie. Plan jest podstawą prezentowanej edycji działek miejskich. Uzyskane dane przestrzenne pozwoliły na porównanie stabilności granic działek miejskich od przełomu XIX i XX w. z obecnymi danymi geodezyjnymi.

Słowa kluczowe: plan miasta, historia kartografii, Warszawa, przestrzeń miejska, działka miejska, HGIS

Abstract: The article focuses primarily on the 1:2,500 Lindleys' map (1897–1901), one of the results of the cartographic work undertaken in connection with the development of the Warsaw sewage and waterways system. The map served as a basis for the edition of urban plots presented in the source. The obtained spatial data enabled comparing the stability of urban plot borders established at the turn of the twentieth century against current geodetic data.

Keywords: town map, history of cartography, Warsaw, urban space, urban plot, HGIS

Introduction

Both terms – “plan” and “map” – are used in reference to cartographic representations of urban spaces. Researchers emphasise the different meanings of “plan” and “map”. For urban history, probably one of the best known notions is the “town-plan” by Michael Robert Günter Conzen.¹ Conzen took it as an axiom in his fundamental work on Alnwick “that the town plan includes all features of the built-up area shown on the 1/2500

Ordnance Survey Plans”.² Thus, its definition can be understood in two ways. Firstly, in the most widespread interpretation, as the topographic arrangement of objects (with an emphasis on streets, plots and buildings).³ On the other hand, Conzen also mentions Ordnance Survey Plans, and later on, he refers to a number of maps he used when surveying Alnwick. In the literature, the city plan also has the meaning of representing the planned future state.⁴ According to Matthew Edney, a plan represents “parts of the world observed and measured by one surveyor or organised

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¹ M.R.G. Conzen, ‘Alnwick, Northumberland: A Study in Town-Plan Analysis’, *Transactions and Papers (Institute of British Geographers)*, no. 27 (1960), 111–122 (p. 3).

² *Ibid.*, p. 4.

³ M.P. Conzen, ‘Core Concepts in Town-Plan Analysis’, in *Teaching Urban Morphology*, ed. V. Oliveira, The Urban Book Series (Cham, 2018); V. Oliveira, ‘The Town-Plan as Built Heritage’, *Heritage*, no. 4 (3) (2021), 1049–1061; Conzen, ‘Alnwick’, p. 4.

⁴ R.R. Churchill, ‘Urban Cartography and the Mapping Of Chicago’, *Geographical Review*, vol. 94, no. 1 (2004), 1–22; R. Goodspeed, J. Grengs, ‘Urban and Regional Planning’, *Geographic Information Science & Technology Body of Knowledge*, no. 4 (2017), <https://gistbok.ucgis.org/bok-topics/gist-urban-and-regional-planning> [accessed on 2 February 2023].

teams of surveyors”, and a map “delineates regions or the whole world beyond the ability of one individual to observe and survey directly”.⁵ “Map” is a more general term, but also more commonly used to refer to the cartographic representation of cadastral data.⁶ Moreover, in the definitions of both types of cartographic works, the difference at the level of elaboration is emphasised – a map must be based on a coordinated system, whilst plans, as a rule, show such a small area that the curvature of the Earth does not have to be taken into account when preparing them. By contrast, Paul D.A. Harvey uses the terms “map” and “plan” interchangeably.⁷

The main focus of this paper is on the cartographic work undertaken in Warsaw in connection with the development of the sewage and waterways system in the second half of the nineteenth century, especially a cartographic source at the scale of 1:2,500 created between 1897 and 1901. In this period (1815–1918), Warsaw formed part of the territory controlled by the Russian Empire (the so-called Congress Poland, Polish: Królestwo Kongresowe, within the Russian Partition).⁸

Paweł Wespiański defines the work in question as “the pinnacle achievement of cartography of Warsaw”.⁹ In previous publications concerning this source, the Polish word “plan” (and its variants) – as in “plany Lindleya” (“Lindley’s plans”) –

prevailed. Polish literature refers to this source as “sekcyjny sytuacyjny plan miasta” (“sectional site plan of the city”),¹⁰ “plan sekcyjny” (“section plan”),¹¹ and also “plan ogólny” (“general plan”).¹² It is worth emphasising that the Polish term “plan” was also used by the people involved in its development.¹³ However, considering the above arguments regarding the differences between “plan” and “map” and conventions in English, I have decided to use the English term “the Lindleys’ Map”.

The first aim of the paper is to characterise the Lindleys’ Map at the scale of 1:2,500 and to discuss the process of editing urban plots presented in the source. The task of plot vectorisation was carried out as auxiliary work in the project “Historical Ontology of Urban Spaces”.¹⁴ The second aim is to trace the stability of urban plots from the Lindleys’ Map compared to modern data.

Related works

The cartographic source that is the subject of consideration was most extensively discussed by Paweł Wespiański in the publication devoted to the map at the scale of 1:10,000 from the same series.¹⁵ Information about the map can also be found in publications on the historic cartography of Warsaw.¹⁶ The map in question was used,

⁵ M.H. Edney, *Cartography: The Ideal and Its History* (Chicago, 2019), p. 3.

⁶ R.J.P. Kain, E. Baigent, *The Cadastral Map in the Service of the State: A History of Property Mapping* (Chicago–London, 1993); I. Williamson, S. Enemark, ‘Understanding Cadastral Maps’, *Australian Surveyor*, vol. 41, no. 1 (1996), 38–52.

⁷ P.D.A. Harvey, *The History of Topographical Maps: Symbols, Pictures and Surveys* (London–New York, 1980).

⁸ S. Kieniewicz, *Dzieje Warszawy*, vol. 3: *Warszawa w latach 1795–1914* (Warszawa, 1976).

⁹ R. Żelichowski, P.E. Wespiański, *William Heerlein Lindley. Plan niwelacyjny miasta Warszawy. Zdjęcie pod kierunkiem Głównego Inżyniera W.H. Lindleya*, *Plany Warszawy Series* (Warszawa, 2016), p. 186: “[...] pod względem sztuki kartograficznej rękopiśmienny plan Lindleyów w skali 1:2500 można traktować jako szczytowe osiągnięcie kartografii Warszawy. Połączenie artystycznego, wysublimowanego rysunku z precyzją obrazowania przestrzeni z licznymi drobnymi obiektami nie miały i nie mają równych w kartografii warszawskiej”.

¹⁰ Archiwum Państwowe w Warszawie [State Archives in Warsaw] (hereinafter: APW), *Plany Lindleyów*, <https://www.warszawa.ap.gov.pl/lindley/planylindleyow.html> [accessed on 20 June 2023].

¹¹ Żelichowski, Wespiański, *William Heerlein Lindley*, p. 181.

¹² A. Jankiewicz, P.E. Wespiański, M. Witecki, *Atlas historyczny Warszawy: Wybrane źródła kartograficzne* (Warszawa, 1999), p. 108.

¹³ M. Jeżowski, ‘Rozdział XV. Pomiar miasta i okolic’, in *Kanalizacja, wodociągi i pomiary miasta Warszawy: wykonane podług projektu i pod głównym kierownictwem W.H. Lindleya*, ed. A. Grotowski et al. (Warszawa, 1911), p. 250, <https://delibra.bg.polsl.pl/dlibra/publication/28905/edition/25338/content> [accessed on 20 June 2023].

¹⁴ Project ‘Historical Ontology of Urban Spaces’ was funded by the Polish National Agency for Academic Exchange (project no. PPI/APM/2019/1/00053/U/00001) and implemented under the supervision of Wiesława Duży, PhD, at the Tadeusz Manteuffel Institute of History of the Polish Academy of Sciences in 2019–2022, <https://urbanonto.ihpan.edu.pl/pl/> [accessed on 20 June 2023].

¹⁵ Żelichowski, Wespiański, *William Heerlein Lindley*, pp. 181–188.

¹⁶ Jankiewicz, Wespiański, Witecki, *Atlas historyczny Warszawy*, pp. 105–126; J. Szymańska, ‘Lindleyowskie mapy Warszawy’, *Rocznik Warszawski*,

among others, in research on Warsaw in the modern era,¹⁷ as well as the basis for considerations and one of the sources in the work on the ontology of historical urban space.¹⁸ It also provided material for bachelor's and master's theses prepared at the Faculty of Geography and Regional Studies of the University of Warsaw.¹⁹ In the future, it will constitute the main base map in a volume of the Historic Towns Atlas on Warsaw,²⁰ as well as one of the base maps for spatial analysis in the research project on the social sources of violence against Jews in the nineteenth-century Polish Kingdom (Królestwo Polskie, 1864–1914).²¹

Cartographic literature encompasses a wide range of works with a broad focus, from simply presenting the history

of an individual source through discussing its practical use or complete and detailed source editions to enriching GIS layers with additional data.²² Editions of urban cartographic sources understood as “elaborations of the spatial database with most important features (e.g. settlements, roads, land cover, etc.), which serve as the geographic index”²³ constitute the core of many historical urban studies.²⁴ Cartographic sources of urban spaces seem crucial, especially in the new approach of urban conservation raised by Kayvan Karimi,²⁵ i.e. “spatial spirit,” which focuses on urban fabric rather than individual buildings. In towns that did not undergo intensive redevelopment in the nineteenth and twentieth centuries, plots are considered to be one of the most stable elements of the town plan.²⁶ Yet, this claim has been challenged by Marcel IJsselstijn and his analysis of the persistence of mediaeval

vol. 3 (1962), 315–320; M. Witecki, *Plan Warszawy Lindleya 1883–1915 ze zbiorów Archiwum Państwowego m. st. Warszawy* (Warszawa, 1990), <https://pbc.gda.pl/dlibra/doccontent?id=61528> [accessed on 20 June 2023]; A. Bartoszewicz, H. Bartoszewicz, ‘Dzieje kartografii miast polskich do końca XIX wieku. Zarys problematyki’, *Polski Przegląd Kartograficzny*, vol. 45, no. 3 (2013), 236–255.

¹⁷ M. Kuc-Czerep, *Niemieckojęzyczni mieszkańcy Warszawy: Droga do obywatelstwa w osiemnastowiecznej Rzeczypospolitej* (Warszawa, 2021); M. Kuc-Czerep, K. Słomska, ‘Wyzwania integracji źródeł kartograficznych i tekstowych na przykładzie Warszawy w XVIII w.’, *Studia Geohistorica*, vol. 7 (2019), 127–143.

