A GENERALIZED INVESTIGATION OF POTENTIAL
AGGREGATE AVAILABILITY BY REGIONAL
GEOMORPHIC UNITS WITHIN THE ADJACENT
48 STATES

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BY

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JOINT HIGHWAY RESEARCH PROJECT

PURDUE UNIVERSITY AND
INDIANA STATE HIGHWAY COMMISSION

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TO: J. F. McLaughlin, Director February 2, 1971
Joint Highway Research Project

FROM: H. L. Michael, Associate Director
Joint Highway Research Project File No: 9-10-2

Attached is a technical paper entitled "A Generalized Investigation of Potential Aggregate Availability by Regional Geomorphic Units Within the Adjacent 48 States". The paper was prepared for presentation at the 50th Annual Meeting of the Highway Research Board. It resulted from research performed under a National Cooperative Highway Research Program (NCHRP) contract.

The paper has been authored by M. W. Witczak, formerly on the JHRP staff and now with the Asphalt Institute, C. W. Lovell, and E. J. Yoder. The paper is presented to the Board for their information.

Respectfully submitted,

Harold L. Michael

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A GENERALIZED INVESTIGATION OF POTENTIAL
AGGREGATE AVAILABILITY BY REGIONAL GEOMORPHIC UNITS
WITHIN THE ADJACENT 48 STATES

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INFORMATIVE ABSTRACT

A Generalized Investigation of Potential Aggregate Availability by Regional Geomorphic Units Within the Adjacent 48 States

by

Matthew W. Witczak, C. W. Lovell, Jr., and E. J. Yoder

The principal activity in this study was an examination of the potential aggregate availability of the Adjacent 48 States within an extant physiographic classification system. The classification selected was a modified version of the Woods-Lovell Physiographic-Engineering System, comprised of 97 physiographic sections.

Estimated potential aggregate availability was rated at four levels, ranging from "abundant-to-adequate" to "severe-problem." Individual physiographic section ratings were assigned following an examination of the major aggregate type(s) used, their distribution within the section, and any quality limitations associated with their use.

Information relative to aggregate types and characteristics was gathered from: the literature, particularly bedrock and surficial maps, and responses to a materials questionnaire sent to each state highway agency.

The study shows that aggregates are potentially in short supply over about one-third of the Adjacent 48 States, i.e., these areas have "limited to severe problem" ratings. Such areas are primarily comprised of regional topography formed from predominantly sandstone and shale bedrock, or from transported deposits deficient in either quantity or quality of sand-gravel and underlain by bedrock with little or no aggregate potential.

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INTRODUCTION

While engineering design and construction decisions are unique solutions to particular problems, such solutions depend strongly upon the store of highly relevant experiences which exist in the engineer's background. How does the engineer organize his experience so that the item appropriate to a particular job is retrieved? For example, are there geographic units within which general geotechnical conditions are unique, and accordingly, engineering solutions are similar.

The search for geographic units within which ground conditions, other environmental factors, engineering problems, and presumably, design and construction practice, demonstrate significant homogeneity, has led to study of the works of physiographers and regional geomorphologists. Through reference to their three major classification factors of structure, process, and stage, which can be practically interpreted as parent material, origin, and age (9)¹, physiographic units are mapped. Each unit has a unique mode of topographic expression, i.e., it differs from its neighbors in this respect. The units of greatest usefulness to engineers are, from largest to smallest, province, section, and subsection.

1. Underlined numbers in parentheses refer to entries in the List of References.

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PURPOSE

The salient objective of this paper is to report a study of the practicality of using physiographic units to rate the potential availability of quality aggregate resources within the Adjacent 48 States. The units were defined by a slightly modified version of the Woods-Lovell Engineering-Physiographic System presented in 1960 (8). This version resulted in the establishment of 97 "unique" areas¹ to be investigated. Table 1 lists each province and section and provides a code for their location, as shown in Figure 1.

METHOD OF ANALYSIS

General

Data on the distribution of potential aggregate resources were sought by literature search and by questionnaires directed to the state highway agencies. Sources were mapped by aggregate type and all quality problems reported for the sources were recorded.