¹⁸ K. Słomska-Przech, M. Słomski, ‘Urban Plot: Developing a Consistent Definition for Comparative Urban Studies’, *Journal of Urban History*, vol. 50, no. 2 (2024), 422–451, <https://doi.org/10.1177/00961442221089942>.

¹⁹ E. Bagieńska, ‘Opracowanie metodyki przygotowania podkładowego planu Warszawy przełomu XIX i XX wieku w skali 1:5000’ (unpublished master’s thesis, University of Warsaw, 2017); M. Wereszczyński, ‘Koncepcja mapy podkładowej Warszawy przełomu XIX i XX wieku w skali 1:10 000’ (unpublished bachelor’s thesis, University of Warsaw, 2016); id., ‘Koncepcja i redakcja mapy podkładowej Warszawy przełomu XIX i XX wieku’ (unpublished master’s thesis, University of Warsaw, 2018).

²⁰ The Historic Town Atlas volume of Warsaw will be developed under the project “Historical survey maps and the comparative study of the functionality and morphology of urban space. Standardisation – Digital processing – Research” (2022–2025) in the BEETHOVEN 4 funding programme (Polish PI prof. Roman Czaja). A. Lampen, et al., ‘HiSMaComp – Historical survey maps and the comparative study of the functionality and morphology of urban space. Standardisation – Digital processing – Research’, Institut für vergleichende Städtegeschichte, <https://hismacomp.hypotheses.org/> [accessed on 14 June 2023].

²¹ ‘The social origins of anti-Jewish violence. The Kingdom of Poland in the second half of the 19th century (1864–1914)’, head A. Markowski, <https://historia.uw.edu.pl/en/research-project/the-social-origins-of-anti-jewish-violence-the-kingdom-of-poland-in-the-second-half-of-the-19th-century-1864-1914/> [accessed on 20 June 2023].

²² In his paper on digital cartographic source editions, Tomasz Panecki names the following approaches: (1) maps as images: digital libraries and collections, (2) geoportals with georeferenced maps, (3) spatial database. However, in this paper, the focus is slightly on different angles, i.e. town maps and plans and their use in urban studies, T. Panecki, ‘Digital methods in cartographic source editing’, *Digital Scholarship in the Humanities*, vol. 36, no. 3 (2021), 682–697; I.N. Gregory, P.S. Ell, *Historical GIS: Technologies, Methodologies, and Scholarship* (Cambridge–New York, 2016); R. Golba, A. Pilaraka, R. Czaja, ‘The Concept of a Georeferential Spatial Database of Topographic-Historical Objects (GSDoT-HO): A Case Study of the Cadastral Map of Toruń (Poland)’, *ISPRS International Journal of Geo-Information*, vol. 12, no. 2 (2023), 26; Z. Mou, ‘Using cadastral maps in historical GIS research: the French Concession in Shanghai (1931–1941)’, *Annals of GIS*, vol. 18, no. 2 (2012), 147–156; T. Panecki, ‘Plan of Kalisz by Andrzej Politański from 1785 – a source edition in the Polish Historic Towns Atlas’, *Polish Cartographical Review*, vol. 54, no. 1 (2022), 92–107.

²³ Panecki, ‘Digital methods’, p. 682.

²⁴ Golba, Pilaraka, Czaja, ‘The Concept of a Georeferential’; K. Lelo, ‘A GIS Approach to Urban History: Rome in the 18th Century’, *ISPRS International Journal of Geo-Information*, vol. 3, no. 4 (2014), 1293–1316; C.D. Lloyd et al., ‘Exploring change in urban areas using GIS: Data sources, linkages and problems’, *Annals of GIS*, vol. 18, no. 1 (2012), 71–80; Panecki, ‘Plan of Kalisz’.

²⁵ K. Karimi, ‘Urban conservation and spatial transformation: preserving the fragments or maintaining the “spatial spirit”’, *URBAN DESIGN International*, vol. 5, no. 3–4 (2000), 221–231.

²⁶ T.R. Slater, ‘The Analysis of Burgage Patterns in Medieval Towns’, *Area*, vol. 13, no. 3 (1981), 211–216, <http://www.jstor.org/stable/20001722> [accessed on 20 June 2023].

plot boundaries in Leiden.²⁷ According to his calculations, the boundaries were more stable between the nineteenth and twenty-first centuries than between the sixteenth and nineteenth centuries, when many analysed plots were divided. On the other hand, Vítor Oliveira,²⁸ who applied the concept of “spatial spirit” to analyse several plots from street blocks in New York, positively verified the stability of a town plan from 1811 up to the present day. Authors analysing plot patterns raise the question of whether they should be subject to heritage protection.²⁹

Lindleys' Map (1:2,500) – origin, execution and implementation

Lindleys' maps and plans are inextricably linked with the work on the sewage and water supply system in Warsaw supervised by the Lindley family.³⁰ William Lindley had led and consulted engineering work throughout Europe.³¹ A preliminary agreement between William Lindley and the Warsaw City Council was signed in 1876, and the project for the construction of water supply and sewage systems was announced in 1879.³² In the same year,

William Lindley retired and was replaced by his son, William Heerlein Lindley.³³ In 1881, William H. Lindley signed the contract to draw up water supply and sewage systems plans and manage the Warsaw Magistrate's engineering work.³⁴

In the same year, the Sewage and Water Supply Construction Office (Biuro Budowy Kanalizacji i Wodociągów³⁵) was established, within which in 1883, the Department of Surveying (Wydział Mierniczy) – the centre of geodetic and cartographic work – was created with engineer Herman Lichtweiss at its helm.³⁶ In 1896, the first main stage of fieldwork was completed, and the Department of Surveying (Wydział Mierniczy) was transformed into the Office of Measurements (Biuro Pomiarów) at the Department of Exploitation of Canals and Waterworks (Wydział Eksploatacji Kanałów i Wodociągów) and Marcei Jeżowski became its new head.³⁷ From that moment, the office's work was aimed not only at handling sewage and water supply work but also at preparing a “general map of the city”,³⁸ which could be used for various purposes. The office's main tasks were to maintain, update and extend the scope of cartographic work, as well as to provide copies of plans and maps – both to private individuals and for the purposes of city management.

²⁷ M. IJsselstijn, 'Tracing the persistence of medieval plot boundaries in a central street: Breestraat in Leiden, The Netherlands', in *Rural Riches & Royal Rags?: Studies on Medieval and Modern Archaeology, Presented to Frans Theuvs*, ed. M. Kars, R. van Oosten, M.A. Roxburgh (Zwolle, 2019), pp. 236–242.

²⁸ Oliveira, 'The Town-Plan'.

²⁹ G.A. Erland, *Plot longevity and urban land tenure: a Norwegian case study*, "Urban Morphology", 14 (1), 2010, 21–29; Oliveira, 'The Town-Plan', pp. 1049–1061.

³⁰ More on history of sewage and waterworks in Warsaw, see: M. Gajewski, 'Warszawskie wodociągi do 1939 roku: projekty i realizacje', *Kwartalnik Historii Nauki i Techniki*, vol. 17, no. 1 (1972), 25–44; A. Grotowski, 'Rozdział I. Zarys historyczny wodociągów m. Warszawy', in *Kanalizacja, wodociągi i pomiary miasta Warszawy: wykonane podług projektu i pod głównym kierownictwem W. H. Lindley'a*, ed. A. Grotowski et al. (Warszawa, 1911), <https://delibra.bg.polsl.pl/dlibra/publication/28905/edition/25338/content> [accessed on 20 June 2023]; R. Żelichowski, *Lindleyowie: Dzieje inżynierskiego rodu* (Warszawa, 2002); Żelichowski, Wespziński, *William Heerlein Lindley*.

³¹ F. Lerner, 'Lindley, William', *Neue Deutsche Biographie*, vol. 14 (1985), (<https://www.deutsche-biographie.de/pnd117026050.html#ndbcontent>) [accessed on 20 June 2023].

³² Żelichowski, *Lindleyowie*, pp. 387, 399.

³³ M. Gajewski, 'Lindley William Heerlein (1853–1917)', in *Polski Słownik Biograficzny*, vol. 17, ed. E. Rostworowski (Wrocław, 1972), pp. 367–368; R. Żelichowski, *Lindley, Sir William Heerlein: (1853–1917)*, in *The Oxford Dictionary of National Biography*, ed. H.C.G. Matthew, B. Harrison (Oxford, 2004). From 1901 on, William H. Lindley was involved in the works on the water supply system for the city of Łódź, see: D. Bartnik, 'Lindleyowskie plany wodociągów i kanalizacji miasta Łodzi w zbiorach Biblioteki Uniwersytetu Łódzkiego', in *Dawna kartografia miast*, ed. J. Ostrowski, P.E. Wespziński, *Z dziejów kartografii Series*, 15 (Warszawa, 2011), 137–152.

³⁴ Żelichowski, *Lindleyowie*, p. 412.

³⁵ The original names in Polish are given in brackets in each case.

³⁶ Żelichowski, Wespziński, *William Heerlein Lindley*, p. 139.

³⁷ Jankiewicz, Wespziński, Witecki, *Atlas historyczny Warszawy*, p. 106; Żelichowski, Wespziński, *William Heerlein Lindley*, p. 139.

³⁸ Jeżowski, 'Rozdział XV', p. 227 ("uznano potrzebę nie tylko posiadania dokładnego planu do wykonania budowy urządzeń kanalizacyjno-wodociągowych, ale także sporządzenia ogólnego planu miasta").

It is customary for cartographic works made in connection with water and sewage works to be named after the chief engineers – William Lindley and his son William Heerlein Lindley.³⁹ However, it is impossible not to mention the other people involved. From 1882 to 1910, the number of office employees varied from four to seventy (in 1894). In general, texts devoted to so-called Lindleys' cartographic work are accompanied by a list of all employees in managerial positions, thus only men. However, the participation of women in this project is worth noting. In both the monograph prepared by the Office of Measurements (Biuro Pomiarów) team edited by, among others, Alfons Grotowski and the most recent studies on works of the Department of Surveying and Measurement Office,⁴⁰ the participation of women in the development of cartographic materials was noted. Women worked as draughtswomen ("rysowniczkini") between 1892 and 1899 (the largest number, as many as sixteen women, were employed in 1896).⁴¹ The most complete list of women employed in the office at the period of interest in the text – but still only six of them – was provided by Romuald Ronisz (1963).⁴² Their names were Kamila Kamieniecka (later Brukalska), Janina Gajkiewiczówna, Maria Czereyska, Helena Karasowska, Zofia Mianowska (later Kraczkiewicz), and Alina Polakówna.

Maps at the scale of 1:2,500 were created according to the same assumptions as the whole series of so-called Lindleys' plans and maps developed at the end of the nineteenth and in the early twentieth

century at the Office of Measurements. These are the first fully mathematically precise maps of Warsaw. All maps have a northern orientation. Figure 1 shows six main geodetic points, as well as the cross of the Augsburg Evangelical Holy Trinity Church (current address: 1 Stanisława Małachowskiego Square), which served as the main point of measurement.⁴³

As a result, the Office's work on the series of maps involved elaborating several manuscripts (street plans at the scale of 1:200, block plans at the scale of 1:200 and 1:250, section plans of suburbs at the scale of 1:500 and 1:1,000, Warsaw with suburbs at the scale of 1:2,500, levelling map of Warsaw with suburbs at the scale of 1:2,500), and printed maps (left-bank Warsaw 1:250, Warsaw at the scale of 1:2,500, and maps at scales of 1:10,000, 1:16,800, and 1:25,000).⁴⁴

The 1:2,500 map is a multi-coloured manuscript developed entirely in the Russian language. The map was made with an accuracy of 30 cm in the field, which means that it does not take into account architectural details, and the location of individual trees is marked for orientation purposes.⁴⁵ In the same sheet division, a levelling map was also made at that time with a contour cut every 0.5 m.⁴⁶ In 1901–1902, the printed black-and-white versions of the 21 sheets were reproduced by means of lithographic print. The lithographic stones were updated if needed, new versions of sheets were printed in 1906 and 1911.⁴⁷

³⁹ Żelichowski, Wespziński, *William Heerlein Lindley*, pp. 132–133.

⁴⁰ Jeżowski, 'Rozdział XV', p. 261, Tablica 81. Skład biura pomiarów podług zajęć"; Witecki, *Plan Warszawy Lindleya 1883–1915*, p. 7; Żelichowski, Wespziński, *William Heerlein Lindley*, pp. 138–139.

⁴¹ Jeżowski, 'Rozdział XV', p. 261 "Tablica 81. Skład biura pomiarów podług zajęć".

⁴² R. Ronisz, 'Biuro Pomiarów m.st. Warszawy w latach 1881–1922', *Przeгляд Геодезии*, vol. 35, no. 2 (1963), 96–100, <https://pbc.gda.pl/dlibra/publication/88961/edition/80389/content> [accessed on 20 June 2023].

⁴³ The preparation for the measurements, the method of their performance and the exact calculations are given in Jeżowski, 'Rozdział XV'.

⁴⁴ It is necessary to mention that the metric system was not fully established in Warsaw at the time, as it had not yet been introduced across the Russian Empire. However, scales of Lindleys' map are well recognised in previous research; I therefore use them as a courtesy to my readers; more about metrics in the former Polish territories during partitions, see A. Barański, Z.L. Warsza, 'Miary na ziemiach polskich w dobie porzobiorowej', *Pomiary, Automatyka, Kontrola*, vol. 58, no. 12 (2012), 1137–1140.

⁴⁵ Jeżowski, 'Rozdział XV', p. 248.

⁴⁶ Jankiewicz, Wespziński, Witecki, *Atlas historyczny Warszawy*, p. 108.

⁴⁷ Jeżowski, 'Rozdział XV', p. 279; Żelichowski, Wespziński, *William Heerlein Lindley*, p. 193.



Fig. 1. Triangulation and polygonisation developed for the needs of measurement plans and maps. This sketch shows how the 1:2,500 map was divided into 21 sheets. Description in the lower right corner: "Measurement and plan made under the direction of Chief Engineer W. H. Lindley Warsaw in February 1911, Head of the Office of Measurements M. Jeżowski". Source: M. Jeżowski, "Rozdział XV", Tab. 68; public domain

The map at the scale of 1:2,500 consists of a total of 26 sheets made in the years 1897–1901. It was created based on reducing the survey sketches at the scales of 1:250 and 1:500.⁴⁸ Sections of the plan at the scale of 1:250 for left-bank Warsaw were made in the years 1891–1896⁴⁹ and for the right-bank Praga district in 1896.⁵⁰ The reduction was made using a pantograph.

First, in 1897, 21 sheets at the scale of 1:2,500 were prepared, covering 7170 hectares.⁵¹ While most of Warsaw within its 1900 expanded borders fitted within the sheets made in 1897, the southern part of the city marked out in 1825 was not presented in its entirety on the first set of sheets. In 1900–1901, the map was supplemented with five additional sheets of southern suburbs (sheet numbers 23, 24, 25, 28, 29).⁵² The new sheets included the city within the city borders from 1900 to the south of Łazienki Park, as well as later extensions (until 1913, without a small part of the eastern outskirts of the town).⁵³

⁴⁸ Jeżowski, 'Rozdział XV', pp. 250, 282.

⁴⁹ *Ibid.*, p. 249.

⁵⁰ *Ibid.*, p. 280.

⁵¹ *Ibid.*, p. 250.

⁵² Paweł Wespziński mentions that neither the missing sheets (numbers 22, 26, 27), nor any mention of them have been found. Probably they were never elaborated. On the other hand, there are two versions of sheets 11 and 20; Żelichowski, Wespziński, *William Heerlein Lindley*, pp. 181–193.

⁵³ The history of the administrative borders of Warsaw is not yet fully explored and authors present different courses of the city's boundaries. Data available online at Warsaw's official map portal do not contain data for the turn of the nineteenth and twentieth centuries; Urząd m.st. Warszawy, Biuro Geodezji i Katastru (City Hall of Warsaw, Office of Surveying and Cadastre), Historical Map, <https://mapa.um.warszawa.pl/en/index.html> [accessed on 20 June 2023]; and authors decide to show the state for 1825 and then 1913, e.g. J. Kaczorowski, 'Jak zmieniły się granice Warszawy?', *ArcanaGIS* 2020, <https://www.arcanagis.pl/jak-zmienialy-sie-granice-warszawy/> [accessed on 20 June 2023]. Information with the highest time resolution can be found in Andrzej Gawryszewski's monograph on Warsaw's population: A. Gawryszewski, *Ludność Warszawy w XX wieku*, Monografie: Polska Akademia Nauk. Instytut Geografii i Przestrzennego Zagospodarowania im. Stanisława Leszczyńskiego Series, 10 (Warszawa, 2009). The boundaries, according to Gawryszewski, were adopted in this paper.

In 1911, Marcei Jeżowski wrote that "in the future, second originals of the section of the 1:2,500 map will be created, on which supplementary measurements will be made so that the originals from 1896 remain intact and are the image of the original measurement".⁵⁴ The plan was actively used in city management, as evidenced by the updates on some sheets.⁵⁵

Before the German army entered Warsaw in August 1915, the plans were taken to Russia during the evacuation of the Magistrate, from where they returned to Poland after 1922.⁵⁶ Then, the plans belonged to the resources of the Archives of Plans in the Office of Measurements at the Regulation and Measurements Department at Warsaw City Council (Archiwum Planów w Biurze Pomiarów, Dział Regulacji i Pomiarów, Zarząd m. Warszawy).⁵⁷

The map of Warsaw at the scale of 1:2,500 was used to make the cadastral map from 1936–1941 and "The Capital Reconstruction Office Destruction Survey Map of Warsaw from 1945–1946" (hereinafter "Destruction Survey Map" – "Plan inwentaryzacji zniszczeń Warszawy Biura Odbudowy Stolicy z lat 1945–1946").⁵⁸

The maps are currently kept at the State Archives in Warsaw (Archiwum Państwowe w Warszawie, hereinafter: APW) in the group "Zarząd Budowy Kanalizacji i Wodociągów w Warszawie" ("Sewage and Water Supply Construction Management in Warsaw").⁵⁹ In 2013, the Archive dedicated a website to the Lindleys'

⁵⁴ Jeżowski, 'Rozdział XV', p. 282: "[...] w przyszłości będą utworzone drugie oryginały sekcji planu 1:2500, na które pomiary dopełniające będą wnoszone, tak aby oryginały z 1896 r. pozostały nienaruszone i były obrazem pierwotnego pomiaru".

⁵⁵ Żelichowski, Wespziński, *William Heerlein Lindley*, pp. 188, 207–209.

⁵⁶ Jankiewicz, Wespziński, Witecki, *Atlas historyczny Warszawy*, pp. 108–109.

⁵⁷ *Ibid.*, p. 109; Żelichowski, Wespziński, *William Heerlein Lindley*, pp. 211–213.

⁵⁸ Urząd m.st. Warszawy, Historical Map; Żelichowski, Wespziński, *William Heerlein Lindley*, p. 289.

⁵⁹ APW, План города Варшавы. Съёмка под руководством Главного Инженера В.Г. Линдлея [Plan miasta Warszawy. Zdjęcie pod kierunkiem

Maps.⁶⁰ Since 2010, on the online map portal of the City of Warsaw, it is possible to use Lindleys' mosaic sectional plans at the scale of 1:250 made in the years 1891–1908, and since October 2021, maps at the scale of 1:2,500 have also been available on the website.⁶¹ The layer 1897–1901 from the Warsaw's map website contains all the first versions of the sheets. Sheets made between 1900 and 1901 are also in a separate layer, allowing comparison of the two versions of sheet no. 20. On the map portal of Warsaw, one can also compare the 1:2,500 version of the map with a contour cut (21 sheets, 1897) and the black-and-white map sheets at the same scale (13 sheets, 1896–1906).

Structure and content of the source

The sheet of the 1:2,500 map has dimensions of 94 x 70 cm. The subject of the work are scans of map sheets with a resolution of 300 DPI obtained from the APW. The map sheets underwent restoration in 2009.⁶² Every sheet from the series has the name of the city in the upper left corner ("Warsaw," original spelling: "ВАРШАВА"), the numeric scale at the bottom in the centre (1:2,500), and in the bottom right corner – the code of the position of the sheet in the local coordinate system (longitudinal and latitudinal slices).

On sheets 1–20, out-of-frame content also includes a description in the upper corner ("Topographic survey under the leadership of Chief Engineer V.G. Lindley." "СЪЁМКА ПОДЪ РУКОВОДСТВОМЪ ГЛАВНАГО

ИНЖЕНЕРА В.Г. ЛИНДЛЕЯ."), and the number of the sheet in red (bottom right corner). Left to the number, there is a printed inscription "Warsaw, April 1897. Head of Department of Surveying Engineer" with a hand signature at the end "H. Lichtweiss" ("г. Варшава, въ Апрельъ 1897 г. Начальникъ Межеваго Отдѣленія Инженеръ Н. Lichtweiss").