Mapping

Aggregate sources were mapped as, (a) sand-gravel sources (Figure 4), and (b) crushed stone sources (Figure 2). The latter group was subdivided

1. Termed Physiographic Sections.

Table 1
Physiographic Unit Code

1. Western Mountains of the Pacific Coast Range Province
 - a. Olympic Mountain Section
 - b. Oregon Coast Range Section
 - c. Klamath Mountain Section
 - d. California Coast Range Section
 - e. Los Angeles Range Section
2. Sierra - Cascade Province
 - a. Northern Cascade Mountain Section
 - b. Southern Cascade Mountain Section
 - c. Sierra Nevada Section
 - d. Lower California Section
3. Pacific Troughs Province
 - a. Puget Sound Section
 - b. Willamette Valley Section
 - c. California Valley Section
4. Columbia Plateau Province
 - a. Walla-Walla Section
 - b. Blue Mountain Section
 - c. Snake River Plains Section
 - d. Payette Section
 - e. Harney Section
5. Basin and Range Province
 - a. Great (Closed) Basin Section
 - b. Sonoran Desert Section
 - c. Salton Trough Section
 - d. Open Basin (Mexican Highland) Section
 - e. Sacramento Highland Section
 - f. Great Bend Highland Section
6. Colorado Plateau Province
 - a. High Plateaus of Utah Section
 - b. Uinta Basin Section
 - c. Canyon Lands Section
 - d. Navajo Section
 - e. Grand Canyon Section
 - f. Datil Section
7. Northern Rocky Mountain Province
 - a. Montana Section
 - b. Bitterroot Section
 - c. Salmon River Section
8. Middle Rocky Mountain Province
 - a. Yellowstone Section
 - b. Bighorn Mountain Section
 - c. Wind River Mountain Section
 - d. Wasatch Section
 - e. Uinta Mountain Section
9. Southern Rocky Mountain Province
 - a. Front Range
 - b. Western Section
 - c. San Juan Mountain Section
10. Great Plains Province
 - a. Glaciated Missouri Plateau Section
 - b. Unglaciated Missouri Plateau Section
 - c. Bighorn Basin Section
 - d. Wyoming Basin Section
 - e. Black Hills Section
 - f. High Plains Section
 - g. Colorado Piedmont Section
 - h. Raton Upland Section
 - i. Pecos Valley Section
 - j. Plains Border Section
 - k. Central Texas Mineral Section
 - l. Edwards Plateau Section
 - m. Osage Plains Section
11. Central and Eastern Lowlands Province
 - a. St. Lawrence Lowland Section
 - b. Champlain Lowland Section
 - c. Hudson River Valley Section
 - d. Mohawk River Valley Section
 - e. Eastern Lakes and Lacustrine Section
 - f. Central Till Plain Section
 - g. Driftless Section
 - h. Western Lakes and Lacustrine Section
 - i. Dissected Loessial and Till Plain Section
12. Laurentian Upland Province
 - a. Superior Upland Section
 - b. Adirondack Section
13. Ozark and Ouachita Province
 - a. St. Francois Mountain Section
 - b. Springfield-Salem Plateau Section
 - c. 1. Boston Mountain Section
 2. Arkansas Valley Section
 3. Ouachita Mountain Section
14. Interior Low Plateaus Province
 - a. Blue Grass Section
 - b. Nashville Basin Section
 - c. Shawnee Hills Section
 - d. Highland Rim Section
15. Appalachian Plateau Province
 - a. Catskill Mountain Section
 - b. New York Glaciated Section
 - c. Allegheny Mountain Section
 - d. Kenahwa Section
 - e. Cumberland Section
16. Newer Appalachian (Ridge and Valley) Province
 - a. Pennsylvania-Maryland-Virginia Section
 - b. Tennessee Section
17. Older Appalachian Province
 - a. Blue Ridge Section
 - b. Piedmont Section
18. Triassic Lowland Province
19. New England Maritime Province
 - a. Seaboard Lowland Section
 - b. New England Upland Section
 - c. Connecticut Lowland Section
 - d. White Mountain Section
 - e. Green Mountain Section
 - f. Taconic Section
 - g. Reading Prong Section
20. Atlantic and Gulf Coastal Plain Province
 - a. Embayed Section
 - b. Sea Island Section
 - c. Florida Section
 - d. East Gulf Section
 - e. Mississippi Loessial Upland Section
 - f. Mississippi Alluvial Plain Section
 - g. West Gulf Section

Note: Numbers Represent Physiographic Provinces
Letters Represent Physiographic Sections

FIG 1 PHYSIOGRAPHIC DIAGRAM OF THE U.S.