Sheets 23, 24, 25, 28 and 29 lack the above-mentioned printed inscriptions on the upper right and downright corners. There is a printed annotation in the lower left corner of the sheets with years ("Compiled in 1900 and 1901", in original "Составлен в 1900 и 1901 г."). Sheets have the number in the same place as sheets 1–21 (bottom right), but most probably added later in pencil. In the same corner is a handwritten annotation: "January Władysław Starzyński sworn surveyor".⁶³

The content of the plan consists of streets and squares (with names), railway lines, buildings (including a distinction between wooden and brick buildings, and a darker shade was used for more important objects), green areas and single trees, waters, as well as larger elements of relief terrain. Military areas (e.g. fortresses) were censored on the map at the scale of 1:2,500. Importantly; the plan shows the division into urban plots. Paweł Wespiański noticed that the plan gave only mortgage numbers of plots without information about police numbers.⁶⁴ However, analysis of the sheets of the right bank of Vistula River showed that the numbers had very low values (e.g. 12, 13, Fig. 2), which is somewhat unusual for cadastral identification systems, and the numbering of plots is recurring. Furthermore, some areas have even numbers on the right side of the street and odd numbers on the left side, or two buildings from one plot are marked with different numbers.

Głównego Inżyniera W.H. Lindleya], W.H. Lindley, 1:2 500, 1897–1901, 785, 72/1001, Zarząd Budowy Kanalizacji i Wodociągów w Warszawie.

⁶⁰ APW, Plany Lindleyów.

⁶¹ Urząd m.st. Warszawy, Historical Map. The colours on the maps on the Historical Map website are different than those presented in this paper, as according to the annotation, the Office of Surveying and Cadastre of the City of Warsaw processed the original scans in order to make the content legible.

⁶² APW, Plany Lindleyów; Żelichowski, Wespiański, *William Heerlein Lindley*, p. 214. It is possible to encounter both versions – before and after conservation scans which differ in colour.

⁶³ "Январь Владислав Старжинский присяжный замерщик".

⁶⁴ Żelichowski, Wespiański, *William Heerlein Lindley*, p. 187.

All issues mentioned are characteristic of police codes for the properties. In spite of that, the plans at the scale of 1:250 present the cadastral numbers for this area. Therefore, the urban plots system shown on the 1:2,500 map is inconsistent.⁶⁵

No legend for the 1:2,500 plan has been found in the archives so far.⁶⁶ The symbols are similar to that of works at larger scales (1:1,000). However, when comparing the available legends (also among themselves), it is impossible not to notice the differences in the signs used.⁶⁷

In the case of the plan of Warsaw from the same series but at the scale of 1:10,000, Paweł Weszpiński⁶⁸ interpreted various street symbols (e.g. marked with a continuous line on one side and a broken line on the other, or dashed on both sides) as a hierarchy in this category. However, having analysed the map at the scale of 1:2,500, I was of the opinion that the type of line (continuous, dashed) was not related to the street itself, but to the type of surrounding areas (Fig. 3). For example, the red line is possibly the symbol of a wooden fence, black – a stone wall, and the dashed line marks the border between different types of the land cover (e.g. alleys, streets and green areas). Symbols from the map at the scale of 1:2,500 are similar to the two legends of map sheets at the scale of 1:1,000 from 1895 and 1896. In a set of symbols for the higher-scale maps, the roads were presented as two dashed lines filled with grey. Solid and broken lines with brown fill for the roads appeared on the set from 1906. Nevertheless, both attempts to explain the symbolisation of the streets – presented by Paweł Weszpiński and in this

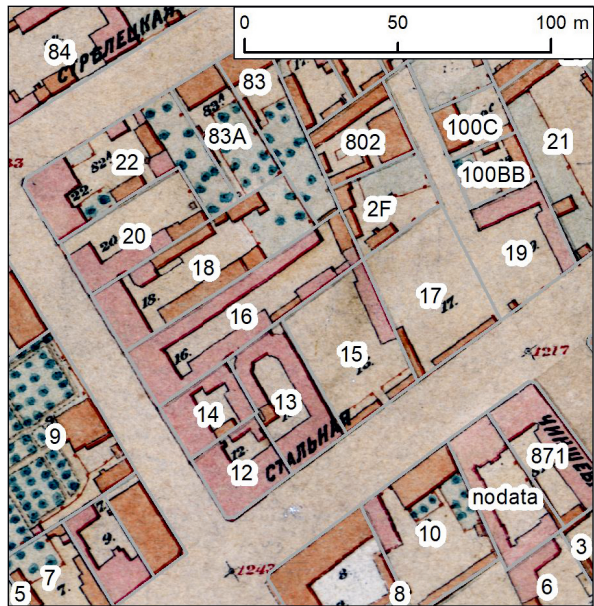


Fig. 2. Inconsistent numbering of plots on the right bank of Vistula River. Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

paper – remain only an exercise in interpretation due to the lack of a legend to the 1:10,000 and 1:2,500 plans.

Digital processing of the source

First, I georeferenced the map sheets from the APW to the grid prepared based on Figure 1 and the dimensions of the map sheets. Then, I clipped the sheets to the border and merged them (Fig. 4). I completed the process of georeferencing in the Georeferencer plugin in QGIS by the transformation with the Polynomial 1 algorithm conducted with 97 ground control points (GCP) in EPSG:2180. I have chosen the GCP, among other things, with the help of the layer “Immovable Monuments” provided by The National Institute of Cultural Heritage of Poland (Narodowy Instytut Dziedzictwa).⁶⁹ Due care was taken to distribute the GCP evenly,

⁶⁵ Słomska-Przech, Słomski, ‘Urban Plot’, pp. 8–9.

⁶⁶ Personal communication with Konrad Szuba, employee of the State Archive in Warsaw in 2015–2019.

⁶⁷ The author made an attempt to reconstruct the legend of the Lindleys’ Map at the scale of 1:2,500 (work in progress, K. Słomska-Przech, K.D. Lilley, ‘Cartography and the city: Exploring urban ontologies through historic town-maps’, in HOUSe project book edited by Wiesława Duży).

⁶⁸ Żelichowski, Weszpiński, *William Heerlein Lindley*, p. 225.

⁶⁹ Narodowy Instytut Dziedzictwa (National Institute of Cultural Heritage; hereinafter NID), Web Map Service “Immovable Monuments”,

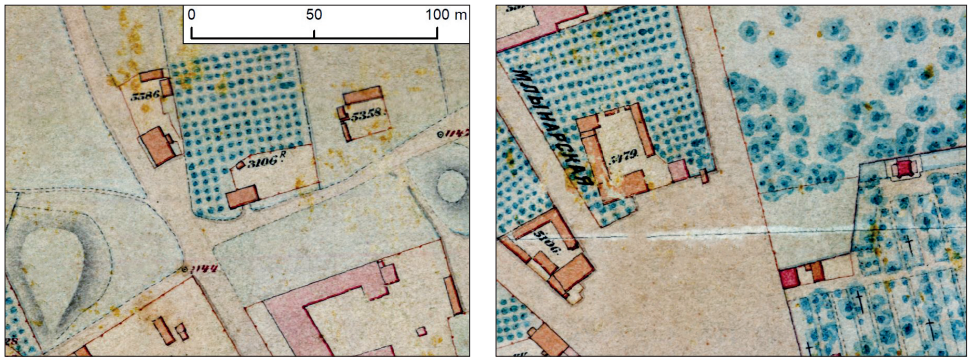


Fig. 3. Examples of line symbols used on Lindleys' Map (1:2,500).

Source: APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

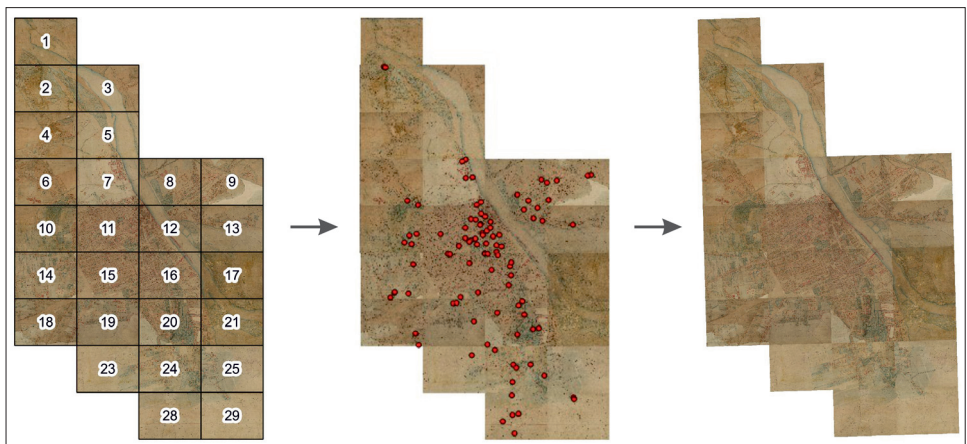


Fig. 4. Mosaicing and georeferencing.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

but finding points for each map sheet was impossible. The root mean square error (RMSE) was 1.38 m.

To investigate the possible local deformations in more detail, I analysed the residual error of 29 control points (CP), i.e. points not previously used for georeferencing (Fig. 5).⁷⁰ As reference points, I used the most accurate data available, i.e. the National Integration of Land Records (Krajowa Integracja Ewidencji Gruntów) provided by the Head Office of Geodesy

and Cartography (Główny Urząd Geodezji i Kartografii)⁷¹ and the “Immovable Monuments” layer provided by the National Institute of Cultural Heritage of Poland.⁷² I considered at least one point from each sheet of the Lindleys' Map for which it was possible to find additional points.⁷³ As in the first step, I performed the procedure in the Georeferencer tool in QGIS using the Polynomial 1 algorithm.

⁷⁰ http://uslugi.zabytek.gov.pl/INSPIRE_IMD/service.svc/get? [accessed on 20 June 2023].

⁷¹ K. Lelo, V. Baiocchi, 'Assessing the accuracy of historical maps of cities: Methods and problems', *Citta e Storia*, vol. 9, no. 1 (2014), pp. 79–87.

⁷¹ Główny Urząd Geodezji i Kartografii (Head Office of Geodesy and Cartography), Web Map Service “Krajowa Integracja Ewidencji Gruntów”, (2023), <https://integracja.gugik.gov.pl/cgi-bin/KrajowaIntegracjaEwidencjiGruntow> [accessed on 5 October 2023].

⁷² NID, Web Map Service “Immovable Monuments”.

⁷³ Lelo, Baiocchi, 'Assessing the accuracy', p. 84.



Fig. 5. Residual errors of control points.

Source: Own elaboration

The residual errors of CP ranged from 1.48 m to 0.09 m (Fig. 5). I found the highest values of residual errors (over 1 m) in the peripheral sheets. In point no. 28 at sheet no. 29 (peripheral, southeastern, Fig. 4), the error was 1.48 m, and in another eastern sheet 21 in point no. 3 – 1.05 m (barracks). In two adjacent western peripheral sheets, no. 10 and no. 14, the residual errors were 1.26 m (point no. 11, corner of the Evangelical Reformed cemetery plot) and 1.17 m (point no. 9, hospital building), respectively. On the other hand, I discovered the lowest values (below 0.3 m) of residual error for the different locations of the points. The lowest value of the residual error was found for a building in the area of the Camaldolese Monastery in Bielany on sheet no. 2 (point no. 27 = 0.09 m). Interestingly, other low values of residual error were found on the same sheets where high values of the error were recorded – on sheets no. 10 and no. 14; the residual errors were 0.15 m (point no. 12, corner of the Evangelical-Augsburg cemetery) and 0.14 m (point no. 10, Gasworks building), respectively. Near the centre, the lowest residual errors were found on sheet no. 7 (point no. 24 = 0.27 m, building at Warsaw Citadel) and sheet no. 20 (point no. 5 = 0.28 m, the Officer Cadets School in Royal Baths Park). Both points from sheet no. 10 were corners of the plots

included in the database of “Immovable Monuments” (point no. 12, the Evangelical-Augsburg cemetery, and point no. 11, the Evangelical Reformed cemetery), yet interestingly, points were found in the group of the lowest and highest residual error values, with the difference of 1.11 m.

As the urban plot is “the basic unit of urban space organisation,”⁷⁴ this project focused on the vectorisation of the plots presented on the Lindleys’ Map within the city border from 1900.⁷⁵ It was also due to the level of detail of the map and its scope, which is 8,867 hectares. I completed the vectorisation in the ArcGIS software. Two GIS specialists performed the process according to the instructions. Initially, the first GIS specialist vectorised the plots from the source. Then, the second GIS specialist verified the borders of polygons and supplemented the attribute table with plot numbers from the map. Finally, the first GIS specialist verified the whole data set.⁷⁶

If possible, modern spatial data on urban plots from the National Integration of Land Records served as a reference for vectorisation.⁷⁷ In some cases, it was difficult to determine the course of the plot, among

⁷⁴ Słomska-Przech, Słomski, ‘Urban Plot’, p. 23.

⁷⁵ Gawryszewski, *Ludność Warszawy*, p. 26.

⁷⁶ I would like to thank Dawid J. Maciuszek – co-author of the vectorisation of the plots.

⁷⁷ GUGiK, Web Map Service “Krajowa Integracja Ewidencji Gruntów”.

other things, due to the vague or missing symbolisation of borders.⁷⁸ Different line symbols (mentioned in section “3. Structure and content of the source”, Fig. 3), which are used at the borders of the plots or separate the types of land use within one plot, combined with the lack of plot numbers – especially in areas incorporated after 1897 – made unambiguous vectorisation challenging. If possible, I compared the course of the borders to the Lindleys’ plan at the scale of 1:250 and the cadastral map at the scale of 1:2,500 from 1936–1941. Due to the issues mentioned above, the spatial data presented in this paper are one of the possible interpretations of the cartographic source of interest.⁷⁹

When it comes to the plot numbers – despite the issue of inconsistent numbering, all values were recorded in the same column, as they are presented in the same manner on the map. If it was impossible to determine the plot number on maps from Lindleys’ series (1:2,500) or specify to which adjacent plots a given area belongs, the second GIS specialist added the annotation “no data”. The division into plots is not presented for the railway and military areas and the territories incorporated in 1889, 1890 and 1900 (especially in south-western and eastern outskirts).

In summary, within the framework of the work described, only the plots were vectorised and supplemented with the numbers assigned to them on the map. Based on the plots, I also developed a spatial data layer with street-blocks. The continuation of the work, i.e. the vectorisation of buildings, water bodies, and green spaces, is planned as part of the project dedicated to the Historic Town Atlas of Warsaw (see fn. 20).

⁷⁸ More on problems in vectorisation of urban plots on the example of Lindleys’ Map at the scale of 1:2,500, see Słomska-Przech, Słomska, ‘Urban Plot’, pp. 4–13.

⁷⁹ Georeferenced map and spatial data discussed in the paper are available at the Atlas Fontium website: <https://atlasfontium.pl/lindleys-map-of-warsaw/>.

Comparison of the Warsaw “spatial spirit” on the basis of plots from 1897–1901 and today

The aim of this part of the paper is to verify the view on the diametrical change in the urban morphology of Warsaw that took place during the reconstruction of the city after the Second World War.⁸⁰ Between 1939 and 1945, 85 per cent of the city was destroyed, and the demolition (even of buildings which could have been rebuilt) continued after the war.⁸¹ What is more, in 1945, a decree on the ownership and use of land in the area of the capital city of Warsaw was passed (“Dekret o własności i użytkowaniu gruntów na obszarze m.st. Warszawy”, also called the “Bierut Decree” after Bolesław Bierut, the President of the National Council).⁸² Under the decree, all land within the boundaries of Warsaw became the property of the commune, and buildings were communalised too. The overriding goal of the introduced decree was „to enable the rational construction of the capital and its further expansion”.⁸³ The aim of the author of this paper is not to describe or evaluate the causes, genesis or legal or social effects of the “Bierut Decree”. The decree’s

⁸⁰ U. Kurcewicz, ‘Ideologiczne oblicze odbudowy śródmieścia Warszawy ze zniszczeń po II wojnie światowej’, in *Oblicza wojny*, vol. 4: *Miasto i wojna*, ed. T. Grabarczyk, M. Pogońska-Pol (Łódź, 2021), pp. 369–392.

⁸¹ The 85 per cent figure comes from the website of United Nations Educational, Scientific and Cultural Organization (UNESCO World Heritage Centre, ‘Historic Centre of Warsaw’, <https://whc.unesco.org/en/list/30> [accessed on 20 June 2023]). In the official Polish data after the Second World War, damage of 84 per cent of the city is mentioned: L. Kowalski, F. Piątkowski, *Warszawa – mapa miasta w skali 1:20 000 wraz z inwentaryzacją zniszczeń popełnionych przez Niemców w latach 1939–1945 = Map of Warsaw at scale 1:20 000 and inventory of the destruction perpetrated by the Germans during the war 1939–1945* (Warszawa, 1949). For discussion on the scale of damages, see: J. Elżanowski, ‘Ruins, Rubble and Human Remains: Negotiating Culture and Violence in Post-Catastrophic Warsaw’, *Public Art Dialogue*, vol. 2, no. 2 (2012), 124–126.

⁸² *Dekret z dnia 26 października 1945 r. o własności i użytkowaniu gruntów na obszarze m. st. Warszawy* [Decree of 26 October 1945 on the Ownership and Use of Land in the Area of the Capital City of Warsaw], *Dziennik Ustaw*, 1945, no. 50, item 279.

⁸³ *Ibid.*

implementation was not carried out under the letter of the law, and irregularities in the fulfilment of the legal act have been documented and described.⁸⁴

The second aim of the paper, as mentioned above, is to edit and trace the stability of urban plots in Warsaw within the boundaries from 1897–1901 based on the Lindleys' Map at the scale of 1:2,500 in comparison with the situation presented in contemporary geodetic data from the National Integration of Land Records. As a comparative material, I used the cadastral map from 1936–1941, where the borders of plots were drawn from the Lindleys' maps, and updates were made with lines of a different colour.

I conducted the comparison process in QGIS software. To determine the extent of the analysis, I divided the layer with plots from Lindleys' Map into two layers for the left and right banks of the Vistula River. I aggregated both sets of plots internally (tool "Dissolve") and created a polygon around the layers with the "Minimum Bounding Geometry" algorithm to include the spaces of streets and squares. I reshaped polygons to the 1900 boundary and refined adjustments to the course of the peripheral plots to avoid large empty spaces. The obtained polygons served as "test areas" (Fig. 6).

I conducted a comparison of plot borders in random cells of the basic grid as rectangles.⁸⁵

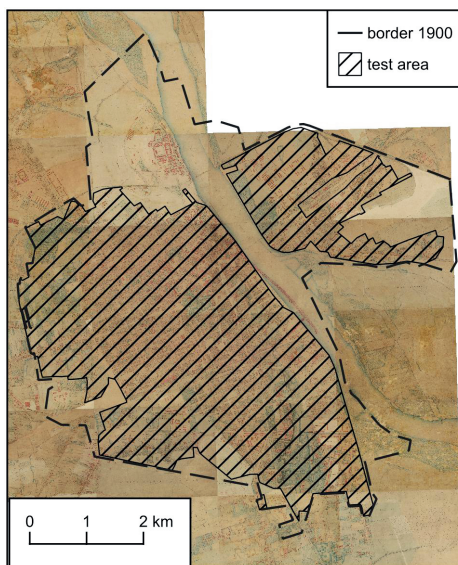


Fig. 6. Scope of the test area within the 1900 Warsaw border.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

The hexagonal grids have advantages when analysing the relations between the cells of the grid in urban studies.⁸⁶ However, in this case, I focused on the situation represented in individual cells, not on relations between cells or the spatial pattern they present. Moreover, the rectangular grids allude to the Lindleys' Map division into map sheets. I used a square with a side of 213.36 m corresponding to the width of the meridional stripes of Lindleys' maps.⁸⁷ The grid is adjusted to intersect the main point of the map and rotated by two degrees to the left. I used the "test area" polygons to trim the grid of squares. In the analysis, I took into consideration the polygons that have at least 95 per cent of the area of the full

⁸⁴ J. Suchy, 'Czy prawo własności nieruchomości w Polsce jest nadal prawem własności?', *Ekonomia*, vol. 25, no. 3 (2019), 55–66; M. Popiołek, "'Miastu – grunty, mieszkańcomi – dom'". Historia powstania dekretu Bieruta na tle europejskiej myśli urbanistycznej, in *Spór o odbudowę Warszawy. Od gruzów do reprivatyzacji*, ed. T. Fudala (Warszawa, 2016), pp. 37–58; M. Pytlewska-Smółka, 'Restytucja mienia objętego działaniem tzw. dekretu Bieruta z 26 października 1945 r. w świetle działań Komisji do spraw reprivatyzacji nieruchomości warszawskich', *Radca Prawny. Zeszyty Naukowe*, vol. 16, no. 3 (2018), <https://kwartalnikradcaprawny.kirp.pl/2018/10/10/restytucja-mienia-objętego-działaniem-tzw-dekretu-bieruta-z-26-października-1945-r-w-swiecie-dzialan-komisji-do-spraw-reprivatyzacji-nieruchomosci-warszawskich/> [accessed on 20 June 2023].