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into carbonate rocks, granitic/metamorphic complexes, and other igneous (primarily basaltic type) rocks. References (1, 2, 4, 5, 6) were particularly valuable in providing state or regional maps of potential sources. Where such direct information was not located, the authors attempted to derive it from generalized state or regional geologic maps, origin-parent material diagrams, and aggregate production data.

In addition to regional potential aggregate areas, existing pits and quarries were mapped on a U.S. scale. These locations were grouped as sand and sand-gravel pits; crushed stone quarries, irrespective of major geologic rock type; and a miscellaneous category. Included within this latter were slag, lightweight aggregate, caliche, clam/oyster shells and coquina.

Aggregate Problems

Many aggregate problems are identified and described in the literature, particularly (3). Problem distribution and magnitude was primarily defined by the responses to the materials questionnaire sent to each state highway department.

Materials Questionnaire

The materials questionnaire responses provided a current resume relative to aggregate types, uses, quality (problems) and availability for each state. The questionnaire responses were coded for convenience. Information was obtained for the specific physiographic sections within each state. Of particular importance to this report were the responses to a request to identify

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those physiographic sections where suitable aggregates were generally absent.

RESULTS

Aggregate Distribution

Figures 2 to 5 partially summarize the results of the mapping effort, both for the potential aggregate areas and the pit and quarry locations. Figure 2 illustrates the generalized potential crushed carbonate stone areas of the United States.¹ It is the general opinion of the authors that the mapping of the carbonate zones east of the Rocky Mountain - Great Plains border affords a relatively accurate pattern of the distribution. West of this border, the carbonate sources are often quite local and scattered, making them very difficult to map at this scale. Figure 3 summarizes the location of crushed stone quarries.

Figures 4 and 5 represent distributive patterns for potential and extant sand and sand-gravel sources. The relative accuracy of the sand-gravel map is quite variable due to the wide range of references interpreted to depict the total distribution.

1. Diagrams showing the distribution of potential crushed granitic/metamorphis, igneous (basaltic) and the miscellaneous aggregate category are shown in (9).

FIGURE 2
DISTRIBUTION OF GENERALIZED POTENTIAL
CRUSHED CARBONATE STONE AREAS

COMPILED FROM NUMEROUS SOURCES

FIGURE 3.
DISTRIBUTION OF CRUSHED STONE QUARRIES IN THE U.S.

FIGURE 4
DISTRIBUTION OF GENERALIZED POTENTIAL
SAND GRAVEL AREAS

FIGURE 5
DISTRIBUTION OF SAND AND SAND GRAVEL PITS IN THE U.S.

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Aggregate Type Usage

Aggregate Type Code

A wide variety of aggregates is used for highways, e.g., a total of thirty-four (34) types are recognized in this study. Table 2 keys these aggregate types to a numerical code. The major groupings are: I. Sands and Gravels, II. Crushed Stone, and III. Miscellaneous. The last group consists primarily of artificial aggregates as well as the authors' interpretation of several "localized" sources, e.g., coquina, clam/oyster shell. The crushed stone group has been further subdivided into: A. Sedimentary, B. Igneous (Extrusive and Intrusive) and C. Metamorphic. The relation between the coded aggregate number and the general category of aggregate should be apparent (sedimentary crushed stone types are the 10 series, igneous crushed stones are denoted by the 20 series, etc.).

Usage

A resume of the major aggregate use by state and aggregate type is given in Table 3. This summary is based primarily upon the responses to the Materials Questionnaire. Where states did not provide such information, input was obtained from references (3, 5, 6, 7), and is accordingly more tentative.

Table 4 is a summary of the aggregate types used for each physiographic section.

Figure 6 shows areas reported by representative state highway officials to be deficient in quality aggregate sources.

Table 2

Aggregate Type Code

	<u>Key</u>		<u>Key</u>
I. <u>Sands and Gravels</u>		II. C. Metamorphic	
Sand	1	1. Non-Foliated	30
Gravel	2	Marble	31
Sand-Gravel	3	Quartzite	32
		Serpentine	
II. <u>Crushed Stone</u>		2. Foliated	
A. Sedimentary		Gneiss	33
Limestone	10	Schist	34
Dolomite	11	Amphibolite	35
Chert	12		
Sandstone	13	III. <u>Miscellaneous</u>	
Novaculite	14	Limerock	40
Argillite	15	Coquina	41
B. Igneous		Clam/Oyster Shell	42
1. Extrusive		Scoria	43
Basalt	21	Volcanic Cinders	44
Diabase	22	Pumice	45
Rhyolite	23	Expanded Clay	46
Andesite	24	Slag	47
Greenstone	25	Silicified Chalk	48
2. Intrusive		Caliche	49
Diorite	26		
Gabbro	27		
Granite	28		
Syenite	29		

Table 3

Summary of General Aggregate Types Used by State

<u>State</u>	<u>Aggregate Type</u>	<u>State</u>	<u>Aggregate Type</u>
Alabama	2,3,10,11,13,28, 30,33,42,47	Nebraska	1,2,3,10
Arizona	3,10,13,21,22,23, 28,31	*Nevada	3,10,13,21,28,30,31
Arkansas	3,10,11,13,14,29,31	New Hampshire	3,28,31
*California	3,10,13,21,28,47	New Jersey	1,3,10,11,15,21,22, 28,31,33,47
Colorado	3,10,13,21,28,30, 45,47	New Mexico	3,10,21,23,24,26, 31,49
Connecticut	3,21	New York	3,10,11,13,22,27,28, 30,31,47
Delaware	1,2,3,33	North Carolina	2,3,10,26,28,30,33
Florida	3,10,41,42	North Dakota	3,43
Georgia	3,10,12,28,30,31,33	Ohio	1,2,10,13,47
Idaho	1,2,3,10,11,21,31,47	Oklahoma	3,10,11,13,28
Illinois	3,10,11,47	Oregon	1,2,3,21
Indiana	3,10,11,47	Pennsylvania	3,10,13,22,28,47
Iowa	3,10,11	*Rhode Island	3,10,28
Kansas	3,10,11,12,13,48	*South Carolina	3,10,28
Kentucky	3,10,47	South Dakota	3,10,13,28,31
Louisiana	3,42,46	Tennessee	3,10,11,13,47
Maine	3,10,13,28,31	*Texas	3,10,13,21,28,30,42, 47,49
Maryland	1,2,10,27,28,30,32, 33,35,37	*Utah	3,10,13,28,30
Massachusetts	3,10,21,22,23,26,33	Vermont	3,10,11,25,28,31, 32,35
Michigan	1,2,3,10,11,13,21, 23,47	Virginia	3,10,11,13,21,22,28, 30,33,42
*Minnesota	3,11,21,28,31	Washington	3,10,13,21,28,31
Mississippi	3,42	West Virginia	1,3,10,13,47
Missouri	1,2,10,11,13,28	Wisconsin	1,3,11,13,21,28,31
Montana	3,10,13,15,21,28,31, 43,47	Wyoming	3,10,11,13,21,28,43

- Notes:
1. See Table 2 for key to aggregate type.
 2. For the states not marked by an asterisk (*) information has been obtained from the materials questionnaire. Those marked by an asterisk (*) have been obtained through a literature search as possible aggregate types only.