⁸⁵ A.J. Kimerling et al., *Map Use: Reading, Analysis, Interpretation* (Redlands, California, 2016), pp. 593–606; P.A. Longley, *Geographic Information Systems and Science*, 4th edn (Hoboken, 2015), p. 39.

⁸⁶ X. Zhai et al., 'Research on the comparison of extension mechanism of cellular automaton based on hexagon grid and rectangular grid', in *International Symposium on Spatial Analysis, Spatial-Temporal Data Modeling, and Data Mining*, ed. Y. Liu, X. Tang, SPIE Proceedings Series (Wuhan, 2009).

⁸⁷ Jeżowski, 'Rozdział XV', p. 249.

rectangle, i.e. 473 of the 686 polygons obtained.

The RMSE value of the georeferenced Lindleys' Map (see above) is low, yet it does not allow comparison with precise modern surveying data from the National Integration of Land Records. Therefore, the analysis here is qualitative.

When selecting street blocks for test sites, I planned to use the "Destruction Survey Map" from 1945–1946,⁸⁸ which should present the same plots based on the Lindleys' Map. However, due to the map's high level of detail, it was impossible to identify uniform test polygons. Thus, the tested area is divided into categories from the "Map of Warsaw at the scale of 1:20,000 and inventory of the destruction perpetrated by the Germans during the war 1939–1945".⁸⁹ The georeferencing process was completed in the "Georeferencer" plugin in QGIS by the transformation algorithm Polynomial 1 (EPSG:2180), which was conducted with 17 GCP and an RMSE of 15.28 m. I divided the test polygons into three classes: (1) "buildings" (278 polygons), (2) "greenery" (83), and (3) "Warsaw ghetto" (112).

The class "buildings" includes "building grounds," "buildings destroyed by systematic mining and in part bombs," "buildings destroyed by systematic setting on fire," and "buildings which the Germans have not succeeded in destroying," and white areas (implicitly understood as "no data" or "confidential data") from the map of Warsaw's destruction at the scale of 1:20,000. For the "greenery" class, I took into account "ploughed land," "meadows and uncultivated land," and "parks and groups of old trees destroyed by the Germans"⁹⁰ from the same source. In the case of polygons

containing both greenery and buildings, the area was assigned to a class that covered a larger area.

I considered the Warsaw ghetto separately due to the level of destruction of this area after the Second World War, which is visible, among other things, on the orthophoto map from 1945.⁹¹ The ghetto area is only labelled – but not delineated – on the map at the scale of 1:20,000. Thus, I adopted the ghetto's borders as drawn by Paweł Wespziński in the book by Barbara Engelking and Jacek Leociak.⁹² Each polygon that contained a fragment of the ghetto area is assigned to this class.

Regardless of the number of polygons in the class, five case study test areas were analysed in each class (Fig. 7).⁹³ The case studies polygons were selected by the QGIS "Random selection within subsets" algorithm with count value method to define the total number of features in the subset. If there were no plot borders in the selected polygon, the algorithm was restarted.

For analysis purposes, I intersected the layer with plots from the Lindleys' Map with case study polygons. Afterwards, I changed the plots' polygons into lines

⁹¹ Layer "RASTER_ORTOFOTO_1945" from Urząd m.st. Warszawy, Biuro Geodezji i Katastru (City Hall of Warsaw, Office of Surveying and Cadastre), Web Map Service, <https://wms.um.warszawa.pl/serwis> [accessed on 20 June 2023]. Compare preserved buildings from the ghetto area on the 'Map 9: Maps of the ghetto – contemporary street grid and remnants of buildings on the background of the pre-war city map', in B. Engelking, J. Leociak, P.E. Wespziński, 'Online Warsaw Ghetto map and database – Atlas of the ghetto – Maps of the ghetto – contemporary street grid and remnants of buildings', <https://new.getto.pl/en/Atlas-of-the-ghetto/Maps-of-the-ghetto-contemporary-street-grid-and-remnants-of-buildings> [accessed on 20 June 2023], from the book: B. Engelking, J. Leociak, *Getto warszawskie: Przewodnik po nieistniejącym mieście*, maps by P.E. Wespziński (Warszawa, 2013).

⁹² 'Map 1: Ghetto plans – ghetto borders before the Great liquidation Action' after plans by Wespziński in Engelking, Leociak, 'Online Warsaw Ghetto map and database – Atlas of the ghetto – Maps of the ghetto – ghetto borders before the Great liquidation Action', <https://new.getto.pl/en/Atlas-of-the-ghetto/Maps-of-the-ghetto-ghetto-borders-before-the-Great-liquidation-Action> [accessed on 20 June 2023].

⁹³ J. Daniel, *Sampling Essentials: Practical Guidelines for Making Sampling Choices* (Thousand Oaks, 2012), p. 322.

⁸⁸ More on the map of Warsaw 1945–1946, see Elżanowski, 'Ruins, Rubble and Human Remains'; J. Elżanowski, C.M. Enss, 'Cartographies of catastrophe: mapping World War II destruction in Germany and Poland', *Urban History*, vol. 49, no. 3 (2022), 589–611.

⁸⁹ Kowalski, Piątkowski, *Warszawa*.

⁹⁰ Spelling in accordance with the source material: *ibid*.

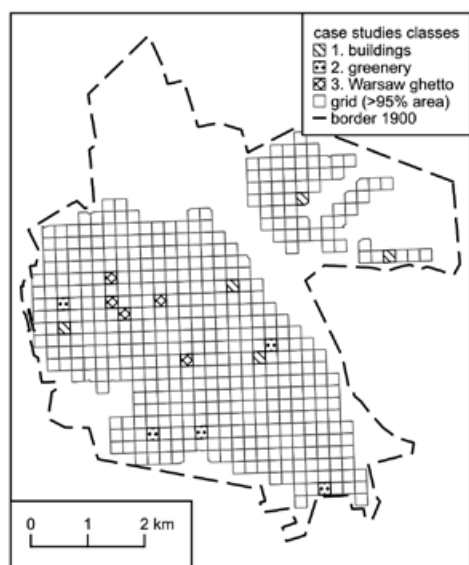


Fig. 7. Random sample of case studies polygons within the grid.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

and split all segments of the lines into separate objects using the tool “Explode lines” from the Processing Toolbox. Then, I removed redundant test polygon boundaries left over from “Intersection” and recurring lines.

For the purposes of comparison, I used layers with plots called “Cadastral parcels from poviats” (“Działki ewidencyjne z powiatów”) from a WMS service of National Integration of Land Records.⁹⁴

The areas selected in the class “buildings” (Fig. 8) encompass two polygons from the right bank of the Vistula River (Fig. 8, polygon 3 at intersection of Grochowska and Mińska Streets, 75 – at intersection of Targowa and Esplanadowa Streets), two polygons from the Warsaw centre (157 – area around Smolna Street and Jerozolimka Alley, 201 – Krakowskie Przedmieście), and one near the western

border of the city at intersection of Górczewska and Młynarska Streets (438).

In terms of the analysis of polygons from the first class, a large role was played by the reconstructed and preserved buildings as well as the associated real-estate areas, which are included in the Register of Monuments (level of the country) or Municipal Register of Monuments (level of commune). It is the case of polygons no. 75 in Praga District and no. 201 at the main historic street of Warsaw – Krakowskie Przedmieście.

In the case study, polygon no. 75 at the northern-west frontage of the Esplanadowa Street (now 11 Listopada Street) was moved to widen the street after the elaboration of cadastral map 1936–1941. The border of the street-block in the centre of polygon no. 75 did not change since 1936, however, half of the plots inside were remodelled.

In polygon no. 201, the main monuments are Carmelite Church with its Seminary and gardens, Namiestnikowski Palace (current Presidential Palace), the guard-house of Potocki Palace and the so-called Zajazd Dziekanka. After the war, the plot where the last building stands was merged with three other parcels to build one large dormitory.

The plots within polygon no. 157 were stable between 1897–1901 and 1936–1941. Parts of the frontage of Smolna Street have survived to this day (and are included in the Municipal Register of Monuments). So do two plots near that street, however, with no buildings, as half of the pre-war street block was turned into a small green area after the war.

When it comes to two polygons on the outskirts of Warsaw from the turn of the centuries, interestingly, plot borders from the left bank of Vistula River have displayed greater stability (no. 3). Mińska and Grochowska streets were widened, and the division of plots in the northern frontage of Mińska Street took place before the war. On the other hand, polygon no. 438 underwent strong development

⁹⁴ GUGiK, Web Map Service “Krajowa Integracja Ewidencji Gruntów”. The National Integration of Land Records WMS service has limitations in terms of printing; therefore, they are not presented on Figs 8–10.