Table 4

Summary of General Aggregate Types Used by Physiographic Section

<u>Section Code</u>	<u>Aggregate Type</u>	<u>Section Code</u>	<u>Aggregate Type</u>	<u>Section Code</u>	<u>Aggregate Type</u>
1a	3,13,21	8a	3,28	13a	1,2,10,11,28
b	1,3,13,21	b	3,10	b	1,2,3,10,11,13
c	3	c	3,10,34	c1	3,10,13
d	3,10,11,13	d	3,10,11,13,34,47	c2	3,10,13,29,31
e	3,10,11,28	e	3	c3	3,10,13,14
2a	3,13,21,28	9a	3,10,28	14a	1,2,3,10,11
b	3,10,21	b	3,10,28,30	b	3,10,47
c	3,10,28	c	3,21,31	c	3,10
d	3,28	10a	3	d	3,10,11,13
3a	3,13,21	b	1,3,10,13,43	15a	3,13
b	3,21	c	3,10,11,13,21	b	1,2,3,10,13,47
c	3	d	3,10,13,28	c	10
4a	1,2,3,21	e	10,28	d	1,2,3,10,13,47
b	1,2,3,21	f	1,2,3,10,11,13,28,49	e	1,2,3,10,11,12,13,47
c	1,2,3,21,47	g	3,10,21,47	16a	1,2,3,10,11,13,22,47
d	1,2,3,21	h	3,10,21,26	b	1,2,3,10,11,12,13,30,47
e	2,21	i	3,10,49	17a	2,3,10,21,22,28,30,33
5a	1,2,3,10,11,21,31	j	1,3,11,13,48	b	1,2,3,11,21,22,26-28,30-35
b	3,21,23,28	k	3,10	18	1,3,10,21,22,28
c	3	l	3,10	19a	3,10,13,23,26,28,31,33
d	3,10,13,21-24,28,31,44	m	1,2,3,10,11,12,13,28	b	3,10,11,21,22,25,26,28,31-33,35
e	3,10,31,49	11a	3,10,11	c	3,21,22
f	3,10,21	b	3,10,11,31	d	3,28
6a	3	c	1,3,10,11,13,31,33	e	3,25,28,32,35
b	3	d	3,10,11	f	3,10,11,31
c	3,13	e	1,2,3,10,11,13,47	g	1,3,10,11,15,22,28,30,31,33,47
d	3,13,21	f	1,2,3,10,11,47	20a	1,2,3,28,42,47
e	3,21	g	1,3,10,11,13,28,31	b	1,2,3,42
f	3,10,21,44	h	3,10,11,28,31	c	1,10,41,42,47
7a	3,10,13,15,21,28,31,34,47	i	1,2,3,10,11,28,31,47	d	1,2,3,10,11,40,42
b	1,2,3,10,15,21,28,31,34	12a	1,2,3,21,23,30,31	e	3
c	2,3,21	b	3,27,28	f	1,2,3,42,46
				g	3,42

FIG. 4 QUESTIONNAIRE SUMMARY OF AREAS LACKING QUALITY AGGREGATES

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Availability Ratings of Aggregate by
Physiographic Section

The estimate of the potential aggregate availability for each physiographic section was based upon a four-level rating scale: (a) abundant-to-adequate, (b) adequate-to-limited, (c) limited-to-problem and (d) severe problem.

Ratings were assigned to the physiographic units by: (a) determining the major type or types of aggregates used; (b) examining their relative distribution within the unit; and (c) assessing their major quality problems. It was thus possible for an area possessing an abundant distribution of a potential aggregate type to receive a "compromised" rating due to the presence of a major problem with that particular type. On the other hand, a more limited supply of a good quality aggregate type, which was well distributed within a physiographic section, could produce a "high," e.g., abundant-to-adequate, aggregate availability rating.

Table 5 summarizes the estimated potential availability ratings of aggregates by section, while Figure 7 shows these regions within the Adjacent 48 States.

SUMMARY AND CONCLUSIONS

Aggregate Availability

This study shows that quality natural aggregate resources are not available over sizeable areas of the U.S.

Table 5

Summary of Estimated Potential Availability

Ratings of Quality Aggregates Within Sections

<u>Adequate to Adequate</u>		<u>Adequate to Limited</u>		<u>Limited to Problem</u>		<u>Severe Problem</u>	
<u>Section Code</u>	<u>Area¹</u>	<u>Section Code</u>	<u>Area</u>	<u>Section Code</u>	<u>Area</u>	<u>Section Code</u>	<u>Area</u>
1e	21,790	1a,c	27,130	1b,d	53,840	--	--
2b,c,d	74,530	2a	16,140	--	--	--	--
3a,b,c	42,310	--	--	--	--	--	--
4a,b	61,100	4d	20,560	4c,e	33,190	--	--
5a,b,d,e,f	352,170	--	--	5c	10,520	--	--
6f	9,290	6a,e	41,520	6b,c,d	73,110	--	--
7a	43,800	7b	34,480	7c	27,500	--	--
8b,c,e	16,950	8a,d	28,390	--	--	--	--
9a,b,c	60,450	--	--	--	--	--	--
10c,e,k,l	68,560	10h,m	124,690	10a,d,f,g,i,j	336,200	10b	123,390
11a,b,c,d	11,000	11e,f,i	262,850	11g,h	119,060	--	--
12a,b	72,540	--	--	--	--	--	--
13a	3,790	13b,c3	48,610	13cl,c2	14,090	--	--
14a,b,d	34,840	--	--	14c	16,540	--	--
--	--	15a,b,c,e	56,830	15d	45,930	--	--
16a,b	45,340	--	--	--	--	--	--
17a,b	90,670	--	--	--	--	--	--
18	6,040	--	--	--	--	--	--
19b,c,e,f,g	46,440	19a,d	23,080	--	--	--	--
--	--	20a,b,d,g	319,900	20c,e	57,540	20f	45,700
Total	1,061,610		1,004,180		787,520		169,090
Percent of)							
Adjacent :	35.1		33.2		26.1		5.6
48 States)							

Note: 1. Areas given in square miles

FIGURE 7
ESTIMATED POTENTIAL AVAILABILITY RATING OF QUALITY AGGREGATE RESOURCES BY PHYSIOGRAPHIC UNIT

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As noted in Table 5, section areas comprising over 26% of the total have a "poor" potential for aggregate resources while sections totaling almost 6% have a "very restricted" potential aggregate supply. In addition, the "true" or "realistic" (in contrast to "potential") appraisal of aggregate resources may show an even more unfavorable situation.

For example, in many western areas good potential aggregate sources exist (particularly crushed stone), but the regions are sparsely populated and in many cases the sources are virtually inaccessible due to the extremely rugged, mountainous conditions. These aggregate resources are not only less needed, they are, by virtue of their location, less available.

In contrast, in the east, many of the areas possessing potentially adequate supplies may be quite restricted for exploitation due to urban development and the associated high population densities. This would likewise tend to reduce the real availability.

Geologic Summary of Sections Having
Poor Aggregate Availability Ratings

Although each section possessing a limited-to-problem or severe-problem rating had its own peculiar combination of characteristics responsible for that rating, these sections can effectively be grouped into three types based upon the causative geologic conditions. Table 6 shows the types and the grouping of aggregate-deficient sections within them.

One of the most significant factors, correlative with an aggregate lack, was a widespread distribution of sandstones and shales. This fact, coupled with

Table 6

Generalized Summary of the Predominant Geologic Conditions
Existing Within Sections Possessing an Aggregate Availability
Rating Lower Than Adequate-to-Limited

Type I: Sections Possessing Widespread Distribution of Predominantly Sedimentary
Sandstone and Shale Bedrock Which Significantly Contributes to a Poor
Aggregate Availability Rating

<u>Section/Code</u>	<u>Remarks</u>
Oregon Coast Range (1b)	Tertiary sandstones and shales.
California Coast Range (1d)	Tertiary and Mesozoic sandstones, shales and some slates.
Uinta Basin (6b)	Tertiary sandstones and shales.
Canyon Lands (6c)	Mesozoic sandstones and shales
Navajo (6d)	Mesozoic, Tertiary and late Paleozoic sandstones and shales.
Unglaciaded Missouri Plateau (10b)	Tertiary and Cretaceous sandstones and shales.
Wyoming Basin (10d)	Tertiary sandstones and shales.
Colorado Piedmont (10g)	Tertiary and Cretaceous sandstones and shales.
Pecos Valley (10i)	Triassic sandstones and shales; Permian sandstones, shales, limestone and gypsum.
Plains Border (10j)	Cretaceous and Permian sandstones and shales; Cretaceous limestone.
Driftless (11g)	Cambrian sandstone and shales; Ordovician carbonates in southwest may be used as crushed stone.
Boston Mountain (13c1)	Pennsylvanian sandstones and shales.
Arkansas Valley (13c2)	Pennsylvanian sandstones and shales.
Shawnee Hills (14c)	Pennsylvanian sandstones and shales; Mississippian limestones quarried.
Kanawha (15d)	Pennsylvanian sandstones and shales; Permian limestones and shales.