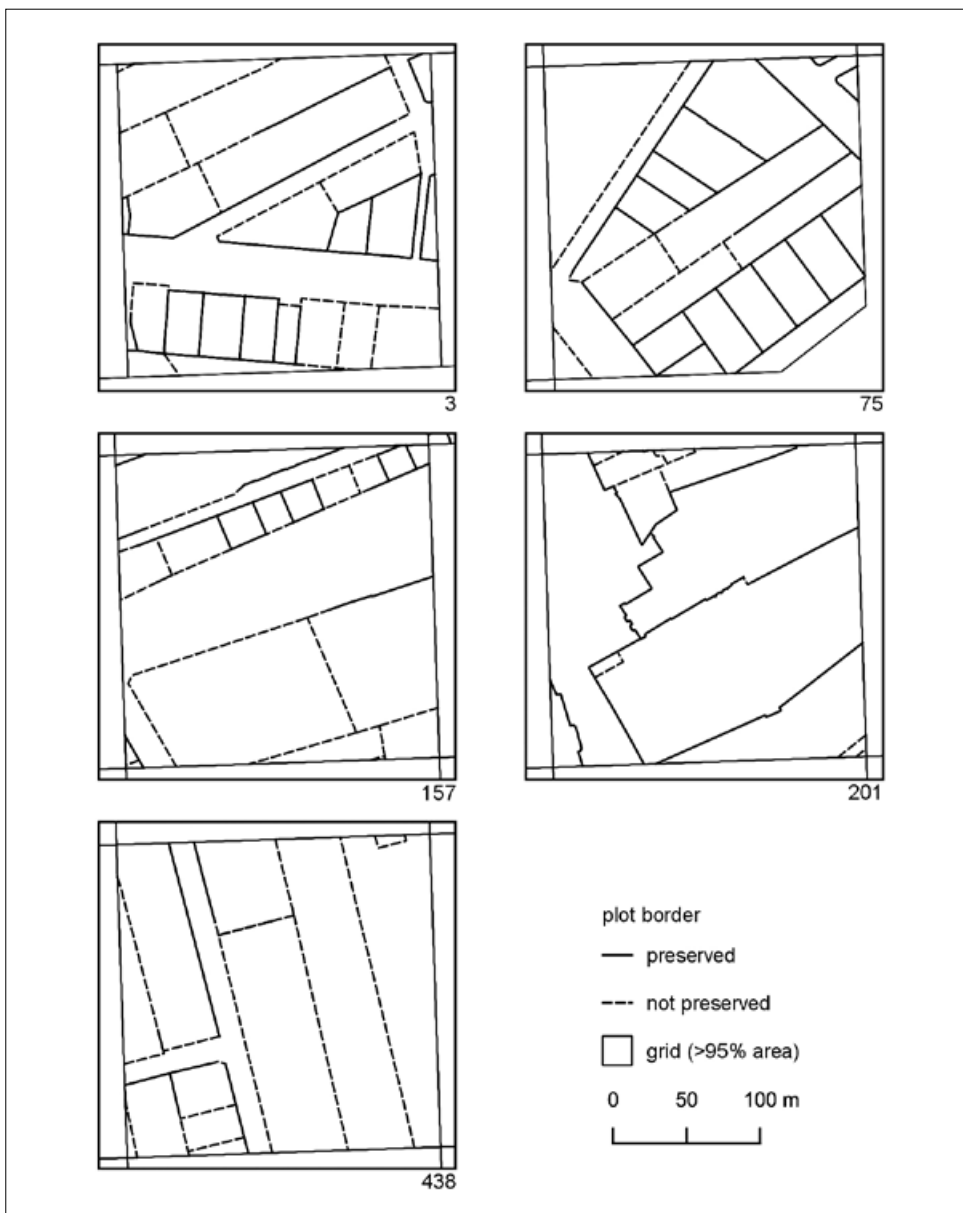


Fig. 8. Case study polygons from “buildings” class.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

before the Second World War. Leszno Street was extended to the west to connect with Górczewska Street. Plots in the western part of the polygon were divided into smaller ones, and in the eastern part (Leszno Street) completely remodelled.

This area’s main remnant of the past is the western frontage of Młynarska Street.

The areas selected in the “greenery” class (Fig. 9) encompass three polygons in the southern part of the city – on the border of the Royal Baths Park (43), on

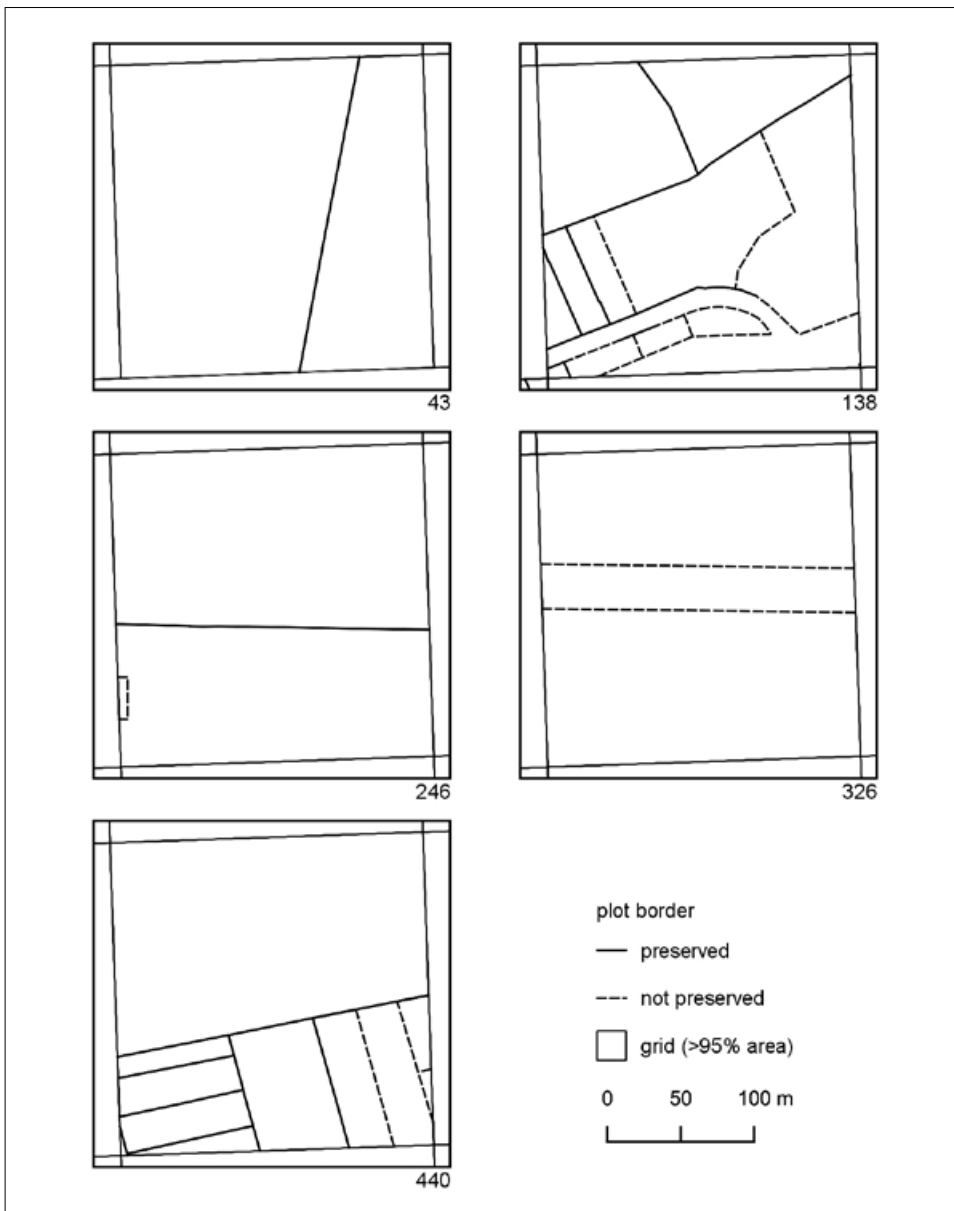


Fig. 9. Case study polygons from "greenery" class.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

Nowowiejska Street (246), and near the Warsaw Water Filters (also known as Lindley's Filters, polygon no. 326), one in the city centre (138), and one in one near the western outskirts of the city on the border of the cemeteries (440).

In the case study, polygon no. 43, the border of the green area is stable, and the Royal Baths Park is still located in this area. Within the case study polygon no. 246, the border of one of the green areas is stable. The city donated the plot

to the Warsaw University of Technology at the turn of the nineteenth and twentieth centuries.⁹⁵ Interestingly, the sheet was not updated with the outline of the university buildings, which was the case with the southern part of the polygon in question. When the plan was created, the southern part was adjacent to the horse racing area. The Lindleys' Map shows an update related to the construction of military buildings and an orphanage in this area at the turn of the nineteenth and twentieth centuries (later Mokotowski Hospital).⁹⁶ The layout of the plots in this area was still maintained during the creation of the 1936 cadastral map.⁹⁷ However, currently, the buildings have various functions and belong to different institutions, and Lekarska Street has been marked out between them. Therefore, the plot system changed after the Second World War.

Case-study polygon no. 326 caused difficulties in the vectorisation process. On the Lindleys' Map, Nowowiejska Street crosses the polygon from west to east, yet it was shortened to the crossing with Sucha Street before 1912.⁹⁸ Since then, the whole area of the polygon no. 326 belongs to one cadastral plot, which is included in the inventory of the National Institute of Cultural Heritage.⁹⁹

Green areas within case-study polygon no. 138 include parks and gardens adjacent to hospitals (Ophthalmic Institute and Red Cross), school (St Kazimierz Institute) and library (Przeddziecki Palace). The last

two gardens are included in the inventory of the National Institute of Cultural Heritage.¹⁰⁰ However, the one around the Przeddziecki Palace was split into two plots. The boundary between the two hospitals' gardens was changed (moved to the west) between 1936 and today, so that the gardens were combined into one green area, the Karol Beyer Park.

Case-study polygon no. 440 contains the southern part of the Evangelical-Augsburg cemetery and the northern part of the Evangelical Reformed cemetery, which were stable in the analysed period. Four plots at Młynarska Street, which are neighbouring necropolises and were largely undeveloped when the map was drawn up, also show the stability of external borders. Only one of them was split in two. Borders of the plots neighbouring cemeteries from the southeast were completely remodelled after 1936. The map from 1936–1941 presents the planned Długosza Street at the southern border of the Evangelical-Augsburg cemetery, yet the plan was not implemented.

The areas selected in the class "Warsaw ghetto" (Fig. 10) encompass polygons on the southern border of the ghetto (272), in the area of the Hospital of the Holy Spirit (317), on the crossing of Pawia and Smocza Streets (394), and two polygons located near Żelazna Street in the area which particular plots were incorporated or excluded from the ghetto in 1941 (373, 392).¹⁰¹

The plot boundaries from the area of the ghetto have displayed a low degree of stability over time. Until 1936 only a few plots from the analysed polygons were divided into two or more plots (e.g. two plots in polygon no. 394 and 234, one in polygon no. 392), and Żelazna Street was widened at the intersection with Leszno Street (373). The changes in the plot borders result from the post-war widening of

⁹⁵ Fundacja Warszawa 1939, Politechnika Warszawska, Gmach główny, <https://www.warszawa1939.pl/obiekt/politechnika> [accessed on 20 June 2023].