Type II: Sections Possessing Widespread Distribution of Bedrock With Poor
Crushed Stone Capability (Other than that Noted in Type I) Which
Significantly Contributes to a Poor Aggregate Availability Rating

<u>Section/Code</u>	<u>Remarks</u>
Snake River Plain (4c)	Cenozoic acidic lava plain; regional sand-gravel sources generally available only near mountain borders.
Harney (4e)	Cenozoic acidic lava plain with widespread pumice deposits and lacking regionally distributed sand-gravels.
Salmon River (7c)	Jurassic granitic rocks are not suitable for use as highway aggregate.

Table 6 (continued)

Generalized Summary of the Predominant Geologic Conditions
Existent Within Sections Possessing an Aggregate Availability
Rating Lower Than Adequate-to-Limited

Type III: Sections Generally Possessing a Non Existent to Poor Bedrock Crushed
Stone Potential Overlain by Transported Deposits Either Deficient
in Quantity or Quality of Granular Materials

<u>Section/Code</u>	<u>Remarks</u>
Salton Trough (5c)	Widespread presence of fine grained alluvial and lacustrine deposits characterize much of Section.
Glaciated Missouri Plateau (10a)	Glaciated region possessing sand-gravel deposits of general poor quality underlain by bedrock similar to that found within Unglaciated Section. (See 10b in Type I grouping).
High Plains (10f)	Crushed stone potential non existent in Section; major source of aggregates is from major rivers and tributaries. Higher concentration of rivers in northern portion of unit; however much of the aggregate lacks coarse fraction and may be reactive with cement.
Western Lakes and Lacustrine (11h)	Western portion of unit possesses Cretaceous sandstones and shales similar in characteristics to those found in Type I grouping. Major areas void of aggregate associated with glacial lacustrine areas (Lake Agassiz and Dakota).
Florida (20c)	Sandy unconsolidated coastal deposits veneer almost entire Section. Regional carbonate zones present in portions of the unit, but much of Section lacks coarse aggregate.
Mississippi Loessial Upland (20e)	Widespread loessial deposits overlie areas lacking in crushed stone potentials.
Mississippi Alluvial Plain (20f)	Widespread distribution of fine grained alluvium throughout most of unit.

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a relative lack of quality natural sand-gravel deposits, generally yields areas of extremely poor potential. From Table 6 it can also be noted that most of these areas (within the Type I grouping) have geologic ages which correspond to the Cenozoic, Mesozoic, Late Paleozoic (Permian and Pennsylvanian) and Early Paleozoic (Cambrian) Eras. It is within the Paleozoic periods older than Pennsylvanian that the majority of the crushed carbonate sources occur.

A modal bedrock pattern of sandstone and shale is not always associated with an overall poor aggregate availability rating for the section in question. Examples of sections which, in general, are characterized by relatively soft sandstone and shale bedrock yet possess abundant-to-adequate potential for aggregates are the Bighorn Basin (10c), the Triassic Lowland Province (18), and the Connecticut Lowland Section (19c). Within these units, the widespread distribution of quality sand-gravels and/or crushed stone (obtained from variant bedrock types within the unit) is responsible for the rating.

Type II deficiency areas are those of poor quality igneous rocks (mostly extrusives), while in the Type III the bedrock is generally deeply buried by unconsolidated material deficient in the coarse sizes.

While the examination of potential aggregate availability in 97 physiographic sections produces a useful general perspective, the physiographic section is commonly too large and varied a region for the purpose. Subdivision of the Adjacent 48 States into 242 subsections has been accomplished (9). Examination of this, or another engineering consideration, for these more homogeneous units would permit more specific regional predictions.

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