⁹⁶ Fundacja Warszawa 1939, 6 Sierpnia róg al. Niepodległości – 1. Szpital Okręgowy im. Marszałka Józefa Piłsudskiego, Szpital Mokotowski, <https://www.warszawa1939.pl/obiekt/szpital-mokotowski> [accessed on 20 June 2023].

⁹⁷ Urząd m.st. Warszawy, Historical Map.

⁹⁸ Żelichowski, Wespziński, *William Heerlein Lindley*, map: Plan niwelacyjny miasta Warszawy opracowany pod kierunkiem W.H. Lindleya w skali 1 : 10 000 z 1912 roku.

⁹⁹ NID, Web Map Service "Immovable Monuments".

¹⁰⁰ NID, Web Map Service "Immovable Monuments".

¹⁰¹ Engelking, Leociak, Wespziński, 'Online Warsaw Ghetto map'.

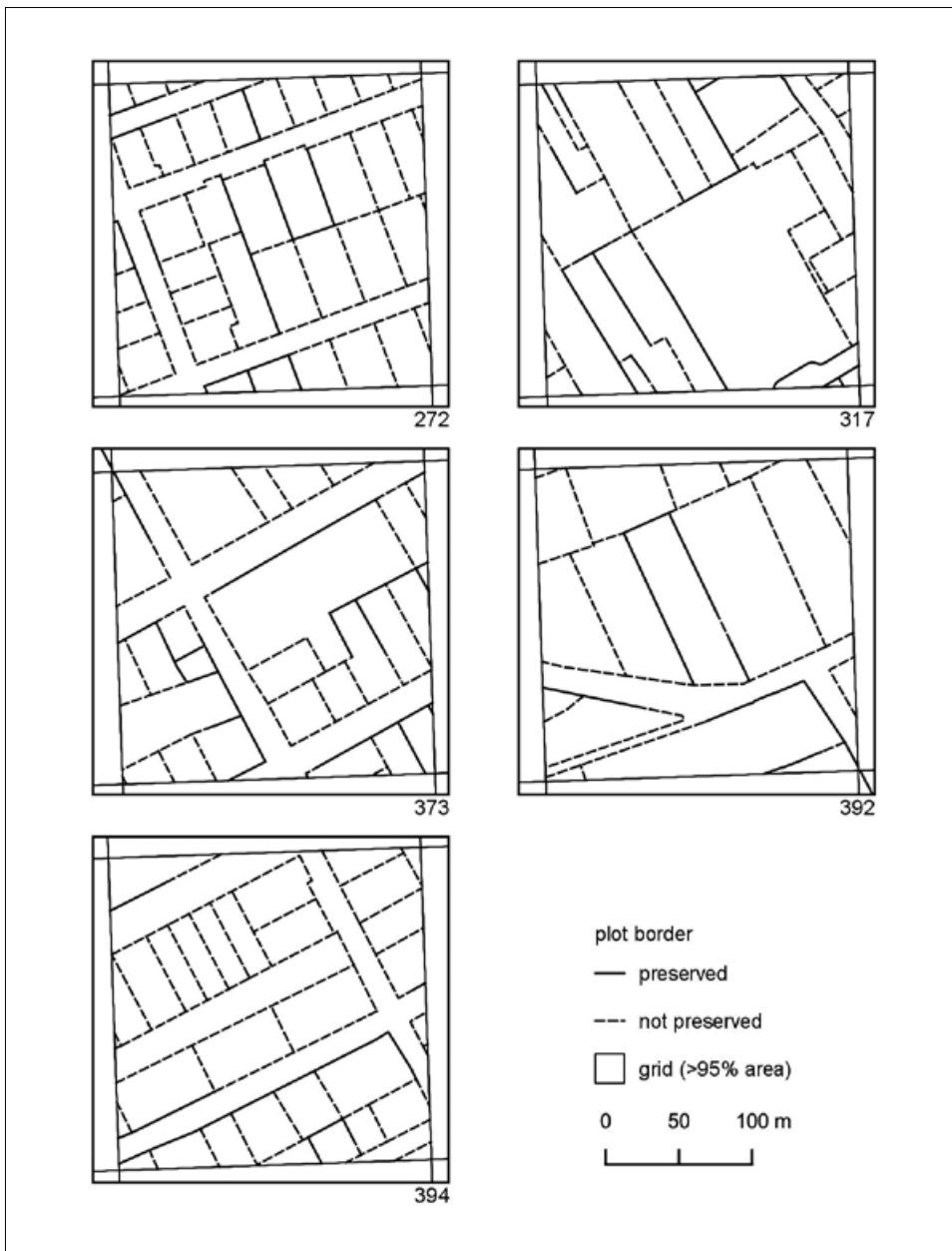


Fig. 10. Case-study polygons from "Warsaw ghetto" class.

Source: Own elaboration based on APW, 785, 72/1001 Zarząd Budowy Kanalizacji i Wodociągów w Warszawie

the streets, as well as the scarcely preserved pre-war buildings. Parts of some boundaries of street blocks, like southern frontages of Pawia Street or Leszno Street (today "Solidarności" Alley), are still visible in

cadastral data. More interesting is the stability of plot boundaries within street-blocks, as if the person cutting the fabric of the city anew used these several-metres-long fragments of the old urban tissue.

6. Conclusion

The 1:2,500 Lindleys' Map, as the first mathematically precise map of Warsaw, constitutes a fundamental source for urban, historical, and geographical studies. Plot vectorisation and sharing available data is essential for studies on the historical urban space of Warsaw, as the map in question was in use for almost 50 years and formed the basis of the pre-Second World War cadastral map and the "Destruction Survey Map". Moreover, the urban plots from the Lindleys' Map at the scale of 1:2,500 had already proven useful for researching eighteenth-century Warsaw.¹⁰²

Reconstruction or construction of new buildings is one aspect in analysing of Warsaw's rebirth after the Second World War, which focuses on what is visible in the urban tissue, and is perceived by us as a complete spatial change as opposed to any nostalgic attempts to recreate pre-war Warsaw, understood as a visible landscape of buildings.¹⁰³ However, the key question is whether the "subcutaneous" tissue of the city in the form of plot borders, invisible at "first glance" and revealed only in geodetic documentation, has also undergone this revolution. Or maybe the course of the borders of cadastral plots preserves the "spatial spirit" of pre-war Warsaw for future generations?

The comparison of plot boundaries on selected case-study polygons proves that even in a city as destroyed as Warsaw, borders of parcels could survive up to this day. Sometimes in the most peculiar forms, as a part of a little park. Due to the level of destruction and the idea behind the

rebuilding of Warsaw,¹⁰⁴ the plots in the city centre could not show the same rate of stability as in New York or Leiden.¹⁰⁵ The persistence of analysed boundaries in the city centre of Warsaw depended on the political decisions indicating which monuments should be rebuilt or preserved. On the other hand, the stability of the plots localised near to the city outskirts does not necessarily undergo a strong remodelling, as the example from the right bank of the Vistula showed. The ghetto area presents interesting examples of how planners with a *carte blanche* probably used some of the pre-war plot boundaries to organise a completely new residential area. When it comes to the greenery, the boundaries of the parks, gardens and cemeteries seem to be stable over time. If hardly surprising in the case of the cemeteries, it might come unexpected in areas which were undeveloped when the Lindleys' Map was elaborated, but their function changed over the course of the century, and they now constitute a part of built-up areas.

The presented results are only one of the possible interpretations of historical sources in relation to contemporary data. Although made with utmost care, it should not be the basis for considering any legal issues regarding individual cadastral plots.

All data are available in the form of an interactive map at the *Atlas Fontium* website: <https://atlasfontium.pl/language/en/lindleys-map-of-warsaw-en/>. I hope that the data shared in this paper will constitute a basis for further projects and analysis, and will serve researchers working with the historic urban space of Warsaw. ■

¹⁰² Kuc-Czerep, Słomska, 'Wyzwania integracji źródeł'.

¹⁰³ In June 2023, the construction of Central Square next to the Palace of Culture and Science in Warsaw began. According to the project, the street network and the outline of buildings from 1939 will be reflected in the square layout with greenery and sidewalks. Urząd m.st. Warszawy, 'Serce Warszawy na nowo – początek budowy placu Centralnego', <https://um.warszawa.pl/-/serce-warszawy-na-nowo-początek-budowy-placu-centralnego> [accessed on 4 Oct. 2023].

¹⁰⁴ Kurcewicz, 'Ideologiczne oblicze'.

¹⁰⁵ Oliveira, 'The Town-Plan'; IJsselstijn, 'Tracing the persistence', pp. 236–242.

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Lindleyowski plan Warszawy (1:2500) jako narzędzie wspomagające zrozumienie stopnia zachowania przestrzeni miejskiej**Streszczenie**

Głównym przedmiotem zainteresowania autorki artykułu jest plan Lindleyów w skali 1:2500 (1897–1901), będący jednym z rezultatów prac kartograficznych podjętych w związku z rozwojem sieci kanalizacyjnej i wodociągowej w Warszawie. Plan jest podstawą prezentowanej edycji działek miejskich. Uzyskane dane przestrzenne pozwoliły na porównanie stabilności granic działek miejskich od przełomu XIX i XX w. z obecnymi danymi geodezyjnymi. Plan Lindleyów, jako pierwsze matematycznie dokładne przedstawienie Warszawy, stanowi podstawowe źródło do badań urbanistycznych, historycznych i geograficznych miasta. Udostępnienie w formie danych przestrzennych zaprezentowanych na planie działek katastralnych jest cenne dla badań nad

historyczną przestrzenią miejską Warszawy, gdyż przedmiotowy plan był w czynnym użyciu przez prawie 50 lat. Głównymi celami autorki artykułu jest scharakteryzowanie planu Lindleyów w skali 1:2500, omówienie procesu cyfrowej edycji działek miejskich oraz przesłedzenie stabilności granic parceli w porównaniu ze współczesnymi danymi. Porównanie granic działek na wybranych poligonach badawczych dowodzi, że nawet w tak zniszczonym mieście jak Warszawa, gdzie dodatkowo wprowadzono tzw. Dekret Bieruta, granice działek mogły przetrwać do dziś. Ze względu na poziom zniszczeń i ideę stojącą za odbudową Warszawy, działki w centrum miasta nie wykazują poziomu stabilności, jaki jest diagnozowany dla innych miast. ■

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